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DEPARTMENT OF MINES, MINING AND GEOLOGY

A. S. FURCRON, Director

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SUBSURFACE "BASEMENT" ROCKS OF GEORGIA

by

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and

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Prepared cooperatively with the U. S. Geological Survey

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LETTER OF TRANSMITTAL

Department of Mines, Mining and Geology

December 31, 1965

His Excellency
Governor of Georgia and
Commissioner Ex-Officio
State Division of Conservation
Atlanta, Georgia

Dear Governor Sanders:

I have the honor to submit herewith, Bulletin No. 76 of the Department of Mines, Mining and Geology, entitled, "Subsurface 'Basement' Rocks of Georgia" by Dr. Charles Milton of the U. S. Geological Survey and Dr. Vernon J. Hurst of the University of Georgia.

This is a technical report, prepared at little expense to the State and deals with the crystalline rock floor which occurs beneath the sedimentary rocks which may contain petroleum in South Georgia.

This report is particularly valuable to those who engage in test drilling for petroleum in that part of the State and a study of its contents will go far to avoid continued drilling at depth into rocks which offer no opportunity for the discovery of oil. The conclusions of this report indicate that all specimens of bottom core should be studied in detail by competent petrologists.

Those who drill tests in the future for petroleum will benefit very much by a serious study of the results of this report.

Very respectfully yours,

A. S. Furcron

A. S. Furcron
Director

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SUBSURFACE "BASEMENT" ROCKS OF GEORGIA

ABSTRACT

South of the Fall Line, extending NE-SW across the middle of Georgia, are the Cretaceous and Cenozoic Coastal Plain sedimentary deposits. These have been drilled for oil and gas, and many borings have passed through these beds into older rocks of varied character. Not far south of the Fall Line these rocks are recognizably similar to the ancient metamorphic and granitic rocks—the true basement—exposed in the Piedmont region north of the Fall Line. Farther south, a series of igneous-volcanic rocks of varying character are found. These rocks show little or no metamorphism, and include shale, sandstone, ash beds, and granular feldspathic rocks which have been termed granite, but may be arkosic sedimentary rocks.

This report describes all available specimens of these older rocks, found as bottom cores or cuttings, by drilling below the Cretaceous or younger Coastal Plain sediments. Specimens have been examined from 29 counties, the northern ten of which are near the Fall Line. The bottom samples from the northern 10 counties are definitely basement; therefore, these counties are not underlain by a thick sequence of rocks of interest for oil and gas exploration. In the remaining 19 counties the bottom-hole rocks are principally a sedimentary sequence of pre-Cretaceous age cut by or perhaps interbedded with diabasic and rhyolitic volcanic rocks. These sedimentary and igneous rocks are described in some detail. In Pierce County, the bottom-hole rocks have a "granitic" aspect. These rocks have been interpreted as the result of contact metamorphism of an arkose (Milton) or the brecciation and hydrothermal alteration of granite. The latter opinion is generally held, and is subscribed to by one of us (VJH). In our description of this rock (the only one in which interpretation may vary significantly), we have tried to present all the data, so that the reader may draw his own conclusions. Until further drilling discloses unquestioned basement rocks, the possibility of oil or gas at greater depths than already drilled in these areas cannot be excluded.

This report also reviews what is known about buried Triassic rocks in states north of Georgia, and discusses the alteration of sandstones by igneous intrusions which results in rocks of granitic aspect. The possibility of Carolina Slate Belt rocks underlying the Coastal Plain is also discussed.

A brief section summarizes structural and geophysical data on the region, and their relation to the data of this report.

INTRODUCTION

This report describes all available specimens of rocks drilled beneath the Georgia Coastal Plain—that is to say, rocks older than the Late Cretaceous Tuscaloosa Formation—and reviews the literature relating to these rocks. Considerable attention has been given to what has been called "basement" in these wells; it appears that except for tests not far south of the Fall Line, in which unquestioned basement (granite, crystalline schists, etc.) was reached; very few and perhaps none of the tests in the southern part of the state reached such rock. Instead, the wells in the southern part bottomed in arkoses (some moderately metamorphosed as by intrusive contact), sandstones, shales, volcanic rocks, and ash beds—certainly pre-Tuscaloosa in age, but possibly younger than the known Paleozoic fossiliferous sedimentary rocks drilled in northern Florida and nearby Georgia. Expert opinion differs as to whether the bottom rock in Pierce County is meta-arkose or altered granite.

The term "basement" is used variously by different writers; for the purposes of this report, we define it as crystalline, igneous and metamorphic rocks of early Paleozoic or older age, underlying unmetamorphosed younger sedimentary rocks that may contain oil or gas. Such sedimentary rocks in Georgia are intruded locally by igneous rock, in part of probable Triassic age; in part, perhaps, older. Recent unpublished data by Robert E. Zartman of the U.S. Geological Survey (written communication, 1965) indicate a possible extension of Cretaceous volcanism in Arkansas and Mississippi to the eastern part of the United States; it is therefore possible that an age even younger than Triassic may be established for some of the buried Georgia volcanic rocks.

The age of these rocks underlying the Coastal Plain sediments is unknown, no fossils having been found, nor radiometric determinations having been made. No stratigraphic succession has been established for the series, and it cannot be shown that a sedimentary bed in one well is older or younger than a bed in another well. In attempting to suggest an age for these rocks, the geologist is inevitably influenced by his past experience, and emphasizes the similarities which exist between these rocks and those he has previously studied. Thus, to one geologist (Milton) who has worked extensively in Triassic rocks of the Atlantic seaboard states, the assemblage of fine-grained feldspathic sediments, diabases, and granophyres, suggests such rocks as are found extensively in the Triassic basins of the eastern states, and described by King (1959, p. 50):

"From Nova Scotia to South Carolina rocks of the Newark group of late Triassic age form long strips in the crystalline area; similar rocks have been encountered in wells under the coastal plain deposits as far south as Florida . . . they probably accumulated in down-faulted troughs . . . while the region still possessed considerable relief. The sediments are not metamorphosed or even folded, but have been tilted, warped, and broken . . . Sedimentation was accompanied by igneous and volcanic activity; in places the sediments are interbedded with basaltic lavas and intruded by masses of diabase . . . ."

On the other hand, geologists investigating the lower Paleozoic(?) mildly to moderately deformed sedimentary and volcanic rocks of the Carolina Slate Belt, which are similarly exposed from southern Virginia to central Georgia, have been impressed with resemblances of the Georgia bottom-hole rocks to rock types characteristic of the slate belt. Thus, W. R. Brown (1949, personal communication) classed the Atkinson County, Sun Oil Company—Doster-Ladson No. 1 bottom-hole volcanic rocks, as "altered silicic flow rock (aporhyolite?)" of Virgilina Slate Belt age, and recently H. D. Sundelius (personal communication) has noted lithologic similarities (detailed below) of many of the Georgia rocks of this report to slate belt types.

Apart from the question of ascribing an age to these rocks, there is a problem of classing them petrographically. Without such knowledge, one cannot even begin to relate them to the geological history of the region, or to discuss these rocks intelligently in relation to the possibility of finding oil or gas. A few of the rocks described in this report are of such character that their petrographic features may bear varied interpretation. Some, if not most, of these difficulties are inherent in the small size of the available specimens and the lack of satisfactory data as to their relation to rocks above and below; sometimes the processes which have produced these rocks are as yet imperfectly understood, and one cannot with confidence infer the nature and history of the rock from laboratory study alone. Also, erroneous designations applied to some of these rocks have persisted in the literature and some have led to further misinterpretations of the nature of the buried terrane. It is hoped that the data here presented will clarify our understanding of the Georgia subsurface rocks. In this report, the specimens are described and most are illustrated; their designation as to rock type represents the consensus of the petrologists who have examined them. Where differences exist the various views are presented.

As of now, there is agreement that below the Upper Cretaceous Tuscaloosa Formation is an extensive series of sedimentary and volcanic rocks that show little or no metamorphism. Mesozoic (Triassic) and early Paleozoic (Carolina State Belt) ages have been suggested. If the rocks in question are Triassic, then the possibility of older strata, as yet unreached by drilling, and containing oil or gas, may be considered. If the rocks are Paleozoic, chances of finding oil or gas would be lessened, but until unquestioned basement, i.e., granite, gabbro, crystalline schists, marble, etc., is reached, such possibility is not ruled out.

In this report, we briefly review the occurrence and character of Triassic rocks exposed or buried beneath younger sediments in the eastern United States; likewise, a brief statement is given for the Slate Belt series in the same general region; both of these have been considered as possible equivalents of pre-Cretaceous rocks found by deep drilling in Georgia. A description of transformation of arkose to "granite" in Finland and Connecticut is cited at some length; similar alterations are known in many places. We believe that such alteration of sediments by intrusive rock is shown by many of the cores and cuttings found by deep drilling in Georgia.

Following this general discussion the wells, not far south of the Fall Line, which did drill into true basement rocks (the buried continuation of the crystalline terrane exposed in the Piedmont) are first listed. Then the wells which drilled through the Coastal Plain sediments into sedimentary and igneous rocks of unknown age are reviewed, with special reference to the nature and depth of the bottom-hole rock.

From this, inferences as to the nature and configuration of the pre-Upper Cretaceous (Tuscaloosa) subsurface are suggested.

ACKNOWLEDGMENTS

In compiling this report, specimens have been obtained from many sources, especially from Paul L. Applin, of the U.S. Geological Survey (retired), M. W. Haas, Humble Oil and Refining Company, and the collections of the State of Georgia Department of Mines, Mining and Geology. Numerous colleagues of the U.S. Geological Survey, in particular Harold W. Sundelius and William B. Joyner, have commented helpfully on this manuscript; for the photographic illustrations of this report, we are indebted to J. Anthony Denson; and for the compilation of the map, to Amos M. White. Dr. A. S. Furcron, State Geologist of Georgia, has given valued suggestions in its preparation. The specimens and thin sections described in this report are now at the Geological Survey, Department of Mines, Mining and Geology, Atlanta, Georgia.

BURIED TRIASSIC ROCKS IN THE ATLANTIC COASTAL PLAIN

Many deep wells north of Georgia in the Atlantic seaboard have been drilled through the Coastal Plain sediments into recognized Triassic and older formations, and in some places into the true basement of metamorphosed granitic rocks and crystalline schists. A few such deep tests are noted below.

Cooke (1936) has recorded a well in South Carolina which at 1,580 feet passed from Upper Cretaceous into 980 feet of Upper Triassic(?) Newark(?) Group, in which diabase occurs at 1,630-1,645 feet, and again at 2,450-2,570 feet (total depth). The well was not drilled below this lower diabase, and similar (Triassic?) rock may extend much deeper.

Olivine diabase was found at a depth of 715 feet in Florence, South Carolina, and is considered, from its appearance, to be of Triassic age (C. Milton, unpublished data).

Swain (1947) has recorded 3,294 feet of pre-Tuscaloosa sedimentary rock in a well in North Carolina; the lower 728 feet, referred to "Pre-Trinity-Coahuila" appears from the published description to resemble the arkosic sediments found in the Georgia wells and the known Triassic outcrops of the middle Atlantic States. Granite was found beneath the pre-Tuscaloosa sediments.

Richards (1945a) has described a deep well on the Eastern Shore of Maryland, which at 5,360 feet entered 269 feet of Triassic (Newark Group) red and greenish shale with alternating layers of coarse arkosic sandstone. Above the Triassic is early Lower Cretaceous or possibly Jurassic siltstone or claystone, nearly all, or all, nonmarine. Below the Triassic is a granite complex.

Richards (1945b) lists a well in Virginia (Bowling Green, Caroline County) as passing from Lower Cretaceous at 1,160 feet into 390 feet of Triassic sedimentary rocks.

It is clear from the foregoing citations that characteristically Triassic sedimentary rocks and diabase, as well as an extensive Lower Cretaceous (Jurassic in part?) section have been recognized as underlying the Coastal Plain north of Georgia. There is no evident reason why similar rocks should not extend into Georgia and even into Florida. As a matter of fact, most of the Georgia wells here studied do go into diabase-basalt or arkosic sediments at depths, and with a relationship to the overlying rocks that suggests a Triassic age. The few wells which entered other types of rock—rhyolite, agglomerate, tuff—may also be considered to be of the same general age, for volcanic rocks of these types are known elsewhere to be associated with diabase and arkosic sediments. Dunbar (1960, p. 278) mentions ashes and bombs from a small area near the Holyoke Range in Massachusetts.

An extensive Triassic section in North Carolina, where the most southerly known Triassic exists, has been described by Reinemund (1949), who gives a generalized stratigraphic section of several thousand feet in thickness. Resting on "metamorphic rocks, mainly schist," is a gray basal conglomerate, some 20 feet thick followed by about 1,700 feet of red siltstone and claystone in lenticular beds. This is followed by a gray siltstone and fine-grained sandstone, about 200 feet thick, then the Deep river coal bed, above which is several hundred feet of black and gray shale. Above this is several thousand feet of red siltstones and claystones, with lenticular beds of buff, coarse-grained arkosic sandstone and conglomerate in the upper part. Numerous diabase bodies cut the entire series.

The similarity of the rocks of this series to those found in many of the wells in the southeastern states needs no stress. However, with the limited information now available, it would be futile to attempt any detailed correlation between this section and anything in deep wells, even in nearby regions, let alone southern Georgia, as these continental clastic strata, being formed under local conditions controlled largely by topography, are essentially lenticular and discontinuous.

Continuing this survey of known and presumed Triassic rocks southward, we find in the Piedmont region of Georgia numerous diabase dikes (Lester and Allen, 1950) as also shown on the Geologic Map of Georgia (Stose and Smith, 1939). Many of the dikes are contiguous to the Fall Line, and their abundance suggests the presence of similar rocks under the Coastal Plain to the south. In several Georgia deep tests, the drill passed into and through diabase. Lester and Allen (1950) note the absence of sills in the Piedmont; this is to be expected because basalt and diabase weather readily, and thin exposed sheets would be easily removed. An almost vertical dike, however, would persist far longer.

It may be noted that Hotz (1949) states that "From bore hole records Triassic rocks are known as far south as Florida." However, he does not cite substantiating data, and probably he was inferring a Triassic age for such rocks from their general lithologic character.

A possible age of some of the pre-Coastal Plain sedimentary rocks is Early Cretaceous; however, the vast thickness of Coastal Plain sediments implies a corresponding erosion of older formations to the north and west to supply such material. For this reason, it is improbable that the Tuscaloosa (basal Upper Cretaceous) rests generally on rocks not much older; more likely a considerable unconformity exists, and the underlying rocks are at least as old as Triassic, which is known to fill troughs several thousand feet in depth.

The possibility that the basalts, rhyolites, tuffs, and sandy sedimentary rocks in southeast Georgia may be part of the slate belt series of early Paleozoic age also cannot be excluded, as suggested by Brown (written communication, 1949) for the ash or rhyolite drilled in Atkinson County, Georgia, discussed below.

Finally, a Paleozoic age, younger perhaps than the Carolina Slate Belt, may be considered. In northern Florida subsurface sedimentary rocks of such age have been dated by fossils. Fossils have not been observed in the Georgia subsurface rocks discussed in this report.

SLATE BELT ROCKS OF THE EASTERN UNITED STATES

Older than the Coastal Plain sediments, but probably younger than Precambrian, is a mildly metamorphosed series of generally fine grained sedimentary and volcanic rocks, found in areas from southern Virginia to central Georgia. In a few places (Arvonia and Quantico, Virginia) Ordovician fossils have been found. Although the series is termed "slate belt," true slate is a minor feature. Sundelius, who has studied the series in North Carolina, describes the Carolina Slate Belt rocks in the following terms (written communication, 1965).

"The slate belt rocks are comprised of interbedded volcanic and epiclastic rocks that are only mildly metamorphosed. Among typical slate belt rocks are argillite, siltstone, fine-grained sandstone, rhyolitic tuffs and flows, and andesitic to basaltic tuffs and flows. These rocks are, of course, cut by Triassic diabase dikes which are black, fine-grained, very fresh, and unmetamorphosed. In general, the basaltic rock (flows, in part, amygdular; tuff, and tuff breccia) in the slate belt are now greenstones and are comprised mainly of plagioclase-chlorite-epidote-amphibole and some calcite. Rhyolitic and rhyo-dacitic volcanic rocks occur as flows, tuffs (in part welded?), crystal tuffs, and crystal-lithic tuffs.

"The epiclastic slate belt rocks, i.e., argillite, siltstone, and fine-grained sandstone, are generally well-bedded and are comprised dominantly of quartz and feldspar (mainly plagioclase) in a fine-grained micaceous matrix that contains both muscovite (sericitic white mica) and chlorite. Epidote, sphene, pyrite, and magnetite occur in accessory amounts. Some of the siltstone is calcareous. True arkoses do not occur in the section with which I am familiar, but feldspathic (mainly plagioclase) siltstone and sandstone occur."

In the descriptions of the various specimens below, Sundelius' suggestions as to possible slate belt relationships are noted.

PSEUDO-GRANITIZATION OF ARKOSE IN FINLAND AND CONNECTICUT

The origin of granite and granitic-appearing rocks generally is a major petrologic problem, and more than a century of investigation has not settled all controversy. It is now generally agreed however, that clastic siliceous-feldspathic sediments may re-crystallize into rocks eventually indistinguishable from granite, and that all degrees of this transformation may exist. It may be, as in Pierce County, that alteration is so far advanced that a sedimentary origin would not be recognized, and the rock would be accepted as truly magmatic. Some students go so far as to assert that **all** granite represents ancient metamorphosed sediments—unlike basalts and diabases, which are thought to represent a primitive fluid layer of the earth's crust.

Without entering these far-reaching speculations, we may consider a few specific examples of such alteration by diabasic intrusives of sedimentary rock into granite-like rock, which should be considered in lithologic studies of such altered ("granitic"?) rocks in Georgia. A study by Kahma (1951) is especially instructive. He shows that sandstone has been partially remelted by diabase, and enabled to flow into joint cracks of the cooling diabase. In Finland, the unmetamorphosed ("no traces of metamorphism") Jotnian Formation is Precambrian, though younger than the Archean metamorphic rocks surrounding it, and consists of rapakivi granite, sandstone, and diabase. Kahma discusses three types of metamorphism caused by intrusion of hot diabase magma into granite and sandstone. In the first of relative low grade (pages 16-17),

". . . The larger quartz grains have rather smooth surfaces in the normal sandstone, but, on approaching the contact, they become toothed (Figure 4, Plate I) while at the same time the fine-grained cement decreases. A fine-grained aggregate of quartz, pigmented feldspar, muscovite and chlorite occurs between the larger quartz grains in the sandstone about 5m. apart from the contact. This fine-grained aggregate has almost entirely vanished at the contact and instead the bigger quartz grains have become toothed, thus joining the constituents of the sandstone more firmly than normal. Neither sericite nor chlorite are found in the sandstone at the contact proper, but instead there are dirty shreds of biotite. Moreover, neither twinning of the feldspar nor perthitic growth of potash feldspar can be detected in the contact zone under the microscope. This also seems to be a result of a contact influence."

Laitakari (1925) is cited by Kahma (p. 18) with reference to a granitized sandstone boulder: "This . . . much resembles granite." A notably stronger degree of metamorphism is discussed by Kahma (p. 23) who cites Sederholm's description of diabase intruding granite; the latter has been partially melted, and a quartz-feldspar melt reciprocally intruded **into** the diabase; the melt has crystallized with micrographic texture.

Finally, extreme metamorphism is shown in a body 20-30 meters thick which is considered to be a hybrid rock, derived from melting of an original granite lens about 7-8 meters thick, enclosed between two diabase sills (p. 40-43).

In the United States, Heald (1956) has described cementation of Triassic arkose in Connecticut and Massachusetts, and believes that most of the cement in these arkoses remote from igneous rocks is nevertheless of igneous origin. He observes that "a magmatic source for cement should not be ruled out even though effects of hydrothermal activity may be absent."

Hotz (1949) in a detailed study of the Dillsburg, Pennsylvania, diabase and associated rocks, describes the granophyre found there. This so-called "red-rock," consists mostly of quartz and feldspar, both often intergrown in micropegmatite. Hotz considers granophyre to be, in general, a late-stage differentiate of the diabase magma; but recognizes that elsewhere anatexis by ingestion of silicic rocks may result in a granophyre. He notes that turbid feldspars are characteristic of such rock.

Many of the Georgia rocks, illustrated below, which have been called "basement" rocks, show features such as Kahma and Hotz describe.

STRUCTURE UNDER THE COASTAL PLAIN

Herrick and Vorhis (1963) present a structure-contour map (500-foot contour interval) of the pre-Cretaceous surface which is in good agreement with the "basement" depth shown on our map (figure 28). The major features of the subsurface they describe are the "Gulf Trough of Georgia," plunging from the center of the state southwestward through the Tallahassee region of Florida into the Gulf of Mexico; and a shallower "Atlantic Embayment of Georgia" ("Savannah-Southeast Georgia Basin") sloping southeastward in southeastern Georgia.

Murray (1961) discusses the Savannah (Southeast Georgia) Basin; the basement is said to be about 6,000 feet in depth near Savannah, and deepens offshore. The age of the overlying deposits is said to range from possibly early Mesozoic to late Cenozoic. Murray shows a map (p. 99) with the boundary of the Savannah Basin, also the Southwest Georgia Basin. A structure section of the Ocala arch of Florida and Southern Georgia (after Gunter and Vernon, 1954) (also on p. 99, Murray, 1961) summarizes the scanty published data.

The depths at which igneous rock or volcanic ash was found in the various counties may be reviewed, for what light may be cast on the problem of the nature and structure of the pre-Coastal Plain terrane.

Considering the depths to volcanic rock shown on the map (figure 28), the Laurens County depth to diabase of 2,546 feet, the shallowest recorded, agrees with the relatively thin cover of Coastal Plain sediments near the Fall Line. At the same general position with reference to the Fall Line is the Montgomery County well; not far southeast of it the depth to igneous rock is 3,390 feet. West of Laurens County, volcanic rock was found in Pulaski County at about the same depth, 2,635 feet; and after penetrating approximately 50 feet of such rock, the drill passed into a sandy sedimentary sequence bottoming at a depth of 3,463 feet. In Dooly County, immediately west, volcanic rock was not found, but from 3,720 feet to 3,748 feet (total depth), feldspathic sandstone or arkose was drilled. Still farther west in Sumter County, at 2,981?-2,998 feet T.D., diabase was drilled. Another Sumter County well drilled much deeper, to 5,240 feet, presumably also in pre-Tuscaloosa rocks.

South of this block of five counties, extending east to west in south-central Georgia, are three counties, Liberty on the coast, Appling near the middle, and Calhoun near the western edge. Liberty County may be considered with two other seaboard counties to the south, Glynn and Camden. In Liberty County at a depth of 4,254 feet is a rock classed as quartz rhyolite porphyry. It could perhaps also be classed as an intensely altered arkose; in Glynn County, rock of similar nature shows the characteristics of granophyre and is at a depth of 4,737 feet, correlating perhaps with a southward dip of the pre-Tuscaloosa surface of some 10 feet per mile. Farther south, in Camden County, and at a similar depth (4,702 feet) volcanic ash was found to a total depth of 4,955 feet. In Appling County basaltic rock was found at about the same depth as in Liberty County; and a similar rock in Calhoun County at a considerably greater depth of 5,265 feet.

Sundelius (written communication) considers that the Camden, Glynn, and Liberty County rocks resemble slate belt rather than Triassic types.

In Mitchell County in southwest Georgia, at considerably greater depth, 6,550-6,612 feet, and again at 7,375-7,377.5 feet, diabase was found, with clastic rocks at 7,487 feet T.D. These depths correspond to a general southward slope of the pre-Tuscaloosa erosion surface, with perhaps a strong westward component also. This is also suggested by the depths to igneous rocks or ash beds in the three counties some 60 miles east, in which igneous rock or ash is found several thousand feet higher (Atkinson County, ash at 4,296 feet; Clinch County, ash at 4,348 feet and amygdaloidal basalt at 4,190 feet; and Echols County, diabase at 4,130-4,140 feet). Data of Woollard and others (1957) also suggest a westward dip of the basement, namely, from 4,088 feet depth in Atkinson County to 5,355 feet 20 miles west in Tift County.

The shallow depth of igneous rock in these three central-southern counties, with appearance of what may be Paleozoic at similar shallow depth, suggests a northerly extension of the Ocala Uplift of central northern Florida.

The depth to basement near Savannah of some 6,000 feet noted by Murray (1961) indicates that a considerable thickness of sediments, possibly exceeding 2,000 feet, underlies the bottom depths reached in the three coastal county wells.

The Screven County well, T.D. 2,677 feet, and the Treutlen County wells, T.D. 3,180 feet and T.D. 3,240 feet, all bottomed in true basement rocks. All counties south of the Fall Line in which true basement has been reached are shown in solid outline on the map.

On the gravity map of Georgia a major anomaly is indicated as a 50-milligal high located approximately at 31°30′ N. lat., 83°25′ W. long. Only one well, the Atkinson County Sun Oil Doster-Ladson No. 1 was drilled near it. The bottom-hole rock at 4,220-4,296 feet T.D. is volcanic ash or rhyolite tentatively assigned to the Virgilina Group of Laney (1917) by Brown (1949, written communication) or the possibly equivalent Carolina slate belt by Sundelius and others. Calculations by W. B. Joyner (1964, written communication) indicates that if such an anomaly were to be ascribed to a volcanic rock or to a sill, a tremendous thick sheet of diabase, on the order of 10,000 feet, would be required. Ruling out a volcanic rock, and assuming that the anomaly reflects density variations in the basement, as for example between densities of granite and gabbro, he finds that the depth to this basement cannot exceed 12,000 feet and is probably substantially less. With some 5,000 feet of Coastal Plain sedimentary rocks, this would leave at most some 7,000 feet of strata between the Coastal Plain and basement.

Some seismic determinations of depth to "basement" have been determined by Woollard and others (1957). These depths presumably indicate the floor of the Coastal Plain strata, and not necessarily the metamorphic rocks of the Piedmont. Commenting on these data, W. B. Joyner (written communication, 1964) observes: "The velocities are all within the same range that Woollard recorded from measurements over the granites, schists, and gneisses in the Piedmont where those rocks are exposed at the surface. The velocities are too high for Triassic sediments and seem rather low for diabase. They are similar, however, to velocities recorded on rocks of the Carolina Slate Belt. They are also about what one might expect from Paleozoic limestones."

WELLS PENETRATING TRUE BASEMENT IN GEORGIA

About a dozen Georgia wells have passed into unquestioned basement, i.e., granite and crystalline schists, Paleozoic or older. All are in ten counties not far south of the Fall Line as shown on the map (figure 28). For the wells, location, drilling company and date, total depth (in feet) and type of basement rock are given below if known.

References: Applin, 1951, unless otherwise noted.

Burke County

2.5 miles east of Greens Cut—Three Creeks Oil Company (1923).

T.D.: 1,033 feet Crystalline rocks

Chattahoochee County

Cusseta (water well).

T.D.: 1,205 feet Hornblende schist (figure 1)

Richmond County

Allen's Station, 9 miles south of Augusta-Three Creeks Oil Company (1921).

T.D.: 400 feet Crystalline rocks

Jefferson County

3.5 miles southwest of Louisville—A. F. Lucas and Georgia Petroleum Oil Well (1907)

T.D.: 1,143 feet Crystalline rock

Washington County

Twelve miles northwest of Sandersville—Middle Georgia Oil and Gas Company (1920).

T.D.: 400 feet (approximately); crystalline rock

Figure 1. Thin section, plane-polarized light; from water well in the city of Cusseta, Chattahoochee County, 1200-1205 ft. depth.

Hornblendite

Consists essentially of blue-green hornblende (black in the hand-specimen), clear quartz, turbid alkalic feldspar, brown biotite, and pale green chlorite. The feldspar appears to be in part orthoclase, in part oligoclase. The characteristic schistose structure of this rock is evident.

Two miles southwest of Tennille—Layne-Atlantic's N.S.C. Water Well (1945).

T.D.: 872 feet. Granite

Reference: McClain, 1953

Houston County

LL 266, LD 13—Gilbert No. 1—Tricon Minerals, Inc. (1949).

T.D.: 1698 feet. Biotite gneiss

LL 44, LD 14—J.D. Duke No. 1—Tricon Minerals, Inc. (1949).

T.D.: 1494 feet. Biotite gneiss

Macon County

LL 182, LD 1—Forhand No. 1—Merica Oil (1954).

T.D.: 2139 feet. Schist

Reference: Hurst, 1960

Marion County

LL 207, LD 1—J. F. Bergin No. 1—Lee Oil and Natural Gas Company and Canadian Exploration Syndicate (1956).

T.D.: 1764 feet. Basement

Reference: Hurst, 1960

Screven County

Four miles N. 89°E. of Newington—F. W. McCain-Hattie H. Pryor No. 1 (1963).

T.D.: 2677 feet. Basement (granite)

Reference: Rinehart Oil News Company, 1964.

This, with the Treutlen County wells, represents the greatest distance south of the Fall Line in which drilling entered unquestioned basement, i.e., passed through the entire sequence of sedimentary rocks.

Treutlen County

Barnwell No. 1 Jim Gillis, 3 miles east of Soperton.

Elevation 356 feet. Completed 8-24-61, T.D. 3,240 feet in "Paleo" (metaquartzite).

Reference: Rinehart Oil News Company, 1962.

McCain and Nicholson H. Gillis No. 1, 7 miles east of Soperton

Elevation 343 feet. Completed 12-1-1962, T.D. 3,180 feet in "Basement" biotite gneiss.

Reference: Rinehart Oil News Company, 1963.

Although Treutlen County is some distance (50 miles) south of the Fall Line, the above two wells undoubtedly drilled into true basement (crystalline metamorphics). The depths reached are some 500 feet below the Laurens County well which reached diabase at 2,546 feet.

NON-BASEMENT DEEP TESTS IN GEORGIA

Counties in which rocks younger than basement were reached beneath the Coastal Plain with depths and bottom rock as listed below. These are the counties outlined heavily on map (Figure 28).

	Depth	Bottom Rock
Appling	4,108	Basalt
	4,098	"Quartzite"
Atkinson	4,296	Volcanic ash (or rhyolite?)
Calhoun	5,273	Basalt or diabase
Camden	4,955	Volcanic ash (or rhyolitic tuff)
Clinch	4,588	Volcanic ash or siltstone
	4,190	Amygdaloidal basalt
Dooly	3,748	Arkose
Echols	4,062	Quartzite (Paleozoic)
	4,185	Shale and sandstone (Paleozoic) (Diabase 4,115-4,150)
Glynn	4,737	Granophyre
Laurens	2,546	Diabase
Liberty	4,254	Quartz rhyolite porphyry (granophyre?)
Mitchell	7,487	Sandstone (diabase sills)
Montgomery	3,433	Diabase
Pierce	4,375	Granite?* Arkose?**
	4,355	Granite?* Arkose?**
Pulaski	2,710	Diabase
	2,895	Diabase
	6,035	Sandstone (diabase sills)
Sumter	2,998	Arkose-sandstone (diabase sills)
	5,240	(no samples)
Toombs	3,681	Arkose
Wayne	4,620	Arkose
	4,541	Volcanic ash
Wheeler	4,002	Siltstone

* Interpretation of V. J. H.
** Interpretation of C. M.

Appling County

LL 522, LD 2—1 mile northwest of Baxley, J. E. Weatherford—S. J. Felsenthal, Mrs. W. E. Bradley No. 1 (1947)

Elevation: 229

T.D.: 4108 ft. Basalt

References: Applin, 1951; Hurst, 1960

This is basaltic volcanic rock. The minerals are those of diabase, but the structure of the rock is different, reflecting different conditions of crystallization of similar magma. Such amygdaloidal variants of diabase are often found and are not necessarily, or even probably, flows, as implied by Applin (1951) who cites F. F. Grout: "altered amygdaloidal basalt, probably a lava flow." Figure 2 shows the appearance of this rock in thin section.

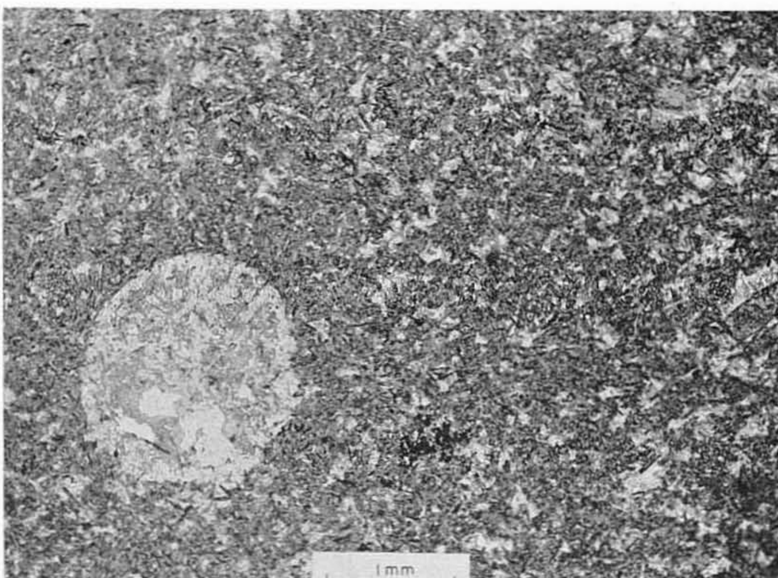


Figure 2. Thin section, plane-polarized light; Appling County; J. E. Weatherford, S. J. Felsenthal, W. E. Bradley No. 1. 4,106-4,108 ft. (bottom).

Amygdular basalt

Amygdular basalt. Volcanic rock, possibly related to diabase of other wells. It is somewhat pyritized, as are other diabasic rocks. The rounded mass is an amygdular cavity (gas bubble) which has been filled with well-crystallized quartz, feldspar, chlorite, and calcite; the groundmass is obscurely crystallized plagioclase, augite, chlorite, and iron oxide.

Circular 3, Georgia Geological Survey (McClain, 1953) does not list this well, but does list a Martin and Harris Drilling Contractors, S. J. Felsenthal No. 1 LL-552 southeast second District, 7 miles north west of Baxley. Completed June 16, 1947 at 4,098 feet in "quartzite (lower Cretaceous crystalline??)."

Apparently the first well drilled into a basaltic sheet, and the second into a sandstone which may have been indurated by the basaltic intrusive. Sundelius (written communication, 1964). notes that this rock resembles similar basalts from the slate belt and is altered to a greater extent than Triassic diabase that cuts slate belt rocks. However, Triassic diabase from other regions does show extensive alteration. The occurrence of normal diabase in nearby Montgomery, Laurens, and Pulaski Counties suggests that this rock may be a variant of the same magma. In New Jersey, Pennsylvania, and other states, both Triassic diabase and basalt occur.

Atkinson County

LL 71, LD 7—Sun Oil Company—Doster-Ladson No. 1 (1945).

Elevation: 222 ft.

T.D.: 4,296 ft. Altered volcanic ash or rhyolite

References: Applin, 1951, Hurst, 1960.

Applin (1951) gives the top of the volcanic rock at 4,220 feet giving 76 feet of volcanic rock, which he lists as "Paleozoic" or "pre-Cambrian." In an earlier publication (Applin and Applin, 1947) the interval 4,282-4,296 feet T.D. is termed "schist," above which is 442 feet (from 3,840 to 4,282 feet) of pre-Atkinson Lower Cretaceous, indicated as sandstone and shale, apparently similar to "The unfossiliferous littoral or nonmarine sandstone and the red shale, which compose the lower member of the Atkinson in the northern part of the Alabama and Georgia Coastal Plain . . . ." (Applin and Applin, 1965, p. 66).

The specimen is a gray fine-grained (aphanitic) rock, sparsely veined with calcitic material. In this section it shows a confused felsic aggregate, heavily strewn with black opaque iron oxide grains. Small alkali-feldspar phenocrysts are best seen under crossed nicols; more abundant are irregular veinlets of calcite and epidote, or quartz with chlorite. Neither shard structures, indicative of ash, nor flowage lines, indicative of rhyolite, were observed. Rhyolitic rocks are known to have formed from material which reached the surface under explosive conditions as a glowing mass which moved as an avalanche ("nuee ardente"). Such rocks could be termed either tuff or rhyolite.

This rock is illustrated in figure 3. It may be instructively compared with the ash in Clinch County described by Ross (1958). It could be hydrothermally altered volcanic ash with many disseminated opaque ore grains, and epidote-calcite veinlets. The absence of ordinary detrital minerals and lack of bedding or stratification, imply rather rapid deposition in still water, at some distance from the volcanic vent, but near enough to undergo moderate permeation by mineralizing (calcite-epidote bearing) fluids. The possibility of this rock being massive rhyolite may also be considered.

Woollard and others (1957) from seismic data find "basement" at 4,088 feet near the Atkinson County well, and Joyner (1964, written communication) notes that the "basement" velocity (16,900 feet per second) is similar to velocities observed in Carolina Slate Belt rocks. Sundelius (written communication, 1964) notes the similarity of the Atkinson County rock to slate belt rocks.

Dr. W. R. Brown's examination (unpublished data) of cores from this well first suggested correlation of the volcanic rock from this well with similar rocks in the Virgilina basin and related basins of volcanic rock to the northeast in the Piedmont province of Virginia and North Carolina. This correlation appears to have been the source of the widespread belief on the part of southeastern geologists that the volcanic rocks of the regional deep wells were Paleozoic or older. Seeking to learn the reasons for such a correlation, the author (Milton) wrote to Professor Brown, who replied: *

"Concerning my report on the core 148 Doster-Ladson No. 1 well, Atkinson County, Georgia, the basis for my correlation with rocks in the Virgilina basin and similar basins to the east is entirely indirect. With present knowledge it could hardly be otherwise. However, I feel that the indirect evidence is rather strong.

"The rocks of the Virgilina basin and related basins in Virginia and parts of North Carolina where I have examined them are

*Letter W. R. Brown to Charles Milton, May 24, 1949.

largely volcanic. Altered rhyolites, andesites, probable basalts, and tuff are included. Sediments derived largely or in part from these also occur. Silicic rocks are prominent enough for Mrs. A. Stose to lump much of the outcrop under the name "aporhyolite" on the Virginia State Geologic Map. The rock from the Doster-Ladson well, as nearly as I could determine is an altered silicic flow rock (aporhyolite?). The degree of alteration or metamorphism seems not to be out of line with that prevailing in the rocks of the Virgilina basin. Because of its degree of metamorphism, I think that it does not belong with the numerous unmetamorphosed flow rocks encountered to the south in the Florida wells. The occurrence of fragments of volcanic (surface) rocks, possibly tuffaceous materials in somewhat metamorphosed rocks in at least one other well in southeastern Georgia suggest a not too limited occurrence in this region for flow rocks, possibly of similar age. The basins of Virgilina and related volcanics

Figure. 3. Thin section, plane-polarized light; Atkinson County, Georgia, Sun Oil Company, Doster Ladson No. 1, 4,282-4,285 ½ ft.

Volcanic ash (or rhyolite?)

Hydrothermally altered volcanic ash or rhyolite with disseminated opaque ore grains (black) and epidote-calcite veinlets (upper and lower) in obscure felsic matrix with scarce alkalic feldspar phenocrysts.

extend, with some breaks, from north of Richmond, Virginia, southwest across North Carolina into South Carolina, where they disappear beneath Coastal Plain sediments. Is it too much to believe that they possibly, or probably, continue (with similar breaks) beneath these sediments as far as south-central Georgia?"

Commenting on these views Philip B. King (written communication 1964), referred to the possible Ordovician age (radiometric) of volcanic rocks in North Carolina; but considers the relation of subsurface volcanics in Georgia to the Virgilina volcanic belt as yet undetermined.

Recently, well-preserved fossils have been found in lower Paleozoic beds in New England, but these occur in definitely metamorphosed rock (schists, etc.). Therefore, evidences of metamorphism, or its supposed absence, must be appraised cautiously, as indicative of relative ages.

Calhoun County

LL 328, LD 4—J. W. West No. 1—C. E. Walters and Sowega Mineral Exploration Company, Inc. (1950)

Elevation: 345 ft.

T. D.: 5273 ft. Basalt or diabase

References: Applin 1951, Hurst 1960

The specimen (5265 ft.) is aphanitic, brown with bright red spots and thin greenish-black chloritic streaks.

In thin section (figure 4) it is seen to be a microcrystalline volcanic rock, consisting essentially of laths of calcic plagioclase feldspar. Colorless diospide-augite is fairly abundant in relatively minute more or less euhedral grains. The conspicuous red spots in the rock are seen to be iddingsitic (?) replacements of coarse disseminated olivine (?). Muscovite, or a similar mineral, is sparingly distributed in the feldspar. No quartz or iron oxide minerals are present.

The rock is a variant of the basaltic-diabasic and related rocks found elsewhere in southern Georgia (Appling County, etc.).

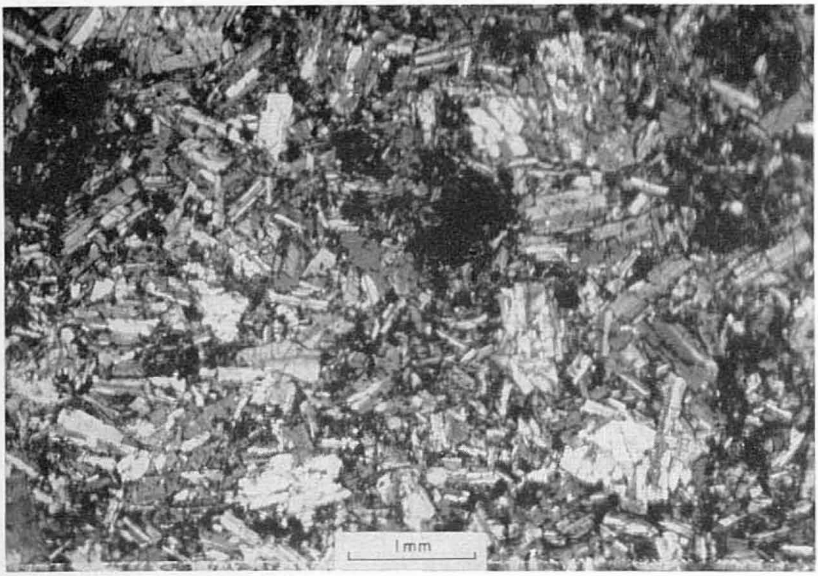


Figure 4. Thin section, crossed nicols; Calhoun County, Sowega Mineral Company, J. W. West No. 1, 5265 fet.

Basalt (or diabase)

The characteristic lamellar twinning of plagioclase feldspar is shown under crossed nicols.

Camden County

Unsurveyed area, lat. 39° 03′ 01″ north, long. 81°52′ 48″ west, about 6 miles southwest of Tarboro—California Company — John A. Buie No. 1 (1948).

Elevation: 65 ft.

T. D.: 4955 ft. Volcanic ash and rhyolitic tuff

References: Applin, 1951; Hurst, 1960

The following specimens were examined:

Core No. 8 4,702-4,711, recovery 2½ feet; ash

Core No. 9 4,779-4,786, recovery 3 feet; ash with quartz- calcite veinlets

Core No. 11 4,952-4,955, recovery 2 feet; ash with quartz-calcite veinlets, epidotic debris, etc.

This well drilled through 281 feet of ash. Figures 5 and 6 show typical aspects of ash or tuff in thin section. Sundelius (written communication 1965) notes that these tuffaceous rocks are quite similar to material from the slate belt in terms of mineralogy, bedding characteristics, lenticular laminate bedding, graded bedding, texture, and color.

Six specimens were examined, as follows:

Core No. 8, 4,702-4,711, recovery 2½ feet.

These fragments to 2 inches in size are aphanitic, buff-gray, and apparently rimmed or completely replaced by similar material of a red-brown color.

Microscopically the rock is an aggregate of euhedral felsic fragments, strewn with opaque dark brown or black iron oxide: there is also submicroscopic reddish dust throughout the section. With some of the coarser dark material is a little bluish green chlorite suggesting the former presence of mafic silicates, of which none remain. Feldspar, twinned (plagioclase) and untwinned (orthoclase?) are fairly abundant though small; some of the plagioclase is subhedral. Minute apatite is also present.

The rock could be ash or rhyolite tuff.

Core No. 9, 4,779-4,786 (recovery 3 feet):

(a) top of 1¼ feet.

Gray, fine-grained, with white calcitic streaks and seams. This shows strong layering shown both by banding of opaque oxide particles and alternation of fine and coarse-grained layers. Figure 5 illustrates this.

(b) middle of 1¼ feet same rock.

(c) bottom ½ foot.

This is also gray, fine-grained, slightly coarser. The white calcitic streaks are absent, but a single face of the small specimen (1½ inches) has a thin seam of pinkish-stained calcite.

This as shown in figure 6 does not show layering, but deformed altered micaceous shreds indicate sedimentation rather than flowage of a rhyolite. The rock consists of abundant euhedral fragments of feldspar and quartz, and brown isotropic areas probably glass now partly devitrified. Chloritized contorted mica wisps, minor epidote, calcite, and apatite are present in the matrix.

Microscopically these three specimens all from 1¼ feet of core show distinctive features indicative of an ash fall rather than a rhyolitic flow.

Core No. 11, 4,952-4,955 (recovery 2 feet):

(a) from top foot.

Dense light-gray stony texture, with minute glassy quartz, and bluish chlorite film on slickensided surface.

Microscopically, it consists mostly of rather turbid sodic plagioclase grains, quite irregular in shape, though some are subhedral; and fewer similarly sized quartz grains. These are in a matrix with much fine grained epidote and chloritic debris. There are no opaques, and calcite veins are few.

(b) from bottom 6 inches.

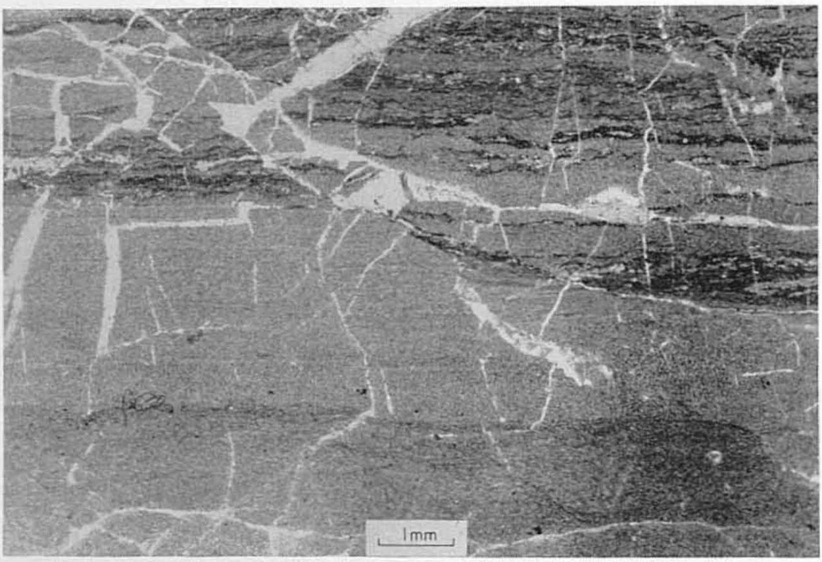


Figure 5. Thin section, plane-polarized light, Camden County, California Company, John A. Buie No. 1, 4,779-4,786, top 1¼ ft.

Volcanic ash

Fine grained ash with calcite-quartz veins. Note resemblance to Atkinson County, Sun Oil Company, Doster-Ladson No. 1, 4,282-4,285 ½ ft. (figure 3).

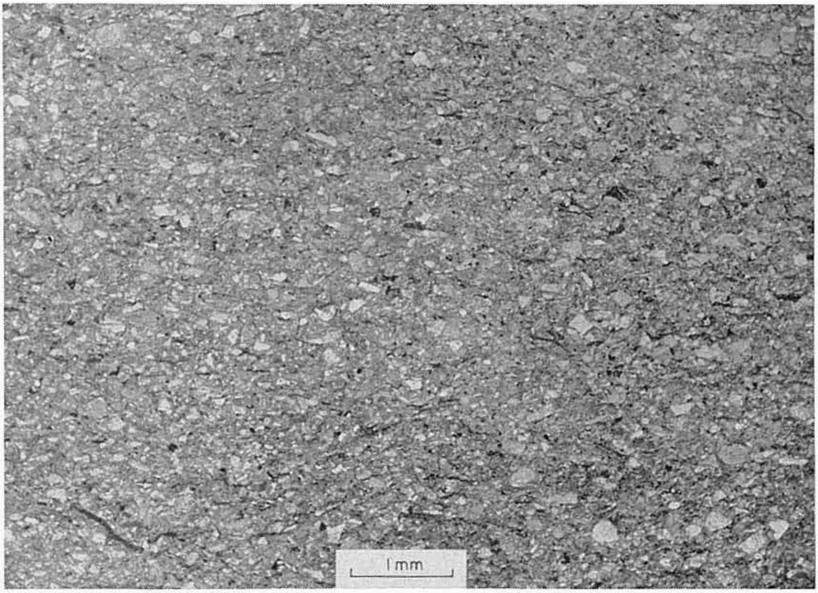


Figure 6. Thin section, plane-polarized light; Camden County, Georgia—John A. Buie No. 1—Core No. 9, 4,779-4,786 bottom ½ foot.

Rhyolitic Tuff

The darker areas are micaceous debris.

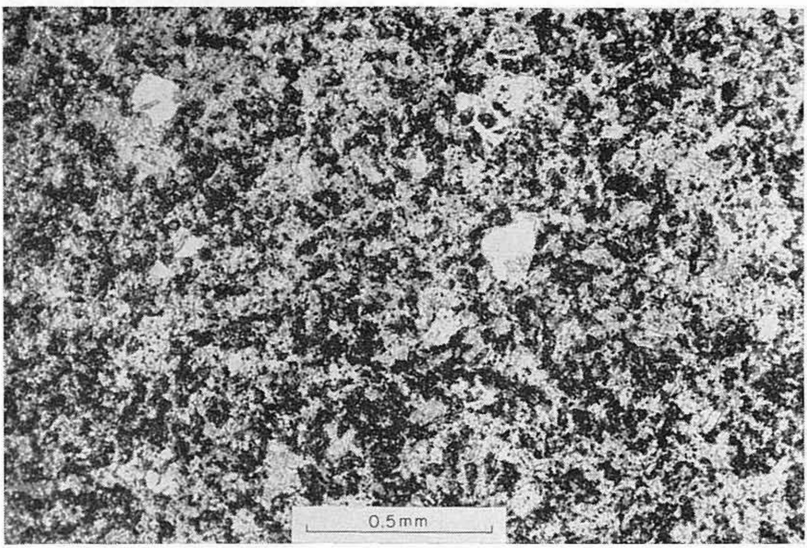


Figure 7. Thin section, plane-polarized light; Camden County, Georgia, California Co., John A. Buie No. 1, 4,952-4,955 ft.

Epidotized volcanic ash

The dark mineral is mainly pale yellow epidote, in an obscure feldspathic matrix. The clear areas are quartz; most of the turbid matrix is feldspar. Calcite veins with euhedral quartz and epidote cut the rock.

Dense very fine grained, with scanty quartz seams, and very scarce feldspar phenocrysts.

This is an obscurely crystallized aggregate of felsic material and epidote, in which are strewn coarser particles of quartz and feldspar. The rock is cut by veinlets of calcite, epidote, quartz, and feldspar (figure 7).

(a) and (b) have somewhat different color and textural aspect.

Clinch County

LL 36, LD 13—12 miles east of Fargo—Brady Belcher et al.—

Lem Griffis No. 1 (1952)

T. D.: 4,588 ft. Tuff

References: Ross, 1958; and Hurst, 1960

A core from 4348 feet was studied. The core consists of tuff of volcanic origin, hard, compact, and very fine grained. It has in general a dark brown color, but a band a centimeter or so wide is slightly coarser, and nearly black. This band cuts the core axis at a low angle. At right angles to the axis, however, are thin fissures filled in part by calcite, some of which is bright red, owing to iron oxide inclusions, and in part by feldspar showing lamellar twinning. These microscopic fissure fillings are in all probability hydrothermal.

Under high magnification abundant particles of finely crystallized or devitrified volcanic rock can be seen, with angular plagioclase and quartz fragments, as well as chloritic material. There are no visible ordinary detrital minerals showing evidence of attrition, such as tourmaline, zircon, etc.

The rock would, therefore, be interpreted as deposited in fairly still water (as shown by uniformity of fine-grain size in the several bands) from ash fall of fairly distant origin. The variation in coarseness of the bands may reflect varying wind velocities and directions, violence of explosive outbursts, water currents, and similar factors. The bright red calcareous feldspathic veinlets are probably of remote hydrothermal origin, and indicate that after deposition and at least partial compaction of the beds, volcanic activity continued.

A quite different sample of hard pink and gray "granitic" rock labeled "George J. Marott et al. LL 36 LL 13 Lem Griffis No. 1 somewhere between 3,983½ to 4,399 feet Clinch County, Georgia" was received from A.S. Furcron, February 10, 1964.

In thin section the rock is seen to be composed of glassy shards, completely devitrified, and in large part replaced by a zeolite (laumontite?). Vesicles filled with green chlorite; small grains of zoisite (?) and titanite are seen, also thin calcite veins.

This is probably one of the rocks described by C. S. Ross (1958), who examined cores from this well, from 3, 981 to 4,119 feet. Cuttings also were examined from 3,830-3,870 feet (rhyolite) and 4,330-4,470 feet (igneous detrital debris, with volcanic fragments, also dense black shale). The 138 feet of core, all volcanic rock from top down represents, successively, transported volcanic debris, rhyolitic welded tuff altered to laumontite, and finally, fine-grained transported volcanic debris, andesite and dacite in composition. Welded tuff structures are well developed.

Following Applin (1951), Ross suggests early Paleozoic or Precambrian age. It may be noted that welded tuffs of the distinctive types illustrated by Ross (1958) have not been observed elsewhere in Georgia. Sundelius (written communication) notes the resemblance of these Clinch County rocks to slate belt types: "The rhyolite tuff from Clinch County with beautifully developed shard structures and small, chlorite-filled vesicles certainly has slate belt counterparts . . . ."

LL 306 LD 7 Wiley P. Ballard, Jr. No. 1B

Timber Products (1956)

T. D. 4,232 ft. amygdaloidal basalt

Reference: Hurst, 1960

Cuttings were examined of 10 ft. intervals from 2,560 to 4,220 feet. The last three from 4,190 to 4,220 feet contained numerous fragments of fresh amygdaloidal basalt, illustrated in figures 8 and 9.

Presumably the basalt extended below 4,210 to 4,232 feet T. D. thus giving a minimum thickness of 42 feet for the basalt, assuming a horizontal sheet.

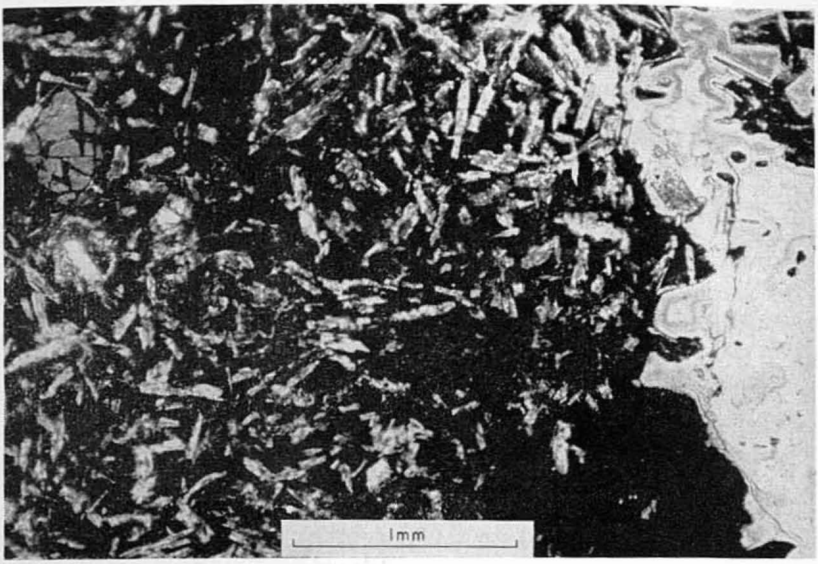


Figure 8. Thin section, plane-polarized light; Clinch County, Georgia, LD No. 7, LL No. 306, Wiley P. Ballard, Jr. No. 1-B Timber Prod. Co. 4,190-4,200 ft.

Amygdaloidal basalt

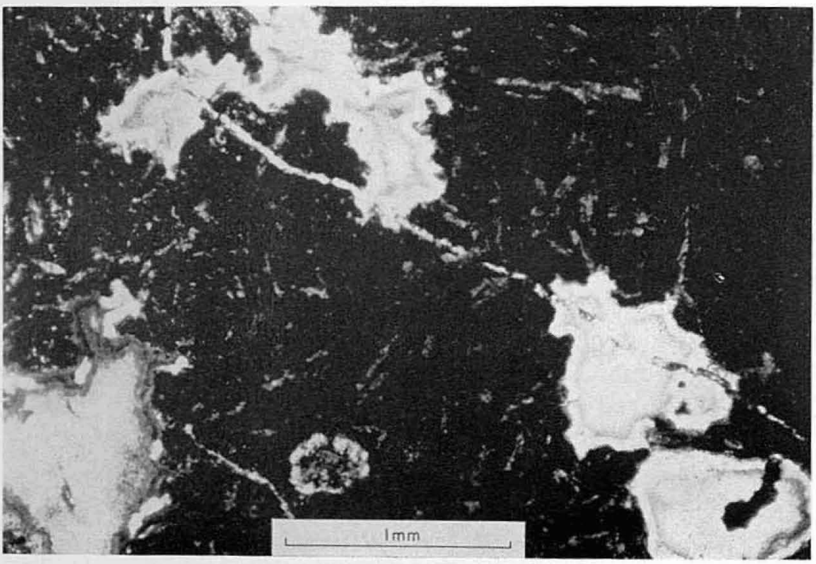


Figure 9. Thin section, plane-polarized light; Clinch County, Georgia, LD No. 7, LL No. 306, Wiley P. Ballard, Jr., No. 1-B Timber Prod. Co. 4,200-4,210 ft.

Amygdaloidal basalt

Dooly County

LL 163, LD 6—H. E. Walton No. 1—Georgia-Florida Drilling Company (1960).

Elevation: 443 ft.

T. D.: 3,748 ft. Arkose

Reference: Hurst, 1960

Three thin sections listed as follows "28 No. 1 H. E. Walton, D. B. Willingham, Dooly County 3,720′-3,730′ core submitted by Mark G. Gormley . . ." are highly feldspathic sandstone or arkose, in part calcitic. They show no metamorphism or basement characteristics.

It may be noted that in Crisp County, just south of Dooly County, Kerr McGee Pate No. 1, LL 144 LD 13, 1½ miles west of Arabi, drilled (1946) to 5,008 feet in the Lower Cretaceous (Hurst, 1960); and in Colquitt County, some 50 miles south, D. C. Arrington, R. T. Adams No. 1 LL 20 LD 8 drilled (1948) to 4,910 feet also in Lower Cretaceous (Hurst, 1960).

Echols County

LL 317, LD 13—Hunt Oil Company—Superior Pines No. 2 (1945)

Elevation: 142 feet

T. D.: 4,062 feet. Quartzite (probably Paleozoic)

Reference: Hurst, 1960

A specimen of core 3,845-3,850 feet is fine gray sandstone or siltstone, with considerable detrital mica along bedding planes. The clayey matrix is moderately recrystallized, as is normal in Paleozoic sandstones. Hurst (1960) mentions fossils of Paleozoic (?) age in Hunt Oil Company Superior Pines No. 4 (1948) LL 219 LD 13, in red micaceous silty shale at 3,816 feet.

LL 146, LD 12—Humble Oil Company—W. D. Bennett and H.

Langdale No. 1 (1949)

Elevation: 181 feet

T. D.: 4,185 feet Paleozoic(?)

Reference: Hurst, 1960

Cuttings: 4,130-4,140 feet are diabase and closely related volcanic rock.

"The diabase? occurs as a sill or dike between depths of 4,115 and 4,150 feet (approximately). The sedimentary rocks above and below the diabase (?) are believed to be Paleozoic in age and are composed of black shale interbedded with fine-grained gray sandstone. The top of the Paleozoic rock is at 4,108 and the well was in sedimentary rocks at the total depth . . . no cores taken in the igneous rocks." Paul A. Applin, written communication to Watson Monroe, U. S. Geological Survey, July 1, 1949.

Several other wells in Echols County also drilled into probable Paleozoic sedimentary rocks but did not encounter diabase.

Glynn County

G.M.D. 1499, 11 miles northeast of Brunswick, Glynn County—Humble Oil and Refining Company—W. C. McDonald No. 1

T. D.: 4,737 feet. ("4,740 feet. Basement") 4-23-1961

The core from 4,732 feet is hard fresh pink 'granite' with quartz and feldspar grains 1 or 2 millimeters in size, and little dark mineral showing.

In thin section, the core consists largely of turbid microcline and sodic feldspar, with much clear quartz, some in anhedral grains, some myrmekitic. The mafics, mostly biotite, are strongly altered. Small aggregates of bright green hornblende, brown sphene and biotite are present. Many of the feldspar grains have turbid cores with clear rims.

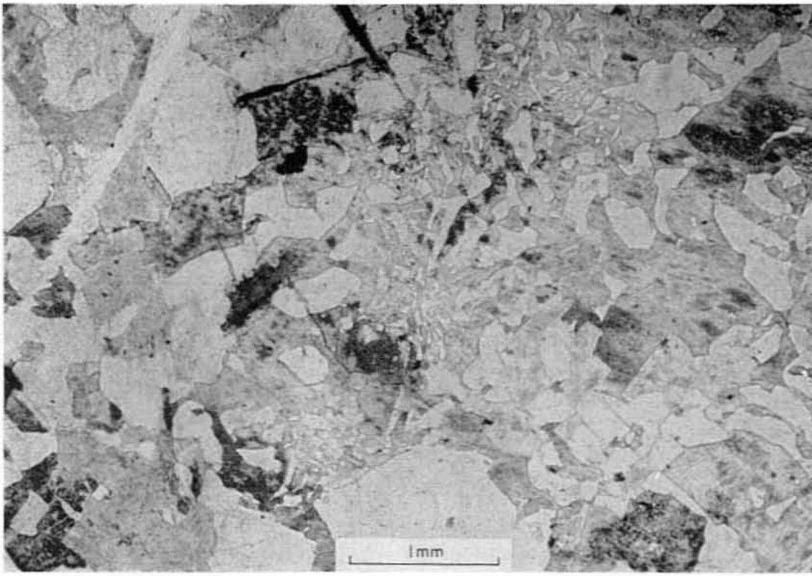
Two thin sections, from 4,737 feet (T. D.) are also typical granophyre (Figures 10 and 11). This rock is usually a differentiate of, or related to, diabase.

Reference: International Oil Scouts Association, 1962, v. 32, pt. 1, p. 58.

G.M.D. 27 Humble No. 1 Union Bag—Camp Paper Co.

T. D. 4,632 feet. "Basement" 5-25-1961

Reference: International Oil Scouts Association, 1962, v. 32, pt. 1, p. 58.



Figures 10 and 11. Thin section, plane-polarized light and crossed nicols, Glynn County, Georgia—Humble—W. C. McDonald No. 1 4,732 ft.

Granophyre

Mainly quartz, feldspar, and minor mafic minerals. Such rock is often found in the upper portions of large diabase intrusions. The texture of the quartz-feldspar is characteristic of granophyre.

Laurens County

Unsurveyed area ½ mile south of Minter, 10 miles east of Dublin—Grace McGain No. 1—Calaphor Manufacturing Company (1945).

Elevation: 280 feet

T.D.: 2,546 feet Diabase

Reference: Hurst, 1960

No cores, but bottom-hole cuttings definitely diabase (written communication from P. L. Applin, 1949).

This is the northernmost of the wells in which diabase was found, and its comparatively shallow depth correlates with the marginally thin cover of Coastal Plain Sediments.

Liberty County

LL 20, GMD 15, 81° 20′ 45″ west 31° 41′ 15″ north—Jelks-Rogers No. 1—LaRue et al (1954).

T. D.: 4,254 feet. Quartz rhyolite porphyry (or granophyre?)

Reference: Hurst, 1960

The quartz rhyolite porphyry (or granophyre?) is composed of abundant rounded reddish feldspar grains and colorless quartz grains, to several millimeters diameter, in a dark reddish-brown aphanitic matrix. Superficially, the rock looks like a coarse arkosic grit.

The igneous character is clearly seen under the microscope (Figure 12). Both quartz and feldspar phenocrysts show some shattering, and magmatic corrosion, with introduction of magma in the cracks. The feldspar appears to be somewhat albitized intermediate plagioclase. The matrix is devitrified glass crowded with fragmental quartz and feldspar. No mafic minerals are present.

The rock appears to have undergone fracturing or brecciation before final crystallization.

It is also possible that the rock represents a type of granophyre, a variant of the Glynn County rock.

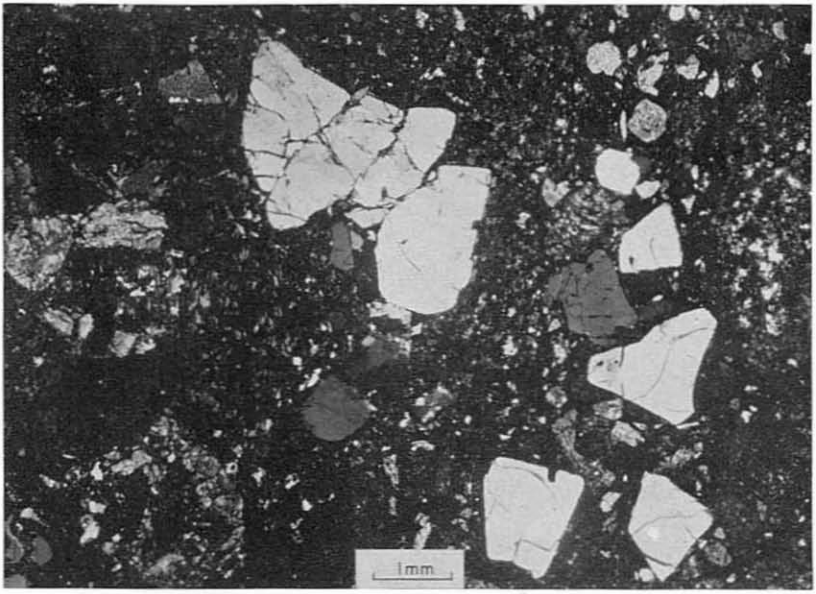


Figure 12. Thin section, plane-polarized light; Liberty County, Georgia—E. B. LaRue's Jelks Rogers No. 1—4,252-4,254 feet, top at 4,250 feet by electric log.

Quartz rhyolite porphyry (or granophyre?)

Shows embayed and magmatically corroded quartz phenocrysts, and considerably altered feldspars (a large composite grain occupies the left third of the field), in an obscurely crystallized pasty matrix.

Mitchell County

LL 133, LD 10—10 miles southeast of Camilla—Stanolind Oil and Gas Company—J. H. Pullen No. 1 (1944).

Elevation: 338 feet

T.D.: 7,487 feet "Clastic rocks" "granite"

References: Hurst, 1960; McClain, 1953

McClain gives a log, with "6230-7300 Triassic or Paleozoic-sandstone and shale—no fossils—olivine diabase sill 6550-6612 and at 7070. 7300-7497 Basement (?) Metamorphic argillaceous sandstonebanded—called a granulite."

A core from 7,375-7,377½ feet is diabase (figures 13 and 14).

From these data, a diabase sill or dike was drilled at two or more horizons, and the bottom rock was not diabase. Presumably these are diabasic sills or dikes in clastic rocks of Triassic (?) age.

Figure 13. Thin section, plane-polarized light; Mitchell County, Georgia, Stanolind Oil and Gas Co., J. H. Pullen No. 1. 7,375-7,377.5 ft.

Diabase

Shows typical composition (dark-augitic pyroxene, light-plagioclase feldspar) and texture of diabase.

Figure 14. Thin section, crossed nicols, Mitchell County, Georgia, Stanolind Oil and Gas Co., J. H. Pullen No. 1, 7,375-7,377.5 ft.

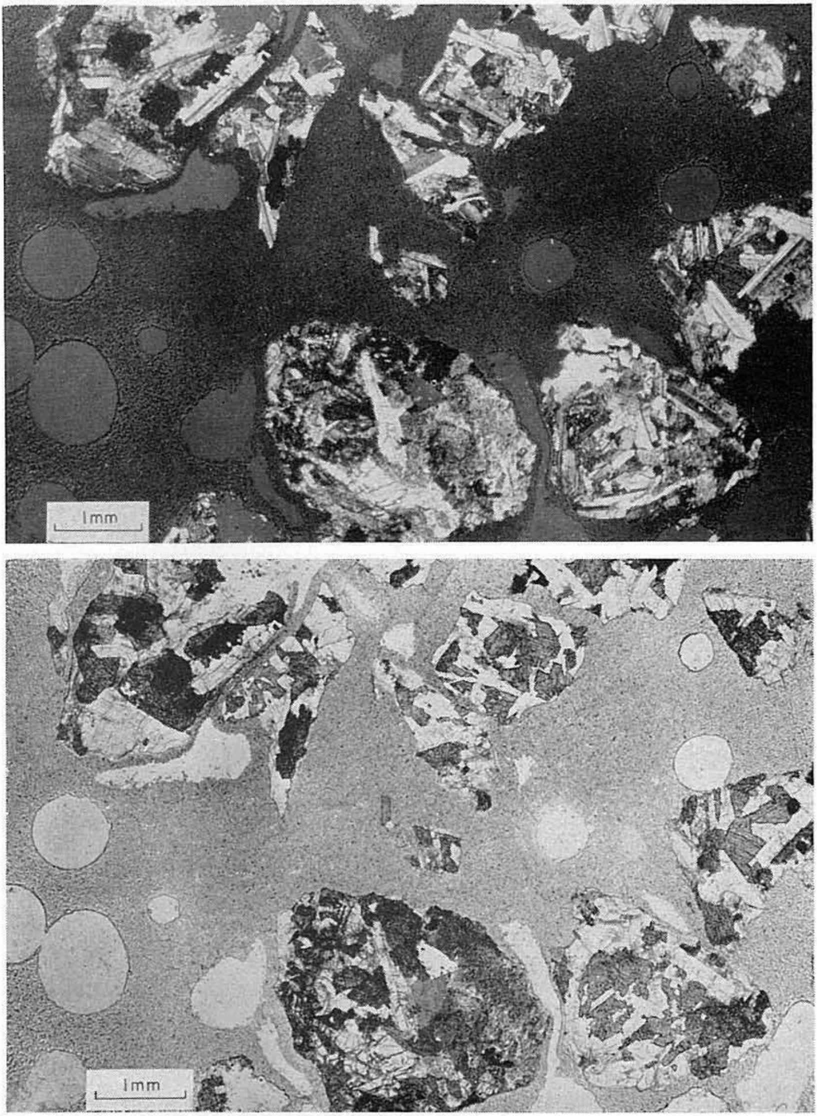
Diabase

Same as preceding, showing characteristic Carlsbad-albite twinning of calcic plagioclase feldspar.

Montgomery County

GM 1567, DF 293—½ mile south of Higgston—J. E. Weatherford—Lonnie Wilkes No. 1 (1946).

Elevation: 293 feet



Figures 15 and 16. Thin section, plane-polarized light and crossed nicols; Montgomery County, Georgia—J. E. Weatherford—Lonnie H. Wilkes No. 1, 3,390-3,420 ft.

Diabase

Cuttings of fresh diabase (embedded in bakelite showing air bubbles).

T. D.: 3,433 feet Diabase

Reference: Applin, 1951

No cores were taken from this well, but cuttings from 3,390-3,420 feet were fresh unweathered diabase. These are illustrated in figures 15 and 16.

Pierce County

LL 329, LD 4—1½ mile east of Offerman—Pan American Production Company—Adams McCaskell No. 1 (1938).

Elevation: 77 feet

T. D.: 4,375 feet Granite? Arkose?

LL 332, LD 4—2.3 miles southwest of Offerman—W. B. Hinton (Donald Clark)—Adams McCaskell No. 1 (1939).

Elevation: 75 feet

T. D.: 4,355 feet

References: Applin, 1951; Hurst, 1960.

Cooke and Munyan (1938) state that "The basement rocks beneath the Coastal Plain of Georgia are believed to consist entirely of igneous and metamorphic rocks, chiefly granites, gneisses, and schists, resembling those of the Piedmont region, which they adjoin and of which they are believed to be the continuation."

A. S. Furcron (personal communication, 1938) noted the granitic and deuteric aspect of this rock; Munyan (1938) stated that the Pierce County well (Pan-American Adams McCaskell No. 1) bottomed at 4,375 in granite. Later Campbell (1940) asserted that the two Pierce County wells bottomed in granite.

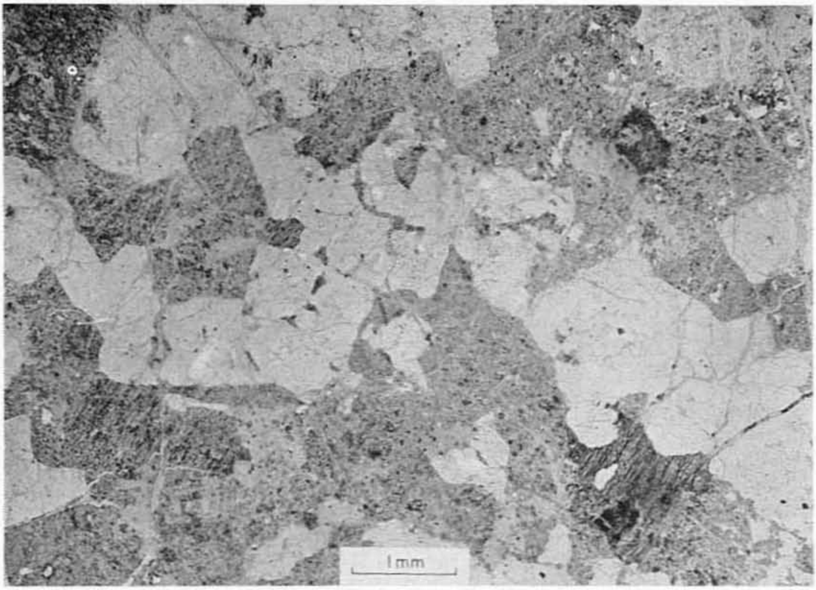
Bottom hole samples from the two wells although both of "granitic" aspect show differences, and it is possible that in the original cores there was considerable variation. Figure 17 shows a polished slab of the McCaskell-Adams No. 1 W. B. Hinton (Donald Clark), with a texture more suggestive of arkose than granite. The mineralogy of this rock shows peculiarities not normal to granite. No microcline is present; the feldspar though present is obscurely crystallized, and appears to have undergone a metamorphism, transforming an original low temperature potassic feldspar (microcline?) to a high temperature form (orthoclase?). Pale or colorless obscure chloritic masses replace shattered biotite. Large areas in the section do not appear to be crystallized at all, but to be an amorphous mass of finely comminuted material. The quartz show extreme irregularity of outline, with fractures filled with the comminuted material just mentioned. Disseminated calcite is more suggestive of coarse clayey arkose, than of holocrystalline granite. Other thin sections consist mainly of discrete grains of corroded, embayed, and shattered quartz, intensely altered feldspar, heavily replaced by calcite, and the whole cut by seams and veins of light brown montmorillonitic clay (?). Obscure greenish areas may represent altered biotite or other mafic mineral. Figures 17-21 illustrate these features.

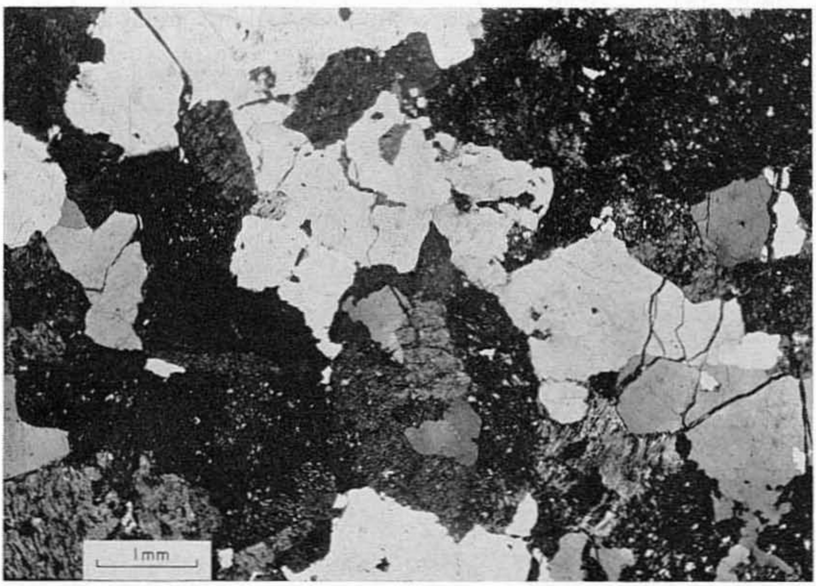
In summary this rock could be arkose altered by hydrothermal solutions, or granite similarly altered. Now that evidence of volcanic activity affecting a sandstone or arkosic terrane is available from numerous holes in adjoining counties, the early ideas of Munyan and of others may be reconsidered. But until drilling has encountered unquestionable basement or sedimentary rocks below this rock, the question as to whether it is an arkosic sediment or basement granite must be considered unanswered.

Figure 17. Polished slab; Pierce County, Georgia, W. B. Hinton (Donald Clark) McCaskill-Adams No. 1, 4,348-4,355 ft. T. D.

Meta-arkose or granite

The texture shown has been variously interpreted as indicating brecciation and alteration of granite (V. J. H.), and as cementation with alteration of a fragmental arkosic sandstone (C. M.).





Figures 18 and 19. Thin section, plane-polarized light and crossed nicols; Pierce County, Georgia—W. B. Hinton (Donald Clark)—Adams McCaskill, No. 1, 4,348-4,355 ft.

Meta-arkose or granite.

The white is quartz, the gray turbid feldspar. Note similarity in texture and composition to the granophyre of Glynn County (figures 10 and 11, left half of picture).

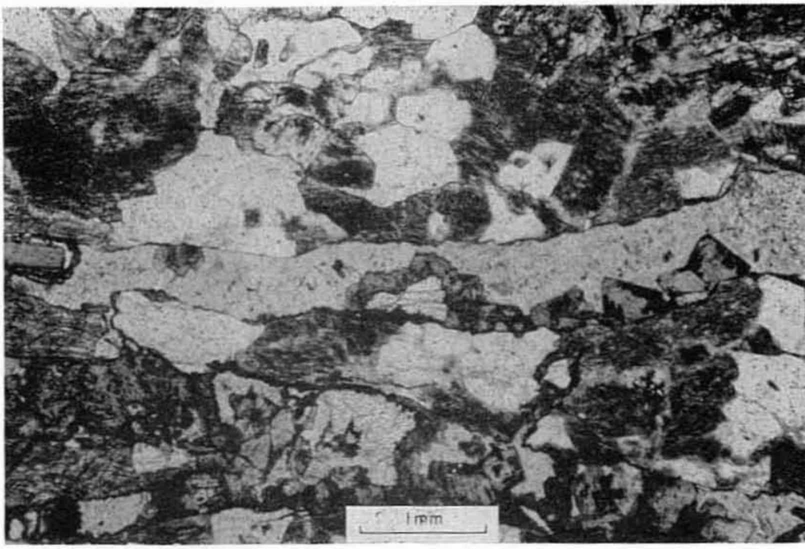


Figure 20. Thin section, plane-polarized light; Pierce County, Georgia—Pan American Adams-McCaskill No. 1, 4,375 ft. T.D.

Meta-arkose or granite

Calcite vein—horizontal across middle of field—with dolomite crystals (left of center and loop, right of center). The large clear grains are quartz, the gray turbid areas, feldspar.

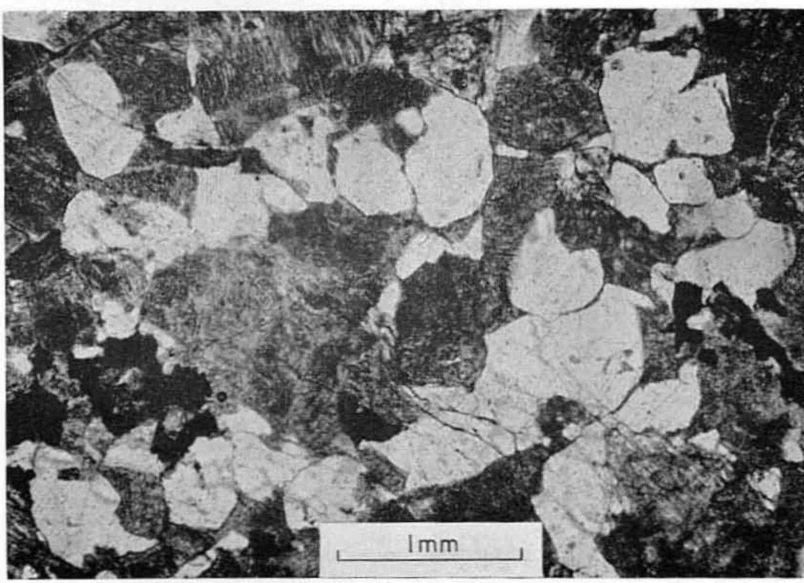


Figure 21. Thin section, plane-polarized light; Pierce County, Georgia—Pan American Adams-McCaskill No. 1, 4,375 ft. T. D.

Meta-arkose or granite

Embayed and corroded quartz (clear) in turbid granular feldspar matrix. The dark area (upper right) is green biotite with brown hydrous iron oxide.

Pulaski County

LL 306, LD 21—Ainsworth Corporation—Tripp No. 1 (1954).

Elevation: 280 feet

T. D.: 2,710 feet. Serpentinized diabase or basalt

Reference: Hurst, 1960

Specimens from 2,635-2641 feet were olivine basalt, brown sandy shale and red ash, both spotted; 2,662 feet, diabase; 2,675-2,684 feet diabase with white veins of laumontite; 2,684 feet heavily slickensided black micaceous-calcitic-serpentine rock.

Figures 22 and 23 illustrate the normal diabase and slickensided rock.

LL 307, LD 21—R. O. Leighton—Tripp No. 1 (1959).

Elevation: 305 feet

T. D.: 2,895 feet? "Metamorphics about 2500" "Granite wash"

Reference: Hurst, 1960; Rinehart Oil News Company, 1960

The depths to volcanic rocks in these two wells agree with the depths to similar rocks in Laurens County (2,546 feet).

LL 280, LD 12—R. O. Leighton—Dana No. 1 (1956).

T. D.: 6,535 feet. "Basement".

Reference: Rinehart Oil News Company, 1958; Hurst, 1960

2,678 feet-Olivine Diabase. Much euhedral olivine, now completely replaced by brown serpentine, and unaltered augite. Rarely the olivine is replaced by hypersthene. Fresh calcic plagioclase, and black ore grains, some spheroidal zeolitic (?) amygdules; and a little vivid green chlorite (?).

3,002 feet. (Cuttings) mostly rather coarse sand, with some diabase fragments.

3,463 feet. (Cuttings) similar, rather finer grained sand, etc.

Evidently, diabase was found at depth similar to that in the other two Pulaski County wells; and the drill then passed into a sandy sedimentary series.

Figure 22. Thin section, plane-polarized light; Pulaski County, Georgia, Ainsworth Tripp No. 1, 2,675-2,684 ft.

Olivine Diabase

Figure 23. Thin section, plane-polarized light; Pulaski County, Georgia, Ainsworth Tripp No. 1, 2,684 ft.

Basaltic rock

Large diabase bodies frequently show streaks or portions of fine-grained poorly crystallized rock. Such an altered rock is shown here; it superficially resembles basalt or serpentine.

Sumter County

LL 194, LD 26—1½ miles northwest of Americus—Seely—Georgia Oil and Gas Company, Inc.—R. S. Moore No. 1.

T. D.: 2,998 feet

Thin sections as follows:

	29 2,680 feet arkose, highly feldspathic
	29a - - - - feet arkose, highly feldspathic
	b 2,750-52 feet arkose, highly feldspathic
(two sections)	c - - - - feet diabase, arkose
(no section)	d 2,983 feet - - - - -
(no section)	e 2,981 feet - - - - -
	f 2,998 feet contact, diabase with arkose-breccia

These sections clearly indicate that the well entered arkose intruded by diabase.

LL 210, LD 17—Flinn-Austin Company—Walter Stevens No. 1 (1955).

Reference: Hurst (1960). This reached 5,240 feet, and at 2,200 feet was in "Lower Cretaceous." No samples below 2,430 feet.

Toombs County

Unsurveyed area, 7 miles southeast of Vidalia and 6 miles south of Lyons—Tropic Oil Company—Gibson No. 1 (1945).

Elevation: 198 feet

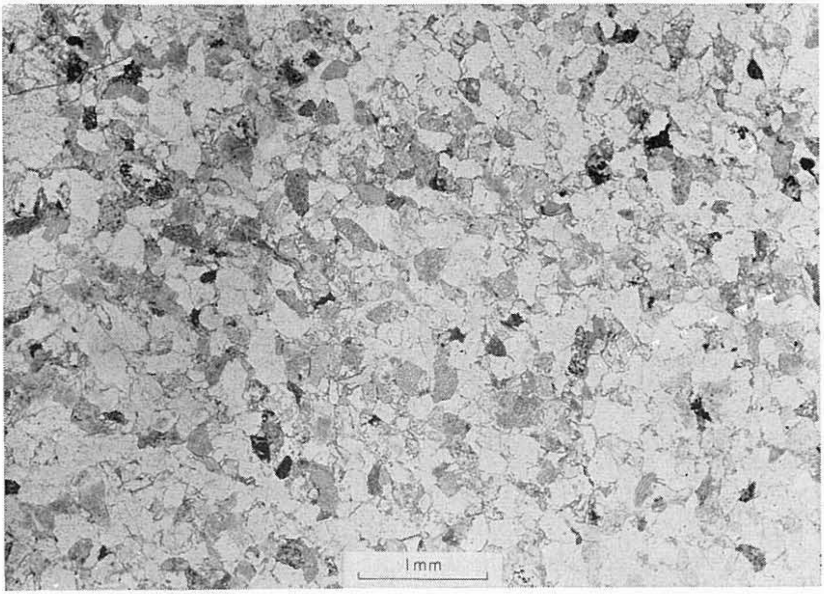
T. D.: 3,681 feet

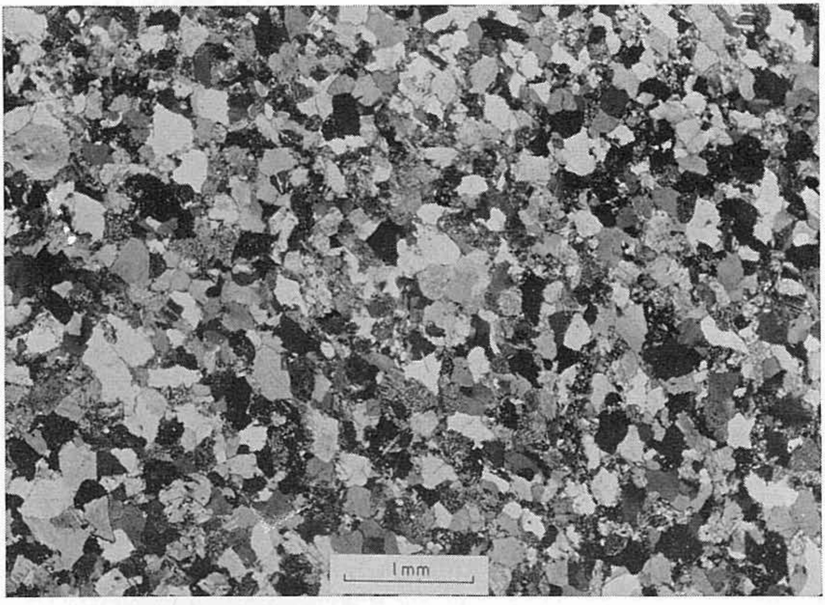
Reference: Hurst, 1961

Core at 3,679-3,680 feet. Light-gray conglomeratic arkose with volcanic fragments ("feldspathic quartzite-metamorphic").

A thin section of this rock is shown in figures 24 and 25. It is not a metamorphic rock.

Sundelius (written communication, 1964) observes that this rock is "compatible with slate belt lithology."





Figures 24 and 25. Thin section, plane-polarized light and crossed nicols; Toombs County, Georgia—Tropic Oil Company No. 1 Gibson, 3,679-3,680 ft. T.D.

Arkosic sandstone

Consists of fairly angular fragments of quartz, sodic plagioclase, turbid orthoclase (?), various types of fine-grained volcanic rock with abrupt variations in grain size. The illustration shows one of the more uniformly sized areas in the thin section.

Wayne County

LL 7, GM 33—1.8 miles east of McKinnon—California—Brunswick Peninsular No. 1—California (1944)

Elevation: 73 feet

T. D.: 4,620 feet. Arkose

A sample from 4,605-4,607 feet is shown in figure 27. Similar rock is reported from 4,570 feet down. In McClain (1953) this rock is termed "basement complex." and in Hurst (1960) "tuffaceous arkose?"

Reference: McClain, 1953, Hurst, 1960

7 miles north of Gardi, Lambert Coords—Humble Oil and Refining Company—Union Bag and Paper Company No. 1 (1960)
T. D.: 4,551 feet

A specimen of core from at 4,540 feet appears to be fine-grained bedded volcanic ash. It is illustrated in figure 26. Sundelius (written communication, 1964) notes the resemblance to slate belt rocks of the arkose and ash from these Wayne County wells.

Reference: Rinehart Oil News Company, 1961, Adams and Davis (1962).

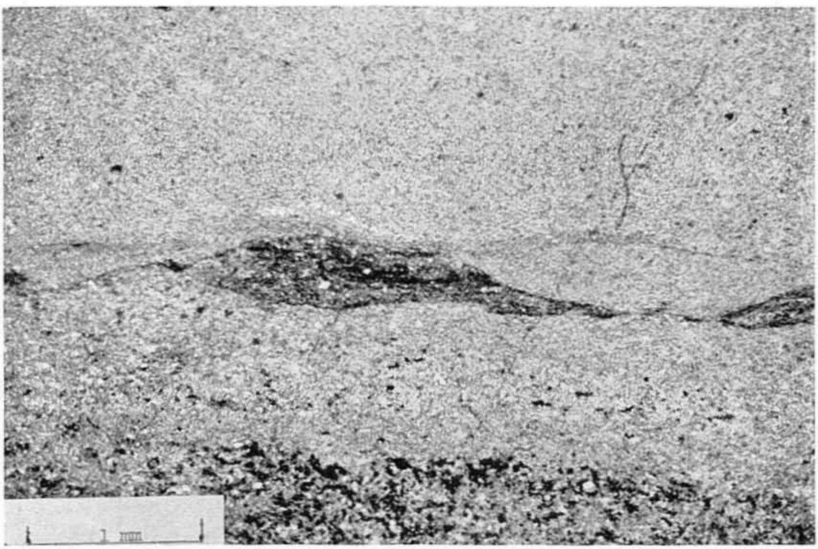


Figure 26. Thin section, plane-polarized light; Wayne County, Georgia, Humble Oil and Refining Company Union Bag No. 1, 4,540 ft.

Volcanic ash

This has been reported as "Paleozoic."

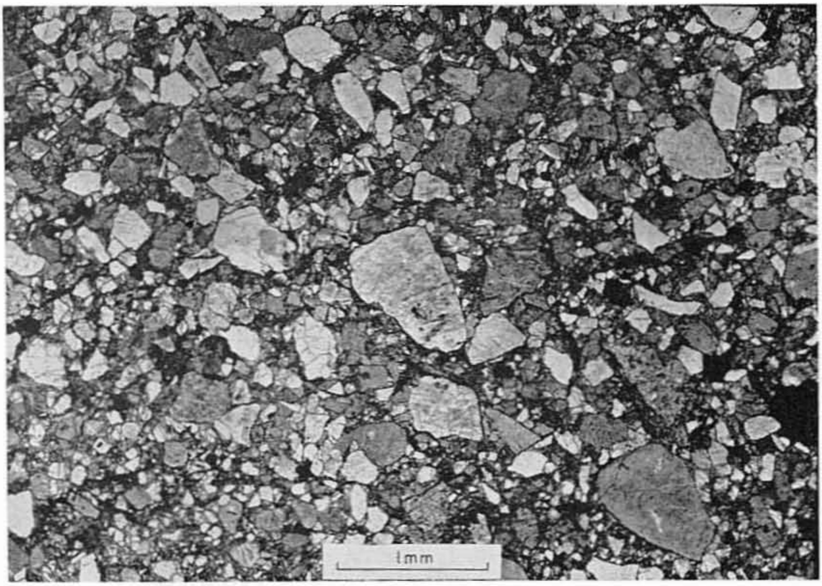


Figure 27. Thin section, plane-polarized light; Wayne County, Georgia —California Company—Brunswick Penninsula Corporation No. 1, 4,605-4,607 ft.

Arkosic sandstone

The rock contains much fresh feldspar (sodic plagioclase and microperthite), quartz and micropegmatite. The grains are very slightly rounded, in a clayey, slightly calcareous matrix, with calcareous veinlets.

Wheeler County

LL 486, LD 7—T. R. Davis and Association (formerly Natural Resources Corporation)—Jordan Heirs No. 1 (1956)

T. D.: 4,002 feet. "Ferruginous sandstone, slightly metamorphosed." (Hurst 1960)

Reference: Hurst, 1960

Specimens from this well at 3,905-3,915 feet are gray siltstone and at 3,995-4,002 feet are red siltstone.

Noting the depths to basaltic or diabasic rock recorded in adjoining Laurens and Montgomery Counties, and Appling County not far southeast, it appears that this well bottomed in the same sandy series intruded by basalt or diabase in those counties. Sundelius (written communication, 1964) notes that the gray siltstone is comparable in general to fine-grained epiclastic rocks in the slate belt. However, he further comments that the red siltstone is "not typical slate belt." In this connection, the observations of Hotz (1949) on contact rocks in Pennsylvania is of interest. Adjacent to the intruded masses of diabase the normally red sedimentary rocks (shale and sandstone, coarse arkosic sandstone and quartzose fanglomerate, etc.) "are bleached and metamorphosed to gray and buff hornstones and quartzites . . ." (p. 3). From this it appears that the Wheeler County siltstones might be Triassic, in one instance bleached, rather than slate belt rocks.

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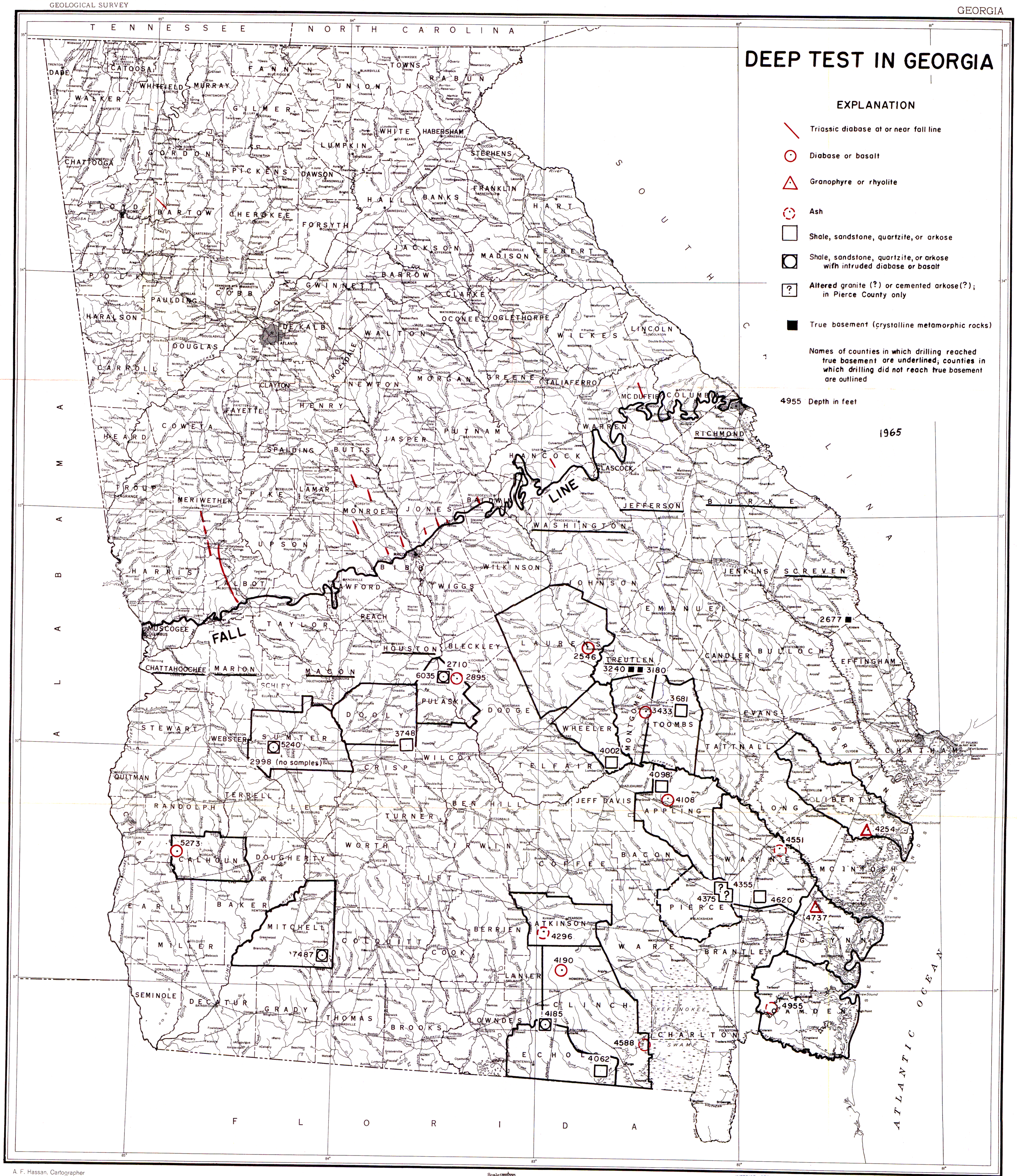

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