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STATE DIVISION OF CONSERVATION

DEPARTMENT OF MINES, MINING AND GEOLOGY

GARLAND PEYTON, Director

THE GEOLOGICAL SURVEY

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SHORT CONTRIBUTIONS TO THE GEOLOGY, GEOGRAPHY AND ARCHAEOLOGY OF GEORGIA

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LETTER OF TRANSMITTAL

Department of Mines, Mining and Geology

Atlanta, February 10, 1950

To His Excellency, Herman E. Talmadge, Governor

Commissioner Ex-Officio of State Division of Conservation

Sir:

I have the honor to submit herewith Georgia Geological Survey Bulletin No. 56, "Short Contributions to the Geology, Geography, and Archaeology of Georgia."

The Bulletin consists of short scientific papers prepared by twenty-two geologists, archaeologists, physicists, mineralogists, geographers, graduate students, and engineers, engaged in professional earth science work in the University System of Georgia, Emory University, the State Geological Survey, the United States Geological Survey, or in industrial mineral production.

Several of these papers were presented at the first meeting of the Earth Science Section of the Georgia Academy of Science, at Athens, Georgia, in 1948. The movement to activate and establish on a firm basis this Earth Science Section was spearheaded by Dr. Lane Mitchell, with Dr. Merle Prunty, Jr., Dr. J. G. Lester, Dr. A. S. Furcron, myself and others cooperating. A number of the papers were given at the 1949 meeting of the Georgia Academy of Science at Emory University. Still other papers, here included, were read before the Southeast Division of the Association of American Geographers at the Annual Meeting, Athens, Georgia, December, 1949.

It is deemed well worth-while by the staff of the Georgia Geological Survey to participate in the activities of these and other similar earth science groups, because of the transfer value which will accrue to the State's mineral industrial picture.

Up to the present time, the organizations referred to above have had no facilities for publishing papers on earth science subjects. The publication of these papers as a Bulletin of the Georgia Geological Survey not only represents a broadening of the scope of our usual activities, but in addition, constitutes a permanent record of valuable scientific information, which will be available to all who may have the need or the desire to refer to it in the future.

Very respectfully yours,

GARLAND PEYTON

Director.

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THE INDUSTRIAL MINERALS OF GEORGIA*

GARLAND PEYTON, Director

Georgia Department of Mines, Mining & Geology
Atlanta

Size and Topography

Georgia, the largest state east of the Mississippi River, comprises an area of nearly 60,000 square miles. From north to south its length exceeds 300 miles, while its greatest width from east to west is approximately 250 miles. The southern part of the state, known as the Coastal Plain, is comparatively level, with an average elevation of about 150 feet above sea level. North of the coastal lowland is the Piedmont Plateau, an elevated area varying in altitude from 300 to 1500 feet; while still farther to the north is the Appalachian Mountain region, where many ridges and peaks attain an altitude of 4000 to 5000 feet above sea level.

Georgia occupies a favorable position from the point of view of climate, between warmer sub-tropical climates to the south and the colder climates to the north. This mildness of climate permits all-year mining throughout the State, and we are not faced with the necessity of seasonal shut-down because of severe weather. The State also occupies a strategic position with reference to the Atlantic Seaboard and for trading with South America and the West Indies. The unusual number of railroads and paved highways converging on Atlanta make it the hub of distribution for the Southeast.

Geologic Provinces

The rocks of Georgia occur in three major geologic provinces, viz., the Crystalline area, the Paleozoic area, and the Coastal Plain.

Crystalline Area

The Crystalline area extends from the Fall Line, an irregular line passing approximately through Augusta, Macon,

*Read at the meeting of Georgia Academy of Science, Athens, Ga., April 10, 1948.

and Columbus, to the Cartersville Fault in northwest Georgia. The geology of this area is extremely complex. The rocks consist of ancient sediments and meta-sediments which have been injected by granites, granite gneisses, basic and ultra-basic rocks. The sediments originally were shales, sandstones, and limestones, now altered to mica schists, quartzites and marbles.

It was conventional, forty years ago, to classify all of these rocks as of pre-Cambrian age. Today, however, many of the granites and volcanics are regarded as being of Paleozoic age. The meta-sediments are regarded as both Paleozoic and pre-Cambrian. Granites and granite gneisses of almost unquestioned pre-Cambrian age occur in the northwestern Blue Ridge section.

This ancient Crystalline Belt of Georgia contains an unusual variety of interesting and valuable rocks and minerals. A very large number of our industrial minerals, such as asbestos, chlorite, chromite, copper, corundum, feldspar, gold, granites, graphite, kyanite, marbles, mica, precious stones, pyrite, sericite, serpentine, sillimanite, talc, and others, come from this belt.

It is from this area that sufficient Georgia marble is produced for building and monumental use to give the State top rank as a producer of this mineral resource. In addition to its use for building and monumental stone, recently announced plans by the Georgia Marble Company indicate that they are preparing to enter the field of fine grinding for such uses as whiting, pigment and filler, and the production of high calcium lime for chemical use.

Georgia ranks third in the production of granite. This rock is quarried in the vicinity of Stone Mountain, Lithonia, Camak, Elberton and Stockbridge. The two largest crushed stone plants in the State are located at Lithonia and Camak. In addition to its use as crushed stone for aggregate, it is also employed on a large scale for both monumental and building stone, as well as for a number of other uses, such as chicken grit, block manufacture, and brick making.

Dolomitic marble is produced on a large scale at Whitestone in Pickens County for use as aggregate and as agricultural limestone.

Other mineral resources produced in the Crystalline area include kyanite, used in the manufacture of refractory materials, sheet mica for electrical use, scrap mica for grinding, stream clays for pottery and brick manufacture, Brevard schist for brick manufacture, sand and gravel for building, and gold. One plant in Jasper County is producing and shipping crude feldspar. It is the announced intention of the Company, however, to begin in the near future fine grinding and the production of a clean feldspar concentrate.

Two companies are operating three plants producing both pencil and ground talc at Chatsworth in Murray County. A recent bulletin of the Georgia Geological Survey, Number 53, by Dr. A. S. Furcron, Assistant State Geologist, and Kefton H. Teague, Associate Geologist, Tennessee Valley Authority, forecasts a very bright future for the talc industry in Georgia.

We have one large producer of slate at Fairmount in Gordon County. The finished products consist mainly of slate granules and slate flour, both of which are used in the manufacture of roofing.

Paleozoic Area

Rocks of established Paleozoic age occur in Georgia to the north and west of the Cartersville overthrust. In this area are rocks of Cambrian, Ordovician, Silurian, Devonian, Mississippian, and Lower Pennsylvanian age. The thickest section is represented by Cambrian and Cambro-Ordovician rocks. The other systems are well represented, but Devonian rocks are very thin in Georgia.

All of these rocks were highly folded into sharp anticlines and synclines and faulted at the close of the Paleozoic era. Consequently, the erosion of these rocks has produced the present topography so typical of the new Appalachians, wherein the more resistant sandstones form the ridges, and the non-resistant rocks, such as shales and limestones form the valley areas. Streams are generally adjusted to the soft rocks, thus occupy the valley areas, except for a few dominating antecedent streams which cross structural trends. This is called the Great Valley province because, since shales and limestones greatly dominate over the sandstone beds, valley areas occupy much of the territory.

The Paleozoic area contains many valuable mineral resources, including barite, bauxite, cement materials, clays, coal, fluorspar, flagstone, brown and red iron ores, high calcium and magnesium limestones, manganese, ocher, road materials, sand and gravel, shale, slate, tripoli, and others.

The barite mined in the Cartersville district ranks Georgia second among the states in the production of barite, according to the latest available statistics of the U. S. Bureau of Mines. Barite is used as a pigment and in the manufacture of barium chemicals; also as a filler in various products and as a weighting material in oil well drilling mud.

The relatively high iron and low phosphorus content of the brown iron ores of Bartow and Polk counties render them desirable by the Alabama smelters for blending with their local red iron ores. The production of this brown iron ore has been maintained on a fairly large tonnage basis, both in war and peace time.

Clays, shales, and limestone are used extensively in the manufacture of Portland and silica cements. One of the two large Portland cement plants in Georgia is located in Rockmart, Polk County. Silica cement is manufactured at Cartersville. Limestone is also used as agricultural limestone and for making building lime. An appreciable tonnage of ocher is mined and processed at Cartersville for use in paints and in the manufacture of linoleum. Recent investigations indicate that some of the shales in the Paleozoic area, which for many years have been used extensively, either alone or blended with clay, in the manufacture of brick and tile, are admirably suited for the manufacture of expanded aggregate.

Georgia manganese ores have been produced in the Cartersville district over a period of many years. They were used rather extensively during and immediately following the First World War. They have not been produced on such an extensive scale during and since the Second World War. With the cooperation of the TVA and the U. S. Bureau of Mines, also the U. S. Geological Survey, considerable exploration and laboratory testing have been done on these Cartersville manganese ores. The results of these projects indicate there are still available in the district worthwhile reserves of fair and medium grade manganese ores and that these may be beneficiated to an extent which will transform them into high grade manganese concentrates.

Coastal Plain

The youngest geological province is the Coastal Plain, which occupies that part of Georgia lying to the south of the aforementioned Fall Line. It comprises about three-fifths of the entire state. The Coastal Plain consists of sands, clays, limestones, marls, and so forth, of marine and non-marine origin, which were deposited during and since Late Cretaceous time. The oldest exposed formation was deposited at the present Fall Line, and is known as the Tuscaloosa formation of late Cretaceous age. Other Upper Cretaceous formations are prominent toward the southwest. The whole of the central area of the Coastal Plain is generally covered by Tertiary rocks, Pleistocene and Recent rocks occur in a belt approximately forty miles in width along the coast.

Deep drilling has shown that Lower Cretaceous, and possibly earlier Mesozoic formations, which are not exposed and consequently do not appear on the geologic map, occur beneath the Coastal Plain of Georgia. Many valuable mineral resources are found in the sedimentary rocks of the Coastal Plain.

From the extensive beds of sedimentary kaolins in the central portion of the Upper Coastal Plain, Georgia mines and ships almost 80 per cent of all the white clays used in the country. These clays are used extensively in the manufacture of coating and filling clays, china and whiteware, and in the manufacture of refractories. Two types of fullers earth are produced at two localities, namely, Pikes Peak in Twiggs County and Attapulgus in Decatur County. Thc Twiggs County fullers earth is used extensively for clarifying animal and vegetable fats and oils, while the Attapulgus fullers earth is admirably suited for processing mineral oils.

Bauxite is being produced by one company in the vicinity of Andersonville, Sumter County, on an appreciable scale. Although the production of this material is not as great as it was some years ago, Georgia still ranks second as a producer of bauxite.

A number of companies are producing limestone in the Coastal Plain for use as agricultural limestone and for road metal.

Over 600,000 tons of sand is produced annually in Georgia. The major portion of it comes from the Coastal Plain. It is used extensively as building sand and to a more limited extent in the manufacture of glass and ceramic products. One producer at Thomasville, Georgia, has installed beneficiating equipment which makes possible the production of sand of a quality which will meet more exacting specifications.

History

The history of Georgia's mineral resources goes back for many hundreds of years to the early Red Men who inhabited the area long before the first white men settled here. The progress which has been made in the utilization of minerals, from early time to the present, has had its parallel in the development of civilization in the area.

The full-scale utilization of mineral resources in industry was not essential to the maintenance of the early, more primitive societies. Mineral utilization by the Indians probably was limited to vein quartz for arrow and spear points, river clays to make crude, poorly-burned pottery and utensils, soapstone mortars for grinding corn, and stone for making crude hammers, axes, and plows. The use of metals probably awaited the coming of the white man, who brought in iron for weapons, utensils, tools and farming implements, lead for bullets, and copper for making utensils and implements.

The industrial use of Georgia minerals dates from early Colonial times, when kaolin was first mined near Macon in 1766 and shipped to the famous Wedgewood Pottery in England. The excellent quality of this clay resulted in its continued use for about ten years, and until the discovery of similar clays in England. Almost one hundred years elapsed before this clay was again mined on a commercial scale.

Gold was discovered in Georgia in 1838. Also in 1838 occurred the first recorded production of Georgia marble, now famous throughout the world for its beauty and durability for building and monumental use.

In 1840, Georgia iron ore was smelted for the first time near the site of Allatoona Dam which is now under construction near Cartersville. The first granite quarry was opened near Stone Mountain in 1850, and the production of coal and tripoli was started in northwest Georgia. Next came the opening of a corundum mine in northeast Georgia in 1873, and in 1877 ocher was mined near Cartersville. The first discovery of bauxite in the United States was made in Floyd County, Georgia, in 1886. Production followed in 1887. It was used to make alum and was also smelted to obtain the metal aluminum. No doubt this original discovery and production served to stimulate the search for and the discovery of other, more extensive, deposits of this important mineral, and the early establishment of this country as the leading producer of aluminum. In 1889, the Georgia Geological Survey was created by an Act of the State Legislature.

If we pause here for a look backward, we find that 156 years had elapsed since the first white colonists landed near Savannah. We find also that during all of these first 156 years only thirteen Georgia rocks and minerals were utilized commercially. Today, after only 58 additional years, the number of industrial minerals has increased from thirteen to more than forty, and approximately thirty-five of these are being produced commercially to the extent of over twenty-four million dollars per year.

While this growth in the development of the State's mineral resources indicates progress, actually we find that we have barely "scratched the surface" by comparison with the potential possibilities offered by this branch of Georgia's natural resources. These mineral resources more properly might be referred to as Georgia's undeveloped mineral resources.

The question may be asked, why has this condition existed? The answer involves a number of factors. Probably the dominant factor in the hindered progress of the proper development and exploitation of Georgia's mineral resources has been her preoccupation with agriculture. Until comparatively recently, Georgians generally have remained uninformed concerning the existence and value of the many minerals of their state, and untrained in the art of producing them, with the result that many land owners have spent a lifetime unmindful of the fact that their soil contained mineral wealth equal to if not greater than that obtainable from agriculture.

The young people of the State have not been provided with adequate educational facilities offering an opportunity to train for the profession of geology, mining engineering and metallurgy. For instance, at the present time, there is no school in the State offering a course in mining engineering, and only one institution is offering a full course in geology.

Bankers and individuals with capital to invest have been reluctant to finance mineral industries because of their lack of sufficient knowledge of minerals to judge properly the soundness of such investments. The steps necessary to correcting these adverse conditions are so obvious as to render unnecessary their enumeration here.

Geological Survey

Basically, the development of mineral resources is dependent upon our knowledge of them. Institutions such as our State Geological Survey are fundamental to the progress of such development.

In November, 1947, the Georgia Geological Survey completed 58 years of uninterrupted service. The high standard of excellence exhibited by more than 50 bulletins and maps which have been published to date upon the geology and mineral resources of the State attests the professional skill and the painstaking thoroughness of the geologists and engineers who have composed its staff. A modern Geological Survey must have a program aimed at both basic and applied knowledge. The time has passed when a mineral deposit can be examined and reported on with any assurance that conclusions of today will not have to be revised next year, or even next month. Each change by the manufacturer of the specifications for minerals, and each discovery of a new use for minerals, creates virgin territory for commercial production in deposits which before offered no promise.

The discovery of a new mineral likewise often results in creating an entirely new field of commercial possibility. In the case of a new mineral discovery, however, the problem of working out all of the details necessary to eventual commercial utilization is much more difficult and complex. In a case of this kind, it is essential that the geologist and the engineer collaborate. The recent discovery of sillimanite in Georgia and in the Carolinas affords a good example of this type of collaboration. In this instance, geologists from the Georgia Geological Survey and the Tennessee Valley Authority worked out and mapped the geology, and conducted the necessary exploration to determine the size of the ore body and to obtain sufficient samples for analysis and the testing laboratory. Engineers from the U. S. Bureau of Mines and the Tennessee Valley Authority then took quantities of this ore and processed it to obtain a satisfactory concentrate which, in turn, was submitted to the ceramics laboratory of the U. S. Bureau of Mines at Norris, Tennessee.

The ceramic engineers at Norris performed a considerable amount of experimental work which resulted in proving the superior virtues of this new mineral as the principal ingredient in the manufacture of special high-duty refractories. Thus, it can be seen that the discovery and utilization of a new mineral must depend upon the cooperation of the geologist, engineer and other technologists who possess special knowledge having direct bearing on the complete economic picture involved. No longer can this be accomplished by the usual promotional efforts of the uninitiated.

The Georgia Geological Survey is small compared to surveys in some other states. It has neither the staff nor the facilities which permit it to function independently in a satisfactory and efficient manner toward the development and utilization of mineral resources. Therefore, our present attitude is to invite cooperation of other agencies, such as the U. S. Bureau of Mines, the U. S. Geological Survey, and the Tennessee Valley Authority, in the conduct of projects involving the investigation and study of the geology and usability of minerals, as well as the discovery of new uses and new minerals. Already a number of such cooperative projects have been conducted in Georgia, with results which prove beyond question that this is a most desirable and certainly a very efficient type of cooperation.

It shall be our principal hope in the immediate future to be permitted to spearhead further efforts to bring about a more proper development and utilization of the State's minerals and to create new industries based on the utilization of these mineral raw materials. If we are successful in this effort, and can manage to bring together the technical knowledge and skill essential to keeping abreast of the new scientific discoveries, then we are convinced that it will be only a matter of a few years before we shall be in position to point to growth in the field of industrial minerals which will raise the State's annual income from these resources to several times twenty million dollars.

GEOLOGICAL PROVINCES OF GEORGIA AND THEIR PRINCIPAL MINERAL RESOURCES*

A. S FURCRON

Assistant State Geologist

Introduction

Georgia, as many of the southeastern states, includes portions of the Atlantic Coastal Plain, the Piedmont, and Blue Ridge provinces of the crystalline rocks, and folded Paleozoic rocks of the Great Valley Province. Our total mineral production for 1947 was $38,034,480. If the value of municipal water, and water used for hydro-electric purposes be added, the total value was $53,375,140. Unless otherwise stated, production figures quoted here are for 1947. Georgia is one of the most progressive states in mineral production, as may be seen by comparing the total production for 1947 ($38,034,480) with that of 1937 ($14,268,281,) and 1927 ($16,758,390). Georgia stands sixth from the top among the twenty-two states with little or no coal and oil. Among the states east of the Mississippi River producing little or no coal and oil, Georgia ranks second, with New Jersey slightly in the lead because of a phenomenal deposit of lead and zinc at Franklin.

*Read at meeting of Association of American Geographers, Southeast Division, Athens, Georgia, December 2, 1949.

The Coastal Plain comprises 60 per cent of the area of the State, and also has the largest mineral production, amounting to $20,499,428. The Piedmont and Mountain area of crystalline rocks comprises 30 per cent of the territory and contains the oldest mining industries, with a production figure of $11,695,242. The much smaller area of Paleozoic rocks of northwest Georgia contains 10 per cent of the area, and ranks third in mineral production, but ranks well up with the other divisions in proportion to its area. Its production amounted to $5,839,810. The Coastal Plain and crystalline areas produce in about the same ratio per unit area, but the Paleozoic rocks of northwest Georgia by comparison produce about twice that amount per unit area.

This three-fold division is characterized also by three distinct types of economic minerals. The production of clays and sand dominate Coastal Plain production. Igneous and metamorphic rocks and minerals comprise most of the production of the crystalline area, and limestone and shales are important in the Paleozoic district.

Mineral Resources of the Coastal Plain

The Coastal Plain leads in mineral production with a total of $20,499,428. This includes six principal commercial minerals, but clay and clay products dominate completely nearly all of the production.

Sedimentary kaolin, Georgia's most important mineral resource, is found in a belt of rocks of Cretaceous age south of the Fall Line in Taylor, Bibb, Twiggs, Wilkinson, Baldwin, Hancock, Washington, Glascock, Jefferson, and Richmond counties. Supplies of white kaolin are very large, and are believed to be adequate for future demands. The commercial deposits range from soft to hard, are white, pure, and essentially free of mica and grit. About 60 per cent of the kaolin produced is used as a filler and as a coating for paper, and also as a filler for other purposes. For use in the manufacture of white ware, a certain amount of ball clay, not discovered thus far in the district, is necessary. Many have pointed out the need for the use of more of our kaolin in Georgia industry, because at present practically all of the paper and filler kaolin is shipped to other markets. Also, by importing ball clay, it is believed that Georgia and its neighboring states could support a flourishing white ware and sanitary ware industry. Because we have the kaolin for filling and coating paper, and a very extensive forest industry with paper and pulp mills in the same district, it is not unreasonable to hope that more of this kaolin will be used in the future in Georgia, and with further development of the industry, this will come about. At present, we labor under the difficulty of adverse freight rates. In the manufacture of white ware, the northern plants use the assembly line method, producing in large capacity, and technicians to design such plants have been scarce in the South.

Fullers' earth, or bleaching clays, are located in two regions of the Coastal Plain. In Twiggs, Wilkinson, and Washington counties, they occur in Eocene rocks, and are used as a bleaching agent for animal and vegetable oils. They are mined especially in the vicinity of Pikes Peak in Twiggs County. In southern Georgia, they are extensively mined at Attapulgus, Decatur County, and are used as a bleaching agent for petroleums. We have a large production of fullers' earth, of which there is an almost unlimited supply.

The Portland cement industry of southern Georgia is an important one at Clinchfield, seven miles southeast of Perry, Houston County, where a soft limestone and hard kaolin are used as the principal ingredients.

Limestone for agricultural purposes is produced in at least four different localities in southern Georgia. Much of the soils of Georgia need to be sweetened with lime; thus, there is reason for a considerable increase in production of this product in South Georgia.

High-grade sands for use in glass manufacture, etc., are produced near Thomasville in Thomas County, and have been produced in other localities. Further exploration, especially in the vicinity of our large river valleys, should produce additional supplies. With available sands, and with feldspar of glass grade already in production, this State is well qualified to support a glass industry.

Sand and gravel are widely distributed throughout the State, most of the production coming from the coastal plain where sands for a variety of uses are abundant. We have notable production of sands for general purposes near the Fall Line in the northwest part of the Coastal Plain, especially in the vicinity of Junction City. There is an unlimited supply of sand for various uses over the Coastal Plain district.

Bauxite was discovered in the Coastal Plain of Georgia in 1907 by the Georgia Geological Survey. The deposits occur associated with kaolins in rocks of Tertiary and Cretaceous age. The leading counties are Sumter, Stewart, Macon, and Schley, with an important area in Twiggs, Wilkinson, Baldwin and Washington. Aside from their use as the principal source of aluminum, hard bauxite with low silica content is much used as an abrasive. The South Georgia deposits were re-investigated by the Federal Government during the war ("Geology of the Andersonville Bauxite District of Georgia," by Alfred D. Zapp), and our deposits are regarded in this country as second to Arkansas. This report estimates the district to contain nearly six million long tons of bauxite, carrying at least 51 per cent alumina. Much of the bauxite is overlaid and associated with an estimated one-fourth billion tons of white kaolin and bauxitic clays.

Mineral Resources of the Crystalline Area

The crystalline area contains the greatest variety of minerals, and offers the greatest opportunity for the discovery of new minerals. Production ($11,694,242) is well divided between those of igneous and sedimentary origin. The igneous minerals and rocks including granite, sheet mica, ground mica, feldspar, serpentine, asbestos, and gold, are valued at a total production of $5,190,190, and sedimentary minerals and rocks (metasediments), including marble, talc, kyanite, ground mica, sand and gravel, and clay products, are valued at $6,505,052. Of this total production for crystalline rocks, marble and granite together are valued at $8,429,691. Increased need for crushed stone has greatly increased the value of the granite industry in recent years. The economic resources of this district are characterized by the almost unlimited supply of granite and marble, for which we may expect a steadily increasing demand in the future.

Granite is the leading mineral resource of this district, and the production is rather evenly divided between dimension stone and crushed rock. Total dimension stone production amounted to $2,884,772, and crushed stone (almost entirely granite) amounted to $2,271,971. Our monumental industry is centered around Elberton. Building stone and curb stone are produced from granites of the Lithonia district in DeKalb County. There are four large quarries for crushed stone in the State located at Tyrone, Camak, Lithonia, and Stockbridge. Since the war, fine granite waste from the crushers has been extensively used in the manufacture of cement block; also, much finely crushed and sized granite in the Lithonia district is marketed as poultry grit. Except for limited outcrops of granite in central Texas, the granites of central Georgia represent the southernmost commercial outcrops in North America east of the Rockies, thus affording adequate supplies for the future, not only for such states as Florida and Mississippi which have no granite, but for Cuba, Central America and foreign export. Supplies of granite for all uses in Georgia are unlimited.

Georgia produces well over $3,000,000 worth of marble in the form of dimension and monumental stone each year, and this is the second greatest mineral industry of this district. Practically all of the marble produced in the southeastern states is produced at Tate and Marble Hill in Pickens County, where the marble beds are not only unusually thick and pure, but by a remarkable incident of flowage, are free of joints and fractures of all kinds. This is one of the oldest of Georgia's mineral industries, and it is believed that the supplies of marble in this district are entirely adequate for future needs. Recently, the Georgia Marble Company has added a fine-grinding plant to produce whiting, ground marble, etc.; thus, they are developing new uses for marble waste, which, when reduced to granular size, has been found excellent for marking athletic fields, or when used as a roofing granule to cut down heat absorption.

The talc mines and mills of Murray County represent probably our third most important industry. Talc is mined at Fort and Cohutta mountains from an impure metamorphosed dolomite. Most of the production is ground and sold in the roofing and filler trade. A certain high-grade type of talc is cut into pencils for use by steel workers. There is a large supply of talc of this variety in the district; at present, four mines are operated, but there are many small mines and prospects which could be developed into successful mines with more work. Attempts this far to improve the quality of these talcs so that they could compete with the pure white talcs have not been very successful, due to the fact that the gray color of Georgia talc is caused by the presence of chlorite and serpentine—minerals difficult to separate from talc or to bleach. However, experiments show that talc from these mines associated with white dolomite can be purified; thus, continuous experimental work may eventually point to a way of materially improving their quality.

In mica, Georgia and North Carolina are competitors. Sheet mica of high quality was produced upon a large scale in Georgia during the two World Wars, but when the Government subsidy was removed after the recent war, the production of sheet mica ceased in this State. Mica suitable for grinding, however, is a peace-time product; and the Georgia Geological Survey, working with the Tennessee Valley Authority discovered recently a large deposit of mica suitable for this purpose in Hart County. The mica occurs in a deeply weathered, coarse-grained pegmatitized granite, which covers a large territory. Below the red kaolins at the surface, the product consists of white kaolin, muscovite, and some quartz. Thus, these deposits offer great reserves of primary kaolin. A plant for mining and the preparation of ground mica is now going into production at Hartwell.

The kyanite-mica schists of Rabun and Habersham counties, Georgia, represent another source of ground mica, although at the present time there is a cessation of production in that district. Chlorite and sericite mined in Pickens and Cherokee counties are ground and sold, competing to some extent with mica and talc. It is believed that our supplies of sheet mica will be adequate for mining in the event of another war, and that our supplies of mica suitable for grinding are almost unlimited in amount.

The feldspar industry is a relatively new one in Georgia, centering around Monticello in Jasper County, where it is obtained from numerous pegmatites. The most desirable grade is a potash spar, and it is believed that sufficient potash feldspar can be obtained over our crystalline area to support such industry. The feldspar industry has progressed very far in North Carolina, where an alaskite type of granite is crushed and the feldspar is floated off. This is a soda spar, containing more or less potash, and goes mostly into the glass trade. This North Carolina production points toward the possibility of floating feldspar from our extensive piles of granite waste built up by the crushed granite industry.

White dolomite is quarried and crushed for agricultural uses and other purposes at Whitestone in Gilmer County. Crushed marble from the Tate and Marble Hill areas have unusually high purity, and are very suitable for this use. Small deposits of limestone and marble occur locally in the Brevard belt between Flowery Branch and the South Carolina State line.

Building brick is manufactured from river clays in the vicinity of Atlanta, and at Bolton, the clays of the Brevard belt are used extensively. This is a very unique industry, inasmuch as these clays are produced from the weathering of sheared metasediments associated with granite mylonites.

Extensive deposits of flagstone occur in the metasediments, especially in the vicinity of Jasper, Pickens County. These are quarried in a small way, but the Atlanta market, if developed, would support a good flagstone industry.

Continuous prospecting by the Georgia Geological Survey constantly reveals the presence of new deposits of minerals in current production, as well as new minerals—potential economic minerals. For example, an extensive sillimanite deposit in Hart County was discovered and reported upon by the Georgia Geological Survey several years ago. Experiments carried on by the U. S. Bureau of Mines and Tennessee Valley Authority indicate a commercial value for this mineral as a high-grade refractory. The Navy has pronounced refractory sillimanite brick satisfactory for high-temperature use, and has agreed that brick made with sillimanite does meet their specifications for high-duty refractories. These deposits are merely awaiting producers with vision and capital.

Large serpentine deposits of Columbia County have been used to a limited extent in the manufacture of magnesium sulphate. The kyanite deposits of Habersham and Rabun counties have been extensively mined, and occur in very large supplies. There are numerous, minor minerals which are mined occasionally, and of which we have small or substantial supplies, such as asbestos, graphite, olivine, vermiculite, chromite, etc.

Georgia is dominantly (at least thus far) a producer of the non-metallic minerals, although gold mining was important in encouraging the settlement of the northern part of the State. Both World Wars put a termination to revivals of the gold mining industry in Georgia, after its original termination by the War Between the States. The deepest mine in the State is a gold mine, less than 300 feet deep, yet most of the deepest mines in the world are gold mines. In other words, there have been no real attempts at deep mining upon selected fissure veins in Georgia.

Our pyrite deposits have been studied at length by this survey, and are known to be quite extensive. Many of them contain appreciable amounts of copper; thus are potential future sources of sulphur, copper, and iron sinter. Lead and zinc deposits are being explored in Lincoln County.

Mineral Resources of the Paleozoic Area

The Paleozoic area of northwest Georgia comprises much less territory than the Crystalline or Coastal Plain districts. The principal rocks are sandstones, shales, and limestones which have been severely folded and faulted, but which are essentially unmetamorphosed. The Cumberland Plateau, which contains the extensive coal deposits of the eastern states, is represented only by two long arms which extend into Dade and Walker counties, as Lookout and Sand Mountains.

Much of the mineral production of this section comes directly from the use of limestone and shale, which are essentially inexhaustible. For this reason, I predict that there will be a steady increase in production in this section to meet the increasing demands of the future. The total mineral production amounted to $5,839,810. Of that figure, Portland cement, slate granules, heavy clay products, crushed limestone and lime, and red ochre amounted to $4,506,460. The metallics, mostly barite and iron ore totalled $1,506,460.

The Cartersville mining district at present is our only metal mining section, and it also produces lime, gravel from the barite washers, etc. Continuous production in this district is principally supported by the mining of barite, and there is sufficient amount of this mineral to supply our needs indefinitely. This district also is one of the few centers of ochre production in the country. The supply of ochre and umber will be sufficient to meet all the demands of the future. The production of brown iron ores has continued in this district from early times, much production extending over into Polk County. The deposits are large and scattered. Large deposits of soft, earthy iron ore with a high iron content exist in the Cartersville district, but cannot be handled very satisfactorily by the furnaces in Birmingham. A process of briquetting these ores in the Cartersville district, in addition to rendering them desirable, would remove the water, thus increasing the iron content and lowering the freight costs.

Manganese is mined sporadically, and there is little or no mining at the present time. Deposits of manganese are numerous, but the ores contain considerable iron, thus normal jig concentrates contain more iron than is desirable to meet the demands. A sintering process which would oxidize the iron and permit its removal by magnetic means should stabilize the manganese industry for this district.

Our coal deposits of Lookout and Sand mountains have been mined for a long time; during the war years, there was a revival of coal mining in this district, and strip mining was done at that time. At present, the prospects are not especially good for any large-scale mining operations in the district because the beds are thin and tend to be pockety in many cases. We are waiting upon the experiments of the U. S. Bureau of Mines near Gorgas, Alabama, where coal is being burned under ground, thus through a coking effect both by-product gases and heat are obtained. It may be possible after this process is perfected, that it can be applied to our thin coal beds.

Bauxite was first discovered in Georgia outside of France, in the Hermitage district of Floyd County. Future, deeper, prospecting may show the presence of other reserves.

The red iron ores of the Birmingham district extend into northwest Georgia, and were used as a source of iron ore in the past, as at the old furnace at Rising Fawn. They constitute future reserves. At the present moment, they offer definite opportunities as a source of pigments.

The old, established and well-known use for slate has gone into a decline. When did you last see a new slate roof? The total production of roofing slate was less than $9,000,000 for the entire country in 1946. In the past, the dark slates at Rockmart were extensively quarried for that purpose, and to a less extent, the green slates from the Fairmount district. At present, our green slates are used as a source of roofing granules, as at the Funkhauser plant at Fairmount. The Rockmart slate has also been used in the past to make black granule. For granules, an ideal cleavable slate is not desirable, so that the massive slate is quarried which will make equidimensional particles.

An incidental resource of this district is flagstone. We have in Lookout and Sand mountains flagstone similar to the formation at the famous Crab Orchard quarries in Tennessee. Also, there is a pink, slabby limestone, the Murfreesboro of Ordovician age in the Valley section, and the Weisner quartzite of Cambrian age near the Cartersville fault. The use and demand for flagstone as a building stone is increasing and there is ample opportunity in Georgia, and in the city of Atlanta, for the development of a successful flagstone business.

This part of the State has unlimited resources of shales for the manufacture of brick and structural tile. At present, we have three brick plants, all of which use Conasauga shale. The Floyd shale is also suitable for this use. Raw materials for this use are practically unlimited in quantity, and since this is a natural industry for this region, it should have an excellent future.

Production of Portland Cement is an important industry in this district, centering around the City of Rockmart in Polk County, where hard limestone and shale are used. This district has almost unlimited supplies of material suitable for its manufacture.

Very little lime is produced in Georgia, the only production coming from this district. There is room for an increase in lime production because of the excellent limestones, especially those of Mississippian age, which are ideal for such an industry; also these limestones should be good enough for the production of chemical lime.

The increased demands for light-weight aggregate could be satisfied by the construction of plants where ideal raw material occurs for its manufacture. Experiments upon the Rome formation and Rockmart slates show them to be suitable material for this use, and probably other shales, such as the Floyd shale, and shales of the Ft. Payne group would be suitable.

Other miscellaneous minerals occur which have possibilities for future development. For example, in the northwest counties of Georgia, we have numerous deposits of tripoli, very similar in character and composition to the Missouri deposits, which are so extensively used in the manufacture of abrasives, scouring powders, and soaps. Our deposits cannot be shipped raw, but will require cleansing and sizing for commercial production. The Chattanooga black shale is an extensive shale formation which contains an appreciable amount of petroleum, which might be obtained by distillation; also, it is definitely radio-active but no positive uranium minerals have been reported from it. Halloysite occurs in beds at the base of the Chattanooga black shale. This is a dense, waxy, clay mineral, formerly mined in Georgia for the manufacture of alum. Bauxite is the principal mineral used now in the production of alum but it is entirely possible that the ceramic engineer may find our halloysite desirable for further use combined with other clays. Small amounts offer a possible substitute for ball clay.

CURRICULAR STATUS OF THE EARTH SCIENCES IN HIGHER EDUCATION IN GEORGIA*

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It is the intent of this discussion to describe the present status of the Earth Sciences in institutions of higher education in Georgia, to list briefly the events underlying their present position, and to indicate areas of both general and professional education to which expanded Earth Science instruction could contribute substantially. During the past four years the writer has spent many hours studying the relationship of the Earth Sciences to other fields of instruction in Georgia's colleges and universities. Although no unique or universal solutions enabling establishment of Earth Science instruction on the most propitious and professionally desirable level have been discovered, the writer has become aware of a number of areas in which basic knowledge of the Earth Sciences is needed for proper fruition of training in another discipline. There appear to be no ready answers to these curricular problems; at least the writer has no pat solutions to offer at the moment.

Since substantial coverage of the history of the Department of Geology at Emory University is included elsewhere in this program†, the present discussion will omit that institution and confine its remarks primarily to the institutions within the University System of Georgia.

Insofar as is known, no courses classed as Geology are offered in Georgia other than in the Athens-Atlanta area schools. Georgia State College for Women at Milledgeville regularly offers several courses in physical, regional and economic geography. All of the courses are offered on a purely elective basis and affect only a very small percentage of the G. S. C. W. student body. A course in Introductory

*Read at the meeting of the Georgia Academy of Science, Athens, Georgia, April 22, 1949.

†Paper read but not submitted for publication.

World Geography is offered at Bessie Tift College by a member of the Social Science Department who has no training in the field. Courses in Economic Geography are offered by economists at Piedmont College, Mercer University, and Oglethorpe University. Three courses in Geography—Principles of Geography, Economic Geography and Geography of North America—are offered periodically at Georgia Teachers College at Statesboro by an M. A. in Sociology. It is apparent, then that the Earth Sciences barely exist in higher education outside of Athens-Atlanta area. Geography is offered in a few institutions and thus has escaped the total omission accorded Geology; the use of untrained and largely unqualified instructors to teach those courses offered has seriously reduced their utility. Furthermore, the professional reputation of the Earth Science field in general has not been enhanced greatly thereby.

Administrative recognition of the Earth Sciences within the academic framework of the University of Georgia and Georgia Institute of Technology accompanied the founding of the University System in 1932. It will be recalled that the pattern of present instruction in Geology and Geography at Georgia Tech is based upon clarification of the objectives of that institution as a result of the 1932 reorganization. The missions of instruction in Geology at Georgia Tech are admirably clear—to provide professional course training for students in Civil and Ceramic Engineering, to provide service-course training for other engineering students, elective training in Economic Geography and advanced training in applied mineralogy within Ceramic Engineering. The curricular pattern needed to fulfill these missions has been in existence since the last decade, is well known to most of us, and produces a thoroughly trained graduate. Unfortunately neither the missions of Earth Science instruction nor the mode of their fulfillment are as clearly defined in other segments of the University System as they are at Georgia Institute of Technology.

For more than 30 years prior to 1932, a course in Geology was offered at the University of Georgia by the Chemistry Department. This course appears to have been a favorite of Dr. Henry Clay White, Professor of Chemistry and at one time President of the State College of Agriculture. Dr. White published several papers in Economic Geology, in addition to his lengthy bibliography in Chemistry. Following the 1932 University System reorganization, a committee of curricular consultants was employed to recommend a basic curriculum for the University System schools. This committee consisted principally of University of Chicago faculty members who were, of course, thoroughly conversant with the Physical and Biological Science Surveys of their own institutions. These survey courses were recommended as models for the University System. Coupled with the tradition established by Dr. White's course in Geology, this recommendation resulted in inclusion of a half-course (five weeks within a quarter) in the Earth Sciences within the Physical Science survey adopted for all University System schools. This course still is a basic requirement in curricula of the University System, though it is not required in several professional curricula at the University itself. In the absence of geologists and geographers the Earth Science half-course has been taught by chemists and physicists in the university system schools. Even at the University proper much of the instruction in this program has been carried by scientists from other disciplines during the past 17 years. That the course has failed to generate general as well as professional student interest is not surprising! Within this situation exists a major problem—how to place instruction for this course in the hands of professionally qualified people when such people are not to be found on the faculties of most University System Schools. In the Atlanta-Athens area schools instruction in the Earth Science survey now is handled virtually entirely by professionally qualified personnel.

As consequence of the 1932 reorganization, the Georgia Teachers College of Athens became part of the University of Georgia. In this amalgamation, E. S. Sell, formerly Professor of Agricultural Education at the Teachers College, was appointed Professor of Geography at the University. Several courses in physical, economic and human geography were established under his instruction, but in insufficient number to enable a student to major in geography. Following several false starts in the post-1932 years, in 1937 the services of a competent geologist were obtained in the person of Prof. G. W. Crickmay. Dr. Crickmay, with the aid of the Chemistry department, established a beginning sequence and three advanced courses in geology at the University prior to World War II. However, Dr. Crickmay was unable to establish a sequence of courses leading to a major in Geology. Thus at the outbreak of World War II the Earth Science at the University were split, uncoordinated as two one-man departments, neither of which could offer a comprehensive concentration in their disciplines. Also, neither department was adequately equipped or housed.

The present department at the University is a post-war creation. Its missions include broad lateral coverage of the Earth Sciences for purposes of general education in the Liberal Arts College, service courses for other curricula of other colleges, and concentration in various phases of the Earth Sciences leading to both B.S. and A.B. degrees. Although the departmental organization still is fluid in several areas of advanced instruction, the basic organizational patterns appear firmly established. Especially is this true in advanced course sequences in cartography and photogrammetry.

It is in the area of service-courses for both general and professional curricular, however, that the University System and the University proper is most deficient in Earth Science training. Presently Introductory General Geology meets 10 hours of laboratory science required for A.B., B.S. and Business Administration students in the University; it is one of five such courses of which the student may select one or two. Introductory Physical Geography, a 10 hour non-lab sequence consisting of basic climatology and areal geomorphology, meets non-lab science requirements as a curricular alternate for Business Administration students, is required of all Forestry students, is a required-alternate for College of Education students, and an elective for Agronomy and Liberal Arts students. Introductory Regional Geography is a required alternate in the curricula of Liberal Arts and pre-Law, a requirement in Veterinary Medicine, and next year becomes a required alternate in the sophomore year of Business Administration. The College of Education requires elementary school teachers to complete a course in Conservation of Natural Resources. These same requirements, or required-alternates, exist in the Atlanta Division of the University.

From the foregoing it is clear that several important student groups are not exposed to instructions in the Earth Sciences at the University. Because of alternates to requirements, the Liberal Arts and Fine Arts students can omit the Earth Sciences. The schools of Journalism, Pharmacy, and Home Economics make no provisions for Earth Science training. The vast majority of students in the College of Agriculture receive neither geographical nor geological instruction of any sort, an anomalous situation, at least. Apparently because of crowded curricula, B.S. Chemistry majors and premedical students are unable to take courses in the Earth Sciences.

In a state whose economic sustenance depends heavily and directly upon earth resources in forestry, agriculture, mining and power production, it would seem that there would be far more educational emphasis on the fundamental wealth-producing science than there is. Why educational emphasis on the Earth Sciences is not greater is not clear. In particular, three phases of the Earth Sciences, each of great economic importance, should be receiving far greater attention than now current. These are geomorphology, climatology and cartography. Certainly the geologists and geographers of this state will agree that there scarcely is a field more fundamental to soils, soil conservation, forestry, horticulture, botany and hydrology than geomorphology. Upon a sound and detailed knowledge of climatology and climatologic processes depends not only many of our geomorphic processes, but also the degree of success obtained in supplemental crop irrigation, plant breeding and adaptation, everyday farm management planning, transportation management, small fruit and vegetable culture, and retail marketing of both durable and perishable goods. Indeed, detailed information of microclimatic conditions in certain areas already has had marked effect upon establishment of new industry. A knowledge of microclimatology within the state itself could have important monetary effects upon the nascent recreation industries. In the opinion of the speaker, geomorphology and climatology are both so basic to the economic progress of this state that they should become mandatory requirements in the general education of every student in the University System. It is presumed that such courses would expose students to the common economic minerals of the state and would indicate something of the significance of adequate and detailed mapping in the development of all earth resources.

Everyone in the Earth Sciences in Georgia is aware of serious state-wide deficiencies in map coverage, not only in topographic maps but also in most other types of maps. While cartographic processes probably should not be made a portion of general education, it is true that development of **appreciation** for the inherent **economic value** of good cartography could contribute substantially to ultimate publication of the maps so sorely needed.

Establishment of the Earth Sciences as mandatory in general Education is not merely a university problem; it is at once a University System-wide problem and a challenge to all Earth Scientists.

Since 14 of the institutions in the University System today are without the services of geographers or geologists, the prospects are poor for immediate resolution of the present status of the Earth Sciences. Apparently, therefore, only personnel additions engendered by administrative decisions offer important possibilities for progress. Until the Earth Sciences have been accorded their proper place as fundamental to general scientific and liberal education their educational potentialities will not have been satisfied. Indeed, in the opinion of the writer, the inherent value of the Earth Science field in general education will not be activated until Earth Science instruction is practiced generally in the public schools by properly trained, competent, public school teachers. There is no immediate or easy route to this goal, either!

RESOURCE-USE EDUCATION IN GEORGIA: PROGRESS, PLANS, PROBLEMS*

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It has been said that the South is the best documented region in America. To put it another way, more research has been completed on the resources and opportunities of the South than on any other of America's regions. The papers which have been presented here this afternoon provide us with more information on the status and opportunities for use of the natural and social resources of the Southeast, particularly in the State of Georgia. These scientific facts on the status of resources paint a picture of the people using but a small part of the wide variety of resources potentially at their disposal.

Why is it that the people, in spite of the fact they have adequate natural resources at their disposal, still find it difficult, and sometimes impossible to achieve satisfactory levels of living? This question poses a problem which has been weighing heavily on educational leaders in the South. Southern leaders know full well that in modern society natural resources, no matter how great their potential value, make little or no contribution to living until the people have the skills, capital, attitudes and the motivation to use resource to satisfy their individual and group needs. Natural resources cannot be brought into effective productive relationship until individuals have the skills, attitudes and motivation to organize working and living arrangements. Therefore, it seems that the future of the South largely rests on the development of dynamic educational procedures which will help the people

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*Read at meeting of Association of American Geographers, Southeast Division, Athens, Georgia, December 2, 1949

to see **what is** as a stepping stone to **what can be** and who view and accept problems as challenges.

What kind of education would contribute to the realization of a better quality of living in the South and other American regions? How can it be made realistic, down to earth? How can the task be begun?

In the last decade, national leaders have witnessed in the South a grassroots movement in education. Resource-Use Education is a movement which has captured the imagination of many people who have wanted education to be more meaningful in the lives of people and communities. Educators, physical scientists and social scientists are working together to make the resources of the South serve the needs of the South and its people through a revitalized educational program.

Educational leaders in the South have begun to plan ways for public education to assist in improving the effectiveness of resource-use. For the past three years, an increasing number of school and non-school groups in Georgia have given more emphasis to resource-use education in the school program. Three approaches have been used in developing the Georgia-Program in Resource-Use Education:

(1) Organizing State Committees on Resource-Use Education, (2) Conducting Workshop for school leaders, (3) Developing programs in the public schools.

Georgia Committee on Resource-Use Education

The Georgia Committee on Resource-Use Education was organized in 1947. Representatives from public schools, teacher education institution, and many state and regional agencies are members of this committee. The purpose of this committee was to decide what resource-use education means for education in the state and how it should be developed and carried out.

This committee has been concerned with raising money to be used in sponsoring workshops for teachers, producing materials to be used by schools and in giving publicity to program developing in the state. At the present time, a committee is studying the possibility of a film on Georgia resources.

Resource-Use Education Workshops for School Leaders

Three workshops in Resource-Use Education have been conducted for teachers, principals and instructional supervisors. In 1947 the Georgia Federation of Women's Clubs in cooperation with the State Department of Education sponsored the first workshop. Ten counties in the state sent a team to attend this non-credit workshop, held at Brasstown, North Carolina. Major emphasis was given to the study of soil resources.

The College of Education, in cooperation with the Department of Geography and Geology, of the University of Georgia, conducted the first workshop in Resource-Use Education in August 1948, and a second one in August 1949. The purpose of the workshop was to help teachers, principals, administrators, instructional supervisors and lay people: (1) to identify possible local problems in the fields of natural, human and social resources; (2) to secure the technical knowledge needed in the solution of these problems; (3) to translate this knowledge into plans of action for improving Georgia schools and Communities.

During summer 1949, 1040 teachers enrolled in fourteen general workshops in the state devoted much time to the study of resource-use education.

Work In Selected Schools

The schools or counties represented in the workshop in resource-use education were selected as spot schools or counties to experiment with certain methods of practices. The teachers, principals and supervisors have given much attention in helping other teachers not represented in the workshop, pupils and adults in the community to know more about their resources and to become concerned about such resource-use problems as soil erosion, forest destruction, poor housing conditions and many other problems that arise as man draws on his environment to meet life's needs. Many classrooms and school projects were carried on which grew out of such resource-use problems.

Time does not permit for a recount of some of these projects carried on by pupils and teachers. Descriptive accounts of some of these activities have been compiled into a publication entitled **"Schools Point the Way."** Kodachrome slides have been made of many of these projects and are available on loan to any group interested in knowing about school programs in Georgia dealing with resource-use.

To summarize the accomplishments of the Georgia Program in Resource-Use Education, it could be said that much has been done to create concern on the part of the school and non-school groups for the need of resource-use education, and to help interested groups become familiar with programs being developed in the state. A series of articles which describe resource-use education were published in recent issues of the Georgia Education Journal. Kodachrome slides, black and white pictures and other materials developed in the school program were displayed at the 10 district meetings of the Georgia Education Association during the fall 1949.

Over 1400 teachers representing all sections of the state have had some workshop experience in resource-use education in the past two years. It is hoped that thousands of teachers have become sensitive to the need for resource-use education.

Supervisory assistance has been given to instructional supervisors, principals and teachers representing 41 counties in the state.

PROBLEMS:

Need For Professional Personnel

In promoting Resource-Use Education in the state, we are faced with several problems. First, there is a need for professional personnel with the resource-use concept. Reports from teachers who have cooperated in the program show certain needs which teachers recognize in their preparation for teaching. These lacks suggest the need for certain new elements or emphases in pre-service education of teachers. They also indicate some specific present needs to be met in in-service programs for teachers.

I. Need For Clarification of Point of View

The first need is for clarification for point of view. Faculty meetings reveal differences of view point which must be reconciled as the school plans a program of instruction. Such questions as these are raised:

1. Is resource-use education to be thought of as a special subject or is it a point of emphasis, a center around which we plan the common experiences for all pupils?
2. Is it appropriate for the school to concern itself with the out of school experiences of children?
3. Does the school have a responsibility for improving the community through participation in the solution of community problems?

Teachers need to approach resource-use education from the developmental point of view. This implies much more than the adjustment of subject matter and method to age or grade levels. It is an approach in which educational experiences are used to develop the potentialities of the learner. Subject matter enrichment is needed, but no body of preorganized material will realize the values of the developmental approach. Programs of general and professional education need to be reconstructed to provide the essential psychological and social background and orientation for a social developmental approach.

II. Need for Subject Matter Competencies

A broad comprehension is essential for the successful realization of a program in resource-use education. The subject matter requirements of resource-use education for teachers simmer down to four basic points. Teachers need (1) to acquire scientific information on community, regional and world resources—natural, human and social. (2) To obtain additional information through the functional application of the formal subject matter in field-work, work conferences, workshops, demonstrations, and visual aids. (3) To expand knowledge of subject matter in a particular field of specialization, (4) and to see how this subject matter may be translated into the various maturity levels.

Strange as it may seem, the traditional college curriculum embodies the courses necessary for training in resource-use education. Why, then, are most teachers unprepared to handle community and regional problems? Could it be that the answer to this question is that college and university faculties have found no common ground for integrating their subject themes and relating them to the improvement of living?

The college teacher who uses his subject from the point of view of problems solving, rather than a recitation of chapters in a text book, is the person, who, in all probability, has been justifying his subject theme in terms of its functional application in the lives of those who have come under his influence.

Resource-Use concepts should be interwoven with all curricula, college, university extension and adult education programs. Resource-Use Education is not peculiar to the needs of teachers alone, but is meant for all college students. The biological, physical and social sciences should all be geared to the problems of living.

III. Need for Professional Insights and Techniques

A third need is for professional insights and techniques. Teaching competence calls for a professional grasp of the fundamentals of human growth and development, and a working knowledge of the ways in which human insights are developed and social motives are engaged at successive levels on the way to physical, intellectual and social maturity.

Teachers need skill in (1) utilizing community resources; (2) in finding and using available materials and resources; (3) in producing materials; (4) in cooperating with non-school agencies, and (5) in adjusting school programs to community needs and participating in community programs.

IV. Need of Teachers for Certain Social Competences

The need for personal adjustment to community life suggests a goal for teacher education. It implies that pre-service education should include first hand experiences in community activities and organizations. The prospective teacher should be taught in a manner which develops his initiative in resourcefulness in dealing with social situations. Many of his learning activities should require of him tact, judgment, persuasion and leadership. The teacher needs to understand and recognize resource-use principles in problems and situations. He should exemplify the principle of wise use of resources in his personal behavior and attitudes toward social and physical problems. A teacher may know that any aspect of the environment is a resource if it satisfies human wants; yet he may not realize that an unattractive classroom or a bare school ground is a crying example of misused resources.

It is the responsibility of institutions which train teachers to meet these needs of teachers through their pre-service or in-service programs. It is encouraging to note the efforts that the colleges and universities are making to help develop the kind of leadership needed for resource-use education. Several institutions in Georgia are studying their pre-service programs and are beginning to initiate changes where deficiencies are revealed.

The University of Georgia in cooperation with Georgia State College for Women is conducting an offcampus workshop at the present time for the teachers in Richmond County. Two hundred teachers from this county are enrolled in the workshop. These teachers have an opportunity to work intensively on the problems of resource-use in the environment in which they are working this year and to plan a program in Resource-Use Education for Richmond County Schools.

Several institutions are planning summer workshops in Resource-Use Education and each year general workshops are giving more emphasis to this area. County supervisors are planning county workshops, clinic or conferences for the teachers in that county.

The college and public schools have an unparalleled opportunity and responsibility to meet the urgent needs of teachers.

NEED FOR MATERIALS

A second major problem in promoting Resource-Use Education in Georgia is the lack of easy reading material adapted to local conditions and to available resources. An attempt is being made to develop some publications for use by pupils on the primary and junior high school level. A directory of resource agencies in Georgia is under preparation. One group is investigating the possibility of a film on Georgia's resources. Two non-school groups are producing some material for pupil use.

We are aware that we have only made a beginning in Georgia in Resource-Use Education but we are encouraged over our few accomplishments. It is our hope that representatives from the public schools, colleges, universities and state and regional agencies will continue to work together in developing educational programs that will contribute to the realization of a better quality of living in Georgia and in the South.

POPULATION NUMBERS, DISTRIBUTION AND GROWTH IN METROPOLITAN ATLANTA*

By C. A. McMAHAN

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The purpose of this paper is two-fold: (1) to provide a general orientation to the city of Atlanta in order "to set the stage" for the papers which follow in this symposium; and (2) to analyze the population of Atlanta as to number, distribution, and growth.

General Orientation to the City

The Metropolitan District of Atlanta is composed of the City of Atlanta, the adjacent incorporated cities and unincor-

*This paper was read at the Fourth Annual Meeting of the Association of American Geographers, Southeast Division on December 2-3, 1949 at the University of Georgia, Athens, Georgia. The paper is a summary of selected topics from a more comprehensive study of the city of Atlanta made by the author. Figures 1-3 were reproduced from a forthcoming book by C. A. McMahan, *The People of Atlanta* (Athens, Georgia: The University of Georgia Press, 1950). The writer is indebted to Mr. Harry W. Martin, graduate assistant in the department of sociology, University of Georgia, for aid in organizing the material in the manner in which it is presented herein.

porated suburban areas. The satellite cities are Decatur, population 16,561, located to the east and the northeast; East Point, population 12,403; College Park, population 8,213; Hapeville, population 5,059, all on the south and southwest; Brookhaven, Chamblee, Clarkston, and Doraville are also on the northeast with Avondale Estates to the east of Decatur. The contiguous unincorporated suburban areas include Buckhead, the northern residential section with an estimated population of 75,000 in 1948; Center Hill west of the city with a population of 12,155; Cascade Heights, Adamsville, and Ben Hill to the southwest; and Lakewood to the south. In 1940 the metropolitan area covered a large part of Fulton and DeKalb Counties and small areas of Cobb and Clayton Counties.

Time and its processes of change are quite visible in the central city of Atlanta. The downtown retail trade area has grown up along the railroads which are laid out in a general east-west direction. The downtown section of Atlanta is something of an elongated rectangle extending about one and one-half miles north and south, and is approximately six blocks wide. The main lines of traffic run north and south through this rectangle, and the greater part of vehicular and pedestrian traffic move in these same directions.

The southern part of the rectangle developed much earlier than did that north of the railroad tracks and is ringed by several large industrial installations, the Federal Penitentiary, East Point and Hapeville. This part of the city contains much more industry than does the northern portion. In the northern end there has been a very rapid development during the two decades preceding 1940.

Within the past decade, the area to the north and northwest has developed rapidly along commercial and industrial lines. Several large office buildings along Peachtree and West Peachtree Streets in the northern area have been constructed or were under construction at the time this article was written. Numerous large industries employing many workers have located along the Peachtree Industrial Boulevard in northern DeKalb County to the northeast; this area has also developed rapidly along residential lines.

The downtown trade area south of the railroads still does a greater part of the retail and wholesale trading for the city. However, some of the smarter and more exclusive shops are located in the northern trade area. Most of the downtown theatres are situated on Peachtree Street in the heart of the northern shopping district. On Marietta Street, leading northwest from the heart of the city, are found many of Atlanta's small industries; the large stockyards and most of the abattoirs of the city are also situated in this northwestern region.

"Five Points" is the heart of the city. Here five streets form a junction, and from this juncture the city has developed in every direction. The city's government buildings are concentrated in the older part of town a few blocks south of the heart of the city. Within two blocks are located the City Hall, the Fulton County Court House, and the State Capitol, and other state, county and municipal office buildings.

The ecological process of segregation has operated in Atlanta, as in other cities; furthermore, the southern custom of segregation which restricts the settlement of Negroes in white areas has produced concentrations of that racial group within the city. Figure 1 shows the position and distribution of these concentrations. The downtown retail area, except for the north end, is circled belt-like by a part of the Negro population. In addition to this belt there are in the western part of the city several Negro universities; this appears to be the section where the "elite" of this racial group are concentrated.

West End on the southwest and Inman Park on the northeast were at one time choice white residential sections; both are now densely populated and include many persons who rent rooms, houses, and apartments. Among residential areas which consist of homes for higher income-level white families are the Druid Hills section on the northeast, and the Ansley Park and Piedmont Park sections on the north. The residential areas of the middle-income families, characterized by small homes usually owned by the occupant, are East Atlanta, Kirkwood, and Sylvan Hills, located on the east, southeast, and southwest respectively.

With this orientation to the city, it is proper that our attention be devoted to the analysis of the number and distribution of the Atlanta population.

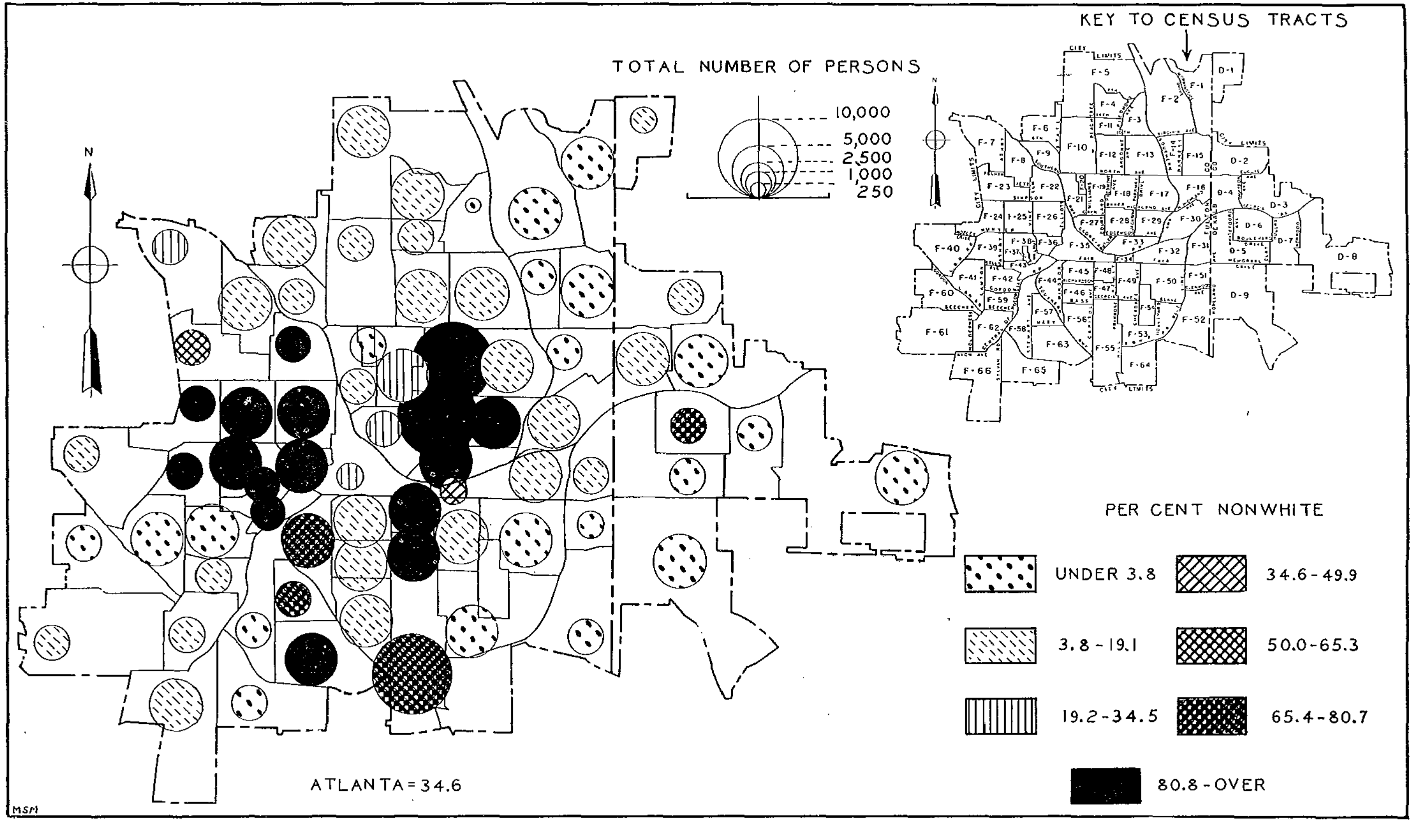

Figure 1. Relative importance of nonwhites in the population of Atlanta, by census tracts, 1940.

Number and Distribution of the Population of Atlanta

In order to give meaning to the size and number of Atlanta's population, its density and numbers have been compared with those of large urban centers of the nation and particularly the South.

The city of Atlanta, as of April 1, 1940, contained 302,288 persons.[1] In April, 1947, an estimate of the Atlanta Metropolitan District, based on a sample population survey, was given at 498,109. The chances were 19 out of 20 that a complete census would have yielded a figure between 472,000 and 525,000 for the total population of the Metropolitan District.[2] "Metropolitan District," as here used, means the core or central city and the adjacent and/or contiguous minor civil divisions containing at least 150 persons per square mile.

Approximately 56.5 per cent of the 1940 population of the United States lived in urban areas (primarily incorporated places from 2,500 up). There were in 1940, 3,354 such places of which 5 contained 1,000,000 or more inhabitants, 9 places had 500,000 to 1,000,000 persons, 23 places, which included Atlanta, had between 250,000 and 500,000, and 55 places ranged from 100,000 to 250,000 persons.[3]

Atlanta's position by rank of size in the United States in 1940 was twenty-eighth. Other cities ranked as follows: New York, first; New Orleans, fifteenth; Dallas, thirty-first; Birmingham, thirty-fifth; and Nashville, fiftieth.[4]

It is seen from an examination of Table I that the Atlanta Metropolitan District had a greater population per square mile (density) than the average of similar districts in the United States. The central city of Atlanta was also more densely populated than the average of similar cities in the South to which it is compared. The suburban areas of Atlanta were also more densely populated than similar areas in the nation, and possessed a much higher density than the suburban areas of other southern cities.

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[1]*Sixteenth Census of the United States: 1940, "Population, Vol.* v, Number of Inhabitants," (Washington: Government Printing Office, 1942), p. 32.

[2]Bureau of the Census, *Current Population Reports—Population Characteristics,* Series P-21, No. 6, August 19, 1947, p. 5.

[3]*Sixteenth Census of the United States: 1940, op. cit.,* p. 26.

[4]*Ibid.,* p. 32.

The general density of the population increases (see Figure 2) as the center of the city is approached, except for one or two census tracts which consist, for the most part, of business establishments. There was little shift of density in the individual census tracts from 1930 to 1940 although the average density rose from 7,939 in 1930 to 8,611 in 1940.[5]

After this brief analysis of the number and distribution of the Atlanta population, it is proper that its growth be considered.

TABLE I

Population Density of Selected Metropolitan Districts of the United States, 1940

Metropolitan Districts	Population per Square Mile
Total (140 Districts)	1,411.0
In Central Cities	7,813.1
Outside Central Cities	515.2
Atlanta	1,717.6
In Central City	8,711.5
Outside Central City	628.4
Dallas	684.9
In Central City	7,259.5
Outside Central City	160.7
Nashville	765.3
In Central City	7,609.2
Outside Central City	253.0
New Orleans	1,617.8
In Central City	2,480.1
Outside Central City	338.5

Source: *Sixteenth Census of the United States: 1940,* "Population, Vol. 1, Number of Inhabitants," (Washington: Government Printing Office, 1942), pp. 58-59.

[5]Works Progress Administration of Georgia Official Project 465-34-3-5, *A Statistical Study of Certain Aspects of the Social and Economic Pattern of the City of Atlanta, Georgia* (n.p.: Works Progress Administration of Georgia, 1939), p. 16; and *Sixteenth Census of the United States: 1940, op. cit.,* pp. 58-59.

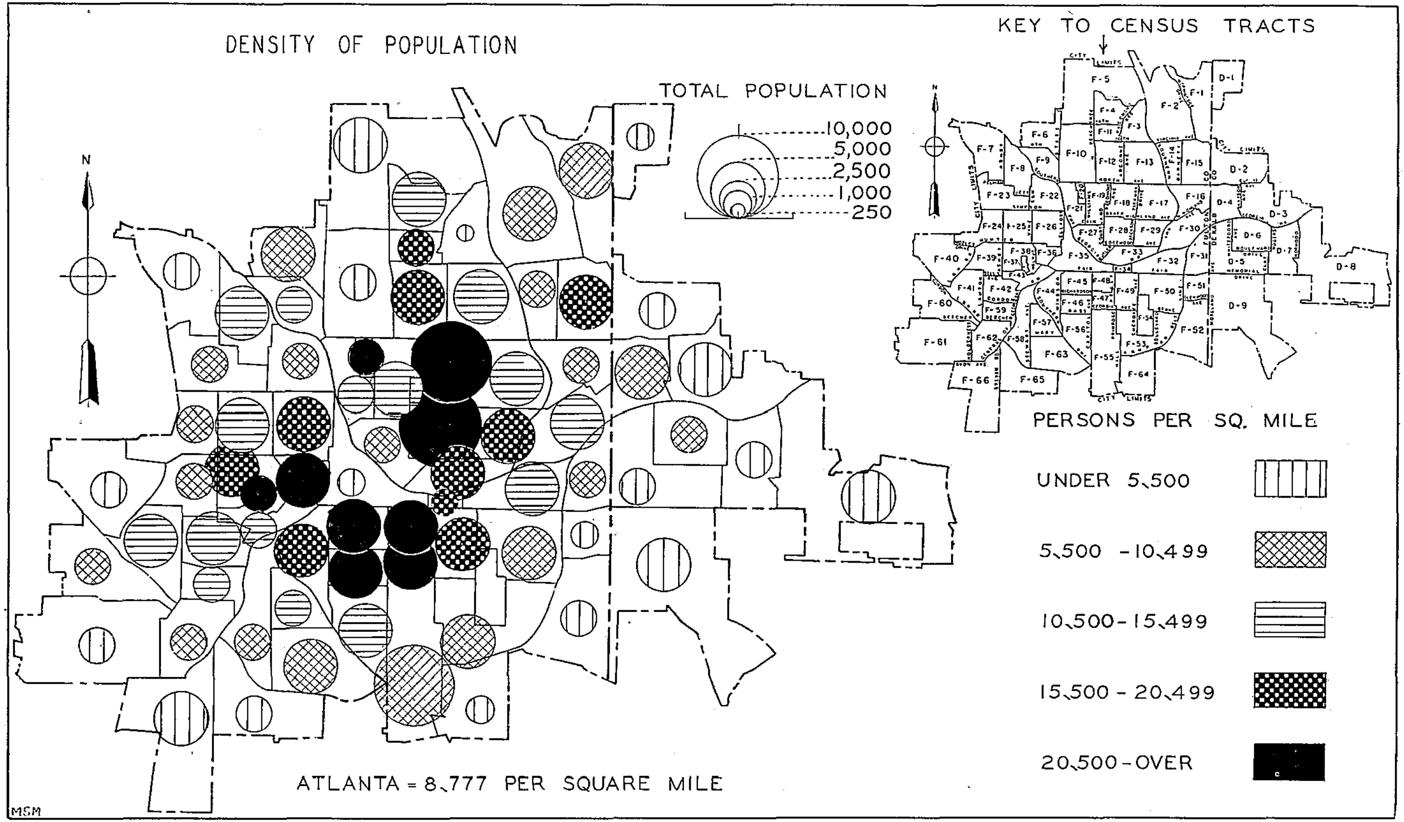

Figure 2. Density of Population of the City of Atlanta, By Census Tracts, 1940.

Growth of the Atlanta Population

There are, basically, two parts to a study of population growth: the analysis of what has already taken place, and speculation or forecasts as to future trends, etc. This paper has been limited primarily to that which has already occurred. The analysis traces the growth and rate of growth of Atlanta's population from 1850, at which time it was a city of 2,572 persons, until the present. It also follows the growth and rate of growth of each of the city's major segments of population (Negro and white) and compares these functions within the city and with those of comparable southern cities.

Many of the urgent problems of the world have arisen from the differential in rate of growth between nations and "races". It is necessary for a well-informed society to be aware of the trends, changes, and directions of its population growth. Insight into these social phenomena is a prerequisite for intelligent planning and progressive action.

There are only three basic demographic processes which determine the number of persons at a given place at a given time; these are fertility, mortality, and migration. Other factors such as climate, level of living, price of food, war, etc., are effective only to the extent to which they affect the three aforementioned basic factors.

Atlanta became an urban center, according to today's criterion, in 1850 when her populace was numbered at 2,572 persons.[6] The census immediately preceding the Civil War (1860) shows that the population had reached 9,554 in one decade, nearly a fourfold increase. In the ten year period from 1860-1870, Atlanta more than doubled her population, numbering 21,789 inhabitants.[7] This increase was effected in spite of the toll taken by four years of war and the devastating fire of 1864, which destroyed 700 of the 1,000 homes. This steady growth continued, and by 1900 the total population reached 89,872. The growth in the twentieth century has not been quite so rapid as that of the nineteenth; however, there has been a steady increase at each census.

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[6]*Seventh Census of the United States:1850* (Washington: Robert Armstrong, Public Printer. 1853), p. 366.

The Sixteenth Census as of 1940 placed Atlanta's population at 302,288; the estimated population of Atlanta on July 1, 1948, was 352,000 inhabitants; thus by the time of the 1950 census, it is likely that Atlanta will have gained some 50,000 to 60,000 persons in the decade since 1940.[8]

Comparison of the growth of Atlanta and other southern cities. Figure 3 presents graphically a comparison of Atlanta's growth with that of several other large southern cities. It can be seen from a study of the figure that New Orleans was the largest of these southern cities in 1850 and has remained so since that time. Dallas has been the city of the most rapid growth. For the total populations, the rate of growth appears to be in the following order: (1) Dallas, (2) Atlanta, (3) Nashville, (4) New Orleans.

In the latter years of the nineteenth century, the population of Atlanta increased more rapidly than that of Nashville, and around 1896 the Atlanta population equaled that of Nashville. Likewise, Dallas equaled and pulled ahead of Nashville about 1915. Although the growth of Atlanta has not been as spectacular as that of Dallas, it has been fairly constant with no outstanding spurts or plateaus. If the rate of growth for the years 1920-1940, of the four cities compared is approximately maintained, it appears likely that both Atlanta and Dallas may reach and even forge ahead of New Orleans. However, no prediction is offered as to when this might occur.

Dallas is first in rate of growth for the white population. Since 1910 Atlanta and Nashville have grown at about the same rate, with New Orleans having the smallest rate of growth.

The Negro populations of Atlanta and Dallas have grown at approximately equal rates, with New Orleans third, and Nashville fourth. In 1890 the Negro populations of Atlanta

[7]Atlanta City Council and the Atlanta Chamber of Commerce, *Handbook of the City of Atlanta* (Atlanta, Georgia: The Southern Industrial Publishing Co., n.d.), p. 5.

[8]*Sixteenth Census of the United States: 1940*, "Population and Housing, Atlanta, Georgia," (Washington: Government Printing Office, 1942), p. 4; and W. E. Uzzell, *Estimated Population of Georgia, July 1, 1948* (Atlanta, Georgia: Georgia Department of Public Health, Division of Vital Statistics, 1948), p. 1.

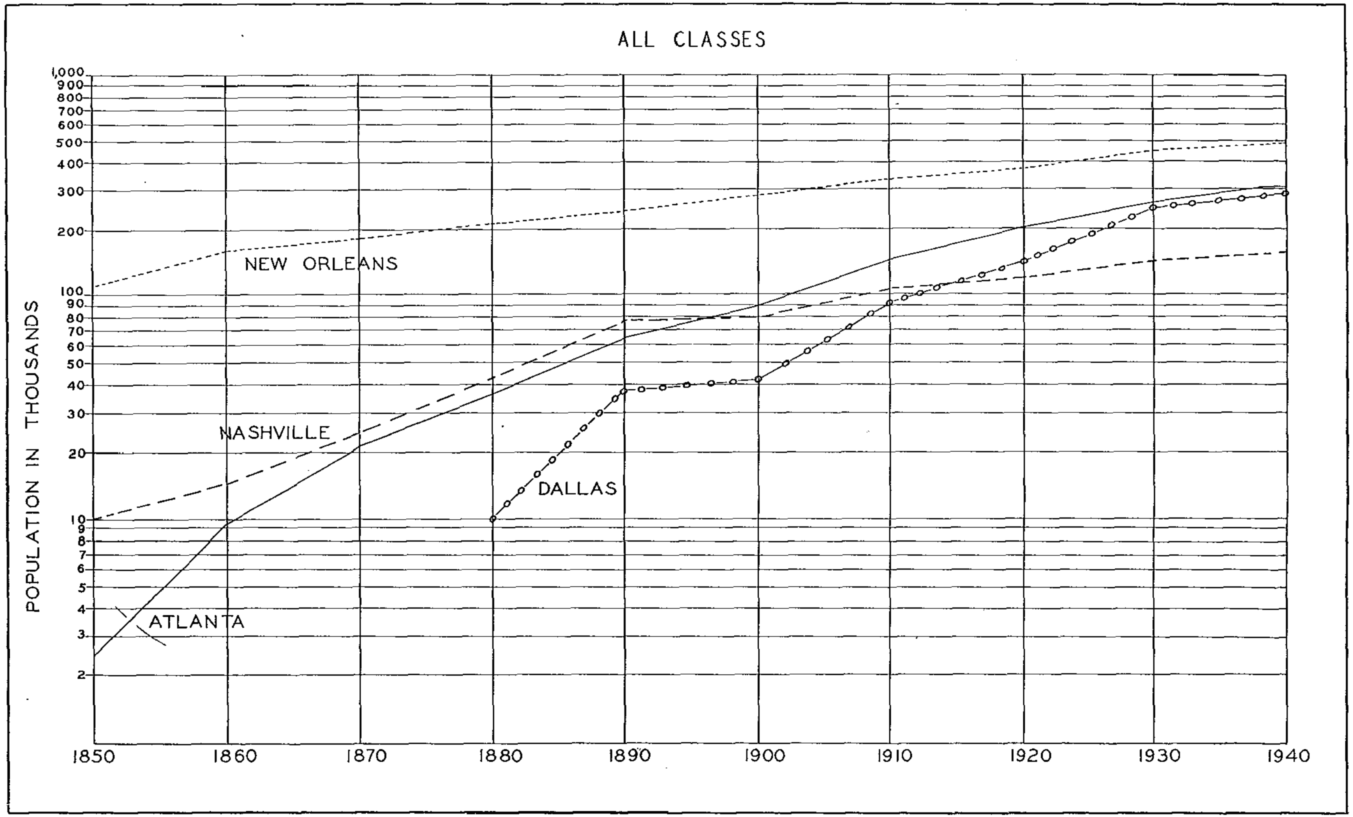

Figure 3. The Growth of the Total Population in Selected Southern Cities, 1850-1940.

and Nashville were about the same size at just under 30,000. By 1940 Atlanta had more than 100,000 Negroes to Nashville's 45,000.

Territorial growth of Atlanta. Closely associated with the population growth of Atlanta is the territorial growth of the city. Figure 4 has been reproduced to afford a clear picture of this territorial growth and for comparison with Figure 3 which shows Atlanta's rate of growth.

Causes of Atlanta's growth. The growth of Atlanta has been largely due to the great number of persons migrating to the city from rural areas. Its growth from natural increase is not nearly so significant as that from migration. Definite identification of contributing factors responsible for Atlanta's

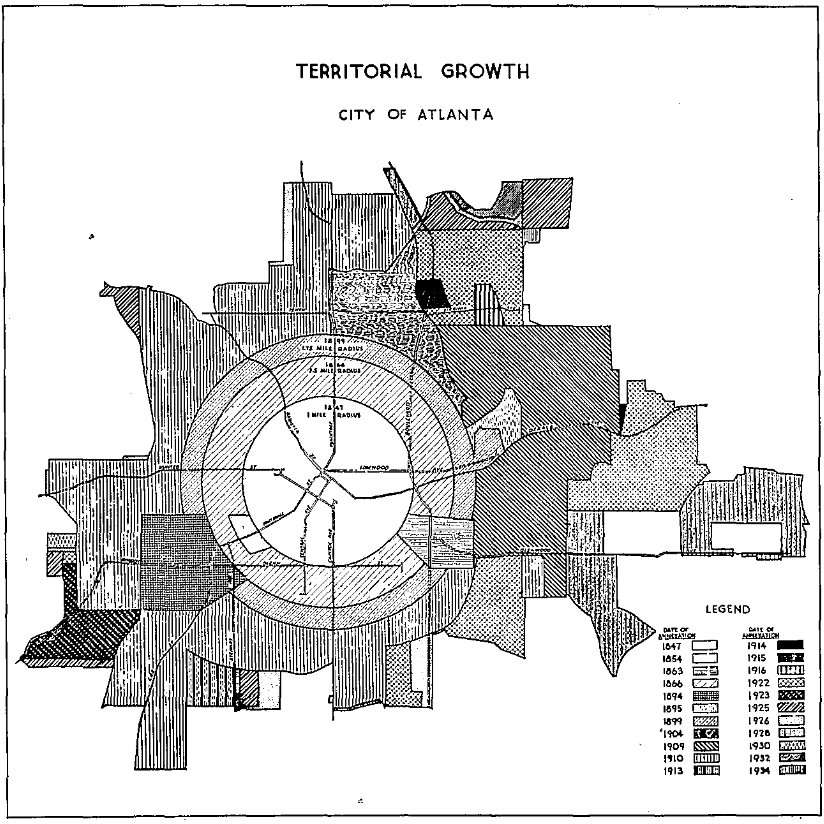

Figure 4. Territorial Growth of the City of Atlanta, By Area Acquired and Year Annexed.

growth is not completely possible, but several factors which are important may be identified.

These factors are as follows: (1) Atlanta is located at the intersection of the transportation systems of Georgia and many of those of the southeast; (2) as a consequence of this advantageous location, trade and commerce have flourished; (3) a further consequence has been the location of owners, branch and regional offices and industries of national concerns in Atlanta; (4) the moving of the state capital to Atlanta in 1868 (officially in 1877) added considerable impetus to the city's growth; (5) the great concentration of wholesale-retail business and the services and institutions necessary for urban life have drawn many people into the city; and (6) as the city has overflowed its political boundaries, more and more territory has been added which is a factor in its growth.

Location seems to be the most important of all the above factors. The city is situated near the foothills of the Blue Ridge Mountains, at an elevation of 1,050 feet above sea level, on a ridge that divides the watersheds of the Atlantic Ocean and the Gulf of Mexico. It is about midway on airline routes from Chicago and Miami; and is in a somewhat central position among the states south of Kentucky and east of the Mississippi River.

The value and importance of Atlanta's location was early recognized. In 1845, when Atlanta had only one railroad and a population of 100, John C. Calhoun of South Carolina made the following remarks at the Southwestern Convention in Memphis, regarding Atlanta and her strategic location:

> What then is needed to complete a cheap, speedy and safe intercourse between the valley of the Mississippi and the Southern Atlantic coast is a good system of railroads. For this purpose the nature of the intervening country affords extraordinary advantages. Such is its formation from the course of the Tennessee, Cumberland and Alabama rivers, and the termination of the various chains of mountains, that all the railroads which have been projected or commenced, although each has looked only to its local interest, must necessarily unite at a point in DeKalb county, in the State of Georgia, called At-

lanta, not far from the village of Decatur, so as to constitute an entire system of roads, having a mutual interest each in the other, instead of isolated rival roads.[9]

Other fundamental factors necessary to produce large cities must not be overlooked. The coming of the industrial revolution with steam power and the factory system is an essential factor in the growth of large, modern, urban communities. Closely associated with this revolution has been the improvement in agricultural production, and improved methods of sanitation and public hygiene. It is well to note that the period of Atlanta's most rapid growth took place during the period in which rapid urbanization was taking place in Western Europe, the British Isles, and the United States. Atlanta's growth has not been an effect of isolated causes, but part of a world-wide pattern of change which is still going on.

Summary

This paper has been a **very** brief orientation to Atlanta and a summary analysis of the number, distribution, and growth of the Atlanta population. A comprehensive analysis of these and many other demographic phenomena pertaining to Atlanta's population is available elsewhere.[10]

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[9]Wallace P. Reed, editor, *History of Atlanta, Georgia* (Atlanta, Georgia: Byrd Printing Company, 1902), p. 19.

[10]C. A. McMahan, *The People of Atlanta* (Athens, Georgia: The University of Georgia Press, 1950).

PLANNING IN THE ATLANTA METROPOLITAN AREA*

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ABSTRACT

Although several planning agencies were already functioning in the area, the Metropolitan Planning Commission was established in 1947 to prepare a "master plan for the orderly growth and development" of a district which comprises all of Fulton and DeKalb counties astride whose joint boundary the City of Atlanta lies.

Staff activities generally follow the dual pattern of (a) survey and inventory of what has been done, and (b) original endeavours toward the accomplishment of the mandated objective. The latter includes a population estimate and forecast, an inquiry into the economy of the area, an investigation of opportunities for expansion of Negro residential areas, and the application to the district of certain provisions of the Housing Act of 1949. A third sphere of activity involves the handling of so-called routine inquiries, some of which are the delight, and others the despair, of the staff.

Geographic aspects of the planning program are evident. Fenneman's diagrammatic description of the content of geography (1919) readily lends itself for adaptation to a comparable description of the content of planning. The implications of this comparison should not be lost to the profession of geography.

* * *

In the year 1836 a surveyor drove a stake into the red clay of Georgia and thereby marked the location at which two railroad lines, if sufficiently extended, would meet. In anticipation of the facts in the case, and with appropriate recognition of Latin gender, the name Terminus was bestowed on that stob-marked site. Subsequently, in 1843, Terminus became Marthasville, but in 1845 when the first rail line actually reached the site, the name was again changed—this time to Atlanta.

Two years later, 1847, Atlanta was incorporated, girded by a circular corporate boundary with a radius of one mile centered on the zero milepost of the Western and Atlantic Railroad. The census of 1850 recorded for the infant city a

*Read at meeting of Association of American Geographers, Southeast Division, Athens, Georgia, December 2, 1949.

population of 2,572, while that of 1940* records over 300,000, an increase across the nine decades of 11,653 percent. However, the seed sown in 1836 has not contained itself within the confines of the present incorporation. The Atlanta metropolitan district had a 1940 population of over 440,000; in the forthcoming decennial census, it is confidently expected that greater Atlanta will have a population well in excess of a half million.

The population now concentrated in the Atlanta area and the rate of past population increase by which the present total has been reached are factors of profound geographic, social, political and economic significance. A truly tremendous physical plant has evolved to accommodate that population in all phases and aspects of its existence. This agglomeration of houses, mills, factories, stores, offices, shops, schools, churches, warehouses, terminals, parks, streets, highways, transportation, communication, water and sanitary systems, is an accomplished fact.

By what process, if any, did this fact become accomplished? What are the prospects for this or any other process in the next decade or more? Briefly, the process by which Atlanta and greater Atlanta have assumed their present proportions is, in general, the all too familiar "Topsy-process" of just growing. This is not said in any sense of criticism.

Many planning problems and many planning agencies have co-existed for some time in the Atlanta area. At present, in and about Atlanta, there are some twenty separate and distinct agencies functioning in the field of planning. On March 27, 1947, by legislative enactment, the Metropolitan Planning Commission entered this seemingly crowded field.

The Metropolitan Planning Commission is the only one of the several planning agencies which is authorized and empowered to make a master plan for an area which embraces the bulk of the Atlanta community. Other planning agencies

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Area	Size in Square Miles	1940 Population
City of Atlanta	34.7	302,288
1940 Atlanta Metropolitan District	257.6	442,294
1950 Atlanta Metropolitan District	1,140.0	518,100

are limited in scope of activity either to smaller areas, as individual cities and counties, or to more restricted functions.

City and county planning commissions serve almost exclusively in the administration of zoning regulations and closely related matters. For example, in the year 1947 the Fulton County Planning Commission's staff of seven persons processed zoning certificates pre-requisite to the issuance of 2,709 building permits. It reviewed a total of 57 subdivision plats and approved 46 of them. It participated in 234 public hearings. Such continuing demands on staff time effectively preclude the serious pursuit of intelligent anticipation.

In some instances, a planning commission has no staff; the members meet generally one evening a month to consider requests for special building permits and appeals for variances from zoning regulations.

As a final example of restricted function, in 1946 the citizens of Atlanta and of Fulton County voted a bond issue in the amount of $40,400,000 for specific civic improvements. These projects were carefully selected and a Joint Bond Committee supervises the expenditure of funds.*

The Metropolitan Planning Commission is essentially and basically a planning agency. It is devoid of any and all responsibility for the administration of local laws or ordinances.

As to the ultimate disposition of the master plan which the Metropolitan Planning Commission is directed to make, legislation stipulates that the Commission shall act only in an advisory capacity and that the individual counties or municipalities which adopt the plan shall be responsible for its administration within their respective territorial limits.

The organic act established the metropolitan planning district and defined it as consisting of "all the territorial area of Fulton and DeKalb counties". The same act gave the planning commission, as its mandate, the directive ". . . to make a master plan for the orderly growth and development of the district." The district designated for its planning operations is at once sufficiently comprehensive to permit the preparation of an integrated plan focused on the Atlanta

*For a detailed statement of the bond issue program, see *FACTS*, Vol. 22, No. 5, May 1949, published by the Atlanta League of Women Voters.

community and sufficiently restricted to enforce confinement of thinking and of planning within reasonable and significant bounds.

Only since January 1949 has the Commission been active in a technical sense. Staffing and program activation have characterized the first year of its existence.

In this year of its advent, the staff has had problems fairly common to any new agency—materials, equipment, work space. As it sought solutions to these individual problems, it also sought to embark on an aggressive program designed to fulfill the need for which it was created. That program consisted in the location and acquisition of basic information reflecting conditions, trends, and problems in the over-all community, and in the preparation of graphic materials representative of certain fundamental statistical information, in studies of population, including a population forecast of the economy of the area, urban land use and zoning, the street and highway system, utilities and of housing.

Housing constitutes a most serious problem throughout the entire urbanized portions of the metropolitan planning district. It is therefore one which commands a large amount of staff attention. Progress has been made in a study of areas deemed suitable for expansion of Negro housing—a subject as critical as it is ticklish; work is underway on a housing market area analysis; on the localization of the principal areas of urban blight; and a detailed inquiry into housing and family characteristics of each of the areas, as a point of departure for a slum clearance and redevelopment program.

The enactment of the Housing Act of 1949 and the anticipated application to greater Atlanta of its provisions regarding slum clearance and community development and redevelopment have caused an advancement in staff consideration of related portions of the metropolitan planning program.

As the Metropolitan Planning Commission completes its first year of operation, it can point to a reasonably impressive array of accomplishments—both tangible and intangible. On the one hand are the many studies completed or in progress which produce a visible accumulation of results. On the other hand is that invaluable and incalculable accumulation of staff experience without which there can be no real organization and little prospect of eventual accomplishment.

Planning is for people; planning is anthropocentric. Planning and geography have much in common. This has been pointed out repeatedly in the past and certainly now presents no new point of view. Fundamentally, planning, as an active operation, draws on the substance of many related fields. Engineering, architecture, sociology, economics, public health and other disciplines, including geography, have substantial contributions to make to the field of planning.

Fenneman in 1919[1] developed rather clearly for the geographic profession this concept of synthesis in regional geography. On a previous occasion[2] I sought to point out that regional planning, like regional geography, is not a discipline unto itself self-created and self-sustaining. Both partake of the varied natures of their constituent disciplines. It is in the synthesis of these contributory parts that regional planning assumes a personality of its own.

Employment opportunities for geographers on planning staffs exist, but they are understandably limited. But, isn't the horizon an expanding one? Efforts exerted by academic geographers calculated to enrich curriculum content through use of the products of the planning profession should enlarge the graduate geographer's employment opportunity as well as generally enhance the stature and status of geography.

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[1]Fenneman, Nevin M.—The Circumference of Geography. *Geographical Review,* Vol. 7, No. 3, March 1919, pp. 168-175.

[2]Zuber, Leo J.—A Comparative View of Regional Planning. *Journal of the Tennessee Academy of Science,* Vol. 12, No. 3, July 1937, pp. 267-272.

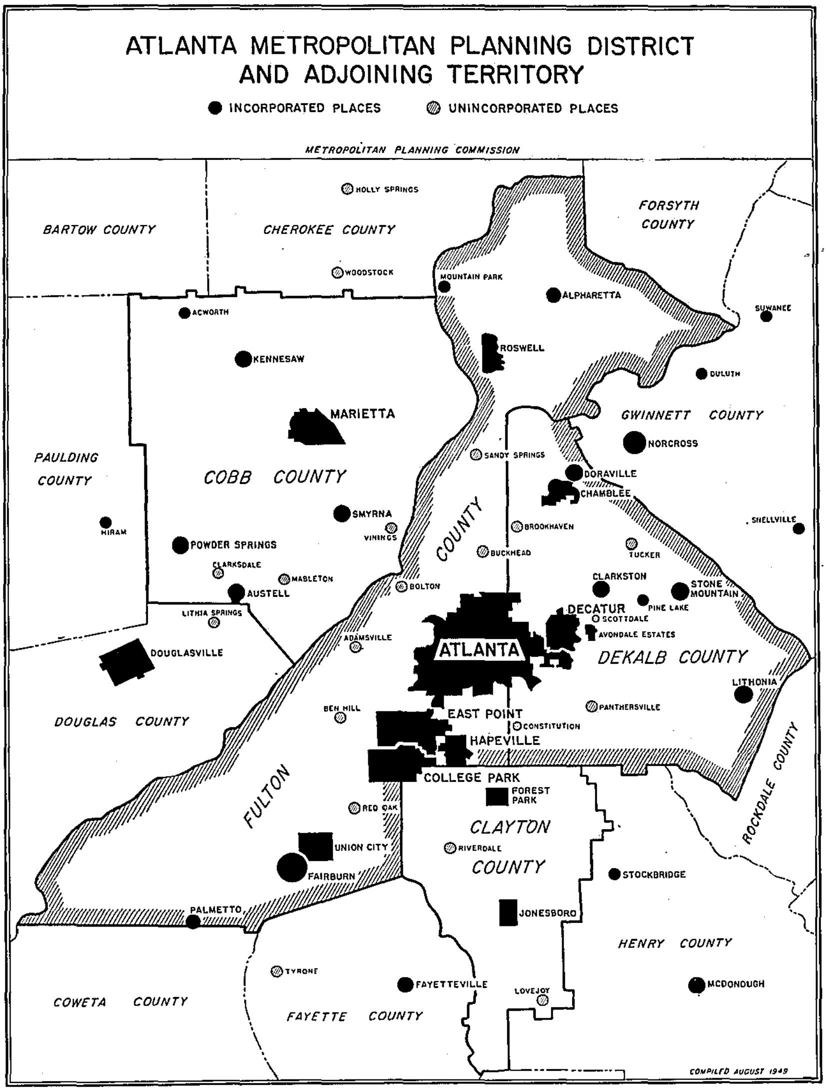
ATLANTA METROPOLITAN PLANNING DISTRICT
AND ADJOINING TERRITORY
INCORPORATED PLACES
UNINCORPORATED PLACES
METROPOLITAN PLANNING COMMISSION
BARTOW COUNTY
CHEROKEE COUNTY
FORSYTH COUNTY
PAULDING COUNTY
COBB COUNTY
GWINNETT COUNTY
DEKALB COUNTY
DOUGLAS COUNTY
FULTON COUNTY
CLAYTON COUNTY
ROCKDALE COUNTY
HENRY COUNTY
COWETA COUNTY
FAYETTE COUNTY
ATLANTA
MARIETTA
ROSWELL
ALPHARETTA
KENNESAW
SMYRNA
DECATUR
EAST POINT
HAPEVILLE
COLLEGE PARK
FOREST PARK
NORCROSS
DORAVILLE
CHAMBLEE
CLARKSTON
STONE MOUNTAIN
LITHONIA
DOUGLASVILLE
POWDER SPRINGS
AUSTELL
UNION CITY
FAIRBURN
PALMETTO
JONESBORO
FAYETTEVILLE
STOCKBRIDGE
MCDONOUGH
COMPILED AUGUST 1949

Figure 1

INDUSTRIAL DEVELOPMENT IN THE ATLANTA SUBURBAN AREA

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Atlanta is becoming recognized more and more as a major industrial center in the South. This does not imply, however, that she has relinquished her position as a commercial and business center. A study of occupations in the Atlanta area shows that in 1947 approximately thirty per cent of the workers were in service industries and twenty-five per cent were in wholesale and retail trade.[1] These percentages should be expected in view of Atlanta's position as the so called "Gate City to the Southeast. The next occupational group in Atlanta is manufacturing with seventeen per cent.[1] Though a smaller percentage than in service industries and wholesale and retail trade, it is very important.

The importance of manufacturing in Atlanta can be further illustrated by noting her industrial production in the state of Georgia and Georgia's industrial production in the Southeast. The value added by manufacturing in the South Atlantic States amounted to $6.9 billion in 1947 as compared with $2.2 billion in 1939.[2] The value added in the state of Georgia amounted to $1,016,000,000[3] which represents an increase of 262% over 1939. Georgia, thus, accounted for about fifteen per cent of the industrial production in the South Atlantic States in terms of value added.

In 1947 seven counties in Georgia shipped goods which had a value of upwards of $25,000.000 in excess of cost of materials and supplies. They were Bibb, Chatham, Floyd, Fulton, Glynn Richmond, and Troup Counties. Of these the production of Fulton County was by far the greatest, amounting to $216,966,000 in terms of value added, or twenty-one per cent of the state's production. This makes up the largest proportion of the industrial production in the Atlanta Metropolitan area which now includes all of Fulton, DeKalb, and Cobb Counties. In 1947 the production of these three counties in terms of value added was $237,012,000 or twenty-three per cent of the state's industrial output, an increase of 290% since 1939. In the Atlanta area are sixteen per cent of the State's industrial establishments and sixteen per cent of the industrial employees. Industrial output, in terms of value added, is greater per industry and worker in the Atlanta area than for the rest of the state.

The Atlanta Suburban Area

The Atlanta Suburban Area (Fig. 1) is made up of a portion of four counties and covers an area of approximately 200 square miles. It is within this area that most of the industries of the Atlanta Metropolitan Area are located. Outside of the Atlanta Suburban Area, but still in the Atlanta Metropolitan Area, are industries which cannot be directly tied to Atlanta.

The Atlanta Suburban Area and the city of Atlanta are served by eight major rail lines, two railroad stations—the Terminal and the Union—and numerous railroad yards. In addition, there are a number of branch rail lines around the city area. In the Atlanta Suburban Area there are close to one hundred miles of railroad trackage to serve the industrial and commercial firms of Atlanta. The major concentrations of industrial plants are along the various railroad lines. Not only is there adequate space for industrial growth along the existing lines outside the city limits, but spurs and sidings are being constructed to meet the growth of new industries and industrial districts. All parts of Atlanta are served by highways and roads. Improvement of the present traffic system is being carried out and fine, modern highways have been constructed to serve new industries and industrial districts.

Industrial Groups In Atlanta

The industries of Atlanta have been grouped into sixteen headings, (Fig. 2). The most important industry in Atlanta, in terms of value added, is food and kindred products, representing about forty-five per cent of the state's production. The largest single category is bakery plants. These plants are fairly well scattered about the city. The largest unit is the National Biscuit Company employing 1,100 people[4] in 1947 producing a nationally known product. Next is the Columbia Baking Company producing bread and pastry products primarily for local consumption.

Meat products have shown an increase of thirty-six per cent in the state since 1939. These meat products constitute about ten per cent of food and kindred products in the Atlanta Area. Meat processing is concentrated in two areas. One is adjacent to the Howell Stockyards in the Northside Drive-Steel Company Industrial District* and the other is in the Southeastern Industrial District. Other food processing plants and warehouses along with miscellaneous types of industries are also to be found in these areas.

Atlanta is famous as the home of Coca-Cola, which has grown into a world wide business. The Coca-Cola syrup plant in the Marietta-North Avenue Industrial District produces syrup for much of the Southeast. Pepsi-Cola, Dr. Pepper, and other beverages, both non-alcoholic and alcoholic, are also bottled in Atlanta.

Next of importance in industrial production in Atlanta are textile mill products accounting for seven per cent of the state's production. An average of 270 people is employed in thirty-one mills which are located in various parts of the Metropolitan area along the railroad lines. Seventeen of the mills are in Fulton County, twelve are in Cobb, with eight of these in the city of Marietta. The two mills located in DeKalb County are in Scottdale. The textile industry represents the most widely scattered of the major industrial plants of an industrial group in the Metropolitan Area. The Fulton Bag and Cotton Mills and the Exposition Cotton Mills employed 2,773 and 1,250 respectively in 1947. Of thirteen other mills in the Atlanta Suburban Area employing over one hundred each, three are in East Point, three are in the Fulton Bag-Edgewood Boulevard Industrial District, and two are in the Southeastern Industrial District. The remainder are scattered throughout the Metropolitan area.

One hundred and seven printing and publishing firms were listed for the Metropolitan Area in 1947; they produced sixty-

*A map was constructed of the Atlanta Suburban Area at a scale of 1/20,000. The industries were located on this map to scale. Most of the industries of the Atlanta Suburban Area (Fig. 1) were found to be concentrated in eighteen districts. The nomenclature for these districts was worked out on the basis of common usage and location.

seven per cent of the printed and published products of the state of Georgia. These firms, for the most part, are located in the business center of the city with others to be found in the smaller towns and suburban centers in the Metropolitan Area. The **Atlanta Journal** and the **Atlanta Constitution,** publishing daily newspapers, employed 725 and 470 respectively in 1947. Seven other printing establishments employing between one hundred and 150 people each are located in downtown Atlanta.

The wearing apparel industry is concentrated in the South Business, Commercial and Industrial District, an area of approximately forty blocks located south of the central business district of Atlanta. The plants are concentrated along Pryor, Mitchell, Trinity, and Whitehall Streets. However, it should be noted that approximately seventy per cent of the plants in this area produce products other than wearing apparel. Following wearing apparel, printing, food processing, and chemicals are of importance in order given. In terms of numbers employed, printing outranks wearing apparel primarily because of the **Atlanta Journal** and the **Atlanta Constitution.** Both of these are located on the northern fringe of this district close to the central section of the city. Seven of the thirteen wearing apparel plants in Fulton County with more than one hundred employees are located in this area. Six other wearing apparel plants with more than one hundred employees each are scattered throughout the Atlanta Metropolitan area. The largest is Cluett Peabody and Company with 1,000 employees, manufacturing Arrow Shirts. It is located on Murphy Avenue in the Oakland City Industrial District.

The chemical industry in Metropolitan Atlanta accounts for eighteen per cent of the state's production. In terms of number of industries, the greatest concentration is in the wearing apparel or South Business, Commercial and Industrial District but extending across the Central of Georgia Railroad tracks to take in the plants located along Peters and Walker Streets. These firms produce for the most part drug products and cleaning and polishing preparations. Most of the firms are small, ranging up to one hundred employed. The largest chemical plants in terms of average numbered employed are cotton seed oil and fertilizer plants all located away from the business district. Of the fourteen cotton seed oil and fertilizer plants, five are in East Point along the Central of Georgia Railroad, three are in the Chevrolet-Federal Prison Industrial District, and three are located in the North Side Drive-Steel Company Industrial District. Armour and Company and The F. S. Royster Guano Company are located in the Lindberg and Southern Railroad Industrial District. The Virginia-Carolina Chemical Corporation has plants in Kirkwood and Oakland City.

If the primary metal industries, fabricated metal products, and machinery, including electrical but excluding transportation, are grouped together under metal working this becomes one of the most significant industries in Atlanta. One hundred and twenty-seven plants were in this category in 1947. They range from the numerous shops producing miscellaneous household products to the large railroad shops, machine shops, and steel plants producing heavier products. There is no readily apparent concentration of these plants other than that the larger plants are located along the railroads while many of the smaller plants may be located away from the rail lines but primarily in industrial sections.

Construction of several large motor vehicle assembly and parts plants has added substantially to industrial production in recent years with other transportation plants planned or actually under construction. These plants are widely scattered in the Atlanta Area with the three major automobile assembly plants* located outside the city limits. Their establishment in the Atlanta area has been encouraged by low taxes and by the construction of adequate highways and railroad spurs. They have had the advantage of suitable, cheap land along rail lines with a plentiful water supply, sewerage, and gas lines available. The labor supply is reported to be both abundant and efficient, enabling the plants to achieve a higher unit production than is obtained by similar plants in other parts of the country. Plants for the production of trucks, agricultural equipment, boats, and other automotive units and parts have been established in the Atlanta Area. Some of these represent new additions.

*General Motors Corporation, producing Buick, Oldsmobile, and Pontiac automobiles is in Doraville; the Chevrolet Motors Company is in the Chevrolet-Federal Prison District just south of the city limits of Atlanta; the Ford Motor Company is in Hapeville.

Industrial Expansion and Development of New Industrial Districts

Probably of greatest interest in the industrial story in the Atlanta area is the development of new industrial districts and expansion in several of the older industrial districts. Most of this expansion is away from the crowded downtown industrial areas. Considerable grading work has been carried out in the northern part of East Point in the Empire Industrial District in preparation for warehouse and industrial development. Considerable grading work, construction of railroad spurs from the Seaboard Air Line, a new highway to serve the area, and the construction of seven industrial and warehouse buildings have taken place recently in the Southland Industrial Center.

Considerable expansion has taken place in the recent years in the East Ponce de Leon Industrial District located just outside the city limits of Decatur. Water, sewer lines, a gas line, a new highway, and rail spurs have been established to serve this new district. Seven new plants have been constructed in the past two years adding to the fourteen generally smaller plants already there. Additional plans are being made for further construction in the area.

Significant expansion has occurred in recent years in the Northside Drive-Steel Company Industrial District. Most of this has taken place on Bishop Street and along Northside Drive in the vicinity of the Seaboard Air Line Railroad.

In many ways the most spectacular industrial development is taking place in the Chamblee area in the northern part of DeKalb County. The area is served by the Southern Railroad and the new million dollar Peachtree Industrial Boulevard. Considerable land requiring only moderate grading is available for industrial development. An adequate supply of water is available through the thirteen inch pipe line of DeKalb County, as well as gas and sewerage. Almost all the industries in this area represented post-war construction. New industries are planned or are actually under construction. The U. S. Naval Air Station, Lawson General Hospital, and the Veterans Hospital are also located in the Chamblee area. This region represents one of the largest new residential districts in the Atlanta Suburban Area. Plans have been drawn and work has begun on the vast Longview development of over 2,600 low cost homes claimed to be the largest housing developments ever undertaken in the South. Other companies are continuing low cost housing construction adding substantially to existing facilities. These homes will provide adequate housing for a large labor force that may be employed in the industries in the Chamblee-Doraville area.

Conclusion

Atlanta, strategically located to serve as a business and commercial center in the Southeast, is becoming of increasing importance as an industrial area. Twenty-three per cent of the industrial production in Georgia is in the Atlanta Metropolitan Area. The industrial expansion has been 290% between 1939 and 1947. Most of the industries are in eighteen industrial districts, seventeen of which are located along the railroad lines. Industrial expansion is concentrated outside the city of Atlanta in new or expanding industrial districts.

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[1]Ivey, J. E., Demerath, N. J., and Breland, W. W., *Building Atlanta's Future,* The University of North Carolina Press, Chapel Hill, North Carolina, 1948, p. 97.

[2]*Projects and Publications of Interest to Plannig and Development Agencies,* "Business Information Service", No. 3, Department of Commerce. Washington 25, D. C., July, 1949, p. 1.

[3]*Census of Manufacturing, Georgia,* MC110, U. S. Department of Commerce, Bureau of Census, Washington 25, D. C., 1949, p. 1. Industrial production figures for the Atlanta Metropolitan Area, Georgia, and industrial groups in Georgia are obtained or computed from data given in this report, unless otherwise indicated.

[4]*Manufacturers of Georgia,* The Agricultural and Industrial Development Board of Georgia, 100 State Capitol, Atlanta, Georgia, May, 1947. The employment figures for individual industries were obtained or computed from this source unless otherwise indicated.

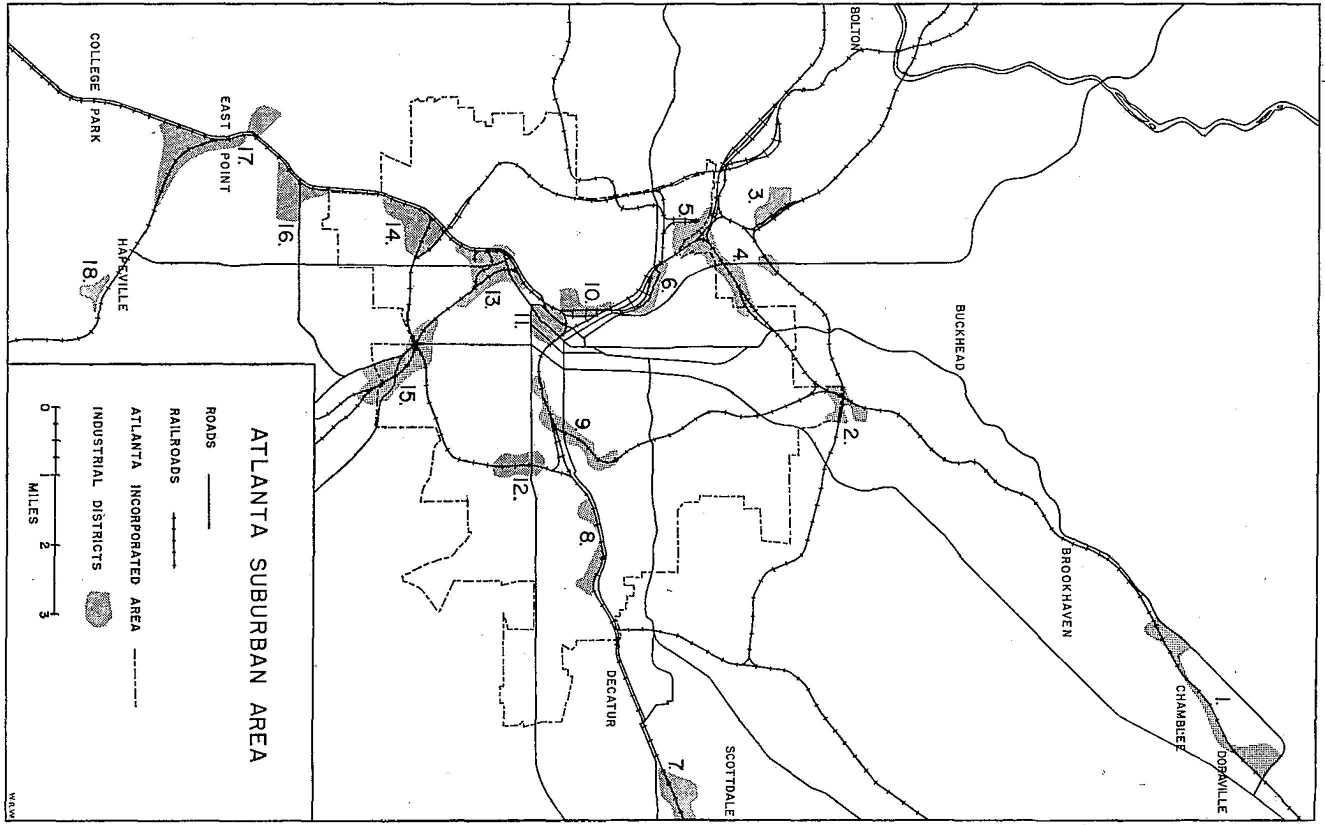

Fig. 1. Industrial Districts: 1, North DeKalb Industrial District; 2, Lindberg & Southern Railroad Industrial District; 3, Southland Industrial District; 4, North Side Drive-Steel Company Industrial District; 5, Marietta and Ashby Industrial District; 6, Marietta and North Avenue Industrial District; 7, East Ponce de Leon Industrial District; 8, Kirkwood Industrial District; 9, Fulton Bag-Edgewood Boulevard Industrial District; 10, Freight Station Industrial District; 11, South Business, Commercial, and Industrial District; 12, Memorial Drive-Belt Line Industrial District; 13, Southeastern Industrial District; 14, Oakland City Industrial District; 15, Chevrolet-Federal Prison Industrial District; 16, Empire Industrial District; 17, East Point Industrial District; 18, Hapeville Industrial District.

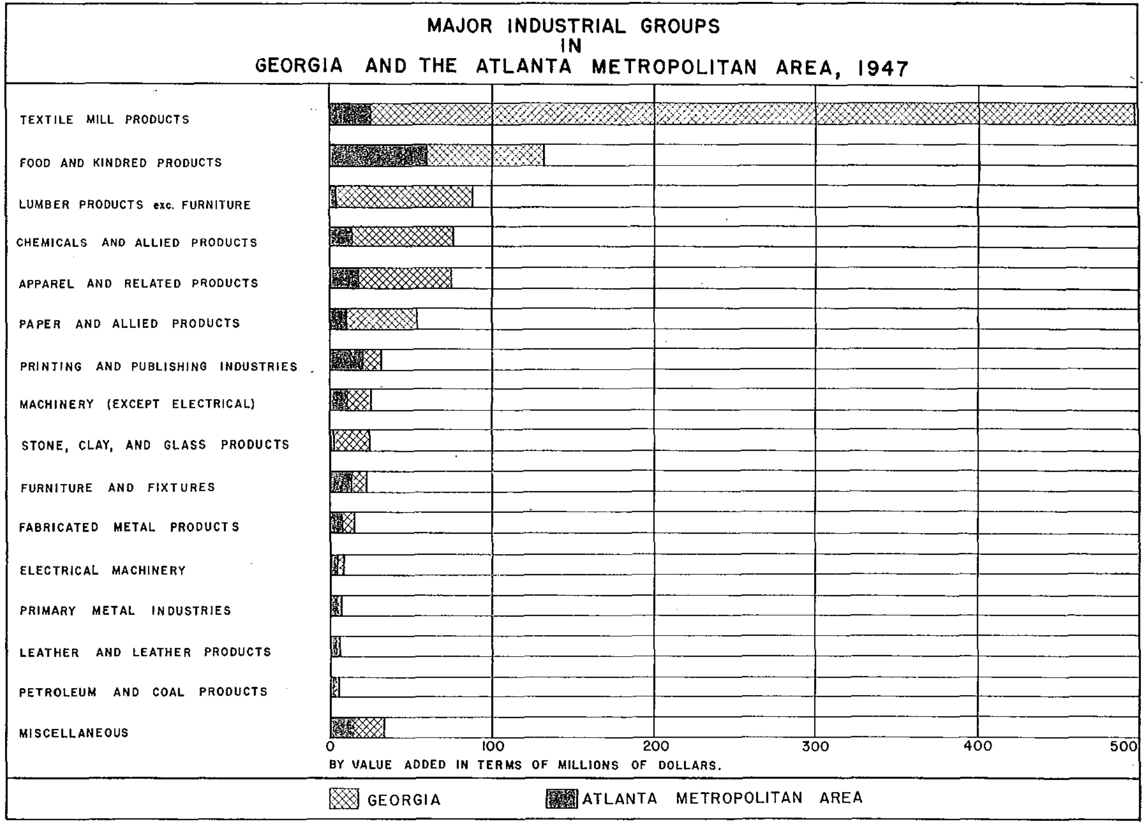
MAJOR INDUSTRIAL GROUPS
IN
GEORGIA AND THE ATLANTA METROPOLITAN AREA, 1947
TEXTILE MILL PRODUCTS
FOOD AND KINDRED PRODUCTS
LUMBER PRODUCTS exc. FURNITURE
CHEMICALS AND ALLIED PRODUCTS
APPAREL AND RELATED PRODUCTS
PAPER AND ALLIED PRODUCTS
PRINTING AND PUBLISHING INDUSTRIES
MACHINERY (EXCEPT ELECTRICAL)
STONE, CLAY, AND GLASS PRODUCTS
FURNITURE AND FIXTURES
FABRICATED METAL PRODUCTS
ELECTRICAL MACHINERY
PRIMARY METAL INDUSTRIES
LEATHER AND LEATHER PRODUCTS
PETROLEUM AND COAL PRODUCTS
MISCELLANEOUS
0
100
200
300
400
500
BY VALUE ADDED IN TERMS OF MILLIONS OF DOLLARS.
GEORGIA
ATLANTA METROPOLITAN AREA

Figure 2

AN APPRAISAL OF GEORGIA'S SURFACE WATER RESOURCES INVESTIGATIONS PROGRAM*

By M. T. THOMSON

District Engineer, U. S. Geological Survey

Atlanta, Georgia

The investigations of Georgia's surface water resources have been carried on through cooperative arrangements between the state and federal government for more than 50 years.

The purpose of the investigations is to make an inventory of the streams to provide the necessary information for their utilization and control, or for protection from them.

The basic part of the investigation is the collection of stream flow data at gaging stations. Unlike other resources or commodities, stream flow is constantly changing, so that the inventory must be a running one carried on continuously over a long enough period of years to give a true picture of the stream's character. One complaint of the users of stream flow information is the lack of adequately long periods of record so that as we appraise our program, we must consider the continuity of record an important factor.

A second requirement of the investigation is that the information acquired be available wherever needed. Again, the users of the information complain that there are not enough places where records are available, particularly on small streams, so that we must also consider it important to have gaging stations at as many sites as are practicable.

A third requirement is that the records be accurate. As the investment in river development grows and as we approach limits in water supplies, the standards of accuracy increase.

A fourth requirement is that the records be available to everyone and promptly. This calls for prompt analysis, for

*Published by permission of the Director, United States Geological Survey
Read at meeting of the Georgia Academy of Science, Athens, Georgia April 10, 1948.

which adequate field data are essential, and early publications. Also, there is question as to the form of publication. At present, records are published by years, each volume of the water supply papers containing one year of record for a group of river basins. To have an inventory of all the records in Georgia requires a library of nearly a hundred volumes. For any user of the information interested in a single stream, it is unreasonable to expect him to acquire many separate volumes, so it is important in our appraisal to consider consolidation of available information in a limited number of volumes.

A fifth requirement is that the cost of water resources investigations be held to a minimum. All the other requirements add up to increasing costs so our appraisal must be in the nature of securing adequate results without making the cost prohibitive.

In the early years of water resources investigation, the primary application of the information, in Georgia at least, was for hydroelectric power development. Gaging stations were established at good power sites. A few years of record of fair accuracy were collected. It was analyzed by consulting engineers and applied to single-unit hydro-power developments. The records covered short periods of years so the consulting engineers could easily accommodate the small library of data. They extended the knowledge of stream flow by using records of rainfall and their projects were designed to develop that portion of the available power that would satisfy the market at the moment with the optimum return on the investor's money.

During the past two decades, this picture has changed. The country has realized that water should be fully developed and that all needs should be served. As a result the dams being built now are huge affairs serving many purposes, each unit designed to extract the greatest possible benefits in conjunction with other dams to be built in the future. Such development is a public enterprise engineered for the most part by government "action" agencies.

These developments are entirely on major rivers and their larger tributaries. The gaging stations serving these projects are also on the same types of streams. As we appraise our program, we find most of the gaging stations in Georgia on major streams serving the needs for future development and for regulation of existing developments.

These developments create large new sources of electric power, alleviate floods, provide for navigation, conserve excess waters for use during droughts and provide extensive recreation facilities. All these items are evidence of an improved economic situation in Georgia. They show more manufacturing, better living conditions and valuable property deserving flood protection. As we look further into Georgia's economic situation, we find a vigorous growth of our cities, more payrolls, better markets for our agriculture and a more prosperous diversified agriculture.

These developments in turn involve water. We find the cities outgrowing their water supplies, fighting rapidly growing pollution problems, seeking additional facilities for industry including more water. We find our highway system a vital part of our living with a demand for better bridges to accommodate floods. People are no longer content to be "water bound". They must have access to their markets with perishable produce. We find stock raisers requiring more certain water supply for their larger and better herds and vegetable and plant growers requiring water for their irrigation systems.

Much of this new type of water development is in small units involving small individual investments of which funds for adequate professional consulting services are either not available or so small that the consulting engineer cannot make an expensive study of fundamental conditions. Yet some of their problems involving stream flow are as involved as on major developments. Such studies as are made for lesser enterprises are made by state and federal government "service" agencies such as the health departments, Soil Conservation Service and county agents, and by industrial agents of Chambers of Commerce, railroads and sales organizations.

As these so-called "lesser" projects, in the aggregate of quite extensive proportions, become more numerous, we find a growing need for reliable flow information on small streams down to the few acres needed to maintain a farm pond. Early limitations to stream flow investigation did not provide for gaging station records on small streams so that we are now faced with a grave deficiency in that type of basic inventory data. Furthermore, gaging station records alone do not serve the needs because the present day users are not expert enough or do not have time enough to convert gaging station flow data into the quantities that they need at the particular sites with which they are concerned.

Thus, as we make our appraisal today, we find an adequate service for development on major rivers by action agencies or consulting engineers, but an inadequate service on minor streams and for general public use. The Geological Survey should participate more actively in public services involving the use of water resources, particularly when the water questions are complex or of paramount interest. At the same time, the information obtained by the Survey should be put into such a form that it can be used readily by the public or service agencies for the less complex water problems.

To best serve the needs foreseeable in the next decade, it is necessary that gaging stations on small streams be established without delay. Further, steps should be taken to get low water information on as many other streams as the opportunities and facilities permit. With an adequate combination of these basic data, it will then be practical to compute and release data directly applicable to water supply problems at specific sites, certainly where municipal and industrial uses are possible, and if desired, at all sites where small agricultural uses may be expected.

At the same time miscellaneous flood information should be acquired, particularly on small streams, and studies made to establish proper flood data applicable to any proposed structure that involves floods, such as bridges, levees and factory sites.

Preliminary investigations are already under way to devise the most effective way of preparing these types of information and presenting them in the most usable form. Some of the results of these preliminary investigations are presented here today. The rate at which results of investigations are released is dependent on the allocation of funds for the project by the state and Congress. The best results will come by starting the new investigations now rather than to wait until our people have wasted both money and resources on developments uninsured by adequate knowledge.

MAGNITUDE AND FREQUENCY OF HISTORIC FLOODS ON CHATTAHOOCHEE RIVER AT COLUMBUS, GA.*

By ALEXANDER A. FISCHBACK, JR.

Hydraulic Engineer, U. S. Geological Survey

Introduction:

Columbus, Georgia has experienced some rare floods from the Chattahoochee River that offer an unusual opportunity for a study of flood frequency and magnitude.

First recorded observations of flood stages of Chattahoochee River were started by the U. S. Weather Bureau in 1893. The Geological Survey has operated a recording gage continuously since 1929.

Source of Historical Flood Data:

The History of Columbus, Georgia, 1827-1865[1], mentions several floods that reached unusual stages. The flood of March 11, 1841 termed the "Harrison Freshet" was the greatest during that period.

Information regarding floods during the period 1866 to establishment of gage was obtained from local residents who had established flood marks.

The five maximum floods during the 123-year period in chronological order occurred March 11, 1841, April 1, 1886, December 10, 1919, January 19, 1925 and March 15, 1929. The last was the greatest and four occurred during a period of years that is less than life expectancy.

Stage-Discharge Relation:

The determination of discharge is normally a routine matter except during extreme flood stages when it may not be possible to reach the scene during the flood.

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[1]Martin, History of Columbus, Ga., 1827-1865.

Discharges at Columbus up to 80,000 second-feet have been determined by current meter measurements.

Higher discharges have been computed from flow over North Highlands Dam 2.4 miles upstream. These computations are based on results of laboratory tests on a scale model of a section of the dam. The results of the model test up to 80,000 second-feet were in close agreement with those obtained with the current meter.

Flood Frequency Curve:

The recurrence interval in years between annual floods of a specified magnitude is computed from the formula, $\frac{N+1}{M}$, where N equals the number of annual floods and M represents the order number or magnitude of each flood, one being the highest.

The recurrence interval of the five highest floods is assigned on basis of the 123-year period but the recurrence of the lesser annual floods 1929-1948 must be assigned on basis of the length of the continuous period of record during which they were observed.

The magnitude and recurrence interval for the various floods is plotted on Gumbel[2] chart paper which has been adopted by the Geological Survey as a satisfactory working tool for studies of annual floods. The horizontal ordinate on this paper represents the recurrence interval in years between floods of a specified magnitude. The vertical ordinate represents discharge in 1,000 second-feet. The plotted data are fitted by a straight line.

Now suppose we had only the record for the past 21 years. Then the position of the highest flood would be at a recurrence interval of 22 years and points representing the lesser floods would not be changed. We could not alter the curve but can readily see the advantage derived from the long term record.

At this time there are generally only ten to twenty years of gaging station records on which to make such studies. The

[2]Engineering News-Record, June 14, 1945.

long period of record at Columbus provides the only good test of the validity of the analysis of short records.

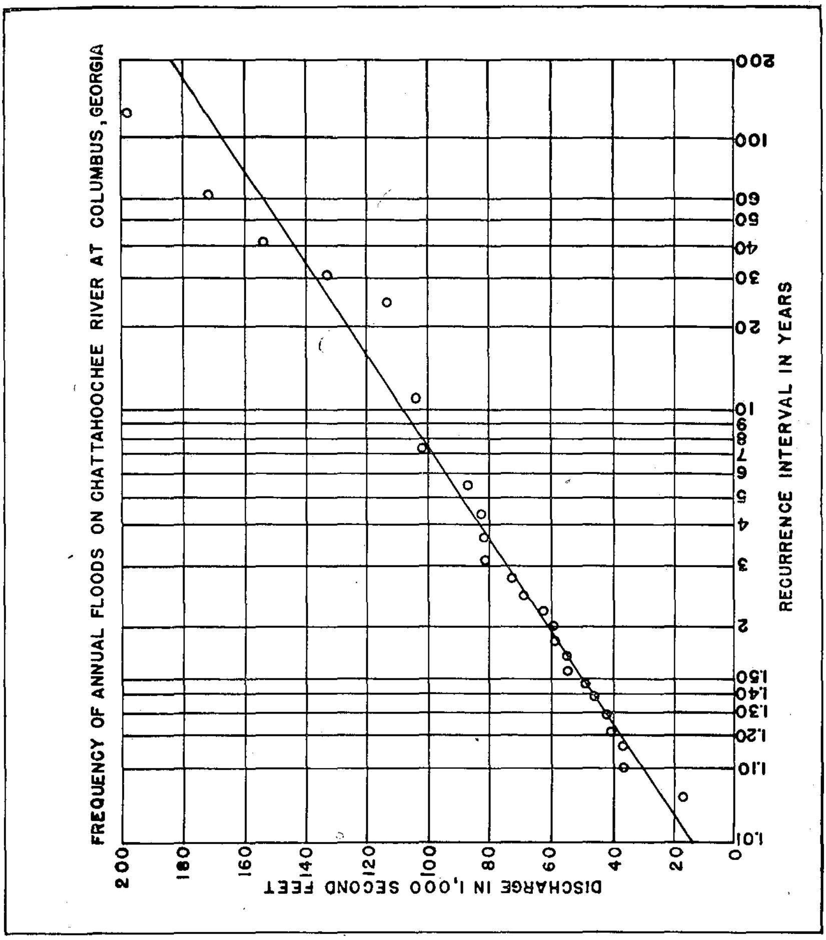

Figure 1

THE FREQUENCY OF FLOODS ON THE FLINT RIVER*

By C. M. BUNCH

Hydraulic Engineer, U. S. Geological Survey

Atlanta, Georgia

Flint River affords an unusual opportunity to study flood behavior in two hydrologic provinces of Georgia. It is the only major river in the State whose drainage basin lies wholly in only two provinces and where long records of stream flow in both are available to provide the data for significant frequency analysis.

In the upper part of the Flint River Basin within the Piedmont region, gaging station records are available at the following locations: (1) near Griffin, near the head waters, with a drainage area of 272 square miles; (2) near Molena and Woodbury, in the middle of the upper basin, where drainage areas are 990 and 1,090 square miles, respectively; and (3) near Culloden at the Fall line, where drainage area is 1,890 square miles. The record at the Griffin gaging station covers the period 1938 to date. The record at Woodbury for the period 1900 to 1927, and that at Molena for the period 1939 to date are comparable. The record at the Culloden gaging station covers two fairly long periods from 1913 to 1923 and 1937 to date, and a brief three-year period from 1929 to 1931.

The lower Flint River Basin lies within the hydrologic province described roughly as the Upper Coastal Plain. The geologic formations within this province are predominantly pervious limestones and sands in a low-relief topography. Gaging station records are available at four sites in this part of the basin as follows: Montezuma, drainage area 2,900 square miles; Oakfield, 3,860 square miles; Albany, 5,230 square miles; and Bainbridge, 6,350 square miles. Records at Montezuma cover the 45-year period 1904 to date and at Albany

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the 50-year period 1900 to date. Records for a 21-year period 1929 to date, are available at Oakfield and Bainbridge.

For the purpose of this study, some records not heretofore published but considered reliable in the range of flood events have been used. Others have been revised tentatively on the basis of flood information not available at the time of publication. At the Bainbridge station a long period of gage height record prior to 1929 could not be used because of questionable gage datum.

Concurrent records are available at all the gaging stations only since 1939. Rather than limit this study to this relatively brief 11-year period, relationships were developed so as to utilize the long periods during which records were available.

In the Piedmont Region where there are no long periods of record on the Flint River, the controlling records used were those on the Chattahoochee River at West Point, drainage area 3,550 square miles with records from 1897 to date and on the Ocmulgee River at Macon, drainage area 2,240 square miles, with records from 1893 to date.

The drainage basin of the West Point station on the Chattahoochee River lies west of the Flint River Basin. It is long and narrow and includes a small portion within the Mountain Province. This characteristic produces a flood frequency trend of many floods of similar magnitude because flood producing storms often cover part of the basin but rarely cover its entire length. The Ocmulgee River which lies east of the Flint River Basin, has many branches of about equal length making its flood characteristic flashy as compared with the Chattahoochee River. By using controlling records on both sides of the Flint River Basin on streams having both extremes of flood characteristics but both within the same hydrologic province, the short, disconnected records on the Flint River in the Piedmont Region could be connected to reasonably reliable records of the same length as those available for the Coastal Plain stations.

The process of converting short records to long periods was by simple proportion. Frequency curves were prepared in the manner described by Fischback[1] for the stations with the

[1]Fischback, A. A., Jr., Magnitude and Frequency of Historic Floods on Chattahoochee River at Columbus, Georgia."

short period of record. Frequency curves for the same period were prepared for the control stations as well as curves for the longer period of record.

The basis for the adjustment is the assumption that the relation between flood frequency for short periods to those for longer periods would be practically the same within a common hydrologic province subject to essentially the same flood producing storms.

The result of this analysis is shown on figure 1. This is a logarithmic plotting of the flood discharge in second-feet against drainage area at the gaging stations in square miles. Curves are shown for the mean annual, 10-year and 50-year floods.

Each curve shows a trend in the Piedmont Region for the flood discharge to increase with increase in drainage area, however, the curves level off, or even show a decreasing discharge, as the river first enters the Coastal Plain. The explanation of this phenomenon is that none of the floods in the past 50 years have come from storms great enough in extent to produce major flood conditions in both the Piedmont and Coastal Plain section of the drainage basin. Major floods in the Piedmont rapidly lose their magnitude because of the great storage effect of the broad flood plains in the Coastal Plain.

A study of the major floods that have occurred in the Flint River Basin shows that none were caused by great storms centered over the basin but rather they resulted either from intense local storms or from the fringe of great storms. For example, the storm causing the flood of 1925, the greatest on record at Oakfield and Albany, was centered east of the Flint River Basin in the Coastal Plain; the storm causing the flood of 1919 was centered in South Alabama; that of April 1948 was local in South Georgia; and that of December 1948 was local in the Piedmont Region. If great storms, such as those of 1925, 1928 and 1929 which caused extraordinary floods in parts of Georgia, were to center over the Flint River Basin when the ground was already saturated, the resulting flood would be of much greater magnitude than any yet experienced.

The fact that floods of a given frequency on the Flint River in the Coastal Plain region have no definite relation to the drainage area illustrates the danger of using flood formulas for estimating the magnitude of floods. Practically all flood formulas use the drainage area as the most important factor. The actual records show that factor to be relatively unimportant on the lower Flint River.

It is also evident that the curves for the Flint River in the Coastal Plain may not be applicable to another river. For example, the curves for the Flint River in the Piedmont Region are similar to those for other rivers in the Piedmont and hence may afford means of estimating flood frequencies for any stream in the Piedmont from 100 square miles drainage area up. For the Coastal Plain streams however, the curves cannot be projected downward to lesser drainage areas. This demonstrates one serious deficiency in stream flow records in the Coastal Plain region of Georgia where nearly all the gaging stations are on large rivers that drain more than one hydrologic province.

The analysis of these floods on the Flint River provides a basis for estimating flood conditions at any point on the main stem of the river. At any point between existing gaging stations the magnitude and frequency of floods could be determined by identifying the elevation of one or more outstanding floods, computing the discharge for that flood from discharge records at the nearest gaging station and relating it to the 50-year flood or any other design value. This type of information is useful in design of bridges, protective works, and for many other purposes.

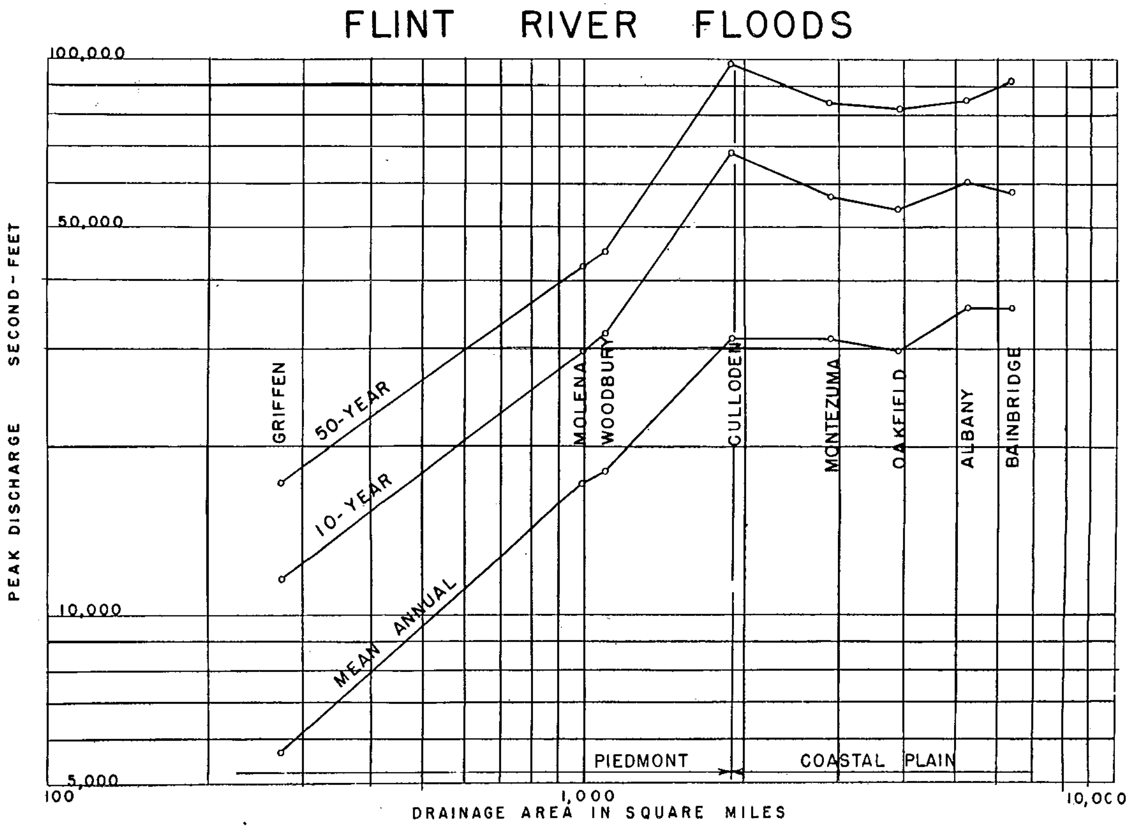
FLINT RIVER FLOODS
100,000
50,000
10,000
5,000
PEAK DISCHARGE SECOND-FEET
GRIFFEN
50-YEAR
10-YEAR
MEAN ANNUAL
MOLENA
WOODBURY
CULLODEN
MONTEZUMA
OAKFIELD
ALBANY
BAINBRIDGE
PIEDMONT
COASTAL PLAIN
100
1,000
10,000
DRAINAGE AREA IN SQUARE MILES

Figure 1

DETERMINATION OF THE LOW FLOW REGIME OF UNGAGED STREAMS*

By R. W. CARTER

Hydraulic Engineer, U. S. Geological Survey

Introduction

There are thousands of branches, creeks and rivers in Georgia but continuous records of flow are available for less than 100. The chances are excellent, then, that when a stream is considered as a source of municipal or industrial water supply, electric power, or irrigation that no detailed information will be available to guide the development. Since the cost of operating a gaging station at every potential development site would be prohibitive, the only answer lies in stretching the available records to cover all streams. Methods have been developed recently whereby the low flow regime of a stream may be determined if several discharge measurements are made at the proper time and there are continuous records of discharge available on some stream in the area. This paper explains the method and shows how it has been applied in the Tired Creek Basin in Grady County.

Nature of Stream Flow

The relation of geology to the occurrence and movement of ground water has long been understood. That geology also plays a dominant role in the distribution of stream flow has more recently been realized.

Stream flow is derived from two sources: (1) water that flows directly to the stream channel when rain falls faster than it can be absorbed by the soil (direct flow); (2) water that percolates through the soil to the water table and seeps through the banks along the stream channel (base flow). Since direct flow ceases shortly after the end of the rain, the stream is dependent upon the ground water reservoir as a source during a large part of the year. The capacity of the

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reservoir is dependent in turn upon the character of the geologic formation in the stream valley, the associated soil and topographic features and the depth to which the stream is entrenched. The formations yielding the best base flows are those composed of sands and gravels such as the Tuscaloosa which outcrops across Alabama and Georgia. The poorest are those composed of tight marine sediments such as the Selma chalk.

During rainless periods the volume of stream flow steadily decreases. The rate of recession is controlled principally by the amount of ground water stored in the valley above the stream bed and the rate at which it is released to the stream. Since the character of the ground-water reservoir remains unchanged, the recession rate is about the same each time the base flow of a stream recedes from a specified level. The hydrograph of figure 1 illustrates the recession curves of Tired Creek near Cairo, Georgia, and Ochlockonee River near Thomasville, Georgia. The recession rate of Tired Creek is somewhat slower than that for Ochlockonee River, probably reflecting deeper entrenchment into the formation since both streams lie in the same geologic formation.

Base Flow Relation

From Hydrograph.—It is the relation between the base flow of the two streams that is of particular interest. This relation is determined by plotting the base flow of one stream against the simultaneous discharge of the other. This relation is developed in figure 2 by plotting the daily discharge of the two streams for April 9, 30 and May 13 and 19. The discharge for other days could have been used as long as no direct flow was included in the daily discharge. The graph of figure 2 approaches a straight line on a log paper as do most plottings of this nature.

Application to Ungaged Streams.—Now suppose no records were available on Ochlocknee River except for discharge measurements made on April 9 and May 19, and we wish to determine the minimum flow during the most severe drought of record for periods of various length. To do this, we must establish the relation between the flow of Ochlockonee River and that for an index stream, Tired Creek, where continuous records are available. The relation between the base flow of the two streams may be developed by plotting the results of the two discharge measurements against the simultaneous discharge of the index stream. The direct flow of the two streams may be assumed to vary directly with the size of the drainage area.

The minimum average flow of the index stream during the drought of 1943-1944 for periods of various length is shown in table 1. During the shorter periods of 1, 7, 10, and 30 days the entire flow the index station was base flow, but for the longer periods, appreciable quantities of direct run-off entered the stream.

The base flow of the ungaged stream during the minimum period may be computed by applying the relation graph developed from the discharge measurements to the base flow of the index station. The direct flow during the period is computed by multiplying the direct flow per square mile of the index stream by the drainage area of the ungaged stream. The sum of the two figures is the total flow of the ungaged stream during the minimum period.

Application of Method to Tired Creek Basin

This method has been applied to the Tired Creek Basin in Grady County. The index station was established on Tired Cheek near Cairo in 1943 and one series of discharge measurements over the basin has been obtained. The map in figure 3 shows how the measured yield per square mile of drainage area varied from 0 to 1.19 second-feet. The variation in flow emphasized the danger of using the measured yield at one point for other sites in the basin.

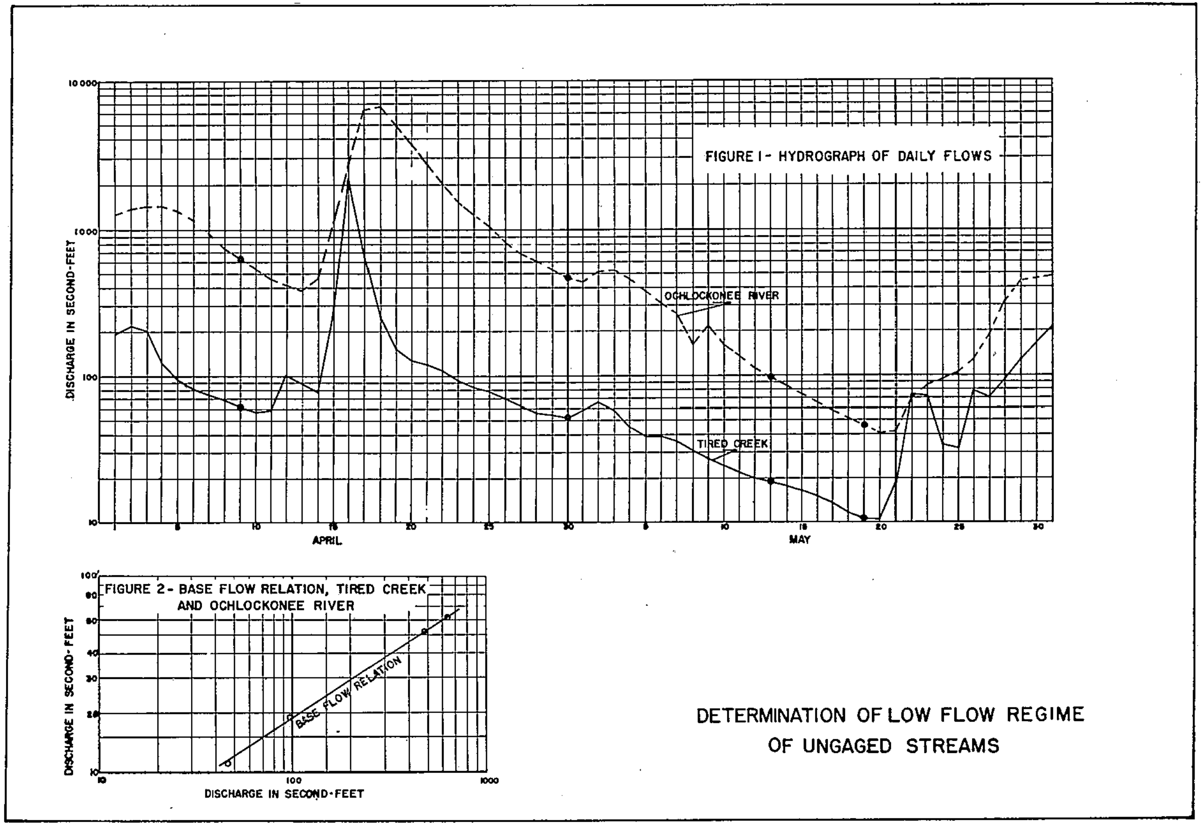
Summary

Here, then, is a method by which the low-flow regime of all the streams of a region may be determined at little cost if continuous records are available on a small index stream in the area. The two essential elements are: first, continuous stream flow records on a representative small stream for a period of years covering both extremes of flood and drought, the longer the better; and second, discharge measurements at the ungaged sites when favorable base flow conditions for such measurements occur. Gaging station records on large streams will not serve for this purpose nor can the site measurements be made when direct storm runoff is present. By making these studies by county units or by groups of counties within a common hydrologic province the maximum returns in stream flow information may be obtained at relatively little cost.

TABLE 1

Flow of index stream, Tired Creek, during drought of 1943-44

Minimum Period		Mean Flow at Index Station		
			Direct Flow	
Date	Length (days)	Base Flow cfs	cfs	cfs/sq. mile
June 27, 1944	1	1.40	0	0
June 23-29, 1944	7	1.80	0	0
June 20-29, 1944	10	2.30	0	0
Oct. 7 to Nov. 5, 1943	30	4.03	0	0
Sept. 28 to Nov. 26, 1943	60	5.62	1.58	0.029
Sept. 11 to Dec. 9, 1943	90	6.31	3.06	.055
Aug. 17 to Dec. 14, 1943	120	6.66	3.83	.070
July 1 to Dec. 31, 1943	184	8.78	8.60	.156



Figures 1 and 2

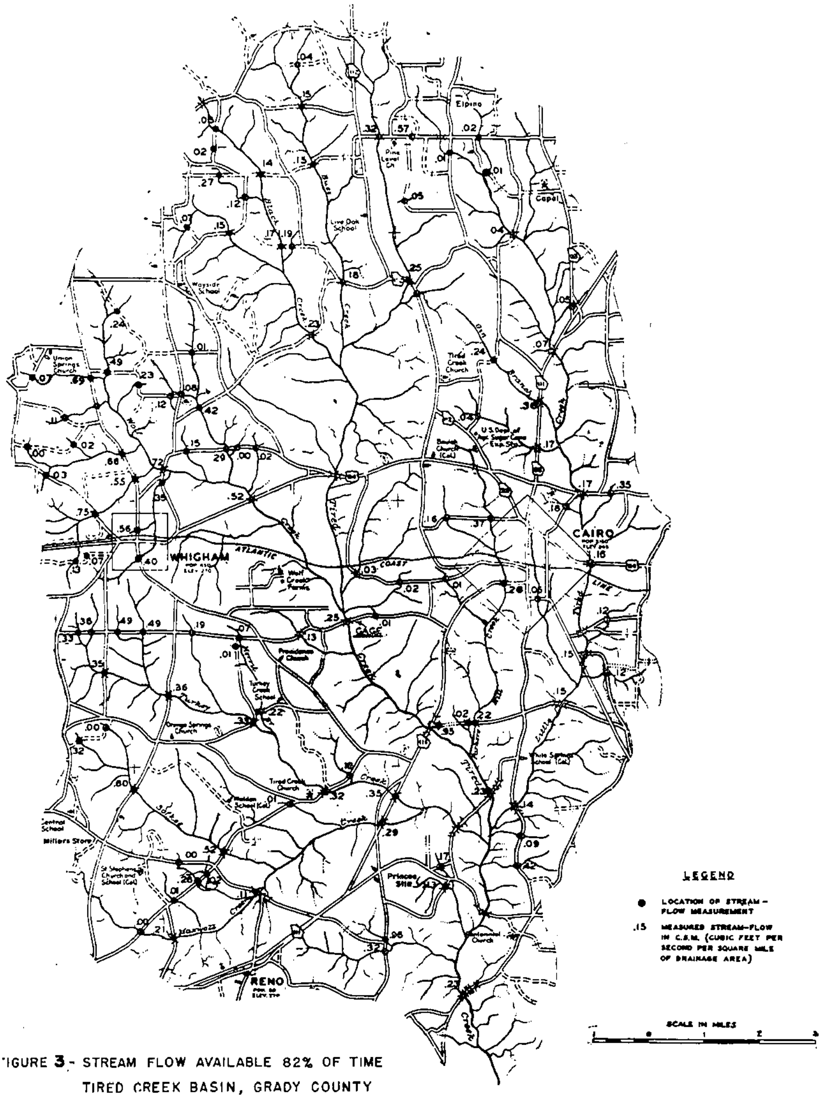


FIGURE 3 - STREAM FLOW AVAILABLE 82% OF TIME
TIRED CREEK BASIN, GRADY COUNTY

PROBLEMS IN THE QUARRYING OF LITHONIA GEORGIA GRANITE*

By NELSON SEVERINGHAUS

General Manager, Consolidated Quarries Corporation

The very large subject suggested by this title cannot be comprehensively discussed in the short space allotted here. In common with other industries, we feel ourselves beset on all sides with problems at present. My immediate problem is to choose a phase of our operations of most interest to you science minded people. I propose to limit my discussion to our handling of by-products of the granite crushing plant of Consolidated Quarries Corporation.

Nature of Problem

Consolidated Quarries started their large crushing plant near Lithonia in 1929. During the following 15 years we accumulated a huge pile containing about one-half million tons of excess fine material from 1/8" to dust.

There was some market for this fine size for asphalt road surfaces and for fertilizer filler but in the process of crushing we constantly produced fines in excess of sales. Disposal of this material into a pile was an expensive operation.

At the present time we are crushing about 4000 tons per day, all to pass a 2" square opening. In doing this we produce about 20% or 800 tons per day smaller than 1/8". This is 16 R. R. carloads per day so it can be seen that the problem involves large tonnage.

Nature of By-Product Material

In studying possible furtherance of uses for these excess fines, we first listed their physical and chemical properties as follows:

*Read at the meeting of the Georgia Academy of Science, Athens, Georgia, April 10, 1948.

(1) **Sizing test of material:**

Screen Size	Percentage Passing
8-Mesh	96.9%
14 "	82.7
28 "	65.9
48 "	43.7
100 "	24.0
200 "	11.2

When you realize that a 100-mesh screen has 10,000 openings per square inch, it is seen that about one-fourth of this material is what might be called dust.

(2) **Mineral Composition:**

Mr. A. S. Furcron of our State Geological Survey made an examination with a polarizing microscope and this in combination with a recasting of chemical analyses gave approximate mineral composition as follows:

Potash Feldspar	27%
Soda Feldspar	26%
Lime Feldspar	7%
Quartz	33%
Biotite Mica	4%
Magnetite	2%

Minerals occurring in minor quantities include:

Garnet
Epidote
Muscovite
Chlorite
Zircon
Apatite

The three feldspars occur together as very fine intergrowths (microperthitic structure) which indicate practical impossibility of commercially separating them from each other.

Grain size of the other mineral constituents is such that they are well liberated when the granite is ground to all pass a 35 mesh screen.

(3) **Chemical Analysis:**

John H. Banks Laboratories, Inc., of New York reported the following chemical analysis on a representative sample:

SiO_2—Silica	73.17%
Al_2O_3—Alumina	14.14
Fe_2O_3—Ferric Oxide	2.30
CaO—Lime	1.44
MgO—Magnesia	.33
K_2O—Potash	4.55
Na_2O—Soda	3.10
Ignition Loss	.54
	99.57

DEVELOPMENTS BASED ON THESE PROPERTIES

Going back to the sizing test of the by-product fines—it suggests possible use of this material as fine aggregate or sand. This is a high volume usage of material. Each ton of stone going into concrete requires about one-half ton of sand in the mix. During 1936 we built a plant to make concrete bricks using this fine size alone as an aggregate with Portland cement. This plant was the first successful one of any size in the area. Many other concrete products plants have since been established around Atlanta and they have created a considerable market for untreated fines. In the relatively dry mixes used in these plants, untreated fines make a satisfactory aggregate.

For use as sand in conventional poured concrete, the untreated fines contain too much minus 100 Mesh dust. This dust, with its high surface area, requires excessive water for a plastic mix and lowers strength of concrete.

In 1946 we built a sand processing plant to overcome this difficulty. Screening of large tonnages of abrasive material with very fine screens is not practical so we use hydraulic classifiers which utilize differential settling rates of different sizes of material in a rising current of water. The sand product of these machines runs 3 to 4% passing a 100 mesh screen which is well within the State Highway specification of not more than 8% minus 100 mesh. This good job of sizing has overcome objections to the use of stone sand and a high tonnage now moves into all kinds of concrete work. During the past two years we have marketed all fines made by current production and also recovered about 200,000 tons or 4,000 car loads from the waste pile.

OTHER POSSIBLE PRODUCTS

A look at the mineral composition of this granite suggests many use possibilities if mineral separation is achieved. About 60% of the rock is feldspar, an important constituent of glass, pottery and enamels. Feldspar for such uses must be relatively free of iron to avoid discoloration of the products.

Our first attempts at mineral separation were done by the Dings Magnetic Separator Co. Using a high intensity roll type magnetic separator, they removed enough biotite, magnetite and other iron bearing minerals to lower the Fe_2O_3 content to 0.10% when working on a feed sized between 35 and 100 mesh. On material finer than 100 mesh, this process was not so successful. A magnetically cleaned feldspar-quartz mix has possible ceramic uses. Laboratory work by W. Harry Vaughan and by Chas. F. Wysong at Georgia Tech Ceramics Laboratory demonstrated some of these possibilities.

The U. S. Bureau of Mines at Tuscaloosa and the American Cyanamid Company have made rather extensive laboratory tests on separation by the froth flotation process. This process offers the possibility of working with minus 100 mesh material now being discarded and impounded by the sand classification plant and also of making a separation of quartz from feldspar besides removing iron bearing minerals. Results are promising. The American Cyanamid Laboratory last year ran a laboratory test in which they produced a feldspar assaying:

SiO_2	69.8%
Al_2O_3	18.16%
Fe_2O_3	0.09%

and quartz assaying:

SiO_2	98.2 %
Al_2O_3	1.5 %
Fe_2O_3	0.06%

Both of these products appear chemically satisfactory as glass batch materials. Further developments largely await an expanded glass industry in this area. There is no glass plant in Georgia now but several are planned for the near future.

Mining and crushing costs have already been spent on our material so it should stand a good chance of competing with present supplies of feldspar and quartz.

CHEMICAL COMPOSITION POSSIBILITIES

A further study of the chemical composition of Lithonia granite fines has suggested several other possibilities which we have investigated.

One of these is the making of mineral wool for insulating purposes. The rock itself would probably make a good mineral wool but melting temperatures would be prohibitively high. Addition of limestone and sodium carbonate lower the melting temperature to about 2,500° F. and gives a chemical composition close to that of some glasses. Good grade of mineral fiber has been made on an experimental scale by blowing a molten stream of such a mixture after melting in a small furnace. The State Department of Mines, Mining and Geology under Capt. Peyton did work on this and you may see samples of the products on exhibition at the State Capitol. Relatively small tonnages of raw material would be involved as a fair sized rock wool plant makes about ten tons of product per day. This project has been temporarily side tracked by our efforts to develop large tonnage uses.

Presence of about 4½% of Potash and many trace elements necessary to best plant growth suggest a possibility of use in agriculture. We have always regarded granite as a relatively insoluble rock whose elements would not be available for plant food in a reasonable time. This viewpoint may be wrong under the complex conditions of soil chemistry, particularly when the granite is extremely fine. We have sent some finely ground granite to the University of Missouri where Dr. Albrecht is doing some experimental field work along these lines. Results have not yet been reported.

It will be seen from this discussion that, by a somewhat scientific approach to the problem, we have developed processes which have opened markets for a large quantity of material formerly regarded as by-product waste. The future offers interesting possibilities of developments not generally associated with the stone industry.

THE KYANITE, STAUROLITE, AND GARNET ASSOCIATION IN UPSON COUNTY, GEORGIA*

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The area included in this report is shown on the Thomaston, Georgia, Quadrangle of the U. S. Geological Survey Topographic Map. It is bounded on the east and west by the meridians 84° 17′ and 84° 25′ respectively; the north and south boundary, 32° 54′ and 32° 48′ respectively. More specifically, the area yielding the best quality and greatest amount of kyanite, staurolite, and garnet is the Dolly Cherry property, consisting of lot 38, 16th district, 3½ miles southwest of Thomaston, Upson County, Georgia. This area is reached by turning off U. S. highway No. 19 two miles south of Thomaston at Shepherd School, and proceeding one and three-quarters miles on dirt road; turn right and continue one mile to the Dolly Cherry Property.

PHYSIOGRAPHY

The area is situated on the Greenville Plateau, a maturely dissected upland, the altitude of which varies from 700 to 900 feet.[1] In Upson and Talbot Counties several irregular quartzite ridges rise from 100 to 400 feet above the rolling upland.[2] All drainage is by the Flint River and Potato Creek, which have cut valleys from 100 to 400 feet deep in crossing the belt of hills of which the above mentioned ridges are a part. The general slope of the Greenville Plateau is to the south and west, but in an area this small it is not noticeable.

CHERRY PROPERTY

The land, situated between Potato and Bell Creeks, is rolling, with numerous small hillocks, and, as a whole, slopes gently toward the southwest. The bed rock is entirely cov-

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ered by deep residual soil. The area is underlain by augen gneiss, outcrops of which may be seen in nearby roadcuts.

The kyanite, staurolite, and garnet are scattered over an area 1400 feet long and from 50 to 200 feet wide. The zone strikes N 60° E and conforms, for the most part, to the structural trend.

The kyanite occurs in typical bladed or tabular gemmy crystal aggregates, varying in size from very small splinters up to six inches in length, one inch in width, and one half inch in thickness. It is often bent, and some pieces are in small, tight folds. The color ranges from a light bluish grey to a beautiful, deep, azure blue. As is characteristic of most kyanite, the color is concentrated in the center of the crystal in a fan-shaped pattern, gradually becoming lighter toward the edges. Several pieces of gem quality have been found.

The staurolite crystals vary greatly in size and shape, and for the most part occur in single prisms although a few crude penetration twins have been found. Some are small, less than one-fourth inch in diameter and one-half inch long, while several quite large crystals have been found. The largest collected to date measures three and one-half inches in length, two inches in width, and one and one-half inches in thickness. This largest crystal is a 60 degree penetration twin of which perhaps one-third has been broken off. In cross-section some of the crystals are flattened so that the length of the macro-axis is as much as five times that of the brachy-axis, while in others the four prism faces and the two brachy-pinacoids are almost equally developed, giving rise to a pseudo-hexagonal form. The color of this staurolite is perhaps its most unusual property. It is brownish-red to blood-red in color, and the smaller crystals are translucent to transparent. The luster is subvitreous to resinous, not unlike almandite garnet, although all faces show considerable etching.

Together with the staurolite and kyanite occur badly weathered crystals of almandite, varying in size from one-half to one inch in diameter. The crystal form of all garnets found so far is the trapezohedron.

Specimens illustrating the following mineral associations have been collected:

Garnet crystals with kyanite as the matrix.
Kyanite crystals with garnet crystal as the matrix.
Garnet crystals with staurolite crystal as the matrix.
Garnet and staurolite crystals intergrown.

PETROGRAPHY

Thin sections of kyanite.

Sections cut parallel to a(100) and b(010) faces are merely typical of kyanite, and show no inclusions.

Thin sections of staurolite.

The staurolite is light, yellow-brown beneath uncrossed nicols; pleochrism is distinct; relief is high; birefringence rather weak, interference color being first-order yellow; extinction is parallel. Typical irregularly arranged inclusions are as follows: zircon, kyanite, garnet, and quartz.

Zircon occurs as typical small euhedral crystals of high relief.

Kyanite occurs as small flakes with characteristic birefringence and extinction.

Garnet is found in fair amount as large anhedrons which are opaque under crossed nicols.

Quartz occurs in fairly small crystals scattered throughout the section with characteristic color and wavy extinction.

Thin section of rock specimen from Cherry property near Potato Creek.

The rock is a leucocratic phanerocrystalline metaigneous rock composed predominately of small crystals of white feldspar and quartz with very thin oriented, discontinuous bands of biotite and small fragments of garnet.

Microscopic Description

The slide shows a xenomorphic holocrystalline metaigneous rock with a preponderance of quartz and feldspar. Scattered augen of embayed and resorbed enstatite and garnet are fringed with flakes of biotite and hypersthene. The minerals present are: apatite, zircon, enstatite, garnet, orthoclase, oligoclase, magnetite, quartz, and biotite.

Apatite occurs as an accessory in long, slender euhedral prisms in the feldspars and quartz. It has low relief and parallel extinction.

Zircon, also found as an accessory as a few long euhedral prisms throughout the rock. It has characteristic high relief and parallel extinction.

Enstatite is found in small anhedrons with the garnet, and is resorbed by quartz which completely obliterates the crystal outline. Quartz is found completely surrounded by the pyroxene locally. Enstatite can be recognized by its lack of color under both crossed and uncrossed nicols, and by its characteristic pyroxene cleavage.

Garnet occurs as fairly large anhedrons forming the centers of the augen. It, too, is resorbed by quartz, though not so much so as the enstatite.

Garnet may easily be distinguished by complete extinction in all positions under the crossed nicols, and by its pinkness with uncrossed nicols.

Orthoclase forms, with quartz, the main body of the rock. It is usually anhedral, but occasional crystal faces are present. It is recognized by its right angle cleavage and by lack of color under both crossed and uncrossed nicols.

Oligoclase occurs as a few euhedrons twinned according to the albite law; the extinction angle with the twinning planes is its distinguishing feature.

Magnetite occurs as a few, small anhedrons, probably as a decomposition product of the garnet.

Quartz is found as one of the most abundant minerals present. It occurs as anhedral grains of low relief which occur by themselves, and in and near the crystals of enstatite and garnet.

Biotite is found as a few scattered flakes throughout the rock, but is more prevalent near garnet, probably as an alteration product.

Because of the granitic constituents, with garnet and enstatite in oriented bands, the rock is probably a metamorphosed, or sheared granite.

Thin section of augen gneiss from abandoned quarry one mile southeast of Cherry property.

The rock is a leucocratic phanerocrystalline metaigneous rock composed of quartz and fairly large anhedrons of feldspar (to 1 cm. diameter) with subhedrons and anhedrons of rhodolite garnet (to ½ cm. diameter) frequently occurring in discontinuous oriented bands with biotite. A few irregular patches of pyrite are also present in the rock.

Microscopic description

The slide shows a hypautomorphic to xenomorphic holocrystalline igneous rock composed predominately of anhedrons of quartz, orthoclase, and garnet. Many threadlike microlites are included in almost all of the mineral crystals, and are usually oriented in the same direction as the "eyes" of garnet. Micrographic intergrowth of quartz in orthoclase is common. The minerals present include apatite, zircon, orthoclase, perthite, albite, garnet, biotite, quartz, and magnetite.

Apatite occurs in euhedral needle-like crystals which in some places are grouped in radiating bunches, and occur in the quartz and feldspar.

Zircon is found as a few small, stout euhedral prisms.

Orthoclase occurs as anhedrons in great quantity throughout the rock. Frequently it contains micrographic intergrowths of quartz.

Perthite is found in small anhedrons as an accessory, identified by its pseudo-microcline appearance.

Albite similarly occurs only in small anhedrons as an accessory.

Garnet (probably Rhodolite) occurs in orbicular or augenlike metacrysts with flakes of biotite (perhaps secondary after the garnet). The crystals themselves sometimes contain inclusions of quartz, raising the question of whether the garnet is primary or secondary.

Biotite occurs as scattered flakes around the garnet metacrysts.

Quartz is present in about the same quantity as orthoclase, and is found in medium to small anhedrons.

Magnetite occurs as anhedral grains near the garnet, after which it may be secondary.

Because of the mineral constituents; i.e., a predominance of quartz, feldspar, and garnet, the rock was, before metamorphism, probably a granite; the mafic mineral was, perhaps, metamorphosed into the garnet. The rock is now an augen gneiss.

A Possible Origin

During severe metamorphism when rocks are folded and faulted and thrust one upon another, the conditions of temperature and pressure undergo great changes, and the minerals are transformed to others in closer equilibrium with the new conditions. It is possible that the minerals herein described resulted from such regional metamorphism.

Van Hise says that the characteristic occurrence of kyanite and staurolite is in metamorphosed argillaceous sedimentary rocks.[3] Kaolin is the chief constituent of such rocks, and perhaps it is from this mineral, in large part, under deep-seated conditions that the minerals are formed. The process is one of dehydration and separation of silica. According to Van Hise the silica may be separated either as quartz or may unite with compounds such as calcium or magnesium or other bases to form silicates.[3]

Muscovite, which is commonly formed in the anamorphic zone during metamorphism, does not usually alter, but by profound and deep-seated metamorphism the material which would have become muscovite under less intense heat and pressure, passes into the heavy ferro-aluminum minerals, staurolite, garnet, etc.

To quote Van Hise again, "staurolite is similar to garnet in its occurrence, but apparently requires more intense metamorphic action for it to begin to form."[3]

It is possible that the three minerals were formed as outlined above at essentially the same time.

In test-pitting the area, the three minerals were found at a depth of approximately six feet beneath the residual soil in a very decayed schist, probably the Manchester formation.

BIBLIOGRAPHY

[1]LaForge, Laurence; *Physical Geography of Georgia,* Geological Survey of Georgia, Bulletin No. 42, Atlanta, 1926.

[2]Prindle, L. M.: *Kyanite and Vermiculite Deposits of Georgia,* Geological Survey of Georgia, Bulletin No. 46, Atlanta, 1935.

[3]Van Hise: C. R.: *A Treatise on Metamorphism,* U. S. Geological Survey Monograph No. 47, Washington, 1904.

THE PETROGRAPHY OF THREE GEORGIA ITACOLUMITES*

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Itacolumite derives its name from the Brazilian mountain Italcolumi.[3] According to O. A. Derby[1] this quartzose rock was first described by Eschwege in a paper published at Weimar, Germany in 1822. The locality from which the description was made is the old diamond fields of Diamantina, Minas Geraes, Brazil. Eschwege recognized two types of itacolumite, one schistose and the other massive. Derby[1] demonstrated in 1882 that the massive and the schistose types represent quite distinct formations and are separated by an unconformity. The overlying massive variety contains elements of the schistose variety, including the diamonds which are mined from it.

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Derby[2] maintains that the term itacolumite should be confined to the flagy, in many cases, flexible quartzites with intercalated unctious hydromica schists and itabirites. Itacolumite is described in several ways by later authors which vary somewhat in detail. In Van Nostrand's Scientific Encyclopedia[7] itacolumite is described as a sandstone possessing a peculiar flexibility which is due to the interlocking of constituent grains, thus, permitting a limited amount of distortion without fracture. Grout[4] classifies itacolumite with the sedimentary and the metamorphic rocks—the latter under the general heading of quartzites. Merrill[5] places itacolumite in the arenaceous group of sediments, defining it more specifically as a feldspathic sandstone in which the feldspathic material serves as a binder for the quartz grains. The flexible variety is attributed to the removal of the feldspathic portions leaving the interlocking quartz grains with a small amount of play between them.

Petrography

All of the specimens utilized in this paper were collected by the author except the specimen from the Hollis quartzite near Manchester which was taken from the collection of the Department of Geology of Emory University. Itacolumite collected from the Gainesville and Dacula areas were found associated with mica and graphite schists which are represented on the State Geologic Map of 1939 as Brevard schist. Not all of the quartzites from these localities exhibit the property of flexibility. Observation at the localities would seem to indicate a relation between weathering and flexibility.

Gainesville—The Gainesville itacolumite is a medium coarse-grained, friable, laminated, white to pinkish-colored rock. Of the specimens examined, this one was the least flexible. Microscopically, the rock is an inequigranular mosaic of interlocking grains of strained quartz. The interstices are filled with an amorphous substance which resembles a limonitic clay. The interstitial distances appear to be about the smallest of the group. A study of the grains under the binocular microscope shows the grains to be hyaline quartz with an occasional iron stained spot. The individual grains have grotesque-sharp, irregular features. Clusters of grains which form the rock seem to be cemented together in the most chaotic manner possible.

Northeast Dacula—The northeast Dacula specimen is a red, yellowish to white, gradationally banded, laminated, micaceous itacolumite. Microscopically it is an inequigranular mosaic of interlocking, strained quartz grains. The interstitial distances appear to be somewhat greater than the Gainesville specimen. The interstitial filling appears to be an amorphous limonitic clay. The binocular microscope showed the grains to be similar to all other specimens examined. The relation of the quartz to the mica is not obvious in the separated grains; but the mica plates appear to be roughly parallel to the lamination planes. Iron staining is apparent to a marked degree.

Southwest Dacula—The southwest Dacula specimen is similar to the other Dacula specimen in many respects, but has greater flexibility. Microscopically it exhibits the same inequigranular mosaic pattern, but is considerably more ferrugenous, containing a few flecks of magnetite which appear to be altering to hematite and limonite. Scattered about erratically are subhedral crystals of epidote. The interstitial distances appear to be about the same as the northeast Dacula specimen.

Manchester—The Manchester specimen, from the Warm Springs district, south of Atlanta, is a yellowish to greyish white, banded, fine grained, micaceous, clayey-appearing, laminated itacolumite. It is the least friable of the group and possesses the greatest amount of flexibility. Microscopically it is an inequigranular mosaic of interlocking grains. The interstitial distances are of sufficient magnitude to render this particular feature less obvious than in previous specimens. Flecks of hematite are observable in the interstices. The remainder of the interstitial filling is the usual amorphous limonitic clay. Under the binocular microscope the usual sharp irregular structure of the grains is apparent. Mica flakes show iron stains around their peripheries.

The determination of bulk densities and porosities listed in Table I are based on the density of crystalline quartz. It is, therefore, apparent that other minerals will induce some

LOCATION	AVERAGE GRAIN DIMENSIONS MMxO.15		BULK DENSITY	% POROSITY
	LENGTH	WIDTH		
N. E. DACULA	0.7	0.5	2.16	19.7
S. W. DACULA	0.5	0.3	2.10	21.2
GAINESVILLE	1.0	0.6	2.02	24.2
MANCHESTER	0.4	0.3	2.09	21.7

TABLE I

SOME PHYSICAL FEATURES OF GEORGIA ITACOLUMITES

error into these figures. The calculations are based on the information given in the Handbook of Physical Constants[6].

Origin

Hypotheses concerning the origin of itacolumite must explain the flexibility and other structural features. Two such hypotheses are presented here, but this does not preclude the existence of others.

The rock is assumed to have been a feldspathic sandstone which was subsequently sheared. The processes of weathering would cause the feldspar to alter to kaolin and silica. The silica would then be utilized to form a secondary growth upon the original quartz grains, giving them grotesque shapes. Subsequent leaching by ground water would carry the kaolin off in suspension. The end product would be a rock having properties similar to itacolumite.

A second hypothesis would assume the parent rock to be a high quartz biotite granite. Kaolinization and secondary growth would take place as mentioned above. The mica would be leached giving rise to sufficient limonite to stain the product rock. Again a rock having the properties of itacolumite would be produced.

Conclusions

All of the specimens examined can be classed as metamorphic rocks. The origin of the rocks is somewhat uncertain. The degree of flexibility seems to be most directly related to the interstitial distances. The estimation of these distances may have been influenced somewhat by grain size. Grain size probably has a secondary effect on flexibility, since numerous small grains would have a greater interstitial area than large grains with equal interstitial distances. The presence of mica may decrease the friability of the rock as a whole but does not seem to contribute materially to its flexibility.

Bibliography

[1]Derby, O. A., Brazilian Evidence on the Genesis of the Diamond: Journal of Geology, Vol. 6, pp. 127-128, 1898.

[2]Derby, O. A., Geology of the Diamond: American Journal of Science, Vol. XXIII. 3rd series, p. 97, 1882.

[3]The Encyclopedia Americana, Vol. 15, p. 426: The Americana Corp., New York, 1938.

[4]Grout, F. F., Petrography and Petrology: pp. 275, 367, McGraw Hill Book Co., New York, 1932.

[5]Merrill, G. P., A Treatise on Rock Weathering and Soils: p. 116, The Macmillan Co., New York, 1913.

[6]Spicer, H. C., Porosity and Bulk Density, Dry and Saturated, of Sedimentary Deposits: Handbook of Physical Constants, Geological Society of America, Special Paper No. 36, pp. 17-18, 1942.

[7]Van Nostrand's Scientific Encyclopedia: 2nd Edition, p. 810, Van Nostrand Co., New York, 1947.

A NEW CLASSIFICATION OF THE CLAYS OF GEORGIA*

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Geologists such as Henrich Ries, Edward Orton, Jr., and others have regarded clays in consequence of their geologic origin and history. From this viewpoint these eminent men have sought to list the types of clays of the earth and to classify them in accordance with their origins. Such classification did little to tie together common physical and chemical properties of clays but rather laid stress on the geologic history of the clays. Clays were regarded as residual or sedimentary, and finally an intermediate grouping called colluvial clays was added. Under residual clays there were listed such clays as primary kaolins, china clays, coal measure fire clays, bentonites, and common red residual clays. Under

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colluvial were gathered the swamp and ditch clays, and under sedimentary were listed such diverse materials as sedimentary kaolins, shales, alluvial clays, loess, marine and littoral deposits, glacial clays, aeolian clays, fullers earth, and delta clays.

From the standpoint of the ceramic engineer, such a classification was lacking in completeness. The ceramic engineer is concerned with availability and properties of the material more than he is with origin.

Hence, I propose the classification of all clays that I can think of under a heading which will group many like properties together in consequence of a like mineral nature. Therefore, I list three general headings: Kaolinites, Montmorillonites, and Illites. These names are plural because I include in the kaolinite group, not only the mineral kaolinite itself, but such similar minerals as nacrite, dickite, halloysite, endellite, anauxite, and allophane. With the mineral montmorillonite, I group such similar minerals as saponite, beidellite, nontronite, hectorite, sepiolite, deweylite, attapulgite. With Illites, I group all of those unnamed hydromicas common in shales and shear zone deposits. The only mineral name assigned in this group is bravaisite. These three groupings have these differences: The kaolinites are non-swelling clays, are almost pure hydrous alumino-silicates, and are refractory and white unless admixed physically with impurities. The montmorillonites are swelling clays with high exchangeable base content and variable refractoriness and color. The Illites are non-swelling clays of low refractoriness and high fusibility. They are almost invariably dark in color and always contain potassium and usually other bases.

Thus in Georgia we have:

Kaolinites:

The sedimentary kaolins of the Fall Line.
The residual kaolins of the Piedmont and upland.
The clay content of granite and gneiss residues such as are around Atlanta and Athens.
The clay content of the brown residues of the trap dikes.
The riverbank clays of the crystalline area which possibly extend down into the coastal plain a short distance.

The coal measure clays of Dade and Walker Counties.
The halloysites of Northwest Georgia and of the Cartersville area.
Some very weathered shales in Northwest Georgia.
The ball clay reported to have been located near Augusta, Georgia.
The swamp and ditch clays as around Augusta, Georgia.

Montmorillonites:

Ordovician bentonites of Northwest Georgia.
Fullers Earth of the Fall Line area.
Fullers Earth of the Attapulgus type in Southwest Georgia.
Films of deweylite, sepiolite, and saponite in the talc beds of North Georgia.
Riverbank clays, swamp and ditch clays of the deep coastal plain.

Illites:

The shales of Northwest Georgia.
Brevard schist clays of the Piedmont and upland.
Some slaty clays from the Little River Series.
Possibly some of the clays resulting from the chlorites and sericites of North Georgia.

Thus this classification separates the water absorptive clays, the refractory clays, and the fusible clays, all on a basis of chemical and mineralogical composition. It groups together the primary and the secondary kaolins and these clays have similar usefulness. Likewise the bentonites and fullers earths are together and the shales and schist clays are compared.

Such a classification is believed to be superior to conventional ones for use of the ceramic engineer. Ceramic engineers find swelling clays economically difficult to use for either red clay products such as brick and tile or for white products. They find the illites most suitable for the manufacture of vitrified bricks, sewer pipe and expanded aggregate. They find the kaolinites most capable of refining for white wares and refractories and can use contaminated kaolinites for structural products when enough flux is present in the contaminants.

THERMAL ANALYSIS OF GEORGIA MINERALS*

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Since Le Chatalier first devised the method of measuring differential temperatures in 1887, much progress has been made in applying such a method to analysis of various materials. Clays, especially, are capable of such an analysis. The differential thermal method consists of heating a test material up through a given temperature range in close proximity to a standard material—such close proximity in fact as to make valid an assumption that normal temperatures of each will be equal. Heat applied to a substance raises its temperature unless some energy is required to rearrange the molecules or building units or to vaporize water suddenly released or for some similar chemical reaction. On the other hand, sometimes heat is suddenly released by a substance in the course of rearrangement of its molecules or building units, and such heat added to the heat of the furnace, drives the temperature of that substance to a higher level very quickly. Well known is the heat generated by the slaking of lime. Heat expelled in an operation is called exothermic and heat absorbed is called endothermic.

In the thermal analysis procedure we insert thermocouples in both the test and the standard materials and connect these couples back to back so as to get the difference or net effect in temperature. Normally the two substances will be at the same temperature, but when an exothermic reaction is in progress the test material will show higher temperatures than the standard and when endothermic actions are in progress, the test material will show a lagging temperature. The Standard material is selected so as to have no known endothermic or exothermic reactions in the temperature range under study. The rate of heating is carefully controlled so as to allow insufficient time for dissipation of the heat be-

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tween measurements. If sufficient time were allowed, no best effects would be observed. The usual rate is about 15 degrees centigrade per minute. The best devices automatically record the attained temperature of the furnace and the simultaneous differential temperature between standard and test specimen. Good sensitivity can be obtained with good couples, good galvanometers, and good control of the furnace and recording mechanism.

Clays examined in such a device reveal their inherent structures and affinity for water. These qualities are indicative of certain mineral content, fineness of grain, and impurities. For instance a kaolinite is known to release its water of crystallization over a range from 450° C. to 650° C. with maximum effect near 610° C. This is an endothermic reaction. At 980° C. an exothermic reaction occurs which is explained as the crystallization of gamma alumina from the amorphous alumina released by break down of the kaolinite molecule upon dehydration. Above 1100° C. another exothermic effect occurs which is explained as the crystallization of cristoballite from amorphous silica, similarly released.

Montimorillonites and illites do not show either the 618° C. dehydration or the crystallization of gamma alumina. Hence, a thermal analysis distinguishes between kaolinites on the one hand and montimorillonites and illites on the other.

Montimorillonites by virtue of very fine grain size, absorb water with a weak **chemical** bond. This shows up as a major endothermic reaction between 150° C. and 350° C. Some fine grained kaolins show similar reactions.

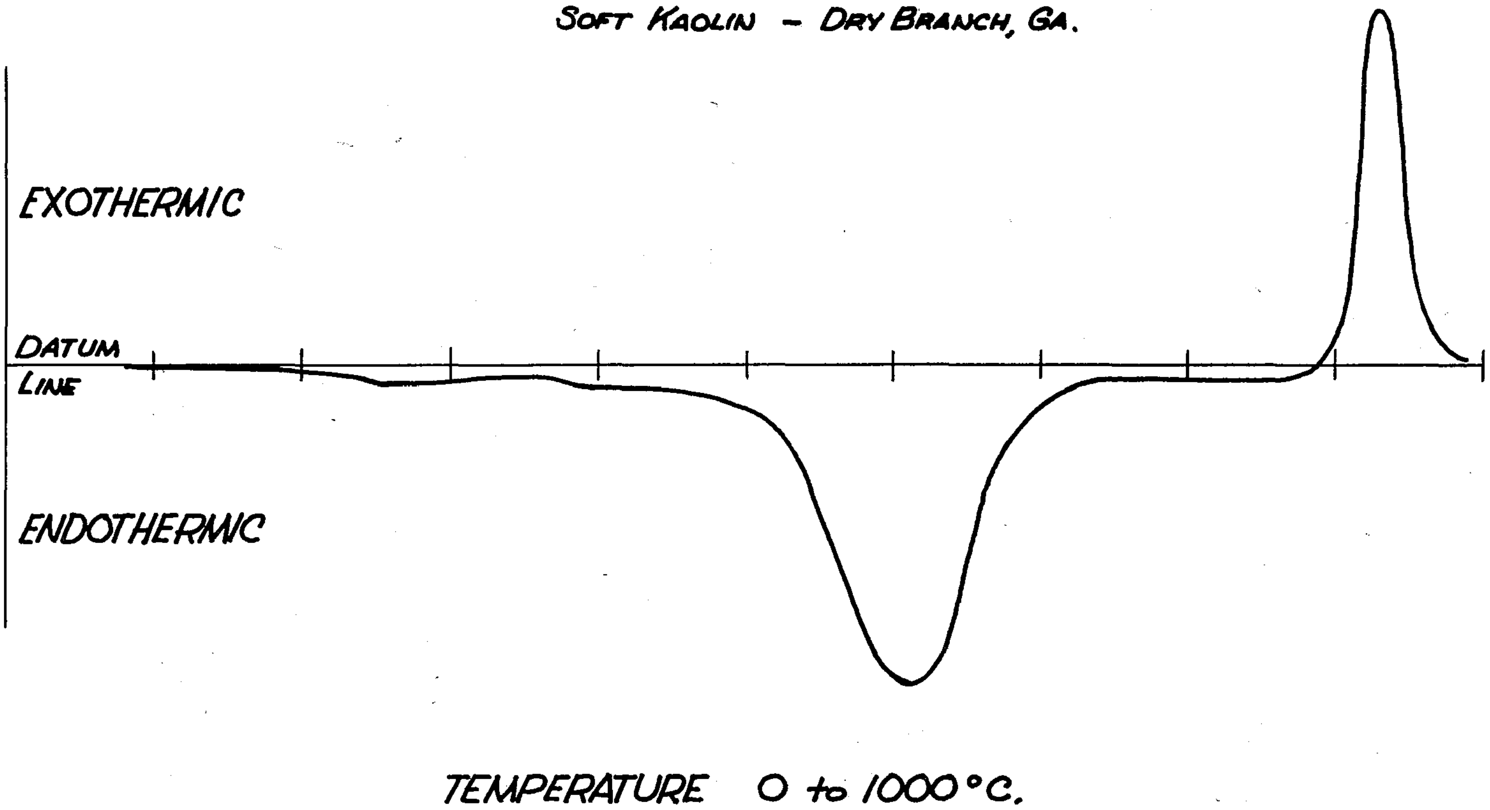
Ball Clays are apt to show a large exothermic reaction around 350° centigrade due to the burning of carbonaceous matter. Otherwise, they are much like kaolins.

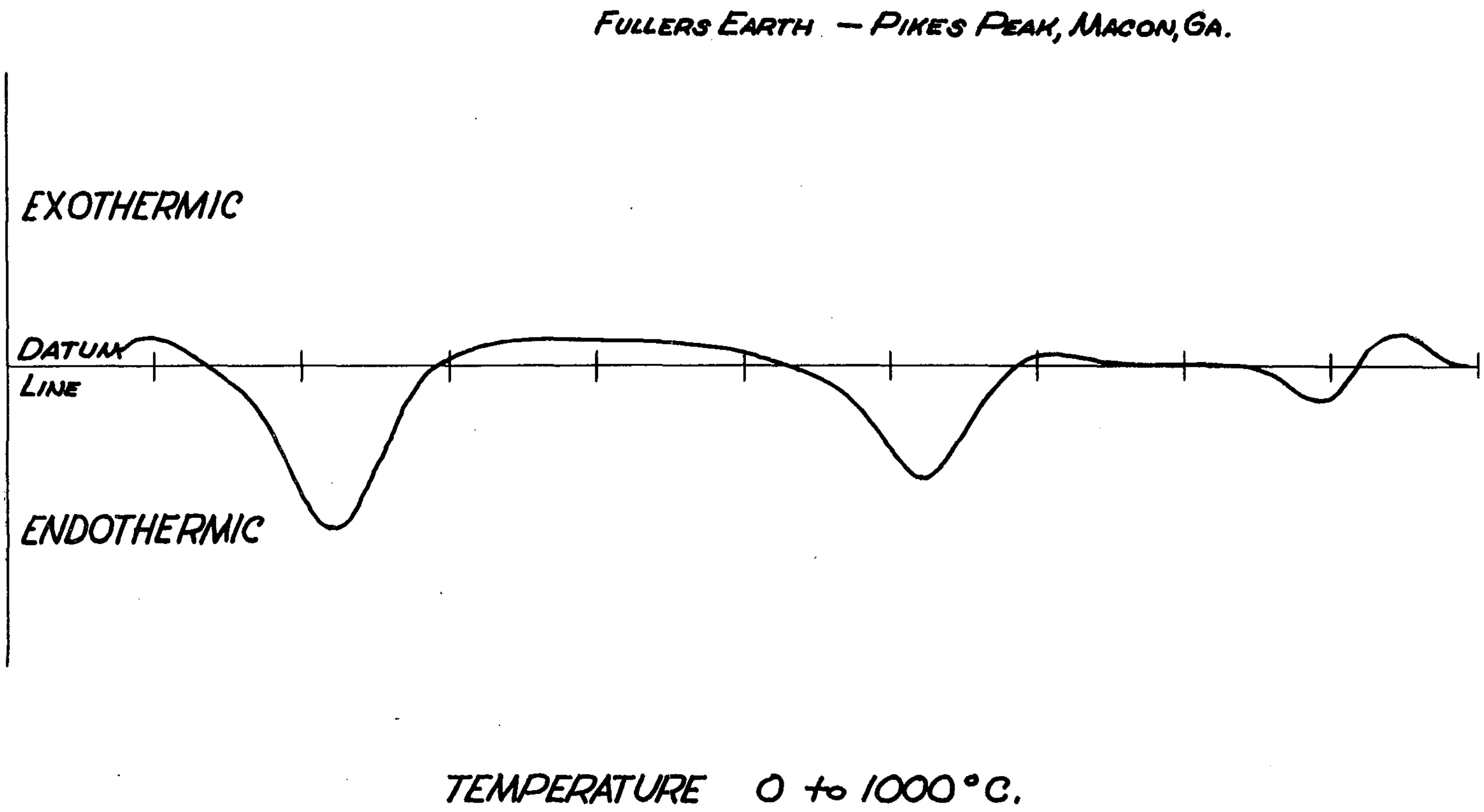
The curves of shales, schists, and illites are not readily typed. Hence, no example of an illite curve is illustrated. Typical curves for hard and soft kaolin, for fullers earth and ball clay are presented.

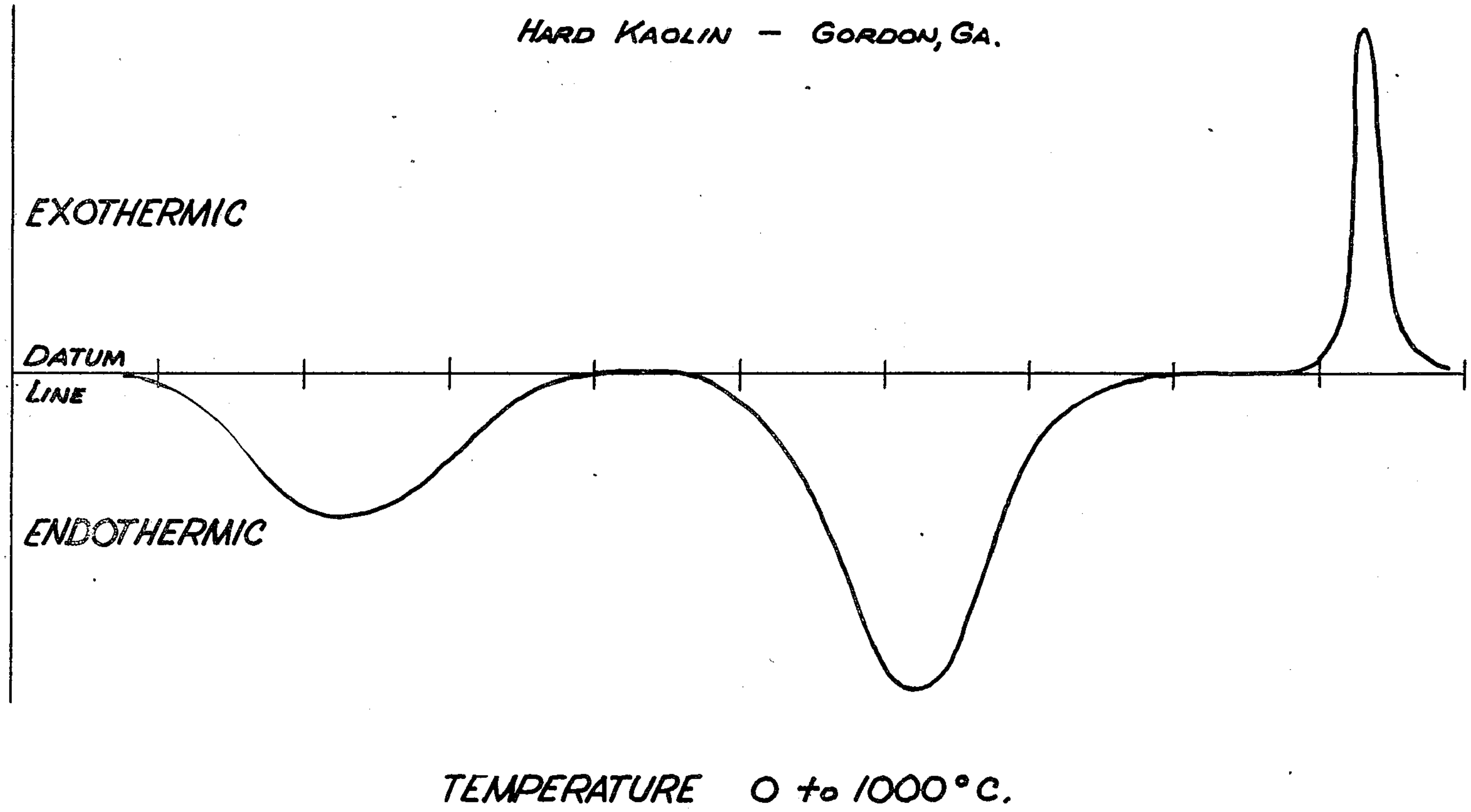
Georgia clays occur in fairly definite zones. The northwestern portion of the state has shales. The piedmont and mountain regions have schists, alluvial clays, and primary kaolins. The fall line area has sedimentary kaolins and fullers earths and the coastal plain has fullers earths. Most clays have kaolinite as their mineral base. This is true of kaolins, most alluvial clays and residual clays of the piedmont, many swamp clays, ball clays, etc. Shales and schists are illites and fullers earth and bentonites are montmorillonites.

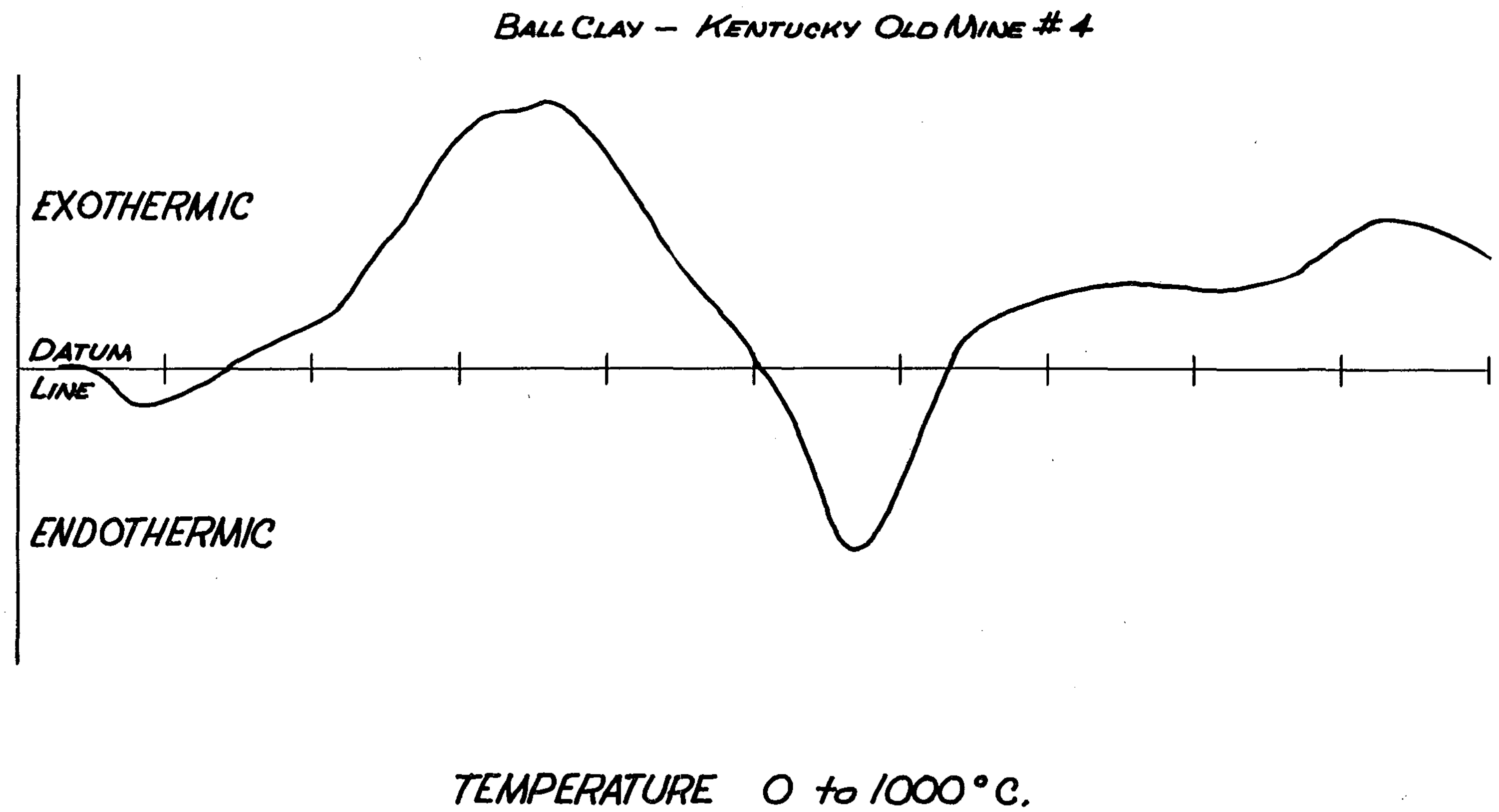
In the curves illustrated, the fullers earth has a typical montimorillonite reaction whereas all the others have kaolinite reactions modified in consequence of grain size and impurities. The low temperature endothermic peak in the hard kaolin is due to small grain size and consequent attachment of water. The big exothermic peak in the ball clay is an indication of combustion of the carbonaceous matter. The lack of definite 610° centigrade and 980° centigrade reactions in the fullers earth indicates absence of kaolinite and the general shape suggests montimorillonite.

Thus, the method of thermal analysis provides a means of identifying the clay type. With increased knowledge of clays and correlation of properties with the energy input or output as shown by thermal analysis, perhaps much greater conclusions can be drawn.


SOFT KAOLIN - DRY BRANCH, GA.
EXOTHERMIC
DATUM
LINE
ENDOTHERMIC
TEMPERATURE 0 to 1000°C.
Figure 1


FULLERS EARTH — PIKES PEAK, MACON, GA.
EXOTHERMIC
DATUM
LINE
ENDOTHERMIC
TEMPERATURE 0 to 1000°C.
Figure 2


HARD KAOLIN — GORDON, GA.
EXOTHERMIC
DATUM
LINE
ENDOTHERMIC
TEMPERATURE 0 to 1000° C.
Figure 3


BALL CLAY – KENTUCKY OLD MINE #4
EXOTHERMIC
DATUM
LINE
ENDOTHERMIC
TEMPERATURE 0 to 1000°C.
Figure 4

STATISTICAL METHODS APPLIED TO SPECIES DETERMINATION OF FOSSIL BRACHIOPODS*

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During the summer of 1948, a large number of fossils was collected in the vicinity of Ringgold, Georgia by members of the Emory University Geology Department Summer Field Camp. The best preserved and most numerous specimens were those fossils which had weathered from Mississippian limestones of Chester age. The best collecting area is in gullies and on hillsides on either side of Cherokee Valley in the northwestern part of Catoosa County. In every case, the fossils had been replaced by silica and were found in the soil where they had weathered from the containing limestone.

Of the fossils collected, a large number were brachiopods, many of which are referable to the genera **Cleiothyridina** and **Composita.** It was suspected that there was more than one species present among the Compositas, but visual inspection, megascopically and microscopically, including serial sections, failed to indicate a recognizable distinction. At the suggestion of Professor Arthur C. Munyan, statistical methods were employed with excellent results.

A simple ratio of length to width of the shell was calculated, which proved to be sufficient for differentiating the species. A size measurement was recorded with each ratio in order to determine the correlation between size and ratio, if such was indicated.

The sequence employed in the statistical evaluation is outlined as follows:

1. Using calipers equipped with a vernier, readings were made to the nearest 0.1 millimeter. The first measurement taken was the longitudinal diameter, or length. This measurement was recorded as the size factor.

2. The lateral diameter, or width, was measured next. In

*Read at the meeting of the Georgia Academy of Science, Emory University, April 22, 1949.

order to speed the work, a simple procedure is to take the length measurement, record it as the size factor, and put the runner of a slide rule over this value on the D scale. Then the width measurement is taken and this value put under the runner on the C scale of the slide rule. The ratio may then be read directly and recorded beside the size factor. Such procedure makes unnecessary the recording of all figures, and amounts to a saving of time when large numbers of individuals are to be handled.

3. The highest and lowest ratio figures were determined from the original or raw ratios. The difference was divided into convenient groupings so that a table of ratios consisting of from 10 to 20 groups could be set up. The original ratios were then tallied in their proper groups and a table of grouped ratios was formed from which a distribution graph was constructed.

4. From the grouped data the average ratio or arithmetic mean and the standard deviation were calculated.

In the case of the specimens of **Cleiothyridina sublamellosa** (Hall), the following results were obtained:

Range:	82.8 % - 108.3%
Mean:	95.4 %
Standard Deviation:	5.36%

Composita trinuclea (Hall):

Range:	102.3 % - 111.3%
Mean:	106.6 %
Standard Deviation:	2.42%

Composita subquadrata (Hall):

Range:	91.8 % - 99.3%
Mean:	96.4 %
Standard Deviation:	1.90%

The correlation between ratio and size was virtually zero, indicating that the ratios obtained are valid regardless of the age or size of the individual specimens.

Figure 1 shows a frequency distribution curve of **Cleiothyridina sublamellosa,** and Figure 2 shows a curve of the two species of **Composita.**

Such methods for species determination are by no means new, and have been used by paleontologists and biologists for a number of years. However, there are few published descriptions of individuals, and thus far no real effort has been made to place the result of such work at the disposal of other workers. There are several advantages in including a statistical summary with each new species description and compiling such data for those already named and described.

Perhaps the chief advantage lies in the positiveness of the mathematical language. A perusal of fossil descriptions written in the past will soon convince one that the various workers did not all use terms in the same sense and applied various shades of meaning to the same word.

A second advantage in published statistics would be that one need not be a paleontologist to understand and use the data. Where apparent species differences are minute or where the describer was anxious to produce an especially erudite and pedantically impressive description, only an expert could use the material. The average geologist who had been schooled in the fundamentals of paleontology could use size ratios intelligently if he had the data.

A third advantage became apparent as the work under discussion progressed. Original and later descriptions by James Hall[1] of the three species were consulted. Specific differences were based primarily on the form and modifications of the brachidial loop, an internal structure of delicate construction, and one which is seldom found sufficiently well preserved to identify. In no case was there any internal structure in the specimens collected and sectioned. The exteriors were faithfully reproduced by the replacing silica, but the interiors were filled with amorphous material or were hollow. Thus, not only was a great deal of time spent in attempting to section specimens, but it was useless and the specimens were destroyed. Had statistics been available, much time and several specimens would have been saved.

Should a system of statistical methods be generally ac-

[1]*Geological Survey of Iowa*, v. 1, pt. 2, p. 703, 1858.
Transactions of the Albany Institute, v. 4, No. 7, 1858.
Hall, James, *Paleontology of New York*, v. 8, pt. 2, pp. 93-96, New York (State) Natural History Survey, 1894.

cepted by paleontologists, a number of possible procedures and results can be suggested, among which are:

1. The requirement that a new species description include such ratios and statistical data as may be possible.

2. Such data be added to existing descriptions by workers who are reviewing or redescribing taxonomic groups.

3. The accumulation of data from work on faunal collections.

4. It could well be that there will be certain differences in values obtained on the same species but taken from different localities. Certainly variations from the type specimens will be indicated. A study of such variations geographically and spatially could be of aid in evolutionary and paleoecological studies.

Limitations which are most obvious are:

1. Certain types do not lend themselves well to measurements or are not consistent in shape and size relations.

2. Fragments could not often be used for measurements.

3. In some formations nearly all fossils are distorted due to weight of the overlying sediments or varying degrees of metamorphism or irregular replacement of the fossils.

In this paper it has been shown that the ratio of length to width is a diagnostic feature of certain brachiopods, and may be used to distinguish closely related species. This ratio is not affected by the age or size of the individual. Mean ratios and standard deviation are given for each species.

The application of this method to other forms is suggested. Various ratios other than the one used here could be determined. The use of any particular ratio or set of ratios would depend upon the fossil type.

It is believed that a type description including a statistical analysis would aid in standardizing descriptions and would be of benefit to the geologist not intensively trained in paleontology.

An accumulation of data on like species from various localities would probably be of value in determining variations in the species and in establishing environmental factors.

Fig. 1. Cleiothyridina sublamellosa (Hall)

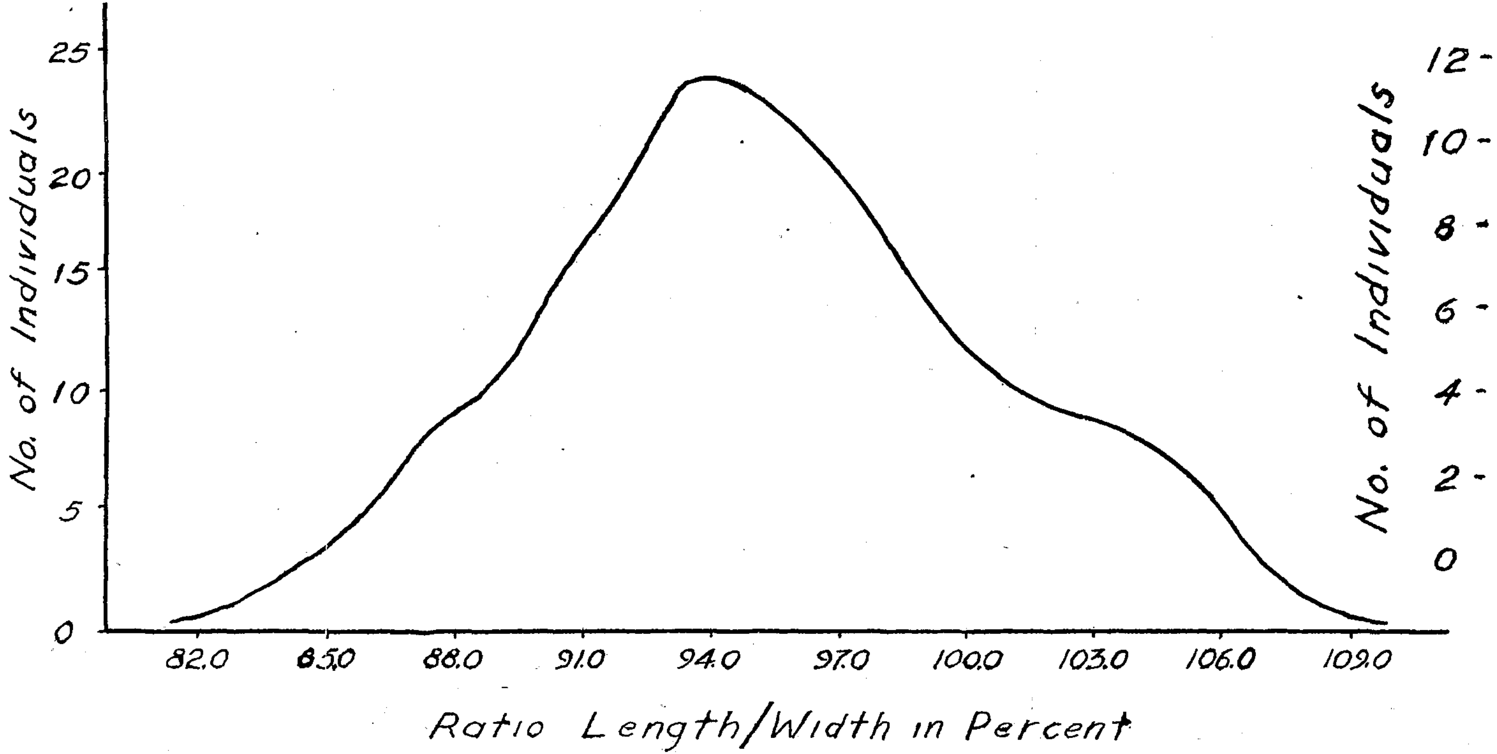
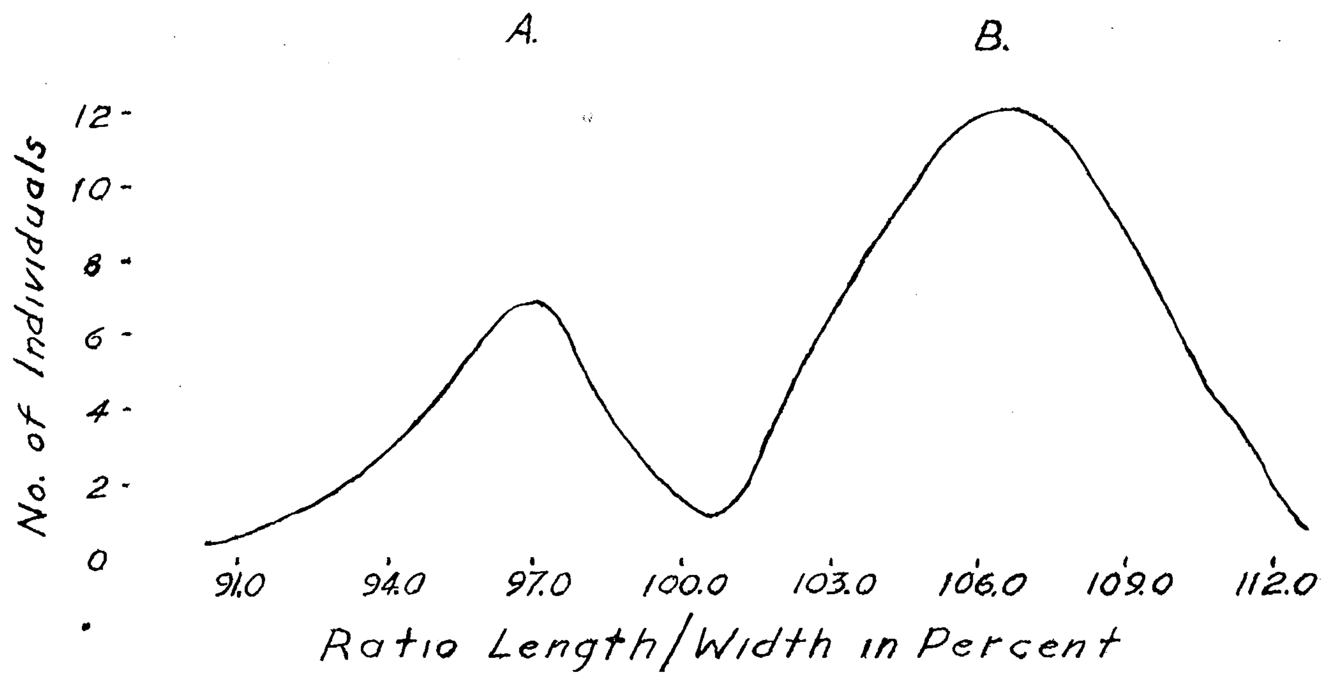


Fig. 2. A. Composita subquadrata (Hall)

B. Composita trinuclea (Hall)



THE GEIGER-MUELLER COUNTER IN GEOLOGIC WORK

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Emory University

Since the late nineteen thirties Geiger-Mueller counters have been used, at one time or another, for various types of work of geologic significance. Some of it may possibly open the way for unusual methods in geologic mapping, for prospecting for certain types of minerals, and for the rapid calculation of the radioactive content of rocks.

In 1937 Edmond Rothe and Madam Arlette Hee,[1] working in France, described a method used by them in which a shielded Geiger counter was employed to locate the buried contact between a trap rock and the Raon granite. They reported very satisfactory results but based their conclusions upon very small differences in counts per minute. Later work on the variations in Geiger counts casts some doubt upon the reliability of this work.

The work by Rothe and Hee started a series of experiments by the Geology Department at Emory University in which unshielded portable counters were used. The first of which was an attempt to locate the contact between Stone Mountain granite, thought to be Carboniferous in age, and the metamorphic and igneous rocks through which and against which it has been intruded.

Before beginning the actual survey for contacts it was necessary to determine the base count of Stone Mountain granite and its soils, the schists and their soils, the Lithonia granite gneiss and its soils, and the Panola granite and its soils.

A benchmark at Emory University was selected which was underlain by a residual clay mantle more than twenty-five feet thick, derived, for the most part, from members of the "Carolina Series". Base counts, including cosmic radiation,

*Read at the meeting of the Georgia Academy of Science, Emory University, April 22, 1949.

were taken at the benchmark before going into the field and a check count taken at the same point upon return to the campus.

Base counts were taken at numerous places on the rocks and the soils derived from them around Stone Mountain. The counter tube used was a small tube about 1 cm in diameter and approximately 3 cm long. Results obtained were as follows:

Benchmark at Emory University near Physics Building	10.8± 2	c/p/m
Stone Mountain granite (average of five benchmarks)	13.1± 1	"
Stone Mountain soils (average of five benchmarks)	12.4± 1	"
Schistose rocks in vicinity of Stone Mountain	8.0± 2	"
Soils above schistose rocks as above	8.1± 2	"
Davidson's quarry (three benchmarks-a Lithonia granite gneiss)	14.4± 2	"
Rock Chapel quarry (two benchmarks-Lithonia granite gneiss)	12.1± 1	"
Pine Mountain (three benchmarks-Lithonia granite gneiss)	16.3± 2	"
Arabia Mountain (three benchmarks-Lithonia granite gneiss)	19.3± 2	"
Panola granite (three benchmarks)	14.5± 3	"
Lithonia granite gneiss soils (average of 11 stations)	15.5± 2	"
Panola granite soils (two stations along flank)	13.5± 2	"

It will be noticed that there is a remarkable agreement between some of the soils and the parent rock and a fair uniformity in the readings taken on the widely separated outcrops of the Lithonia granite gneiss.

World War II interrupted this work which may soon be continued. However, the preliminary results seem to warrant the following generalizations:

a—In order of radioactivity, as indicated by the Geiger-Mueller counter used, the rocks are from lowest to highest, the schists, Stone Mountain granite, Panola granite, and Lithonia granite gneiss. All of the rocks measured show a higher count than Stone Mountain granite except the schists.

b—The flanks and lower parts of all gneiss and granite exposures give a higher count than the crests. This is perhaps because of the formation of uranophane and its concentration along sheet joints which frequently run out to the surface along the flanks. Also seep water may dissolve some of the uranophane and bring it closer to the surface as it makes its way to the outside of the rock along the same sheet planes.
c—Careful and almost complete shielding of the counter tube against cosmic radiation seems to be in order before actually attempting to locate buried contacts.

Another type of work was attempted in which fault zones and shear zones were examined with the counter. It was hoped that disputed faulting in certain strategic regions of the State could be proven or disproven by this method. The idea for this attempt was supplied by Dr. Newton Underwood,* then of the Physics faculty of Vanderbilt University.

Attempts by Professor Munyan near Rockmart, Georgia were not fruitful. Neither were the attempts by Professor Martin over the known fault zones of North Carolina. Some results were obtained by others in various places which seemed to be significant until it was seen that the counting circuit was unbalanced and the results unreliable. The sum total of the work done by the members of the Geology Department at Emory on shear zones and fault zones has been very discouraging. No further attempts along this line are anticipated until a more suitable counter can be obtained.

Professor Munyan and I, working under a grant-in-aid from the Research Committee of Emory University, ran a profile of counts from St. Simons Island, Georgia to the Fall Line in an effort to locate, if possible, strata of monazite-bearing sands.

Starting at the Lighthouse at St. Simons Island, where monazite sands had been previously reported, we traversed along a route which would give us the greatest number of exposures of the Coastal Plain formations.

Counts taken along the route and the formations examined are as follows:

*Personal interview with Dr. Underwood while he was acting as visiting Professor at Emory University, Summer, 1943.

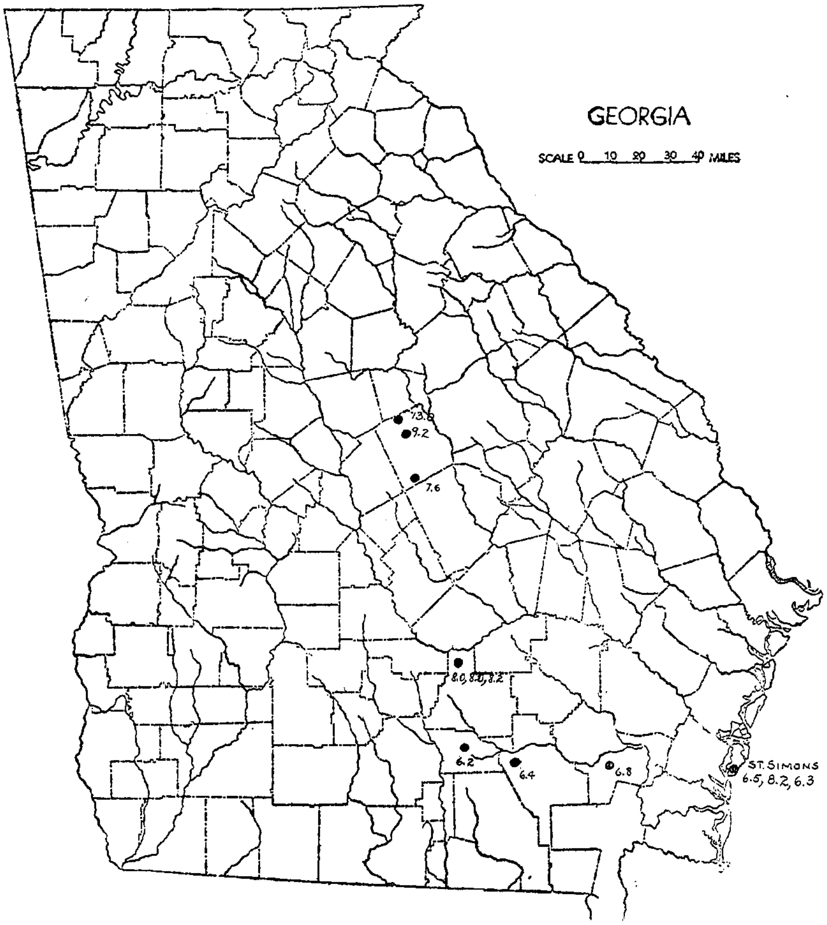

Figure 1. Outline map of Georgia showing general direction of route from St. Simons Island to Fall Line. Dots represent approximate locations of readings.

Base count taken in front of St. Simons Drug Store	6.5	c/p/m
Black sand stratum at Lighthouse	8.2	"
New excavation on East Beach road	6.3	"
1 mile west of junction of U. S. 17 and U. S. 84 toward Waycross, Georgia on black sands of Pleistocene terrace	6.8	"
3 miles east of Hoboken, Georgia on Trail Ridge where black sands similar to above were exposed	6.4	"

13 miles east of Pearson, Georgia on Waycross road (Ga. 50) on Hawthorne formation of Miocene age	6.2	"
5 miles south of Jacksonville, Georgia on Douglas-McRae road on a 30 ft. section of Hawthorne formation	8.0	"
7 miles southeast of Irwinton on Dublin-Irwinton Road on the Twiggs clay formation of Eocene age	7.6	"
11 miles north of Irwinton on the Milledgeville Road on sandy layers of the Tuscaloosa formation of Cretaceous	9.2	"
14 miles north of Irwinton on Milledgeville Road on an ironstone layer of the Tuscaloosa formation which is about 250 feet lower, stratigraphically, than the first Tuscaloosa exposure	13.0	"

The above figures show a remarkable uniformity in counts until the sandy members of the Tuscaloosa were encountered. Examination of these layers reveal a goodly percentage of monazite and zircon fragments.

The results of this profile suggested a third type of work in which the counter would be used to pick out stratigraphic positions and facies changes along the strike of sedimentary formations. This work has not been attempted and there are some obvious objections to initiating it.

In a recent issue of Science, Szalay and Csongor[2] report the results obtained in measuring the radioactive content of rock specimens by means of the Geiger counter. An attempt is being made to evaluate their results and to apply their derived formula to measuring the many specimens brought to the Geology laboratory.

In the light of the results obtained at Emory with the Geiger-Muller counter as a geologic tool it can be said that, insofar as we know now, its uses are restricted and limited but it continues to be the most satisfactory instrument for rapid qualitative radioactive determinations and for use as an exploratory tool in our search for radioactive minerals and for finding lost radium. It may in time become of some use in age determinations of rocks and minerals.

Bibliography:

[1]E. Rothè & A. Hèe—Prospect of the Raon—l'Etape granite and "trapp" quarry by penetrating radiation.
Comptes Rendus, Vol. 204, June 14, 1937, pp. 1835-37.

[2]A. Szalay & E. Csongor—Determination of radioactive content of rocks by means of the Geiger-Mueller counter. Science, Vol. 109, No. 2824, pp. 146, Feb. 11, 1949.

A PORTABLE HIGH-SPEED GEIGER COUNTER FOR GEOLOGIC SURVEYS IN GEORGIA*

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Portable Geiger-Mueller field sets responding to gamma radiation and suitable for geological surveys, locating radioactive deposits, and recovering lost radium have been available for more than ten years. Surveys of the radioactivity of rocks and solids in Georgia using commercially available sets have been reported by J. G. Lester[5]. The task of gathering this data proved to be a tedious and slow one due to necessarily low average counting rates of the Geiger tubes employed in these instruments. It was for the purpose of shortening the time required for taking data that the modified counter described in this paper was develop for the Department of Geology at Emory University.

The portable field sets now available are equipped with a small Geiger-Mueller tube whose copper cylinder dimensions of length, diameter and thickness are usually 1″ x ⅜″ x .007″. Such a tube has a background count ranging from six to twelve in various localities of the state. Counts made on some granite formations have been recorded in Georgia as high as 19.2[5]. This is too high to be considered as background and is undoubtably due to abnormal amounts of radioactive materials in the rock.

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*Read at the meeting of the Georgia Academy of Science, Emory University, April 22, 1949.

Geiger-Mueller tubes counting at slow rates are necessary if the cost of the field equipment is to be kept low. The least expensive counting sets use headphones for detecting the activity registered by the Geiger tube. When he desires to record data at various stations, the operator must be able to keep a tally of the number of clicks heard in his phones. Usually, a hand counter is used. Radioactivity counts are random in nature, and often two or more occur so close to each other that even at the slow average rates encountered in this neighborhood the observer is unable to record every count of the Geiger tube.

At an additional cost, an electrically driven mechanical recorder can be substituted for the headphones. This has many advantages over the less expensive method. The set may be placed at a point to be investigated and left running unattended for the period required to obtain the desired reliability of the data; and the recorder, having a resolution time of about 1/100th of a second, will miss fewer counts than the observer with phones. Instruments used at Emory were equipped for use with headphones and mechanical recorders.

It is of interest to note that the recorder described above is expected to have a counting loss of approximately two per cent at average counting rates of 120 counts per minute[6] (p. 117). If the counting pulses were regularly spaced, such a recorder should miss nothing up to a rate of 6000 counts per minute at which point it would stop counting altogether because it would not have time to reset itself before the next count occured.

When two or more counts occur within 1/100th second of one another, such a recorder will indicate only one count. The probability of two or more counts occurring within the resolution time for average rates of six and sixty per minute are shown in the second column of Table I. The percentage of counts missed is much higher than the probability indicates, however, because often more than one count is missed during a resolution period.

When the average rate of counting is to be measured with a Geiger counter, it is well to remember that the counts have a random distribution. If, in a set interval of time, N counts are recorded, the expected standard deviation is the square root of N. To explain the significance of this information, let us suppose that at a station where the radioactivity is supposedly constant, twenty readings of one minute duration are taken, and the average is fifteen counts per minute. A total of three hundred counts would be recorded in this case. Assuming a Poissonian distribution of counts, the standard deviation would be 17.3. The average count should then be written as 15 ± 0.87. If the data checks the Poissonian distribution, 68% of the twenty readings should fall within these limits, and about 95% should fall within the limits of 15 ± 1.74[4].

It should be noted that at this counting rate, twenty minutes was required to obtain data whose standard deviation was about six per cent of the average count. A smaller standard deviation-to-count ratio (Figure 1) could be obtained only by spending more time at the point of measurement or by employing a more sensitive counter.

The sensitivity of a Geiger counter to gamma radiation is roughly dependent upon the amount of copper in the cylinder of the Geiger-Mueller tube. It was decided to modify the existing counters by using a larger Geiger tube and adding a scaling circuit which would divide the counting rate by a factor that would allow the use of our electro-mechanical recorders.

The largest Geiger tube known to be available was purchased. This tube has cylinder dimensions of 18″ x 2¼″ x 0.01″ and operates at approximately the same voltage as the smaller ones. It was possible, therefore, to use the high voltage supply in one of the existing field sets as part of our portable apparatus.

Comparing the amount of copper in the large tube with that in the smaller ones already in use, one might expect the larger one to count gamma radiation at 153 times the rate of the smaller ones. This estimate was confirmed by checking the average count of the two tubes under identical conditions. The larger tube counts in the neighborhood of 1500 counts per minute at the same location where the smaller ones count between nine and eleven. With the proper associated circuits, it is possible to gather in one minute with the large Geiger-

Mueller tube data which would require two hours and thirty minutes with the small ones. Figure 2, showing the time required to obtain sufficient counts to reach a desired minimum standard deviation-to-counting rate ratio for various average counting rates, gives a fair indication of the time saving advantage that can be realized by using the large Geiger tube. The vertical shaded areas show the regions in which the two tubes normally count in this locality. Area A is that of the smaller, and area B that of the larger tube. A comparison of the physical dimensions of the tubes is shown in Figure 3.

A random count averaging 1500 per minute (25 per second) is much too high for accurate counting by existing electro-mechanical recorders, the best of which can not receive more that 100 **evenly** spaced pulses per second. A means of reducing the average count by a constant factor is required. The most satisfactory device is the Eccles-Jordan electronic scaling circuit[3]. One stage, employing two amplifier tubes, will deliver from its output one pulse for every two it receives. Ratios of 2, 4, 8, 16, 32 etc. can be obtained by cascading these stages.

In dividing, these scalers have an effect of averaging the pulses received. It is, therefore, not necessary to divide the count from a large tube by 150 in order to be assured that the probable percentage of counts missed by a register is not greater than the percentage missed using the field sets with small Geiger tubes. A circuit dividing the pulse rate of the large tube by sixteen proves to be quite satisfactory. The rate of count fed to the recorder from the large tube through a scale-of-sixteen circuit will be 9.4 times that received from a small tube feeding pulses directly to the recorder, but there is considerably less probability in the former case than in the latter that the recorder will receive one or more pulses during its recovery time, thus failing to record these counts. The second and last columns of Table I show the comparison of the theoretical probabilities that one or more counts will be missed by the same recorders under the two conditions described above. Calculations assumed a Poissonian distribution of counts and followed a method outlined by Lewis[6] (p. 119).

The schematic diagram of the circuits required for use with the large Geiger tube is shown in Figure 4. The Geiger tube and a pre-amplifier are contained in a light-proof cylinder made from a mailing tube and covered with weather-proofing material. It is necessary to shut all sunlight out of the Geiger tube to avoid spurious counting. The high voltage to polarize the Geiger tube is supplied from a portable field set designed for small tubes which is shown in block form.

The pulses from the Geiger tubes are amplified and fed through a four foot shielded cable to the limiter-amplifier contained in the scaling circuit case. This amplifier stage is designed to limit the amplitude of the pulses fed into the first scaling circuit. A switch provided at the input is used as an "on-off" switch for the recording circuit when accurate timing of intervals is needed. The third position of this switch is provided for checking the operation of the scaling circuits should the apparatus appear to be out of order. Following the limiter-amplifier are four scale-of-two circuits in cascade. These circuits are similar in form to the usual Eccles-Jordan scaling circuits[1, 2, 3] but are unique in that they respond to positive pulses only. This feature adds to the stability of the scaling action. A potentiometer in each scaling circuit is provided for initial adjustment. The operation of each scaling circuit can be checked with a pair of headphones through jacks provided at the input of each circuit as well as the input of the limiter-amplifier and the recorder driving amplifier. The latter stage employs a miniature type power amplifier tube biased beyond cut-off. It has sufficient driving power to operate the electro-mechanical recorder which records one count for every sixteen generated in the Geiger tube.

A voltmeter is provided which can be used to check battery voltages both in the scaler and in the original field counter. Low battery voltages are usually the primary cause of circuit failure.

The physical features of the apparatus are shown in Figures 5, 6 and 7.

Although no extensive geological surveys have been made with this instrument since it has been in operation, it has proven to be a useful field instrument in locating radium, and in some soil surveys. Normally a three-minute observation is sufficient for obtaining reliable data with a standard deviation-to-count ratio of .015 or 1.5%. With standard equipment seven and one-half hours at one station is required to attain the same reliability.

TABLE I

	Small Tube	Large Tube	
		Direct	Scale of 16
Normal Counting Rate	10/min	1500/min	94/min
Average Interval Between Pulses	6 sec	.04 sec	.64 sec
Probability of a Miss When Rate of Small Tube is 6/min. *	5×10^{-7}	-	3×10^{-29}
Probability of a Miss When Rate of Small Tube is 60/min. *	5×10^{-5}	-	9×10^{-13}

* Resolving time of register assumed to be .01 sec.

Bibliography

[1]S. C. Brown—Nucleonics, Vol. 3, No. 4, p. 46 (Oct. 1948).

[2]W. L. Buys—Nucleonics, Vol. 3, No. 5, p. 49 (Nov. 1948).

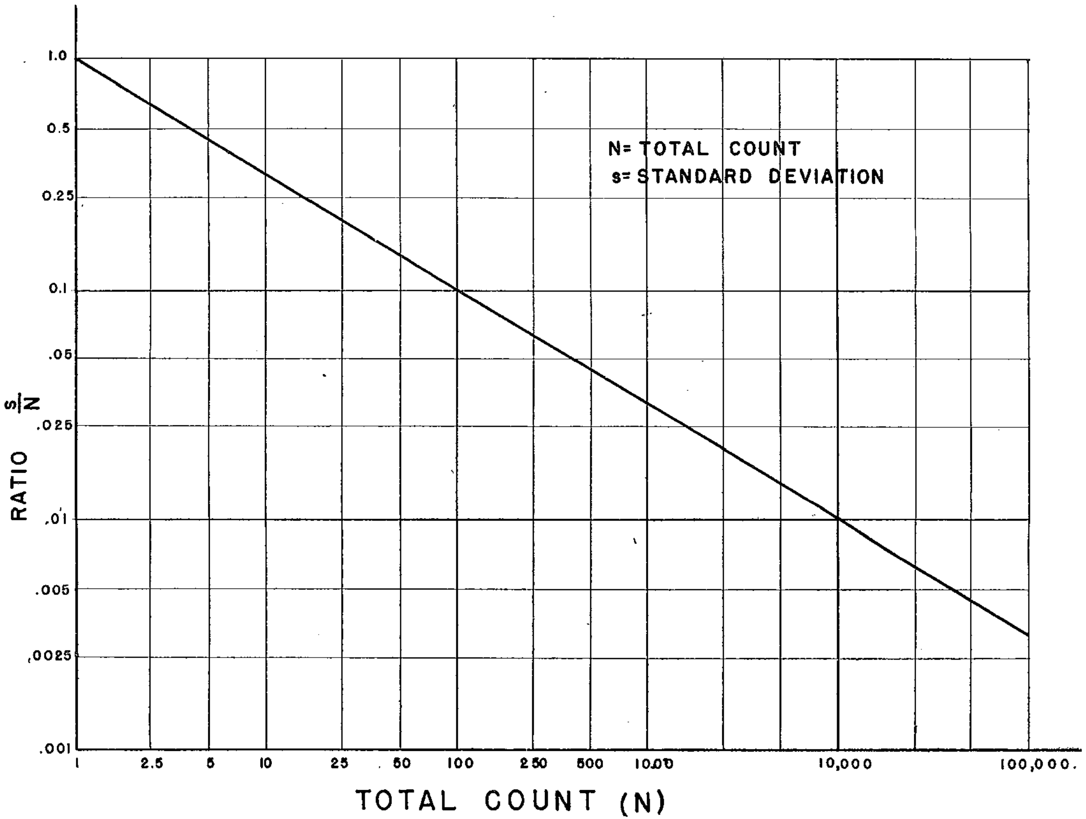
[3]W. H. Eccles, F. W. Jordan—Radio Rev. 1. p. 143 (Dec. 1919).

[4]J. F. Kenny—Mathematics of Statistics. Part 1. D. Van Nostrand Company Inc. p. 90.

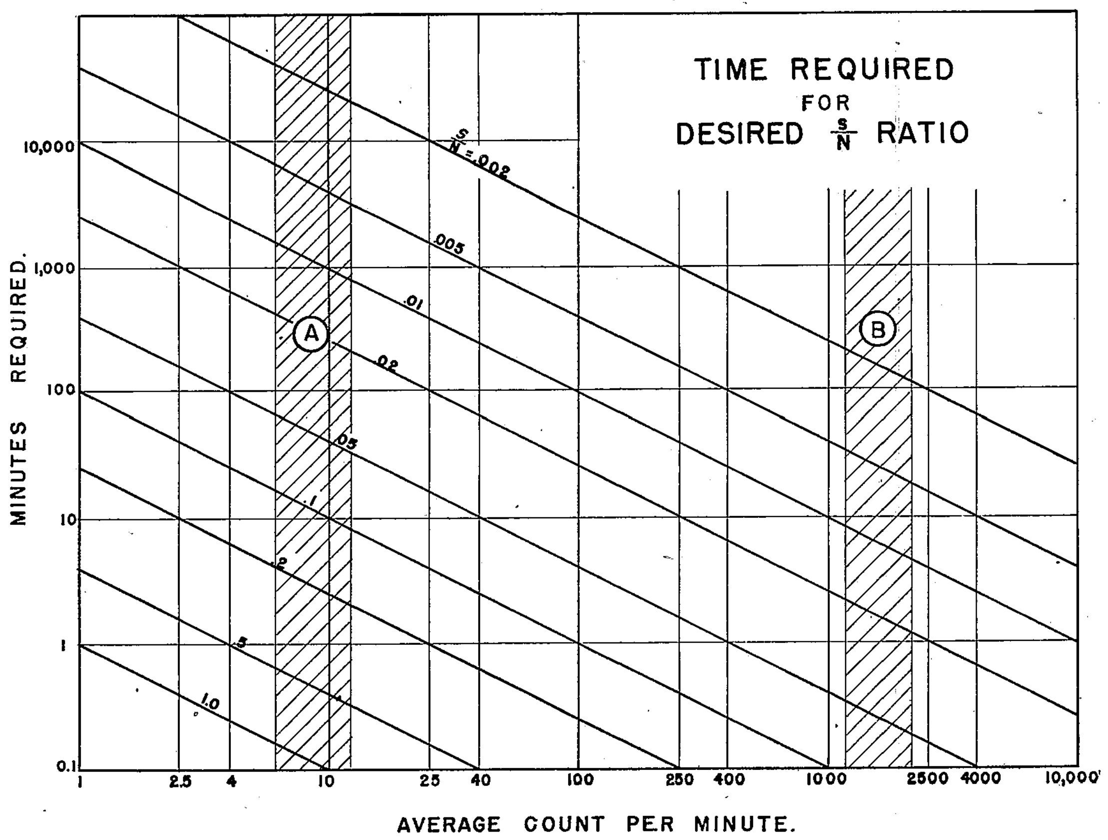
[5]J. G. Lester—The Geiger-Mueller Counter in Geologic Work. (In this issue).

[6]W. B. Lewis—Electrical Counting. Cambridge University Press.

Figure 1



Graph showing total count (N) plotted against ratio $\frac{S}{N}$



TIME REQUIRED
FOR
DESIRED S/N RATIO
S/N = .002
.005
.01
.02
.05
.1
.2
.5
1.0
A
B
MINUTES REQUIRED.
10,000
1,000
100
10
1
0.1
1
2.5
4
10
25
40
100
250
400
1000
2500
4000
10,000
AVERAGE COUNT PER MINUTE.

Figure 2

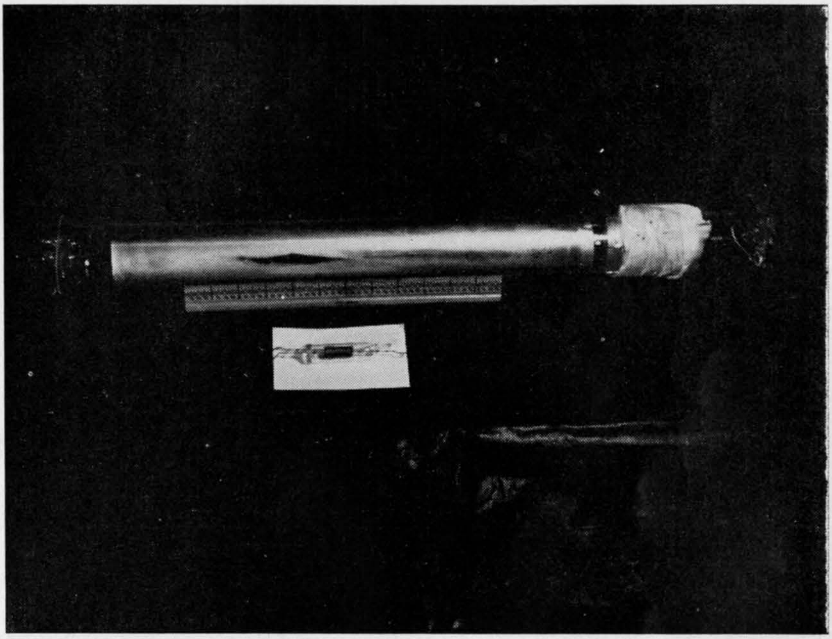


Figure 3. Comparison of the small Geiger-Mueller tube similar to the type normally used in field sets with the large tube employed in the high-speed counter.

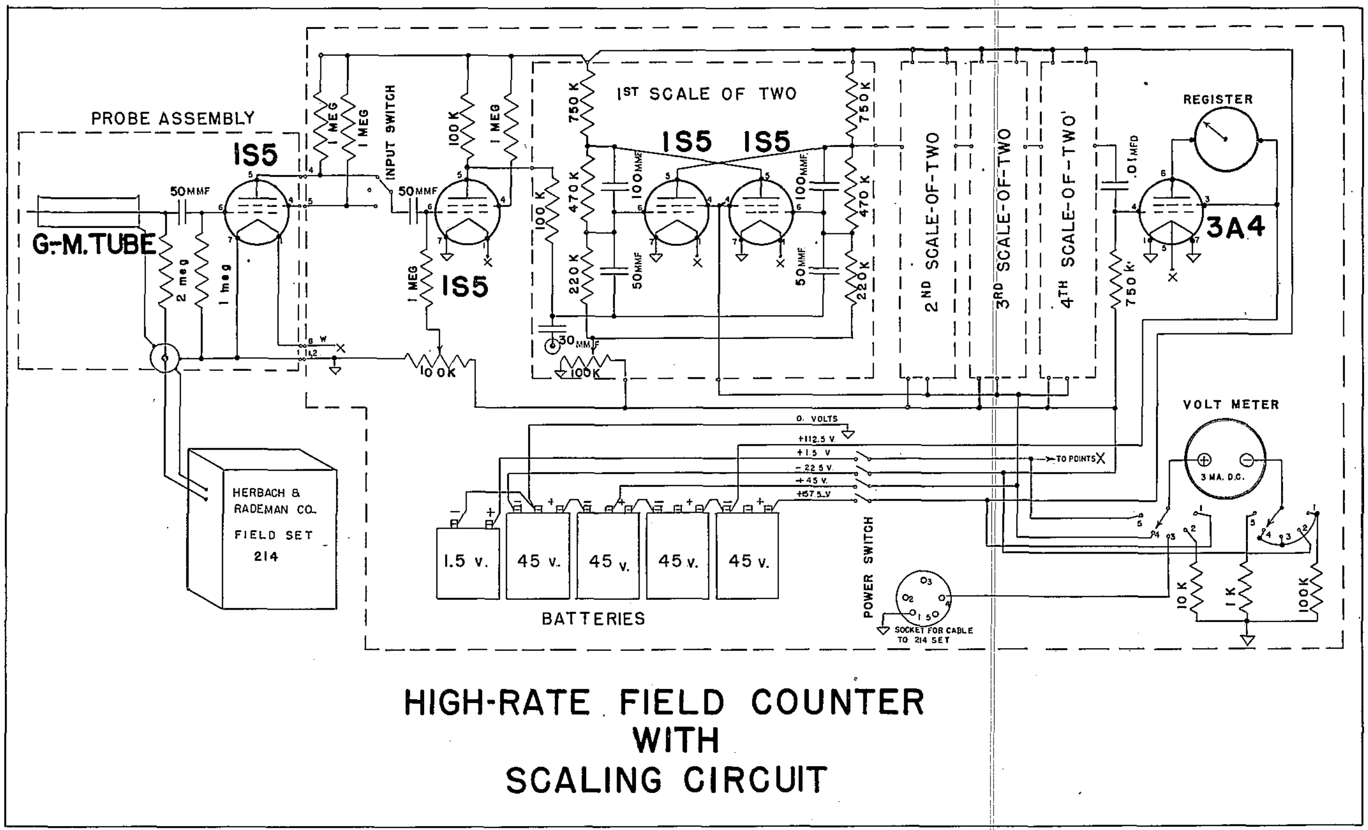

PROBE ASSEMBLY
G-M. TUBE
1S5
50MMF
2 meg
1 meg
1 MEG
1 MEG
INPUT SWITCH
100 K
100 K
1ST SCALE OF TWO
1S5 1S5
750 K
470 K
220 K
100MMF
50MMF
30MMF
2ND SCALE-OF-TWO
3RD SCALE-OF-TWO
4TH SCALE-OF-TWO
.01MFD
750 K
REGISTER
3A4
VOLT METER
3 MA. D.C.
0. VOLTS
+112.5 V
+1.5 V
-22.5 V
+45 V
+67.5 V
TO POINTS X
HERBACH & RADEMAN CO.
FIELD SET 214
1.5 v.
45 v.
45 v.
45 v.
45 v.
BATTERIES
POWER SWITCH
SOCKET FOR CABLE TO 214 SET
10 K
1 K
100 K
HIGH-RATE FIELD COUNTER
WITH
SCALING CIRCUIT

Figure 4

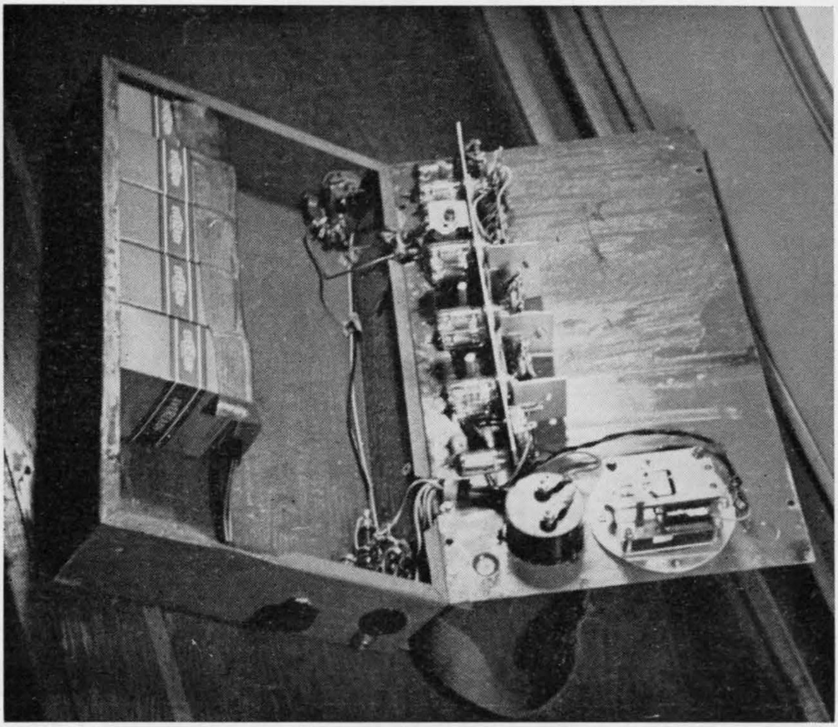


Figure 5. View showing the position of the batteries, electronic circuits, and other components inside the scaling unit case.

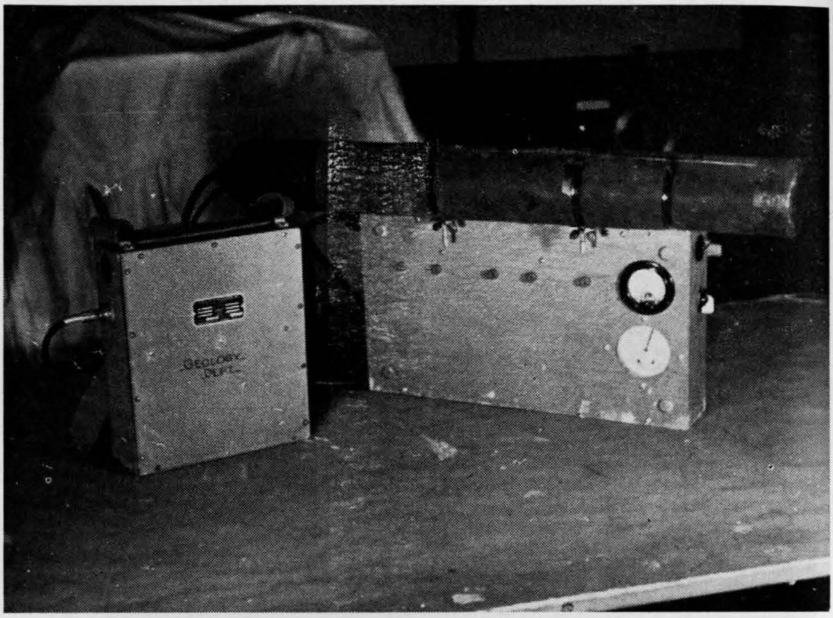


Figure 6. Field set assembled. Wing nuts secure the Geiger-Mueller tube housing to the scaling unit. Jacks are provided for monitoring the performance of the set with headphones.

Figure 7. The Field set in use. The small unit under the right arm contains a high voltage supply for the Geiger-Mueller tube.

APPARATUS FOR IMPREGNATION OF ROCK*

By ARTHUR C. MUNYAN

Emory University

The development of a technique and suitable apparatus for the impregnation of rock specimens arose from the necessity of preparing thin sections of soft or loosely coherent material. Standard methods of mounting the rock specimens with Canada balsam have been found to be inadequate when applied to many types of rock.

The ordinary procedure, after the specimen is sawed and smoothed on one side, is to mount the smoothed rock surface on a glass slide by means of Canada balsam in order to be able to reduce the slice uniformly to the required thickness. The cementing medium is, as stated, usually Canada balsam, but may be any of several substances. If balsam is used it may or may not be dissolved in xylol. But, regardless of its manner of modification it is necessary to heat the balsam to a critical point in order to secure a rigid cementing medium between the rock slice and the glass plate. One of the most common mishaps resulting from this procedure is overheating the balsam which discolors it. Underheating permits some degree of residual fluidity to remain with consequent loss of adhesive power. However, the necessary skill is generally quickly acquired and acceptable thin sections produced from many kinds of rocks. Special care must be exercised, however, when sectioning certain specimens.

A friable, soft, or loosely coherent specimen offers particular difficulties in handling by the usual technique. Such a material, cemented to the slide, very often during grinding shows a regrettable tendency to lose grains and fragments which have been torn away from the cement. This disintegration also often becomes progressively worse as grinding continues because of loss of support of grains adjacent to one another. Since the smoothed surface of the specimen must be attached to the glass slide without entrapped air, it is obvious that the balsam must be an extremely thin film be-

*Read at the meeting of the Georgia Academy of Science, Emory University, April 22, 1949.

tween the two. This means that total adhesive area on the specimen must be the surfaces of the truncated grains appearing on the smooth surface of the slice. Pressing the slice into the balsam on the glass slide forces but very little balsam up into the rock and around the peripheries of its grains. Therefore the grains are attached to the plate with a film of balsam only along their lower edges and it becomes an easy matter to destroy this bond during grinding of the mounted specimen.

This fact has long been known and a corrective procedure is to impregnate the slice of rock before mounting it upon the slide. Some preparators soak the rock for several hours or overnight in a solution of balsam dissolved in xylol; others attempt to speed this by heating the balsam while the rock is immersed in it. Both methods work after a fashion, but the first requires too much time, and the second demands that great care be taken not to overheat the balsam. It was to overcome both of these difficulties that the present apparatus was designed.

Equipment common to most laboratories was so arranged that it will produce the desired results, but also may be maintained or duplicated with little effort. Balsam was dissolved in five parts of benzine in sufficient quantity to cover a specimen within the beaker. Beaker, solution and slice were then placed within a dessicator (figure 1) to which a vacuum line was attached. Between the pump and dessicator was arranged a drying tube, safety chamber and mercury manometer. Rubber hose was used as connectors in order to make the apparatus flexible as well as make it possible to demount the dessicator lid quickly. Although hose does not make a very high vacuum possible, pressures are quite sufficiently reduced.

After sealing the system, pressure within the dessicator is reduced 26 inches of mercury (i.e.: from 30 inches down to 4 inches) in about 15 seconds. Boiling of the thin balsam solution occurs but at the same time much of the air entrapped within the pores of the rock emerges from it thus permitting the entrance of the balsam. The replacement of the air by the balsam requires from two to ten minutes to complete during which time the air will continue to bubble up through the balsam. Upon cessation of this, the system may be returned to atmospheric pressure, and the prepared specimen removed. The impregnated rock is placed in a drying oven at 100 C. for five minutes. Upon removal it is ready for mounting upon the glass slide by the normal procedure.

Several hours are saved by this technique, and it may be made still more efficient if several samples are impregnated at one time. Friable sandstones, shaly limestone, shales, and deeply weathered igneous and metamorphic rocks have been so treated in the Emory University laboratories. Thin sections prepared from such specimens demonstrate the usefulness of the method.

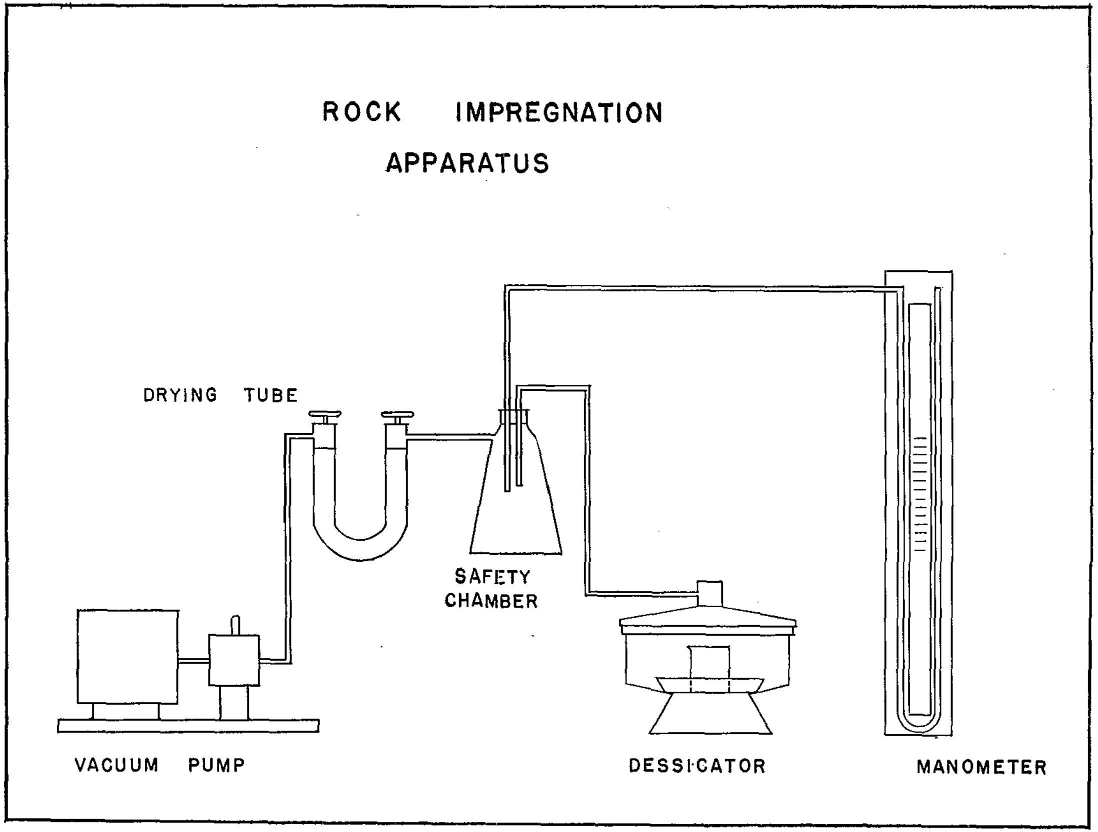

ROCK IMPREGNATION
APPARATUS
DRYING TUBE
SAFETY
CHAMBER
VACUUM PUMP
DESSICATOR
MANOMETER

Figure 1

A CRITICISM OF "GONDWANA LAND BRIDGES"*

WILLIAM H. PINSON, JR.

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Emory University

Since the early nineteenth century founding of the science of **Historical Geology** there have been three chief schools of thought concerning the manner in which sea and land areas alternately replace each other.

One school, namely that represented by the great geologist Lyell, held that there had been a complete interchange of land and sea areas; that every place that is now dry land once had been under the sea, and, conversely, that all the sea bottoms once had been dry land. This school of thought now has few, if any, serious supporters.

Geologists are divided on the other two explanations. One school holds that the continental areas have always been continents, varying in area only by encroachment of the seas towards the continental interiors or by recession to the edge of the continental shelves. The other school (Suess) holds that there is no concrete evidence for the eternal permanency of continental areas and that continental interiors may have become abysmal depth or the depths of the oceans may be uplifted to mountainous heights. Schuchert belongs to this last school of thought, and was one of the foremost proponents of land bridges being raised from the ocean depths, in order to account for similar faunae and florae in widely separated continents.

The idea of land bridges was early introduced by biogeographers in an effort to explain the cosmopolitan but discontinuous distribution of some faunae and florae. The land bridge across the South Atlantic, Ihering's **Arch-hellenis,** backed by the fond myth of Atlantis, was invented to solve the geographical problems of Africa and South America. Similarly, Sclater's **Lemuria** (the land of Mu of the Hearst **American Weekly** magazine section) served the African and Asiatic continents. The great globe-girdling land mass was

*Read at the meeting of the Georgia Academy of Science, Emory University, April 22, 1949.

given the name "Gondwana Land," for the Gondwana district of central India.

Now, these land bridges quite nicely solved all of the paleo geographic problems of plant and animal distribution. But their existence is not backed by geologic evidence, and such explanations are unnecessary. Dr. Maurice Ewing of Columbia University, director of the famed **Atlantis** expedition, states that he has found not the slightest evidence of the existence of an east-west land bridge connecting South America with Africa. Likewise, the "ridge," only vaguely extant, that connects India with Madagascar would require an uplift of nearly 10,000 feet to make it a dry land connection.

There is as yet no proven case of deep sea deposits being found on continental areas. The radiolarian ooze of Barbadoes, Trinidad, and Curacoa, long suspected of being a deep sea deposit, has now been shown to be a shallow water deposit. Deep sea deposits have likewise been reported on the islands of Timor, Borneo,[10] and Rotti,[11] but as yet these reports have not been substantiated. Also, extensive dredging of the sea bottom by the Atlantis expedition and others has brought up none of the familiar sedimentary rocks of continental areas.

The principle of isostasy now is quite generally accepted, and points to the fact that the continental areas are underlain by lighter, acidic rocks, while the ocean deeps are underlain by heavier, basic rocks, pointing to permanency of the continental and ocean deep areas. Furthermore, all of the continents (and the continental islands) are characterized by continental shelves or platforms surrounding their borders. Thus shallow water extends gradually to a depth of about 600 feet and then drops off into abysmal depths—to an average for the oceans of about 10,000 to 12,000 feet. There is much evidence for the permanency of the continents, and little or none against it.

It seems entirely unnecessary to resort to land bridge other than those extant today such as the Isthmus of Panama and the former bridge across Bering Strait, to explain either present or past plant and animal distribution. If the lands of Earth were upraised 600 feet, then all the continental areas of the world, with the exception of Australia and Anartica, would be united. Land routes would exist throughout North and South America, Europe, Asia, and Africa. If the theories of evolution and dispersal of W. D. Matthew[6] are accepted, which state that evolution (of vertebrates, especially) is most rapid in the northern temperate and subarctic regions, and dispersal occurred from these regions to the southern climates, nearly all of the geographic distribution of plants and animals may be explained. Anomalies, such as the **Glossopteris** flora of Africa and South America, and the characins and cichlids fishes, which Eigenmann[3] regards as so strikingly similar in the two continents, and the fauna of the Antilles and Madagascar, may all be explained either by migration along existing land routes or by past proven land routes, by parallel evolution from some ancient common stock, or by natural transportation such as by the wind, ocean currents, or natural rafts.

There are numerous similarities today in the faunae and florae of widely separated areas of the Earth. For example, there are but two species of alligators, **Alligator sinensis** found in the Yang-tse-kiang River basin of China, and **Alligator mississippiensis**, of the southeastern United States. Another example are the spoonbilled "catfishes" of the family **Polyodontidae.**[2] Only two species, each of a separate genus, survive today—one in the Yang-tse-kiang and the other in the Mississippi basin. Other examples are the lizards of the genus **Eumeces.** The species **Lygosoma laterale Lay** is stated to be common to both regions,[5] and likewise is the genus of amphibians, **Amphiumidae.**

Asa Gray[4] lists resemblances between the florae of Eastern United States, Japan, and China, which are as striking as those of the faunae.

Now it would be absurd to look for an explanation of these similar faunae and florae in direct land bridges, or in continents drifting apart. It seems most logical that dispersal was from common types in northern Asia or in North America during the Tertiary. A possible ancestor of the two species of alligator found today is **Alligator thompsoni,**[8] discovered in middle Tertiary (Miocene) deposits of Montana. It is well known that northern latitudes at this time had much milder climates than at present. As the climate got cooler the genus

Alligator migrated southward both in Asia and in North America, with accompanying special modification and radiation.

It seems unlikely that a species could remain unchanged when migrating, but it is possible. Climatic changes seem most likely to be the motive for migration—migration seeking an environment similar to the changing one in which the animal lives. Those animals that remain will either adapt themselves to the new environment or become extinct. Most of those that migrate will undergo species modifications unless by chance they keep abreast of climatic and environ changes. Possibly this could account for the reported identical species reported in China and the southeastern United States.

Thus, the old proponents of the Gondwana land bridges found a remarkable similarity in the fishes of Africa and those of South America, especially among the cichlids and characins. Eigenman[3] states that there are no identical species or even genera of these fishes in the two continents. Also he states that there are no ancestral representatives of these fishes found in North America or in Europe. But he quite overlooked the fossil fishes of the Eocene (Green River) beds of Wyoming, where a number of similar genera occur. These genera include **Lepidsteus, Phractocephalus,** and **Osteoglossus.**[6] (page 128).

If we do not prove that the cichlids and characins of Africa and South America are both derivable from northern migrations, then we may turn to an equally logical explanation—that of a common marine ancestor from which the present fishes were derived. Quite a similar situation exists today among the Atlantic salmon. A species is common to both the American and European coasts, but a number of species arise among the landlocked salmon of both coasts. Obviously both had the same ancestors.

That land bridges connected the continental islands such as Borneo, Sumatra, Ceylon, etc., there seems to be no question. The faunal lists of the islands and adjacent continental mainlands are nearly complete. But it is an unescapable fact that on the oceanic islands such as Cuba and the Antilles, Madagascar, and New Zealand, there is a remarkable absence of just those animals that we would expect to find had land bridges to the adjacent continents existed. Thus in Cuba we find none of the present North American land mammals. And the animals that we do find are invariably either small animals that could conceivably be transported by rafts or those animals which are aquatic in habit, such as the pigmy hippopotamus (fossil) of Madagascar and the true crocodile of Florida, which could have swum over from the Yucatan peninsular, and in Cuba, the Manatee.

In the case of Cuba and the other Antilles islands it seems likely that population resulted from transportation by natural rafts. That the population of the many islands of the Antilles groups are generally homogeneous points possibly to former land connections between the islands and this possibility is not ruled out. It is generally believed that block faulting of tremendous magnitude is occurring even today in the Carribean, and such faulting could conceivably separate a land mass that was formerly continuous. Such minor land connections and severances as these are readily admitted, but they do not in any way alter the belief in the permanency of the continents in isostatic balance. Also, the faunae and florae of the Antilles more closely resemble that of South America than that of North America. Explanation probably lies in the fact that the severe storms sweep up from the south and east, for it is probable during these storms that rafts are swept from the mouths of South American Rivers with sufficient speed for the animals clinging to them to survive the journey. During ordinary storms small animal life may take refuge and protect themselves, but in the great storms such as the tropical West Indian hurricanes it seems likely that small animal life could be swept uncontrolably out of their habitat and to some distant shore aboard natural rafts.

Since South American faunae and florae are not represented in Florida, subjected as is Cuba to tropical hurricanes, it can be guessed that immigration took place only on the islands closest to the South American continent, and that subsequent migration was over continuous land routes, which never reached to North American shores, at least during the Tertiary period.

Probably most striking of all the anomalies of faunal and floral distribution is that of bipolar species. Two striking examples are the bipolar species of **Globigerina pachyderma,** and two nearly identical species of primroses, **Primula farinosa** of the northern temperature latitudes and **Primula magellanica,** found only in Patagonia. Of the primroses the two species are nearly identical, but are separated by over six thousand miles of land and ocean, barren of intermediate species. Between the bipolar **Globigerina pachyderma** is the intermediate species **Globigerina dutertrei.** A possible explanation is that the bipolar species was derived from the more cosmopolitan temperate species—the evolution following parallel and identical lines in the two similar though widely separated marine environments—an orthogenetic development. To the primroses another explanation could be applied, other than the polytopic, i.e., independent development of identical species in widely separated habitats, such as was proposed by Wetterhan,[1] Briquet,[7] and others. It would seem more likely that formerly, in a milder cosmopolitan climate, the distribution of **Primula** was continuous, or nearly so, from North America to Patagonia. The two nearly identical species extant today are relics of a past wider distribution. But this explanation is not dogmatically held to, and the polytopic theory still remains possibly plausible. It seems possible that parallel evolution could produce nearly identical species. That exact special duplication could occur does not seem plausible.

In conclusion let it be said that, though land bridges may have existed where they are not now even suspected, there seem to be no known cases of either faunal or floral distribution that do not lend themselves quite well to explanations along the lines of migration, natural transportation, and parallel evolution.

Bibliography

1Briquet, J., "Recherches sur la flore des montagnes de la Corse et ses origines," (Ann. Conserv. et. Jard. Bot Geneve, vol. 5), 1901.

2*Bartholomew's Physical Atlas,* Vol. V. Pl. XXV, map VI.

3Eigenmann, C. H., "The Fishes of South America", Popular Science Monthly, pp. 515, 530, 1906.

4Gray, Asa, Proc. Amer. Assoc. Adv. Science, Vol. 21, pp. 1-31, 1872.

[5]Kobelt, W., Die Verbreitung der Tierwelt, gemassigte Zone, Leipzig, 1902.

[6]Matthew, William D., *Climate and Evolution,* 1939.

[7]Wetterhan, "Uber die allgemeinen Gesichtspunkte der Pflanzengeographie" Ber. Senckenb. Naturf. Ges. Frankf. a./M.)

[8]White, Theodore E., "A New Alligator from the Miocene of Florida", *Copeia,* No. 1, pp. 3-7, 1942.

[9]Wulff, E. V., *An Introduction to Historical Plant Geography,* p. 55, 1943.

[10]Kon Ak Wet. Amsterdam, Reprint from Proc. of meeting, June 26, 1909, of N. Y. Ac. of Sc., pp. 141-147.

[11]Kon Ak Wet. Amsterdam 23, pp. 1058-1073 (Reprint 1-16).

Additional Bibliography

[1]Allen, J. A., "Mutations and the Geographic Distribution of Nearly Related Species in Plants and Animals," *American Naturalist,* vol. 41, pp. 653-655, 1907.

[2]Barbour, Thomas, "The Crocodile in Florida," Univ. of Mich. Museum of Zoology Occasional Papers, non. 131, Feb., 1923.

[3]Hesse, Richard, "*Ecological Animal Geography,* Jno. Wiley & Sons, 1937.

[4]Jordan, D. S., "The Origin of Species Through Isolation," Science, N. S., Vol. 22, pp. 545-562, 1905.

[5]Leavitt, R. G., "The Geographic Distribution of Closely Related Species," American Naturalist, vol. 41, pp. 207-239, 1907.

[6]N. Y. Acad. Sci., Vol. 24, pp. 171-318, 1915.

[7]Scott, William B., *A History of Land Mammals in the Western Hemisphere,* MacMillan, 1937.

[8]Symposium of Tertiary Faunae, G. S. A. Bull. 35, 1924.

A BRIEF EXAMINATION OF THE FOREST RESOURCE OF GEORGIA*

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Sixty-six percent of the total land and water area of Georgia is forest land. This does not mean land that **should** be in forests, or land that has **been** in forests in the past; this means that sixty-six percent, two of every three acres, **are** forest land, and are now supporting a forest crop.

Sixty-six percent of the total land and water area of Georgia amounts to 25,000,000 acres. This is more forest land than is within the boundaries of any other state, except one.

Many persons, when confronted with so large a forest acreage as 25,000,000 acres, immediately conclude that there must be many large ownerships and perhaps large holdings of State and Federal lands such as exist in many of our far western states. Such is not true in Georgia.

There are several contributing causes for this lack of large ownerships. First and probably most significant, is the fact that Georgia is an agricultural State, composed for the most part of comparatively small farms. Each of these farms has, as an integral part of the whole, a forested area; and to purchase the forested area and not purchase the agricultural soil is almost an impossibility. Therefore, the acquisition of large forest holdings has not been feasible.

Secondly, Georgia's forests have always been productive. In many cases, especially in the Coastal Plain, the income from the forested portion of the land is greater than from the non-forested area, and few men are willing to sell their means of livelihood at any reasonable price.

Thirdly, state ownership of forest land has never been seriously considered; probably because of the high cost of acqui-

*Given before the Association of American Geographers, Southeast Division; Athens, Georgia; December 2, 1949.

sition. As for Federal ownership and control, I doubt if you can find a less popular subject among the forest landowners of Georgia. Today, the State and Federal agencies own only 4.3 percent of the forest land in Georgia or approximately 1,075,000 acres.

In terms of forest acreage, 5,000 acres is not considered to be a large area. Yet in Georgia, only 9.7 percent, or 2,425,000 acres are in ownerships of more than 5,000 acres. Also, only 16 percent, or 4,000,000 acres, is in ownerships of from 1,000 to 5,000 acres in size. Thus only 7,500,000 acres or 30 percent of the 25,000,000-acre total is in State or Federal ownership or in holdings of more than 1,000 acres. Thus, Georgia not only ranks second in total forest acreage in the nation, but ranks **first** in the number of privately owned acres, and **first** in the number of individual owners.

A resource such as this; of such magnitude, and affecting so many individuals, is well taken as the pride and the problem of every resident of Georgia. Just how important is this resource to the economic life of the people of Georgia? In an attempt to partially answer that question, examine a few of the facts.

As was mentioned above, only 4.3 percent of the forest land in Georgia is under State or Federal control; which leaves 95.7 percent of the forest area of Georgia under private control. That makes the forest resource, principally one of private enterprise; and removes from consideration all factors, good or bad, of public ownership and control.

During the past year more than 120,000 persons were **directly** employed in forest activities. This does not include the farmers who cut a few logs, or a few cords of pulpwood from their woodlands during the slack agricultural season between crops, or after the crops were "laid by". Neither does it include those additional tens of thousands of persons in the families of the directly employed; nor does it include those who operate businesses and services who are dependent wholly or partially upon the trade of the directly employed for their existence. Not one of Georgia's 159 counties fails to feel the impact of this forest-spawned trade, for every county in Georgia has one or more wood-using industries.

Furthermore, the number of wood-using industries is on the increase.

During the years 1947-48, 159 new wood-using industries were established in Georgia, including two large pulp mills. This is a greater number of new industries than was established in any other class.

The pulp and paper industry furnishes another example of the rapid growth of the forest industry in Georgia. In 1936 there were two pulpmills in Georgia; in 1946, three; today there are six. These six mills have a total capital investment of approximately 75 million dollars, employ over 7,500 persons, and have an annual payroll of approximately 15 million dollars. The size of the mills vary. The smallest mills in the state are the St. Marys Kraft mill at St. Marys, and the Armstrong mill at Macon, each with a total 24 hour production of 200 tons of pulp. The largest mill is the Union Bag and Paper Corporation mill at Savannah, with a 24 hour production capacity of 1,120 tons of pulp. The range in investment corresponds with the capacity for production.

These six pulpmills consume a total of approximately 4000 cords of pulpwood each day. In addition to these pulp mills, **seven** others draw a part of their wood supply from Georgia.

The growth in the production of pulpwood in Georgia is also of significance. In 1940, 587,500 cords were cut; in 1946, 1,100,000 cords; in 1948, 1,771,000 cords.

This is a tremendous volume, amounting to approximately a 15 million dollar return to the landowners, yet it is only 10 percent of the total drain of wood per year in Georgia; and is less than one-half the drain due to fire, insects and disease.

The returns from all of the wood-using industries to the people, in the form of wages, is unavailable data; but the value of the processed products each year is more than one-quarter **billion** dollars. In **addition** to this the land-owners receive approximately 125 **million** dollars for their forest products. **This is a larger return than from any other single crop, in Georgia.**

What is happening to this forest resource in Georgia, upon which so much of the economic welfare of the state depends?

An important incident in the history of the forest resources of Georgia, came shortly after the War Between the States when Georgia began shipping pine to the northern markets. These first shipments were small, but it was not many years until they became a veritable flood as the high quality and low cost of southern pine became known to the ultimate consumer. This flood tide abated following World War I, and many prognosticators voiced the opinion that as a timber producing state, Georgia was through, unless drastic steps were taken. Criticism of these persons should not be too severe. What they observed as they travelled the State certainly must have appeared to be forest devastation. And the estimates, or "guess-timates", which they received prior to 1936 with relation to the forest situation, were assuredly not of the rosiest hues. To the best of their knowledge of the physical situation, they were on sound ground. What they did not reckon with, however, was the startling recuperative powers of the Georgia forests.

In Georgia 1936 is a milestone in the knowledge of Georgia forests. It was the year in which the United States Forest Service, through the Southern Forest Experiment Station, completed a forest survey of the state. It was a good survey. No one doubts its validity.

Results of that survey showed a volume of 32 billion board feet of pine and 13.5 billion board feet of hardwood and cypress sawtimber in the state. Complementing this board foot volume were 36 million cords of pine, and 44 million cords of hardwood and cypress in trees smaller than sawtimber size. This total volume, plus reproduction-size trees, was reported to be standing on 21.4 million acres of forest land.

In 1944-45 the Agricultural and Industrial Development Board of Georgia joined forces with the American Forestry Association, the Georgia Department of Forestry and the Georgia Forestry Association to conduct a new survey of the forest resources of the state. Unlike former surveys in Georgia, this more recent study was made on the county level, so the results would be useful to local interests and industries.

What happened to the timberlands of Georgia in the 10 years from 1936 to 1946? Were the lands devastated? Was the cutting by the so-called "timber and pulpwood barons" rampageous and heedless of Georgia's future supply of timber? A study of the facts and trends we now have gives some surprising answers.

During the 10 year period from 1936 to 1946, the total board foot volume of wood in trees of sawtimber size decreased by 13 percent. If no other factors are considered the forest resource picture in Georgia is black indeed. It must be remembered, however, that sawlog sized trees must have at one time been cordwood sized trees. To think otherwise is to also assume that children never grow to adult stature.

The key to whether or not Georgia actually depleted her forest resource, or merely cut large volumes of sawlog-sized trees which should have been harvested under any standard of good crop management, lies in an examination of what happened to the cordwood volume during the 10 year period. It is upon this cordwood volume that future growth of sawtimber must depend.

During the 10 year period, the pine cordwood volume in the state increased by 11 percent and the hardwood cordwood volume increased by 5 percent.

And what of the stands below cordwood size? In addition to the natural regeneration of forests constantly taking place following harvest cuttings, Georgia maintains the largest tree planting program of any state. The interest and growth of this aspect of forestry, which incidentally signifies the most intensive type of forestry, is almost startling, even to foresters. In 1946, the state produced in its two tree nurseries, five million seedlings. The demand exceeded the supply. In 1947, they produced 19.5 million seedlings. The demand exceeded the supply. In 1948, they acquired and put into operation an additional nursery of 100 acres in size, and produced 32.5 million seedlings. The demand exceeded the supply. This year, 1949, they will lift from the seedbeds 50 million seedlings, and again the demand has exceeded the supply. Fifty million seedlings, will plant 50 thousand acres.

If you will ponder over these data for a few moments it will become self-evident why the foresters in Georgia are optimistic. Today Georgia has a greater base upon which to build for future sawtimber supply than she has had at any time in the past 10 years, and probably a greater supply of cordwood sized timber than previously existed in Georgia, at any time!

With this base upon which to build; with the progress which has been made during the past 10 years to bolster the belief that forests are the solution to Georgia's economic plight; with a multi-million dollar industry based upon forest products; and with a citizenry enlightened to the cause of forestry; with, and because of these things, Georgians feel there is no cause for alarm; and refuse to become stampeded by the exhortations of those who cry: "Timber famine"!

AN EARLY FLINT INDUSTRY IN SOUTHWEST GEORGIA

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At Lane Springs, on upper Spring Creek, in northern Decatur county, near Brinson, Georgia, in April, 1948, a flash flood washed out a sandy ridge, dislodging scores of flint artifacts. At the time of the cloudburst, the writer was engaged in carrying out a preliminary site survey of the land area bordering on the confluent lower Flint and Chattahoochee rivers which will be inundated by the reservoir created by the Jim Woodruff dam under construction at Chattahoochee, Florida. Widespread damage to bridges and roads all over southwest Georgia temporarily disrupted traffic and public services. Emergency repair of a country road to permit passage of school buses led to the initial discovery of large numbers of flint tools recovered from sand and clay being used to fill in the road bed. A report to survey headquarters

*Read at the meeting of the Georgia Academy of Science, Emory University, April 22, 1949.

at Bainbridge on these finds led to an investigation of the Lane Springs site a few days after the washout.

Lane Springs is a typical example of the many deep, limestone sink springs that are so characteristic a feature of southwest Georgia, particularly in Decatur and Seminole counties along the lower Flint and Chattahoochee rivers and the large tributary stream, Spring Creek, which enters into the Flint River a few miles below its confluence with the Chattahoochee. Spring Creek is fed by a number of such deep pools or "boils", which line its course from Lane Springs and Brinson Springs in north Decatur Co., with Yates Springs, Eggleston's Springs, Oil Still Springs, Grantham Springs, White Springs, Shackelford Springs, and others spaced at intervals to the junction with Flint River.

These springs are from thirty to sixty feet or more in depth. They are remarkably clear, in appearance almost an indigo blue in color as one approaches them in a boat, but showing a uniform calcareous white expanse over the bottom as one looks directly down. Fish can be observed to take a fisherman's bait at a depth of thirty feet or more.

The members of Hernando de Soto's expedition were duly impressed with these unusual outpourings of water and commented upon the "White Springs" which they remarked soon after entering upon the limestone sink region after leaving the wire grass country. Dr. John R. Swanton, in seeking to establish the line of De Soto's march through southwest Georgia, is doubtful whether the identity of the particular "white spring" site noted by De Soto commentators can be identified beyond dispute, other than to affirm that it "must have been between Spring and Ichawaynochaway creeks and the territory marked out by the lines of the Central of Georgia and Atlantic Coast Line railways."[7]

The big springs or "boils" well up usually off the main course of Spring Creek, and their outlets, or "runs", feed the creek. During the excessively heavy winter rains of 1948-1949, which soaked the porous top soils and choked the underground drainage channels in the limestone substratum, the volume of water in the springs developed a terrific pressure which burst out of its confines, and finding the outlets inadequate to carry the excess, cut many new broad channels.

At the site of Lane Springs, the storm water ripped through a seven foot sandy ridge or terrace, along the course of the "run" and stripped off the sand for a distance of approximately 100 yards down to an underlying hardpan of clay. The sand ridge was cut away clean and vertically, and the stiff bed of clay at the base was gouged and scarified by the force of the water. Fresh ponds of water were pooled between the sheer banks after the storm, and at the bottoms of the pools, lying on the clay hardpan, were found hundreds of worked flints, which had been ripped from their context in the sand ridge as if by hydraulic mining operations.

By far the greater part of the archaeological material gleaned from the Lane Springs site consists of flint artifacts washed out of the sand. A few scattered potsherds, including the remains of one or two large pottery vessels, lodged in the exposed roots of a tree, completed the findings.

A related, and significant feature, of the Lane Springs site is a large flint outcrop, located a hundred yards or more north of the "run", overlooking the site of Lane Springs. This outcrop of flint constitutes a ridge some twenty feet in height, covering several acres. Examination of the area showed numerous individual boulders exposed at the surface which exhibited many fractures and broken facets where stone had been spalled out in primitive mining operations. The whole surface of the ground was littered with the debris of flint spalls, with innumerable smaller fragments forming heaps. It was possible in a few hours of investigation to pick up typical "rejects" of artifacts which had developed flaws in the process of being manufactured on the spot. Occasionally, a completed specimen, especially large plano-convex, heavy "turtle-back" end scrapers, were to be found. At one point of the flint quarry site, where some soil cover had developed near the spring, we found a few potsherds exposed in a freshly eroded ravine in an old road bed. It was noteworthy, however, that pottery was very scarce at the site of the flint quarry, as it was at the site of the "run" and the cut sand bank where the majority of the assemblage herein to be described was found.

The collection of flint artifacts, regarded in their totality, is the main point of interest in this presentation. Typologically considered, these present a most unusual assemblage of forms and types of flint tools, and exhibit a crude, primitive technique in manufacture hitherto found only in association at a relatively small number of sites in Georgia and the Southeast. Moreover, most of these flints show a marked chemical alteration or decomposition of their cortex which is not characteristic of flint artifacts or flint scrap taken from shell midden, mounds, and pottery bearing village and campsite areas on the lower Flint and Chattahoochee.

One of the most frequent and common types of flint tool found in the Lane Springs assemblage is a large, crudely prepared fist-axe or hand-chopper. These are about the size of a man's fist and have been roughly shaped by primitive percussion in which a number of flakes have been knocked off from the working end to provide an effective chopping surface. The upper portion remains rounded to fit the hand conveniently. A distinguishing feature of these specimens is the fact that the cores have been spalled off and worked up in a manner to retain one flat side with the other convex side worked down to give the proper facets and planes for effective chopping. The unifacial aspect is present in all specimens except one or two which show a general dressing of all contours in the fashion found in most hand-chopper flint industries in the palaeolithic stage. This asymmetry in construction does not seem to affect the working balance of the choppers when they are held in the hand, whether they are grasped with the flat surface directed toward the workman, or whether they are held sideways. The broadly expanded base fits the contours of the hand comfortably despite the fact that the upper portion of the choppers have been roughly spalled into shape. The chopping edges are definitely pointed, usually describing a broad oval cutting surface. Very little retouching is found on any of the choppers; most of the flakes detached are large.

A second important class of tools consists of a large assortment of flint blades, from one to three inches in diameter, again exhibiting the unifacial appearance with one flat surface and the other convex side dressed down. Shapes vary from broad oval to narrower, elongated cutting tools, with some flakes showing a more geometrical shape. Most of these blades show only the minimum of workmanship in detaching large flakes by percussion to make them useful as tools. Secondary retouching appears on only a few specimens along the working edge.

Some of the smaller reworked flakes show retouching along the sides and are indicated to be side scrapers or knives. The larger, oval or ovoid blades, are in the majority. The plano-convex appearance is maintained throughout and in many tools the secondary reworking has not bothered to remove portions of the altered cortex that belonged to the parent flint where it had undergone decomposition in exposure in the original outcrop.

Another important group of tools consists of large plano-convex, so-called "turtle-back" end scrapers. These tend to be broadly convex to narrowly ridged on the upper surface, with the ridges running longitudinally. The front, or working edge, of these end scrapers varies from a squared planing edge to a broad obtuse angle. The collection of end scrapers from Lane Springs shows a predominance of heavy, almost cumbrous types, an inch and a half to two inches long. The small, thumb-nail size of end scraper has not been observed in present collections. The technique of preparation is the same as that found in other early flint industries in North America, but the over-size in end scrapers at Lane Springs is characteristic.

Several of the plano-convex elongated specimens show definite retouching at the distal portions to produce a narrowly pointed tool that would be effective as a punch or awl. Two or three highly individualized flints have the curved, eagle-beaked (rostro-carinate) shape found in very early palaeolithic, even pre-Palaeolithic, specimens in England. This striking convergence in typology to the widely distributed gravers and burins of continental Europe is remarked as an interesting coincidence. Flint is a relatively intractable material to work with, and given the common necessity to produce tools for recurrent similar purposes it is not remarkable that different human groups in widespread geographical areas of the world should have reproduced forms, and even apparent styles, of implements that are closely assimilated to one another.

One of the classes of tools that will help to give special character to the assemblage from Lane Springs is a bun-shaped type of rubbing stone that fits neatly into the palm of the hand. A dozen or more of these were recovered from the pond in the "run". A few specimens are of a quartzitic rock, ordinary stream rolled boulders which have been used in some sort of rubbing operation until they are planed down by attrition on the upper and lower sides. A majority of hard sandstone show the same general bun-shape, but are planed or rubbed down on the bottom side, with the upper side knocked into shape for grasping. A few show the under side worn but exhibit a small circular cup mark on top about the size of a quarter dollar. Only one mortar type of artifact, complementary to the manos or rubbing stones just described, was recovered from the Lane Springs site. The numerical superiority and frequency of occurrence of the smaller hand tool, or rubbing stone, seems to be significant.

Projectile points recovered from the site consistently tend to be stemmed, usually short, relatively narrow-stemmed, but with a minority of broad stemmed forms, with a few notched shoulders. One specimen has the characteristic "fish-tailed", elongated, longitudinally expanded, thin blade aspect of the so-called "southeastern folsomoid" type, but lacks the fluting or removal of a central channel flake. Another piece is a small beveled stemmed projectile with shoulder notching recalling the widespread "spinner" type of central Georgia.

It is perhaps worthy of recording that most of these projectile points from the storm water ponds at Lane Springs either show raw, unmodified flint cortex, or exhibit less cortical decomposition than is found in all the classes of tools initially described for this assemblage. This may not be significant in any consideration growing out of a discussion of decomposition of worked flint indicated to be a condition of relatively great age.

Only a handful of pottery was found on the site, and most of the larger potsherds belong to one pottery vessel which had an unusual punctuated design on the side, closely resembling what the farmer owner of the site called "baseball stitch." Loop handles and other morphological and paste characteristics relate the pottery to the proto-historic site excavated by the University of Georgia survey in the summer of 1948-1949 at Hornsby's Bluff, located on upper Spring Creek about two miles north of the Lane Springs site. None of the Lane Springs assemblage of flints was present in the midden at Hornby's Bluff. In terms of the northwest Florida coastal chronology, the Lane Springs pottery resembles most closely the Fort Walton Manifestation.[2] The facts of occurrence at Lane Springs imply a meager campsite occupation of the area by pottery using peoples. On the other hand the evidence of long continued quarrying activities at the large flint outcrop overlooking the springsite, and the typological ensemble representation of the flint indicate a pre-pottery occupation of the site that was much earlier.

Thus far archaeological survey and exploration in Georgia has produced only one other example of a site that duplicates or closely approximates the assemblage of flint tools found at Lane Springs. That is the large collection of decomposed or altered flint tools taken from the weathered clay loam on the Macon Plateau by the author in an expedition to the Ocmulgee river near Macon, Georgia, in the years 1938-1939. This area is now preserved in the Ocmulgee National Monument. The Macon Plateau flint industry contains several specialized types not found at Lane Springs.[3] Also, the Lane Springs industry exhibits a few peculiar traits of its own. The resemblance in totality of specimens and types is sufficiently strong to argue some sort of cultural relationship. The areal spread hardly seems to suggest a spatial determination for the observed discrepancies. Lane Springs is a more primitive flint complex, shows fewer specialized types, and has less of the putative "folsomoid" or "Folsom-like" facies of the Macon Plateau flint industry. This may be due in part to the fact that conditions of discovery were not ideal from an archaeological point of view; the collections at Lane Springs were not in the best archaeological context. On the other hand, the Macon Plateau flints were catalogued from a context that had been progressively and continuously churned up by successive occupation by several major cultural groups living on the same area. Even at the present stage of investigation, however, one important conclusion seems clear: Lane Springs belongs to the same general time level and cultural category as Macon Plateau, and both are distinct from other early cultural horizons at present known to the larger region.

In recent literature, William G. Haag of the University of Kentucky, has given us one of the most thoughtful attempts to plumb the relations of these horizons,[2] without of course considering Lane Springs only recently discovered.

The difficulties in a comparison of Lane Springs and Macon Plateau will be found to be of the same order as those met in discussing the whole problem of early flint industries, and pre-pottery assemblages, in the Southeast. It has become abundantly evident that there was a widespread cultural manifestation in the Southeast, antedating the earliest pottery-bearing occupations, which has been variously denominated "pre-pottery" or "Archaic". [1] The relationships of these early groups, not only in the American southeast, but in the expanded eastern United States and the concept of early culture in North America, are not at all clear, and some sharp doubts have arisen as to the validity of the whole concept of an "archaic" horizon.[6] F. H. H. Roberts, Jr., has discussed the wider continental problem. [4-5] As long as comparisons must rest upon the resemblances in typology alone, without geochronological or palaeontological associations to give reliable indications as to relative age, those who must deal with the problem work at a severe disadvantage. Just now we need more data as to specific sites which appear to yield material suspected to belong to still earlier human occupations of the region. The Lane Springs site, along with Macon Plateau, may well represent such an horizon.

Bibliography

[1]Fairbanks, Charles H., "The Taxonomic Position of Stalling's Island, Georgia." American Antiquity, Vol. VII, No. 3, Jan. 1942.

[2]Haag, William G., "Early Horizons in the Southeast." American Antiquity, Vol. VII, No. 3, Jan. 1942.

[3]Kelly, Arthur R., "A Preliminary Report on Archaeological Exploration at Macon, Georgia." Anthropological Papers, Bureau of American Ethnology, Bulletin 119, Washington: 1938.

[4]Roberts, F. H. H. Jr., "The Folsom Problem in American Archaeology." Smithsonian Institution, Annual Report, 1938.

[5]Roberts, F. H. H. Jr., "Developments in the Problem of the North American Paleo-Indian." In Essays in Historical Anthropology of North America, Smithsonian Miscellaneous Collections, Vol. 100, Washington: 1940.

[6]Sears, William H., "What is the Archaic?" American Antiquity, Oct. 1942, Volume 14, No. 2.

[7]Swanton, John R., "Final Report of the United States De Soto Commission," House Document No. 71, 76th Congress, 1st Session, U. S. Government Printing Office, Washington: 1939.

[8]Willey, Gordon R. and Woodbury, R. B., "A Chronological Outline for the Northwest Florida Coast." American Antiquity, Vol. VII, No. 3, Jan. 1942.

CHANGES IN BASES OF SUBSISTENCE AMONG PREHISTORIC GEORGIA POPULATIONS*

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Archaeological exploration during the last twenty years in the eastern United States, and in the southeastern region, has uncovered definite sites and materials revealing the growth of native civilizations, increasing populations with indicated development of more and more complex settlement patterns, and an expanding subsistence base in terms of food economy and the more efficient utilization of natural resources. Beginning with simple hunting and collecting societies, whose campsites reveal a semi-nomadic and seasonal occupation, other sites occur to show a subsequent adaptation to subsistence on shellfish and marine life on coastal areas of the Southeast, and on freshwater molluscs in the interior drainages.

The main subsistence during all the early phases of aboriginal life was upon the hunting of riverine mammals and deer. The earliest "pre-pottery" sites exhibit a variety of large, stemmed "dart points", too topheavy and unwieldy to have served as points to arrow shafts, implicit evidence of the long-continued use of the atlatl or throwing stick before smaller, slenderer forms emerge that approximate closer to the ballistic requirements of an "arrow head". The bison does not appear in the midden refuse of early archaeological sites east of the Mississippi, although ethnographic accounts frequently mention them during the 18th century. In lower, middle, and upper Tennessee archaeological finds of elk (wapiti) bones occur, indicating a more southern limit to this species in aboriginal times.[1] Studies of large collections of animal bones, shell, and ethno-botannical materials from archaeological sites of approximate relative dating afford a fairly reliable

[1]T. M. N. Lewis and Madeline Kneberg, Hiawassee Island, 1946, p. 45.

*Read at meeting of Association of American Geographers, Southeast Division, Athens, Georgia, December 2, 1949.

indication of the dependence of human groups, occupying culturally delimited areas of territory, upon the prevailing bounty of nature.

The main requirement for a settled mode of life is a subsistence base capable of supporting the local population without the necessity of seasonal or frequent movement to seek new sources of food. Historically, most primitive groups have been able to secure such an ample food supply only by the cultivation of storable cereals, so that the surplus can support the population during the growing season, or when hunting or combined hunting and food-gathering are not adequate to provide current subsistence.

It is possible, however, to achieve considerable stability of settlement under special circumstances, even without the benefit of cultivation of any kind. A constant supply of fish or seafood located near the occupied territories is one possibility. The huge shell middens of the south Atlantic and Gulf Coastal regions exemplify this economy where marine food is the chief reliance. The equally large inland shell middens on the Tennessee river and its tributaries, sometimes 25-30 feet deep, explored by Tennessee Valley Authority archaeologists, indicate a similar concentration on fresh-water molluscs.

In this conection reference is made to the buffalo (bison) hunting tribes of the Great Plains. These animals were slaughtered in great numbers by community hunting or co-operative drives. With the buffalo supplying the main food source, supplemented by minor hunting of smaller mammals, and some food-gathering, a sufficient subsistence base was provided to enable local groups to form fairly substantial campsites. Some incipient farming began as sedentary agricultural tribes of the northeastern woodlands gradually became acculturated on the fringes of the prairies to the hunting patterns of the typical Plains Indians. When the horse was introduced, however, and firearms were obtained from Europeans, the buffalo herds became decimated and the old hunting economy failed.

Transitional between the so-called "pre-pottery", flint-bearing sites, to the earliest pottery making peoples, are sites which are characterized by a stone ware, hewn from either sandstone or soapstone. Then, in the Georgia prehistoric chronology, equating with the general Southeastern area, comes the oldest pottery, fibre-tempered ware. Sandstone and steatite vessels occur together in the upper levels of shell middens in northern Alabama. In north Georgia steatite quarries and sites exhibiting broken steatite vessels occur frequently. The largest steatite quarry yet recorded is found at Soapstone Ridge on the River Road near Decatur, Georgia. The large, bin-like receptacles hewn from this material are noteworthy. A typical specimen from the Panthersville district is on display at the State Museum in the Capitol Building in Atlanta. It is perhaps significant that some of the earliest pottery, fibre-tempered, appears on the basis of functional morphology and size to have served as containers. A large fragment of a fibre-tempered vessel, obtained by the University of Georgia survey of the lower Flint near Bainbridge, Georgia, has a diameter of 22 inches. Large linear or bold-check stamped vessels from north Georgia, recovered from the Allatoona basin by Smithsonian archaeologists, have in some instances diameters even larger.[2] The significance of these over-size pottery and stone containers, found in "late Archaic" horizons, relates to their use as containers. This indication, along with the many pits containing carbonized nuts, is implicit proof of the efficacy of the food-gathering economy. It is beginning to be evident that these early food-gathering groups had a far more stable economy than was formerly supposed, and that sites were occupied longer and more continuously. If one reconstructs in the mind's eye the heavily wooden terrain, the impracticability of moving household goods of such heavy, cumbrous, relatively fragile construction along primitive forest trails is apparent.

The earliest areas to be settled in Georgia tended to be located in the upland, piedmont sections. Surveys in north and northeast Georgia reveal numerous hilltop sites, exposed today to archaeological survey by the extensive sheetwash erosion resulting from modern agriculture and the destruction of vegetative cover. The flints are left standing in stark profusion on the top and slopes of raw red hills as if washed out by hydraulic mining. A popular description of such sites.

[2]Personal communication of Joseph R. Caldwell, with the Smithsonian survey in the Allatoona basin.

frequently met with by archaeological surveyors, is that these places were the scenes of Indian "battles". Mr. E. B. Mell of Athens, Georgia, found a cache of over 300 stemmed dart points, made from a crude standstone, on a hill overlooking the Apalachi river near Bishop, Ga. There should be a caution against the over-emphasis of the hilltop character of these sites; it may well be that the same erosion which uncovers them also mantles the river bottoms, thus concealing site occurrences there from surface survey discovery.

The number and distribution of these sites indicate a surprisingly heavy occupation in north and northeast Georgia in the pre-agricultural phase of aboriginal life. Simple additive figures for comparative purposes are not available in the present stage of study but the preponderance of "early sites", early enough to antedate Eastern Complex maize, is obvious. The many shell middens on the Georgia coast, and on the northwest Florida Gulf coast, show the heaviest occupation there later. The deepest substrata of the shell middens may be in some instances pre-pottery, pre-agricultural, as at Stalling's Island near Augusta, Georgia, at other island sites near Savannah, Georgia, and in the St. Johns river area. But the greater number of shell middens are demonstrably later in age than the "Archaic" sites in the interior, and the piling up of populations on the coast may well have been a peripheral spread from the rich river basin areas of the interior, as successive enrichment of the subsistence bases enabled larger populations to be maintained. This may be true despite the fact that the largest single early pottery concentration found thus far in Georgia has just been reported on Sapelo Island by Dr. A. J. Waring, Jr., of Savannah, Georgia.

The early sites of the hunting-collecting groups show a consistent occurrence of large, heavy "spear point", javelin type of projectiles, or darts, found with carved stone, banner stones, now known to have served as atlatl or throwing stick weights. Recent finds by Smithsonian Institution investigators in the Allatoona Basin near Cartersville, Georgia, may fix precisely the time of introduction of the first projectiles reflecting the use of the bow and arrow.[3] This in itself may have been a critical invention, vitally effecting the economy of the "late Archaic" groups. In southwest Georgia, on the lower Chattahoochee river, a field party of the University of

Georgia last summer found stratified shell deposits in which similar projectiles appeared in a basal deposit, underneath stratified shell of a later occupation.[4]

The first radical change in subsistence in the Southeast, and in Georgia prehistory, occurred when maize or corn was introduced in Burial Mound times. Archaeological sites increase in size, largely clustered along the lower terraces and river and creek bottoms. There is some evidence on the Gulf Coast of Florida, and in southwest Georgia, that eventually the dependence on shellfish became lessened, and the inference is drawn that possibly this change in the archaeological deposits may indicate the incidence of maize agriculture.[5] Sites begin to show more extensive habitation areas, greater accumulations of kitchen debris with an increasing variety of animal species contained, more substantial house-patterns, larger and more consecutively-buried interments, indicating in general a longer-lived settlement pattern.[6] A more populous occupation is indicated, along with a more effective utilization of the resources of the immediate land area. The middens reveal the greatest variety of animal bone, fish, turtle, and other local food items, with shellfish declining as one proceeds upstream into the interior of Georgia.

As yet, in the first upsurge of population, with enlarged settlement patterns permitted by the expansion of maize agriculture, mound-building was still in the Burial Mound stage. The incidence of pyramidal, temple mounds in the Southeast, with the full implications of this type of mound architecture

[3]Personal communication of Joseph R. Caldwell of the Smithsonian Allatoona survey.

[4]The substratum in which the "bow and arrow" type projectiles occurred is a "pre-Swift Creek" horizon which thus far has been localized only at one site, the Fairchild's Landing site on the lower Chattahoochee river in Seminole county, Georgia.

[5]Gordon R. Willey's comment on the situation at Unit No. 1, Fairchild's Landing, where shell layers were heaviest in Swift Creek and Weeden Island I strata, declining markedly in overlying Weeden Island II. Elsewhere on the lower Flint in Decatur Co., Georgia, however, Weeden Island II and a "pure" check stamped horizon (Wakulla?) exhibits heavy shell use.

[6]Early Swift Creek in middle Georgia on the Ocmulgee shows no shell midden at all. Yet the closely related Swift Creek levels at Fairchild's landing and Willey's Santa Rosa-Swift Creek sites on Florida Gulf Coast show heavy shell accumulations. The same is true of simple stamped sites and check-stamped sites in central and north Georgia as contrasted with coastal sites.

for the expansion of religion, is still an unsolved problem in American archaeology. The general concensus of investigators is to derive both maize agriculture and temple mounds from a Meso-American source, but the time, point of entry, and routes of diffusion of the introduced trait-comples, and their immediate reception, remain to be worked out. The temple mound civilization of the lower Mississippi and the Southeast is relatively full-blown, definitely developed without clear annectant early stages, when studied at various key sites by southeastern archaeologists. What is flambouyantly evident is the ultimate effect of these new influences on southeastern populations. Maize came first and soon after intensive agriculture set in came the religious expressions. Large flat-topped mounds appear, central tumuli, flanked by satellite mounds arranged in tiers around a broad plaza, suggestive of the layout of large Meso-American centers of antiquity. Temple architecture was perhaps not as elaborated in southeastern mound centers as in Mexico or Meso-America because wooden constructions did not offer the possibilities of stone. There are abundant indications, however, of a rich ritualism and ceremony, heirarchical classes of priests and artisans, an ornate and highly symbolical religious art, as exemplified at such great mound centers as Etowah in north Georgia, Moundsville in Alabama, and Spiro in Oklahoma. Many of the large Mecca-like establishments, prehistoric urban centers, are fortified by log palisades, moats, or earthworks. Settlement extended upstream, smaller occupied areas united to the main centers. The size of these nucleated settlement patterns, the magnitude of physical construction, the religious heirarchy, organized community activity, trade and commerce, argue a greatly expanded subsistence base only made possible by the full development of the potentialities of cultivating Eastern Complex maize, with beans, squash, melons, plus seasonal hunting of deer and riverine mammals. The formative period of civilizational growth had run the gamut of a long nurturing in the Burial Mound interval. The seeming mushroom growth of great centers far removed geographically in the Southeast has suggested a rapid, messiahnic development, similar to the spread of the Ghost Cult in the Plains area of the United States in the late nineteenth century, and impelled some investigators to telescope the period of cultural efflorescence into a small time period hardly antedating the 16th century Spanish exploration. More recently, however, studies have tended to indicate a more native upspringing from older mound cultures in the middle Mississippi and Southeastern region, the new religious influences including temple mounds finding a soil made all the more receptive by a long formative period of gradually developing agriculture in Burial Mound times.

Many of the evidences of these developments may be seen at the large mound center on the Ocmulgee river near Macon, Georgia.[7] An important discovery here was a prehistoric cultivated field, sealed up and preserved for posterity beneath a large house-mound. The hillocks of this cultivated field, laid out in parallel or broadly curving rows, are reminiscent of the field patterns drawn by 16th century camera artists, John White and the Huguenot, LeMoyne, who saw and perpetuated the appearance of maize fields as they were worked by aborigines 400 years ago. The tempting conclusion might be drawn that the particular field at Macon was deliberately sealed up and enshrined by the construction of a mound over it, thus monumentalizing a site that was to be made a National Monument by the United States government 600 years later.

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[7]Kelly, Arthur R. A preliminary Report on Archaeological Explorations at Macon, Georgia. U. S. Bur. of American Ethnology, Bulletin No. 119. Washington, 1938.