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NORTH CAROLINA  
DEPARTMENT OF CONSERVATION AND DEVELOPMENT  
ROBERT L. STALLINGS, JR., *Director*

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Division of Mineral Resources  
JASPER L. STUCKEY, *State Geologist*

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Bulletin 75

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# GEOLOGY OF THE ALBEMARLE QUADRANGLE, NORTH CAROLINA

By  
JAMES F. CONLEY

Raleigh

1962



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## Letter of Transmittal

Raleigh, North Carolina  
December 14, 1962

*To His Excellency, HONORABLE TERRY SANFORD*  
*Governor of North Carolina*

Sir:

I have the honor to submit herewith manuscript for publication as Bulletin 75, "Geology of the Albemarle Quadrangle, North Carolina", by James F. Conley.

This report contains the results of detailed geologic mapping and mineral studies carried out in the Albemarle quadrangle and should be of value to those interested in the geology and mineral resources of the area.

Respectfully submitted,

ROBERT L. STALLINGS, JR.  
*Director*

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# GEOLOGY OF THE ALBEMARLE QUADRANGLE, NORTH CAROLINA

By

JAMES F. CONLEY

## INTRODUCTION

### Location and Description of Area

The Albemarle quadrangle is bounded by latitude  $35^{\circ} 15'$  and  $35^{\circ} 30'$  N. and  $80^{\circ} 00'$  and  $80^{\circ} 15'$  W. longitudes and contains approximately 244 square miles. The quadrangle covers parts of western Montgomery and eastern Stanly counties.

In the northeastern part of the quadrangle, the Uwharrie and Yadkin rivers join to form the Pee Dee River. The Yadkin River flows to the southeast draining the northcentral part of the quadrangle, and the Uwharrie River flows to the southwest draining the northeastern part. From the confluence of the Yadkin and Uwharrie rivers, the south flowing Pee Dee River drains the southern part of the quadrangle. The western part of the quadrangle is drained by Town, Long, and Little Long creeks which join Rocky River southwest of the quadrangle.

The Albemarle quadrangle is located in the Piedmont province. The rolling hills constituting the western two-thirds of the quadrangle are typical of the Piedmont and contrast to the Uwharrie Mountains in the eastern one-third of the map area.

The highest ground elevation in the quadrangle is 945 feet above sea level on top of the mountain southeast of Blaine. The second highest elevation is the top of Morrow Mountain which is 936 feet above sea level. A number of hills in the area between Blaine and Morrow Mountain exceed elevations of 800 feet. In the northwest part of the quadrangle the Piedmont uplands average 600 feet above sea level; whereas, in the southwest part of the quadrangle the uplands elevations average 500 feet. Lake Tillery whose spillway is at 278 feet, forms the lowest level in the Albemarle quadrangle.

Albemarle has an average annual rainfall of 46 inches. The greatest amount of rainfall occurs in the late spring and late fall. The Albemarle quadrangle has an average July temperature of approximately  $78^{\circ}$  F. and an average January temperature of approximately  $44^{\circ}$  F. The area is free of frost on

an average of 200 days per year.

A considerable amount of the quadrangle is covered by second growth hardwood and to a lesser extent to mixed forest. The most abundant varieties of trees are white oak, red oak, and pine. In places the Uwharrie Mountains support a lush growth of mountain ivy and laurel. Cedar is abundant in parts of the quadrangle and columnar varieties are observed.

Albemarle, the county seat of Stanly County, is the largest town in the quadrangle. The quadrangle also contains the towns of New London and Badin, and the villages Eldorado, Isenhour, Uwharrie, Blaine, and River Haven.

The western half of the quadrangle is served by federal, state and county highways and roads. Due to the hilly topography and lack of development, the eastern one-third is relatively devoid of roads and highways. The Winston-Salem Southbound Railroad, which lies in a north-south direction across the west central part of the quadrangle, passes through Albemarle. The Southern Railway passes through New London, terminating at Albemarle with a spur line which serves Badin.

The principally agrarian economy is complemented by the Wiscasset Textile Mill at Albemarle and the Aluminum Corporation of America's plant at Badin. Recreation facilities are available at Morrow Mountain State Park, Lake Tillery, and Badin Lake. Hunting is provided by the Uwharrie game preserve, east of Badin.

### Purpose and Scope

Although a generalized sequence of rocks comprising the Carolina Slate Belt has been recognized for over 100 years, little is known about its stratigraphy and structure. A reconnaissance survey of the Albemarle quadrangle and surrounding area indicated that a relatively complete stratigraphic sequence could be worked out within the quadrangle, and that metamorphism and structural deformation had affected this area less than most parts of the

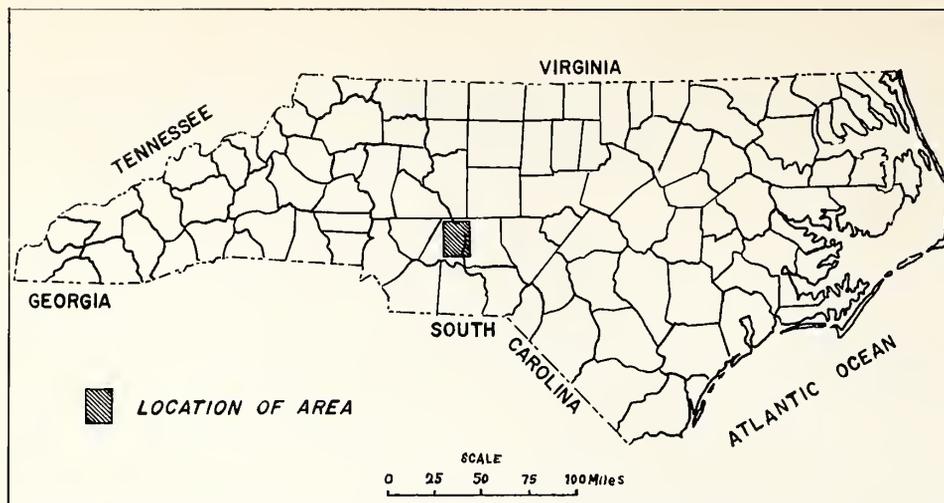


Fig. 1—Index map of North Carolina showing the location of the Albemarle quadrangle

Carolina Slate Belt. For these reasons the quadrangle was chosen for a study of the stratigraphy and structure of the Carolina Slate Belt.

By subdividing the lithologic units as much as possible and paying particular attention to structural control, certain beds evolved as marker horizons some of which have been traced for many miles. The lithologic units were plotted on the U. S. Geological Survey topographic map, preliminary sheet, of the Albemarle quadrangle, scale 1 to 48,000. Field mapping was supplemented by petrographic analyses of the major rock units. Chemical analyses of representative samples of these units were made by P. M. Sales, North Carolina State College Minerals Research Laboratory, Asheville, North Carolina. In practice it was found that soil as well as color and texture of weathered saprolite gave good indications of rock types.

#### Field Work and Acknowledgments

Field mapping began in February 1958 and continued until October 1959. The area was field checked in February and June 1961. William F. Wilson, Division of Mineral Resources, assisted in the field mapping from May to October 1958. Sam D. Broadhurst, Division of Mineral Resources, supervised the field work. In addition, he gave freely of his experience and time and aided in every way possible to bring the project to a successful conclusion. Jasper L. Stuckey, State Geologist, visited the area from time to time and critically reviewed the final paper.

Since 1955, Arvid A. Stromquist, U. S. Geological Survey, has been mapping the Denton quadrangle just to the north of the Albemarle quadrangle. Cooperation between the members of the two projects

has resulted in a more thorough understanding of the geology of both quadrangles. In addition, Mr. Stromquist reviewed the final manuscript.

W. A. White, Department of Geology, University of North Carolina, read the geomorphology section of the report. His suggestions greatly improved this section of the report. E. F. Goldston, Department of Soils, North Carolina State College, visited in the field and gave valuable information on the relationship of soil types to underlying rock types. Oscar B. Eckhoff, Division of Mineral Resources, prepared most of the thin sections and accompanied the author in the field on several occasions. Kenneth M. Drummond, Division of Mineral Resources, aided considerably in the final field checking of the quadrangle and the preparation of the report.

#### General Geology

The Carolina Slate Belt is a northeast trending band of low rank metamorphic volcanic and sedimentary rocks cropping out from southwestern Virginia to central Georgia. This belt of rocks lies in the central and eastern Piedmont section of North Carolina. To the west, the Carolina Slate Belt is in contact with the Charlotte Belt; to the northwest, it is in contact with gneisses and schists of the central Piedmont; and, to the east, it is overlapped by sediments of the Coastal Plain (N. C. State Geologic Map, 1958).

At the Virginia state line the outcrop area is about 70 miles wide, in the central part of North Carolina it is 130 miles wide, and along the South Carolina border it is exposed in an area only 50 miles wide.

Oil test wells drilled through Coastal Plain sediments in Onslow and Camden counties penetrated

Carolina Slate Belt rocks, indicating they extend under the Coastal Plain for a considerable distance. The central part of the belt in North Carolina is interrupted by the Deep River Triassic basin. East of Raleigh the Carolina Slate Belt has been intruded by a large granitic pluton which can be traced northward to the Virginia line. This pluton has metamorphosed the surrounding country rock into gneisses and schists. A number of smaller granitic bodies have intruded the Carolina Slate Belt along both its northeastern and northwestern borders.

### Previous Investigations

Olmstead (1822) described novaculite, slate, hornstone, and talc from areas now known to be underlain by the Carolina Slate Belt. In 1825 he referred to the "Great Slate Formation", which "passes quite across the State from northeast to southwest, covering more or less the counties of Person, Orange, Chatham, Randolph, Montgomery, Cabarrus, Anson, and Mecklenburg." He described the rocks of this "formation" as consisting of clay slate, argillite, porphyry, soapstone, serpentine, greenstone, and whetstone. Eaton (1830), in a report on gold in North Carolina, added "talcose slates". He stated that they occur in association with novaculite, and might have been referring to sericite developed in silicified zones so often found in gold and pyrophyllite deposits.

Ebenezer Emmons (1856) placed the Carolina Slate Belt, which he considered to be subaqueous deposited sediments of very ancient age, in his Taconic system. He divided this system into an upper and a lower member. The upper member consisted of clay slates, chloritic sandstones, cherty beds, flagstones, and brecciated conglomerates. The lower member consisted of talcose slates, white and brown quartzites, and (on his cross section, plate 14, he added) conglomerates. He did not recognize volcanic rocks in the Carolina Slate Belt. In his lower unit, Emmons found what he thought to be fossils and named them Paleotrochis. These were later identified by Diller (1899) as spherulites. Emmons recognized both the anticline near Troy and the syncline near New London.

Kerr (1875) described the rocks of the Carolina Slate Belt and proposed that they were of Huronian age.

Williams (1894) first recognized volcanic rocks in the Carolina Slate Belt. The following year Becker (1895) published a paper in which he noted the presence of volcanic rocks and proposed that they were Algonkian age.

The name Carolina Slate Belt was first applied by Nitze and Hanna (1896). They recognized volcanic rocks interbedded with the slates, and proposed that the volcanic rocks were laid down during times of volcanic outbursts, followed by inactivity at which time the slates were deposited. They observed that some of the rocks had true slaty cleavage, whereas others were schistose. They proposed that these rocks were altered by dynamo and hydrometamorphism.

Weed and Watson (1906) studied the copper deposits of the Virgilina mining district. They believed that the country rock in this area was an altered andesite of Precambrian age.

Laney (1910) published a report on the Gold Hill mining district of North Carolina. In this report he divided the rocks into slates with interbedded felsic and mafic flows and tuffs. He stated that the slates differ from the fine dense tuffs only in the amount of land waste they contain, indicating the slates, in part, were derived from volcanic material. He did not define "land waste", nor did he explain how it might be recognized. He stated that the rocks all show much silicification and are only locally sheared.

Pogue (1910) published a report on the Cid mining district, and Laney (1917) published a report on the Virgilina mining district. These reports are in general repetitions of ideas expressed in Laney's report of 1910.

Stuckey (1928) published a report which included a geologic map as well as a description of the Carolina Slate Belt of the Deep River region of Moore County. He divided these rocks into slates, acid tuffs, rhyolites, volcanic breccias, andesite flows, and tuffs. He noted that the schistosity dipped to the northwest and interpreted the structure as closely compressed synclinorium with the axes of the folds parallel to the strike of the formations. In addition, he pointed out that metamorphism is not uniform throughout the area.

Theismeyer and Storm (1938) studies slates showing fine graded bedding near Chapel Hill, North Carolina, and proposed that they represented seasonal banding. Theismeyer (1939) proposed that similar sediments found in Fauquier County, Virginia were deposited in pro-glacial lakes during late Precambrian and early Cambrian times. The bedding was thought to be seasonal varves. In addition he proposed that, "The Hiawassee slates of Tennessee and the slates in North Carolina, near Chapel Hill, belong to the same category; even may have been deposited more or less contemporaneously".

F. O. Bowman (1954) studied the structure of the Carolina Slate Belt near Albemarle, North Carolina. He recognized sedimentary rocks, volcanic tuffs and flows, and mafic intrusives in the area. He proposed that the structure was a series of undulating open folds.

### Stratigraphy

Until more mapping has been completed within the Carolina Slate Belt, time-stratigraphic designations would be premature. Consequently, this report designates the rocks by their lithologic characters rather than by stratigraphic names, and the various rock types have been assembled into sequences and units (see map and legend, pl. 1). However, although the rock types are not yet officially named the entire "Carolina Slate Belt" should be thought of as the equivalent of a supergroup, the "sequences" as groups, the "units", within the sequences, as formations. In this paper sequence has no implication on origin as defined by Sloss, Krumbein, and Dapples in the textbook by Krumbein and Sloss (1958).

The Albemarle quadrangle contains three distinct sequences of rocks: (1) Lower Volcanic sequence, consisting largely of felsic tuffs that have been folded into an anticline plunging to the southwest; (2) Volcanic-Sedimentary sequence, consisting of a lower argillite unit, an intermediate tuffaceous argillite unit, and an upper graywacke unit, which have been folded into a syncline also plunging to the southwest; (3) Upper Volcanic sequence, consisting of mafic and felsic volcanic rocks which unconformably overly the first two sequences named. Because of an error during final preparation of the map legend, the word unit was inadvertently omitted after andesitic tuffs, basaltic tuffs, and rhyolite of the Upper Volcanic Sequence. However, these rocks are regarded as units as the term is used in this paper.

These sequences of rocks constitute a stratigraphic succession which is probably over 30,000 feet thick. The exact thickness of the sequence can not be determined because the base of the succession has not been recognized. Determining overall thickness of individual sequences is complicated by folding, thickening, and thinning of individual beds.

### Lower Volcanic Sequence

The Lower Volcanic sequence crops out from western Montgomery County to central Moore County and can be traced from southern Montgomery County northward to northern Randolph County.

Recent mapping by Edwin Floyd, U. S. Geological Survey, in Union County indicates that the Lower Volcanic sequence reappears along the western border of the Carolina Slate Belt in contact with plutonic rocks of the Charlotte Belt.

The Lower Volcanic sequence lies at the bottom of the stratigraphic succession in the Albemarle quadrangle and contains the oldest rocks thus far recognized in the Carolina Slate Belt. This sequence is at least 3,500 feet thick and could be as much as 20,000 feet thick. The contact between Carolina Slate Belt and basement rock has not been observed, but Laney (1917) proposed that the Carolina Slate Belt was underlain by gneisses and schists of the Piedmont to the west.

The Lower Volcanic sequence consists of interbedded felsic lithic tuffs, crystal and lithic-crystal tuffs, welded flow tuffs, flows, occasional mafic pyroclastic beds and rare bedded argillites. The tuffs which make up the Lower Volcanic sequence, exposed in the Albemarle quadrangle, are felsic in composition (lft). The best exposures of the Lower Volcanic sequence are found along new Highway N. C. 27 from 1 mile east of the Pee Dee River to the eastern edge of the quadrangle. These rocks are light grey in color and weather to white clay. They are especially susceptible to spheroidal weathering and, in many places, the outer surfaces are covered by a thin white weathering rind. The rocks are exceedingly dense, emitting a metallic ring when struck with a hammer, and break with a conchoidal fracture. Rocks of the Lower Volcanic sequence are generally massive except near the top of the stratigraphic section where they contain faint bedding. They have been closely jointed and many of the joint planes have been healed by thin veins of quartz, some of which are not over  $\frac{1}{8}$  inch thick. In general, axial plane cleavage is poorly developed.

The felsic tuff is composed predominantly of lithic tuff with interbeds of crystal tuff and at least one flow tuff. The lithic fragments consist of red and grey rhyolites containing flow lines, light grey fine grained felsite, and rare mafic crystal tuff. Red rhyolite fragments have been observed only in the Lower Volcanic sequence. The subrounded to angular fragments are exceedingly poorly sorted and range in size from  $\frac{1}{8}$  inch to over 2 feet in diameter. Some of the felsite fragments have pitted amygdular surfaces, indicating they were liquid when ejected.

The crystal fragments are composed of both quartz and feldspar. The quartz crystals are somewhat spheroidal in outline; whereas, the feldspars occur as both broken laths and euhedral crystals. They

range in size from 1/32 inch to over 1/8 inch in diameter.

Under the microscope (see pl. 2, No. 1) the feldspars make up from 3 to 5 percent of the rock and were determined to be predominantly orthoclase, with some oligoclase, and rare sanidine? and andesine. They were cloudy from primary inclusions, but did not appear to be greatly altered. About 30 percent of the rock was composed of quartz. The quartz occurs as embayed beta crystals, but more often as lenticular shaped granular masses. Except for rare porphyritic specimens, the lithic fragments are too fine grained to be identified under the petrographic microscope. The groundmass, which makes up approximately 60 percent of the rock, is also exceedingly fine grained, but appears to be predominantly granular masses of quartz, with sericite, kaolinite, and numerous small crystals of pyrite and aggregates of chlorite.

A welded crystal flow tuff is interbedded with the felsic tuff one mile northeast of Stony Fork Church. It is an exceedingly dense, pale pink rock which breaks with a concoidal fracture (see pl. 3, No. 1). The rock contains about 6 percent semi-rounded pink-orthoclase and microcline crystals interspersed throughout the matrix. The most prominent structures are the numerous collapsed pumice fragments and wispy flow lines. Originally the rock must have been exceedingly porous, but the vesicles are filled with granular quartz which now composes as much as 60 percent of the rock. The groundmass could not be resolved, but appears to be predominantly quartz with some kaolinite.

### Volcanic-Sedimentary Sequence

The Volcanic-Sedimentary sequence crops out from northwest of Asheboro southward to the South Carolina line. It covers most of the western three fourths of the Albemarle quadrangle. In the quadrangle it is made up of three dominant rock types: the argillite unit, the tuffaceous argillite unit, and the graywacke unit. The Volcanic-Sedimentary sequence apparently conformably overlies the Lower Volcanic sequence and in turn is unconformably overlain by the Upper Volcanic sequence. The Volcanic-Sedimentary sequence is estimated to be about 10,000 feet thick. The only fossils recognized in the Volcanic-Sedimentary sequence are worm trails (Conley, 1960) and one questionable Ordovician brachiopod (Stuckey, personal communication). The resemblance between this sequence and Ordovician Arvonian and Quantico slates also suggest Ordovician age for this sequence.

### Argillite Unit

The argillite unit (ar) has been traced from northwest of Asheboro to the Triassic contact in southern Montgomery County. The outcrop belt of this unit is from 3 to 8 miles wide in the Albemarle quadrangle. It trends northeast-southwest and parallels the Uwharrie River in the northern part and the Pee Dee River in the southern part and underlies the eastern one fourth of the quadrangle. This unit is variable in thickness along strike, but averages about 500 feet thick.

The argillite unit directly overlies the felsic tuffs of the Lower Volcanic sequence. Although a discontinuity cannot be ruled out, the contact between these units appears to be gradational over a thickness of a few hundred feet. Bedded and sorting increases upward from the base as argillite becomes predominant. The major characteristic of this rock is its thin graded beds (see pl. 3, No. 2). The graded beds range in thickness from 1/16 to 1/2 inch. The fresh rock is dark grey, changing to ochreous browns and reds upon weathering. The rock has a well developed bedding plane cleavage and an incipient axial plane cleavage which causes it to weather into small thin chips.

Thin interbeds of lithic crystal tuff occur near the base, indicating that volcanic activity was still going on during the time of deposition. The basal part of the unit also contains thin conglomerate beds. The conglomerate pebbles are composed of volcanic rocks which might have been derived from erosion of the Lower Volcanic sequence. Slump bedding has been observed near the base of the unit along Clarks Creek in the southeastern part of the quadrangle. These structures indicate the basal portion of the argillite unit was deposited on a slope at an angle high enough to cause plastic flowage and deformation before the argillite was compacted and lithified.

The graded bedding is easily observed in thin section (see pl. 2, No. 2). The bedding consists of a bottom silt layer which grades upward into a clay layer. The silt sized particles are predominantly angular quartz grains with some feldspar fragments, as well as relic outlines of ferromagnesian minerals now completely changed to chlorite. The clay layers are altered to sericite. Chlorite and kaolinite occur sparingly in all thin sections observed.

### Tuffaceous Argillite Unit

The argillite unit grades upward into the tuffaceous argillite unit. The contact between the two is an arbitrary line based on the predominance of thick bedded, water laid, fine grained tuffs over argillite

exhibiting graded bedding. The thickness of the unit is variable from northeast to southwest. The unit probably does not exceed 2,000 feet in the northern part of the quadrangle, but could be as much as 10,000 feet thick to the south. The great thickness of massive tuffaceous argillite in the southwest part of the quadrangle, as opposed to its relative thinness in the northeast part, indicates that vulcanism was affecting sedimentation to the southwest long before it began to affect the northeast. This is further indicated by the gradational and pulsating nature of the graded beds at the base of the tuffaceous argillite. The graded beds gradually become further spaced and finally die out as intermittent pulses of pyroclastics became more pronounced and constant.

### Felsic Tuffaceous Argillite

The major rock type of the tuffaceous argillite unit is felsic tuffaceous argillite (fta). The best exposure of the felsic tuffaceous argillite is at the southern city limits of Albemarle. The felsic tuffaceous argillite is coarsely bedded with beds ranging in thickness from 6 to 24 inches. It is medium grey when fresh, but weathers light grey and becomes creamy white when completely decomposed. The fresh rock breaks into splintery fragments oriented at right angles to bedding planes; whereas, the weathered rock breaks with a concoidal fracture.

In hand specimens, the felsic tuffaceous argillite appears to be a fine dense tuff containing a few feldspar crystal fragments scattered throughout the matrix. Wispy particles which might represent devitrified glass shards are scattered through some beds and are in places concentrated at the base of the beds (see pl. 2, No. 3 and pl. 3, No. 3). The best outcrop of rock containing these particles is exposed north of Badin along Highway N. C. 740, 50 yards west of the Southern Railway. From Albemarle southward, thin beds and lenticular masses of impure calcite, usually not over 3 to 4 inches thick, form interbeds within the felsic tuffaceous argillite. These carbonates probably represent thin primary limestone beds. When fresh they are lighter grey than the tuffaceous argillite, but readily weather brown. In the zone of weathering these beds are usually completely decomposed, leaving a silty clay along the bedding planes.

In thin section the felsic tuffaceous argillite is a micro-crystalline tuff, (see pl. 2, No. 3). The only two readily identifiable minerals are quartz and orthoclase. The remainder has been altered to sericite and kaolinite. The wispy particles are now

completely altered to kaolinite and quartz. Outlines of relic crystals and felsite fragments can still be observed. These outlines average about .02 millimeter in length with an occasional feldspar fragment reaching up to .5 millimeter. The carbonate beds are composed of interlocking crystals of calcite and detrital quartz. Tiny cubic crystals of pyrite are disseminated throughout the rock. The particles making up the rock appear to be well sorted.

### Felsic Crystal Tuff

Thin beds, consisting of crystals in a tuffaceous argillite matrix, are interbedded with the felsic tuffaceous argillite. In hand specimens (see pl. 3, No. 4), the felsic crystal tuff (ca) is a lathwork of white feldspar crystals, ranging in length from 1 to 2 millimeters, in a fine grained granular groundmass indistinguishable from that of the felsic tuffaceous argillite. Rare angular lithic fragments, ranging from 1 to 2 centimeters in diameter, some containing cellular structures which are probably vesicles, are found in the crystal tuff.

Under the microscope the feldspars generally appear to be abraded and rounded and vary from euhedral crystals to broken laths (see pl. 2, No. 4). Almost all of the feldspars exhibit albite twinning, but a few are both albite and carlsbad twinned. The feldspars range from oligoclase to andesine, and are partially altered to sericite and kaolinite. Some of the lithic fragments are an exceedingly fine meshwork of crystals too small to be identified under the microscope. Others are completely altered to chlorite. The matrix is composed of minute unoriented needle-like crystals with originally fine-grained volcanic debris, now altered to sericite and kaolinite, filling the interstices. When fresh, the rock is medium grey, but it weathers to a light grey color similar to that of the felsic tuffaceous argillite.

### Vitric Tuff

Vitric tuff beds (vt) are very resistant to erosion and form a series of northeast trending hills across the east-central part of the quadrangle.

These beds make excellent key horizons which can be traced over wide areas. The vitric tuff is usually underlain by thin beds of lithic tuff and grades upward into thick bedded massive felsic tuffaceous argillite.

In hand specimens (see pl. 3, No. 5), the vitric tuff is a light grey massive rock which when hit with a hammer, emits a metallic sound and breaks with a concoidal fracture. Bedding planes are obscure and consist of alternating light and dark bands

which become more pronounced upon weathering. The rock is well jointed, giving the outcrops a somewhat blocky appearance. These joint surfaces are in many places healed with quartz, ranging in width from hair lines to 1/16 inch. The fresh rock has a glassy appearance and when broken into thin slivers is translucent. It develops creamy white weathering rinds which often gives the misconception that it is a white colored rock.

Under the microscope the rock is an interlocking meshwork of crypto-crystalline quartz, sericite, and possibly kaolinite. It is similar in composition and texture to rhyolites in the area. As the rock contains bedding planes and does not contain either lithic or crystal fragments, it may be a devitrified welded vitric tuff. Possibly the devitrification of the glass released free silica which crystallized as crytocrystalline quartz to produce a highly silicic rock.

#### **Felsic Tuff of the "Flatswamp Mountain Sequence"**

During reconnaissance in both the Denton and Albemarle quadrangles, as well as surrounding area, it was found that an associated stratigraphic sequence could be traced as a key horizon for over 35 miles. For the purpose of field mapping, this marker horizon was given the informal term Flatswamp Mountain sequence (Stromquist and Conley 1959). This term is used in this report and on the accompanying map.

The major rock type of the "Flatswamp Mountain sequence" in the Albemarle quadrangle is a light to dark grey, fine grained to aphanitic, massive felsic tuff (fft) which weathers chalky white. Scattered throughout its matrix are occasional crystal fragments of orthoclase, oligoclase, and rare fragments of quartz. One small bed of mafic lithic crystal tuff was located south of Blaine in the Albemarle quadrangle. However, Stromquist (personal communication) suggests that the Flatswamp Mountain sequence may interfinger with mafic members of the tuffaceous argillite unit in the Denton quadrangle. The rocks of the Flatswamp Mountain sequence in the Albemarle quadrangle rarely show bedding or other sedimentary features. They grade upward into water deposited felsic tuffaceous argillite, but Stromquist (personal communication) feels the lower part of the sequence was deposited subaerially on a local landmass.

#### **Mafic Tuffaceous Argillite**

Beds of mafic tuffaceous argillite (mta) are found within the tuffaceous argillite unit and in the over-

lying graywacke unit. In fresh outcrop the medium grey mafic tuffaceous argillite is difficult to distinguish from felsic tuffaceous argillite, but on weathering the mafic tuffaceous argillite turns to an easily recognizable dun brown. It is predominantly a siltstone, but contains numerous fissle lenticular clay beds. Individual beds range from 2 to 6 inches thick. Well developed bedding plane cleavage is apparent in the rock. Graded bedding has been noted in some outcrops.

Because of the minute size of the particles, the individual minerals could not be identified under the microscope. However, they appear to be mostly quartz and feldspar. The groundmass is apparently an aggregate consisting almost entirely of chlorite.

#### **Mafic Tuff**

Two lenticular beds of mafic lithic crystal tuff (mt) occur in two small areas south of Albemarle (see pl. 1). They are composed of angular lithic fragments and feldspar crystals dispersed in a chloritic groundmass. The angular to subrounded fragments range in size from 1/16th to 1/2 inch in diameter. A few fragments contain amygdaloidal structures filled with chlorite and epidote. The feldspars range from 1/16th to 3/16th inch in length, and are lath shaped broken crystals of andesine, laboradorite and bytownite. The matrix is a meshwork of needle like pyroxene? crystals and chlorite.

#### **Graywacke Unit**

The graywacke unit is about 3,000 feet thick and crops out in a belt approximately 5 miles wide beginning at the northcentral part of the quadrangle and is traceable southwestward into Union County. It is predominantly a graywacke sandstone with minor interbeds of mafic tuffaceous argillite, mafic crystal tuff, and felsic lithic tuff. Thin beds of mafic tuffaceous argillite occur at the base of the graywacke unit.

#### **Graywacke**

Graywacke sandstone (gr), the major rock type of the graywacke unit, (see pl. 3, No. 6) is dark grayish green when fresh, but weathers to light maroon and vermilion saporlite. Upon complete decomposition it produces a sticky sand clay. It has a massive blocky appearance in outcrop due to the wide spacing, 2 to 5 feet, of major bedding and joint planes. The wide spacing of the joint planes and major bedding planes makes the graywacke usually susceptible to spheroidal weathering.

Stratification in the form of graded bedding and, less common, southwest dipping cross-bedding exists between these planes. The graded beds consist of a sand sized layer which grades upward into a silt sized layer. The contact between individual graded beds is in many places irregular. The coarse graywacke found in the north-central part of the quadrangle grades to the southeast into finer grained equivalents.

In thin section (see pl. 2, No. 5) the graywacke is composed of equal parts of slightly rounded chloritized rock fragments and quartz grains with occasional albite twinned feldspar laths ranging in composition from oligoclase to andesine. Argillite fragments are relatively rare in the graywacke but have been observed in some hand specimens. When graded bedding is present the matrix varies in composition from the base to the top of individual graded beds. The base, or sand sized particles, consist of equal parts of kaolinite and sericite with some chlorite. The chlorite becomes more prominent toward the top, or silt sized layer, where it almost completely displaces the kaolinite and sericite. Pyrite cubes ranging in size from 1/16 inch to 2 inches are disseminated throughout the rock.

#### **Mafic Tuff**

Two lenticular bands of mafic tuff (mt) occur within the graywacke unit in the north central part of the quadrangle. These tuffs are massive in appearance, and show neither bedding nor cleavage.

The mafic tuff is dark green when fresh, weathering to a rust brown. Subsoils are deep chocolate brown clays. The rock is susceptible to some spheroidal weathering along joint planes, but it is generally more resistant than are the graywackes and produces elongate hills paralleling the strike of the strata.

In thin section, the mafic tuff contains stubby crystals of feldspar which do not exceed 1 millimeter in length. These crystals are, for the most part, euhedral but rare broken crystals have been observed. Albite twinning is absent, but carlsbad twinning was noted in about 10 percent of the crystals. The feldspars are so extremely saussuritized as to be rendered unidentifiable. Large light emerald-green crystal masses, up to 1 millimeter across, were observed. These masses might be antigorite replacing augite. The dense, green, aphanitic groundmass is too fine to be resolved, but appears to be dark greenish black chlorite with a light yellow anisotropic aggregate which might be sericite.

#### **Lithic Tuff**

One small interbed of felsic lithic tuff (lt) occurs in the graywacke unit approximately 0.2 mile due west of Isenhour. It consists of a fine grained groundmass composed of crystalline quartz and sericite containing angular, dense, white, light and dark gray aphanite and porphyritic rhyolite, as well as rare flattened mafic fragments. The fragments range in diameter from 2 to 4 inches. The fresh rock is light grey with a speckled appearance due to the lithic fragments. On exposure it develops white weathering rinds and weathers to a kaolinitic clay.

#### **Upper Volcanic Sequence**

The Upper Volcanic sequence has been found from near Asheboro, Randolph County, to southeast of Albemarle, Stanly County. Rocks of this sequence occur in all but the southwestern part of the Albemarle quadrangle. The Upper Volcanic sequence is approximately 450 feet thick and rests unconformably on both the Lower Volcanic sequence and the Volcanic-Sedimentary sequence (Conley, 1959). The Upper Volcanic sequence comprises the youngest rocks thus far recognized in the Carolina Slate Belt. This sequence from base to top is composed of the andesitic tuff unit, basaltic tuff unit, and rhyolite unit.

The age of the rocks of the Upper Volcanic sequence is purely conjectural. However, they might easily be of Silurian or younger age, because the angular unconformity that separates them from underlying rocks is similar to the one found at the base of the Silurian in many places in the Appalachian geosyncline.

#### **Andesitic Tuffs Unit**

The andesitic tuffs unit (uat) is found only in the area east and south of New London. They attain a maximum thickness of 140 feet. These tuffs occur at the base of the Upper Volcanic sequence and unconformably overlie the graywacke unit and are conformably overlain by basaltic tuffs unit. The andesitic tuffs are massive and bedding can be ascertained only by observing flattened pumice fragments and orientation of lithic fragments. They are grey-black when fresh, but are exceedingly susceptible to chemical weathering, developing deep clayey, maroon colored saprolite. The partially weathered rock has a red-gray mottled appearance caused by accentuation of lithic fragments. The tuffs are spongy in appearance and emit a dull sound when struck with a hammer. The major rock of this unit

is composed of numerous vesicular fragments which resemble scoria and range in diameter from 1/16 inch to 4 inches (see pl. 2, No. 6). The vesicles are now usually filled with calcite. Many of these fragments contain flow banding and are irregular in outline which suggests they were molten when deposited. In places these fragments have collapsed into lenticular shaped masses which locally comprise as much as 60 percent of the rock. The matrix is a dark grey translucent mass with numerous crystals ranging from 0.3 to .15 millimeter in diameter. Large quantities of hematite were noted; locally, masses of hematite make up as much as 25 percent of the rock.

An exposure of slightly different character was noted southeast of New London on the road paralleling Mountain Creek. It is a purple to red-gray porphyric rock containing feldspar laths and exhibiting faint flow lines. It is exceedingly dense, and when struck with a hammer, emits a metallic ring and breaks with a conchoidal fracture. This rock is interbedded with the andesitic tuffs and might be a welded ash flow but it is more likely an andesitic lava flow.

#### **Basaltic Tuffs Unit**

The basaltic tuffs and flows (ubt) attains a maximum thickness of 200 feet and crop out over a wide area in the central and northern part of the quadrangle. The basaltic tuffs unit unconformably overlies the argillite and tuffaceous argillite units of the Volcanic-Sedimentary sequence and probably conformably overlies the andesitic tuffs of the Upper Volcanic sequence. These rocks are well jointed, but do not exhibit cleavage. They are susceptible to spheroidal weathering and develop dark brown clay soils.

A number of exposures of the basal section of the basaltic tuffs in the area near Morrow Mountain and Badin contain a basal conglomerate composed of mafic lithic fragments and rounded argillite pebbles, derived from the underlying argillite unit, in a matrix of fine grained mafic tuff. Basaltic flows have been observed near the base of the basaltic tuffs, but are not everywhere present. One such flow occurs in a roadcut a few hundred yards south of Badin Dam. Amygdaloidal basalt is found northwest of Blaine. The amygdules are ovoid in shape and are up to 2 inches in length. Many of the cavities are filled with secondary quartz and resemble miniature geodes when broken open. Columnar jointing has been noted in a questionable flow east of the Badin power plant. This rock contains num-

erous secondary masses of calcite and highly dispersed minute grains of native copper. Above its base the basaltic tuffs unit consist of faintly bedded, well jointed lithic-crystal tuffs.

In the north central and northwestern parts of the quadrangle the basaltic tuffs take on a spotted appearance due to the increase in quantity of lithic fragments (see pl. 3, No. 7). These fragments range in size from 1/16 inch to over 8 inches in diameter. They are rounded to sub-angular in outline and exhibit an inconspicuous graded bedding characteristic of air laid pyroclastic rocks.

In thin section the matrix of the basaltic tuff is composed of a meshwork of exceedingly fine grained particles which appear to be predominantly chlorite. Intermixed with the tiny particles are numerous needlelike crystallites which appear to be feldspar. Larger crystals of both euhedral and broken laths of feldspar and stubby hornblende crystals are scattered throughout the matrix. The lithic fragments are of different composition than the matrix (see pl. 2, No. 7). They are composed of aggregates of needlelike crystals in a matrix even finer grained than the rock matrix and might represent devitrified glass.

The flow rocks are a mesh of angular interlocking needlelike crystals consisting of feldspar, hornblende, and pyroxene—probably augite. Chlorite is present as an interstitial material. Faint flow banding, outlined by the development of chlorite, can be occasionally observed in most thin sections.

#### **Rhyolite Unit**

The rhyolite unit (ur) is as much as 200 feet thick and apparently caps only the highest hills in the eastern part of the quadrangle. This rock is interpreted to conformably overlie the basaltic tuffs where present, but unconformably overlies the Lower Volcanic sequence and the Volcanic-Sedimentary sequence. The rhyolite is exceedingly resistant to erosion and produces steep sloped, flat topped hills. This rock is well jointed, but does not exhibit schistosity. The color of fresh rhyolite is grey to greyish black. Upon exposure to weathering it develops a white, chalky outer coating. The saprolite is white to buff in color. Subsoils, if present, are sandy loams which vary from buff to vermilion in color. Topsoils are light grey silty loams.

In most places the basal part of the rhyolite section in Morrow Mountain State Park consists of a lithic tuff composed of rhyolite fragments. The lithic fragments are angular and range in maximum dimensions from 1/4 inch to 3 inches. One of the

better exposures of this tuff is located in Morrow Mountain State Park where the park office road crosses Sugarloaf Creek.

Above the base, the rock is a dark greyish black porphyritic rhyolite containing numerous flow bands (see pl. 3, No. 8). The phenocrysts consist of white feldspar laths, 0.5 to 2 millimeters long; and beta quartz crystals, 1 millimeter in length. The flow lines are of a lighter color than the rest of the rock. In fresh outcrops the flow lines are relatively inconspicuous, becoming accentuated by weathering. Numerous strikes and dips were taken of the flow banding; however, the results were too erratic to form a reasonable pattern.

Rhyolite flows on the higher peaks of the Uwharrie Mountains in the eastern part of the quadrangle contain numerous spherulites which range from  $\frac{1}{8}$  inch to over 2 inches in size (see pl. 3, No. 9). Some are cone shaped, others have the form of a double cone. The sides are usually striated, ribbed, and sometimes have a depression in the center which resembles the calyx of a tetracoral, giving Emmons (1856) the impression that they were fossils. The spherulites are usually replaced by quartz; however, specimens collected north of Zion Church still contain radiating feldspar laths.

The rhyolite exposed on top of the Uwharrie Mountains southeast of White Crest Church is a light grey brecciated porphyritic flow rock containing angular blocks 4 to 6 feet across. These blocks appear to have been rotated in place and might represent a brecciated flow top.

The groundmass of the rhyolite flows can not be resolved under the microscope, but appears to be a mixture of kaolinite, sericite and cryptocrystalline quartz (see pl. 2, No. 8). Interlocking unoriented lenticular masses of quartz occur parallel to the flow banding. Sericite masses also seem to be concentrated parallel to the flow bands. Unoriented phenocrysts of orthoclase, oligoclase, and beta quartz are sparingly distributed throughout the ground mass. The orthoclase phenocrysts are usually euhedral and are seldom carlsbad twinned. Oligoclase phenocrysts are lath shaped and exhibit carlsbad, albite and pericline twinning. Some of the oligoclase crystals are clustered as though they began growth from a central point. They are clouded because of replacement by another mineral, probably zoisite. In addition the feldspars contain inclusion of sericite oriented parallel to the C-axis of the feldspar crystals as well as sericite alterations around the outer edges. The beta quartz phenocrysts, though normally euhedral in outline, are in places much embayed and corroded.

The quartz phenocrysts contain minute dust-like inclusions of zircon, many of which are oriented parallel to the axes of the quartz crystals and exhibit simultaneous extinction with the quartz. Most of the quartz phenocrysts show reaction rims, are slightly corroded, and reabsorbed. Rare masses of emerald green chlorite, which might represent alteration of biotite, have been noted.

Under the microscope the spherulites have usually been replaced by quartz. However, some consist of identifiable feldspars, whereas others are composed of fibrous radiating crystals which show undulatory extinction and a biaxial character. These might represent feldspar crystallites. The center of many of the spherulites is a mass of interlocked, sutured, unoriented quartz grains, indicating that the spherulites have been replaced by quartz from the inside outward (see pl. 2, No. 9).

## INTRUSIVE ROCKS

### Gabbro Sills

A number of northeast trending gabbro sills have intruded the argillite and tuffaceous argillite units in the southern part of the quadrangle. They are greenish black in color, highly variable in grain size and usually contain large lath shaped dark green amphibole phenocrysts from  $\frac{1}{16}$  inch to 2 inches in length. The country rock in contact with the sills exhibit baked zones which are from 2 to 3 feet wide near minor sills and are tens of feet wide near larger intrusive bodies. These zones are not easily perceptible unless the rock is weathered; then it turns to a distinctive dark brown. The larger sills appear to have domed the overlying country rock. This is especially true of the sill at Stony Mountain and the sill located due west of Albemarle at the western margin of the quadrangle. Some of the sills southeast of Porter near the south edge of the map contain amygdules, first noted by Bowman (1954) which indicate a near surface emplacement (see pl. 3, No. 10). The sills located on the peninsula caused by the entrance of Mountain Creek into the Pee Dee River and along new Highway N. C. 27, have been intruded by mafic pegmatites consisting of hornblende, 40 percent, and plagioclase 60 percent. Small basaltic dikes, thought to have originated from the sills, occur sparingly throughout the southeastern part of the quadrangle.

In thin section the gabbro is porphyritic and exhibits ophitic texture. It mainly consist of amphibole, apparently hornblende, which in some instances makes up as much as 60 percent of the rock. The

amphibole is much embayed and might represent uralitization of pyroxene. Rare subhedral and euhedral feldspar laths are scattered throughout the rock. The feldspar phenocrysts are usually embayed and partly replaced by serpentine around their borders. They still show carlsbad and albite twinning and are near labradorite in composition. The feldspars have for the most part been altered to kaolinite, sericite, pinitite, and zoisite. It was noted in one feldspar crystal that one set of the albite twins was replaced by zoisite, whereas the other set appeared to be relatively unaltered. Unless pleochroism were noted in plain light, this might easily go unnoticed. Occasional embayed crystals of ilmenite, altered to leucoxene, were observed. Cubic crystals of pyrite are present. The matrix adjacent to the faces of the pyrite appeared to be altered and formed a halo around the crystal. The matrix of the rock is composed of calcite, fibrous serpentine and zoisite.

Some of these rocks were evidently emplaced and then altered by late hydrothermal solutions. This is further indicated by the presence of mafic pegmatites which occur within the sills, but not in the country rock. The original constituents have been partially to completely altered to hornblende, serpentine, leucoxene, zoisite, kaolinite, and pinitite.

The gabbro sills have been observed intruding the Volcanic-Sedimentary sequence, but have not been observed intruding the Upper Volcanic sequence. This suggests that the gabbro might be of the same age as the Upper Volcanic sequence. In fact, they could represent feeders for the basaltic tuffs of the Upper Volcanic sequence. Such a hypothesis is further substantiated by the presence of amygdules in the gabbros, and the presence of occasional basaltic dikes in the vicinity of the gabbros. Although proof is lacking, it is possible that the gabbros might be extensions of the Charlotte igneous belt.

### Rhyolite Dikes

Essentially vertical dipping rhyolite dikes, seldom over 10 feet in width, have been observed in the southeastern and south central parts of the quadrangle. The dikes are medium grey in color and usually are more resistant to weathering than the surrounding country rock. They are dense, massive, well jointed, emit a metallic ring when struck with a hammer, and break with a conchoidal fracture. The dikes are rhyolite porphyrys containing megascopic lath shaped orthoclase and plagioclase feldspar and beta quartz phenocrysts in an aphanitic groundmass. The plagioclases have a subhedral out-

line and exhibit reaction rims in the form of sericite alteration along the contact with the matrix. The crystals are both pericline and albite twinned and are oligoclase in composition. The orthoclase feldspars are relatively rare, and appear as euhedral, usually untwinned crystals. The beta quartz phenocrysts are much embayed and enclose numerous minute zircon phenocrysts ranging from dust sized particles up to about .02 millimeters in length. The matrix of the rhyolite is a meshwork of unoriented cryptocrystalline quartz, sericite, and kaolinite.

About 2 miles southeast of Badin a large coarse grained porphyritic rhyolite dike has been traced from the spillway at Falls Dam along the northeastern flank of Falls Mountain into the rhyolite unit of the Upper Volcanic sequence which caps the mountain. This rhyolite, as well as the other rhyolite dikes, resembles the rhyolite of the Upper Volcanic sequence in hand specimen and thin section and has been mapped with the rhyolite of the Upper Volcanic sequence. It is thought that the rhyolite dikes probably represent feeders for the rhyolites of the Upper Volcanic sequence.

### Diabase Dikes

Diabase dikes, considered to be of Triassic age, (Reinemund, 1955) have intruded rocks of the Carolina Slate Belt in the Albemarle quadrangle. The dikes are most prevalent along the eastern border of the quadrangle and are less so to the west. In general, they trend in a northwesterly direction although a few trend to the northeast.

The diabases are greyish black when fresh and weather to a rusty brown color. They are extremely susceptible to spheroidal weathering. In many places all that could be observed in the field were dark brown clayey soils containing rusty spherical boulders of diabase.

The diabase dikes range in thickness from 3 to 10 feet, rarely exceeding more than 10 feet. They have produced exceptionally narrow baked zones and do not appear to have altered the surrounding country rock to any great extent.

The dikes are fine grained with only a few minerals exceeding a millimeter in length. In hand specimen the only minerals identifiable are the needle-like greenish black pyroxene and grey albite twinned plagioclase. In descending amount of occurrence, the diabases are composed of lath shaped crystals of plagioclase corresponding closely to labradorite, lath shaped greenish brown augite, green hornblende, and occasional olivine and magnetite. The diabases exhibit diabasic texture with the py-

roxenes filling interstices between feldspar laths. The minerals making up the diabases occur as a meshwork in which no preferred orientation could be detected.

### CHEMICAL ANALYSES OF CAROLINA SLATE BELT ROCKS

Chemical analyses of selected samples of Carolina Slate Belt rocks were run by Mr. P. N. Sales, Chemist, N. C. State College, Minerals Research Laboratory, using standard silicate procedures. The results of these analyses are given below:

TABLE I

Major Constituents of Carolina Slate Belt Rocks

	SiO <sub>2</sub>	* R <sub>2</sub> O <sub>3</sub>	** Fe <sub>2</sub> O <sub>3</sub>	CaO	MgO	Na <sub>2</sub> O	K <sub>2</sub> O	Ign. Loss	
Upper Volcanic Sequence	Porphyritic rhyolite, rhyolite unit.	79.0	13.0	1.3	0.1	nil	1.55	2.79	0.60
	Porphyritic rhyolite, rhyolite unit.	83.6	9.91	0.86	0.1	nil	1.19	2.29	0.35
	Mafic lithic-crystal tuff, basaltic tuff unit.	58.9	18.4	5.1	4.9	4.2	1.63	0.77	4.00
	Amygdaloidal basalt, basaltic tuff unit.	53.6	18.4	5.2	7.0	5.9	1.88	0.25	3.07
Volcanic-Sedimentary Sequence	Graywacke, Graywacke unit.	57.5	27.7	4.3	2.5	0.4	0.69	0.76	4.80
	Felsic tuffaceous argillite, tuffaceous argillite unit.	62.9	12.8	3.2	2.3	0.4	1.46	1.47	3.47
	Mafic tuffaceous argillite, tuffaceous argillite unit.	54.1	24.2	2.0	4.2	3.2	.30	1.47	6.80
	Vitric tuff, tuffaceous argillite unit.	78.0	8.8	5.6	1.7	0.3	2.17	0.12	1.15
	Argillite, Argillite unit.	68.9	16.5	7.2	1.5	2.8	1.40	1.5	3.8
Lower Volcanic Sequence	Felsic tuff.	73.1	15.1	2.5	2.5	0.3	2.04	0.55	1.07
	Welded felsic flow tuff.	78.5	12.3	1.4	0.3	0.2	1.95	1.86	1.29
Intrusive Rocks	Gabbro sill.	41.1	15.5	5.0	8.9	16.3	0.60	0.10	5.61

\*Predominantly Al<sub>2</sub>O<sub>3</sub> but could contain amounts of TiO<sub>2</sub>, MnO, P<sub>2</sub>O<sub>5</sub> and other elements precipitated by NH<sub>4</sub>OH after silica dehydration.

\*\*Total iron content reported at Fe<sub>2</sub>O<sub>3</sub>.

A general comparison of the chemical composition of analyzed rocks of the Albemarle quadrangle with published rock analyses of the average composition of similar rocks (Pettijohn, 1957) indicates that the argillite approaches the composition of an average slate with the exception that the K<sub>2</sub>O content is low. This had been previously noted by Laney (1910), Pogue (1910), Stuckey (1928), and Council (1954). The graywacke is much lower in R<sub>2</sub>O<sub>3</sub> and total iron than is average graywacke.

The chemical analyses supported the field and petrographic classification used in this report. It is further noted that the SiO<sub>2</sub> content is consistently

higher, and the K<sub>2</sub>O and Na<sub>2</sub>O contents are lower than published data for similar rocks. Furthermore, the rocks which were originally thought to be composed predominantly of volcanic glasses—the welded flow tuff, vitric tuff, and rhyolite—contain a disproportionately high SiO<sub>2</sub> in proportion to their low K<sub>2</sub>O content.

### Environment of Deposition

The general lack of sorting and bedding in the felsic tuffs of the Lower Volcanic sequence (lft) indicates that they were deposited under subaerial conditions. The interbedded welded flow tuff also indicates subaerial conditions, because it is unlikely that volcanic ejecta deposited in water could retain enough heat to weld and flow. The top of the unit is composed of bedded tuff and grades upward into the argillite unit, suggesting a change from subaerial to subaqueous deposition.

The argillite unit (ar) was deposited below wave base in quiet water. This is indicated by the fine graded bedding which could only develop in relatively quiet water not subjected to wave action or strong currents. The source of the sediments of the argillite units is not known, but it contains thin basal conglomerate apparently derived from the Lower Volcanic sequence. If the Lower Volcanic sequence were exposed as a landmass, erosion of this landmass could have provided the sediments of the argillite unit.

The contact between the argillite unit and the overlying tuffaceous argillite unit is locally gradational but may also be abrupt, which indicates an increased volcanic activity which rapidly overwhelmed the environment of deposition of the argillite unit and produced the tuffaceous argillite unit. The felsic tuffaceous argillite of the tuffaceous argillite unit probably originated as volcanic ash blown into the air, where it was sorted and carried by wind currents, after which it settled directly into a body of quiet water. This is indicated by the excellent sorting, coarse bedding and presence of wispy glass shards which could not have survived reworking. In addition the unit contains mafic and felsic crystal and lithic tuffs and flows which further attest to the volcanic nature of the rock.

Two source areas for the tuffaceous argillite unit are indicated by the interbedded coarse pyroclastic rocks of the "Flatswamp Mountain sequence" which grade both vertically and laterally into tuffaceous argillite and die out to the south, and the vitric tuffs and associated coarser pyroclastics which also grade vertically into tuffaceous argillite and die out to the

north. These two groups of volcanic rocks suggest that there were two active sources during time of deposition of the tuffaceous argillite unit, one to the south and the other to the north of the quadrangle.

The change in lithology from waterlaid tuff to graywacke sandstone (gr) indicates a change from volcanic to clastic sedimentation as well as a change from a predominantly felsic to a mafic source area. The source of the graywacke sediments was to the northeast as indicated by southwest dipping cross-bedding and decrease in particle size to the southwest. The presence of mafic crystal tuff (mt) and felsic lithic tuff (lt) interbeds in the graywacke unit suggests that brief periods of volcanic activity occurred during sedimentation. The mafic tuffaceous argillite (mta) underlying and interbedded with the graywacke unit may be a fine grained equivalent of the graywacke. This is further indicated by the similarity of the chemical composition of these two rocks.

The graywacke in the Albemarle quadrangle could be the product of turbidity currents and probably was deposited in marine water under reducing conditions. This is indicated by the presence of graded bedding and diagenetic pyrite cubes. Rapid erosion, transportation, and deposition is indicated by the presence of mineral and rock fragments in the deposit.

As the andesitic tuff (uat) only occurs in the area around New London, it probably originated from nearby fissures. The absence of recognizable water deposited material and poor bedding and sorting of the tuff suggests subaerial deposition. A flow rock found associated with the andesitic tuff unit did not contain pillow structures further indicating its subaerial deposition.

The widespread occurrence of the basaltic tuffs unit (ubt), the variation in its composition, and the presence of isolated flows near its base suggest that the basaltic tuffs must have originated from a number of vents. The absence of pillow structures in the interbedded flows, apparent absence of interbedded clastic sediments, and general poorly defined stratification suggests that the tuffs represent subaerial deposits.

The rhyolite (ur) probably represents a subaerial series of coalescing flows originating from several vents which produced an almost sheet-like deposit in some parts of the quadrangle. The flows in the Morrow Mountain area were preceded by a deposition of pyroclastic rocks which are now found at the base of the rhyolite unit in parts of this area.

## Structure

Structurally the mapped area is characterized by the northeast trending folds and foliation (axial plane cleavage). The larger of these folds have wave lengths on the order of 10 to 12 miles and plunges gently to the southwest; generally the axial plane cleavage dips steeply to the northwest. Although minor faults are common, no major faults have been mapped in the Albemarle quadrangle. Because of the great thickness of some of the stratigraphic units, faults of considerable displacement could exist and show little or no signs of their presence.

### Troy Anticlinorium

The southeastern part of the Albemarle quadrangle contains the nose of the southwest plunging Troy anticlinorium, the axis of which apparently passes northeastward close to Troy in Montgomery County. Reconnaissance in this area and more detailed work in Moore County indicates the development of an axial plane cleavage dipping to the northwest at approximately 60°, suggesting that the structure is asymmetrical, with the axis inclined to the southeast. The Troy anticlinorium appears to be composed of a series of asymmetrical minor open folds. On the eastern flank of the anticlinorium the axial planes are inclined to the southeast.

Exposed in the center of this structure is the Lower Volcanic sequence, the oldest rocks in the quadrangle. These rocks crop out from near the Pee Dee River in the west to central Moore County in the east to where they plunge under the argillite unit to the southwest, around the nose of the Troy anticlinorium. The rocks have been traced along the axis of the fold from the southeastern part of the Albemarle quadrangle northeastward to beyond Asheboro. As previously noted, a northeast trending belt of felsic tuffs cropping out from the southern part of the Albemarle quadrangle northward to the Virginia state line is shown on the 1958 State Geologic Map of North Carolina. If this felsic tuff actually represents a belt of rocks of the Lower Volcanic sequence, then the Troy anticlinorium is one of the major structures of the Carolina Slate Belt.

### New London Synclinorium

The New London synclinorium is a north 30° east trending fold, the axis of which passes approximately 2½ miles east of New London. It is slightly asymmetrical with the axial plane dipping to the southeast at 75°. The structure plunges to the

southwest causing the sedimentary units in the northwestern part of the quadrangle to wrap around its nose. The graywacke unit, the youngest stratigraphic unit below the Upper Volcanic sequence, is exposed in the center of the structure. The tuffaceous argillite unit wraps around the nose of the structure and is exposed along both its limbs. Down plunge the tuffaceous argillite unit has been warped into a series of minor folds having wave lengths on the order of 50 to 500 feet. The axis of these folds parallels the axis of the major structure. Axial planes of these minor folds converge upward, indicating that the major structure is a normal synclorium. Even with the development of minor folds on the major structure, overall dip remains in the direction of the axis of the synclorium.

### Angular Unconformity

An angular unconformity separates rocks of the Upper Volcanic sequence from the underlying Volcanic-Sedimentary sequence and Lower Volcanic sequence. The contact between the upper volcanic sequence and the underlying units is rarely observed because it is usually covered by soil and talus slump.

The actual unconformable contact is best exposed in two places. The first is in Morrow Mountain Park where the road to the Ranger's office crosses Sugarloaf Creek, here rhyolite is in contact with argillite. The other is on the east shore of Badin Lake approximately one mile north of Badin Dam, where basal conglomerate of the basaltic tuff unit is in contact with argillite of the argillite unit.

Further indications of the unconformity are:

1. From east to west, rocks of the Upper Volcanic sequence overlie and are in direct contact with the felsic tuff of the Lower Volcanic sequence and the argillite, tuffaceous argillite, and graywacke units of the Volcanic-Sedimentary sequence.

2. Where bedding can be observed in both the Upper Volcanic sequence and underlying rocks, the Upper Volcanic sequence is essentially flat lying, whereas the underlying units dip at fairly steep angles.

3. Rocks below the Upper Volcanic sequence have well developed bedding plane cleavage and incipient axial plane cleavage both of which are totally absent in rocks of the Upper Volcanic sequence.

4. Rocks of the Upper Volcanic sequence occur as erosional remnants capping the highest hills throughout the area. They always occur on the hilltops and can not be traced across major drainage valleys.

5. Hills, not capped by the Upper Volcanic sequence, are formed by resistant interbeds which produce elongate northeast trending ridges parallel to regional structure. However, hills capped by the unconformable, flat lying, Upper Volcanic sequence are highly irregular in outline and do not exhibit a regional trend.

6. In Morrow Mountain State Park the basal beds of the rhyolite unit of the Upper Volcanic sequence, in most places, is composed of a lithic rhyolite tuff. The tuff beds can be traced completely around some of the monadnock-like hills.

7. East of Badin the basaltic tuff unit, the basal beds of the Upper Volcanic sequence in this area, rests on the argillite unit of the Volcanic-Sedimentary sequence. In many places the basaltic tuff unit contains a basal conglomerate. Within this conglomerate are pebbles, derived from the underlying argillite unit, which indicate the argillites were eroded before the basaltic tuffs were deposited. These conglomerates are a widespread recognizable horizon, occurring in the eastern, central, and western areas of outcropping basaltic tuff unit. The fact that the basal beds of both the rhyolite and basaltic tuff units can be traced over wide areas disproves any suggestion that these units are interbedded with the underlying Volcanic-Sedimentary sequence.

8. Small discrepancies in elevation of some of the basal contacts of the Upper Volcanic sequence suggest that it was laid down on a mature, well-developed erosional surface having a relief less than present topography. In addition, it has been noted that these rocks have been slightly warped into gentle open folds. These folds are of a much less magnitude of deformation than those developed in the underlying rocks.

The time span represented by this unconformity represents a major break in Carolina Slate Belt time. This is the only unconformity recognized in mapping the Albemarle quadrangle. However, the possibility that a disconformity might exist between the basaltic tuff and rhyolite of the Upper Volcanic sequence is suggested by the fact that in the east central part of the quadrangle the rhyolites (ur) rest on the basaltic tuff (ubt); whereas, in the eastern part they rest directly on the argillites; (ar) and in the southeastern part of the area they rest on felsic tuffs of the Lower Volcanic sequence (lft). Whether or not the basaltic tuff unit was eroded away from the eastern and southeastern parts of the quadrangle or was not deposited in this area has not

been positively determined. Such an abrupt ending of the basaltic tuff unit to the east suggests that they were eroded away.

### Shear Zones

Two northeast trending shear zones, developed in the argillite unit, have been noted in the northeastern part of the quadrangle. One of these occurs from north of the Coggins mine in the northeast to beyond Eldorado in the southwest. The second can be traced from Uwharrie southwestward to the Pee Dee River. When shearing parallels bedding plane cleavage, phyllites are developed, and when it is at an angle to bedding, slates are developed. Oftentimes these shear zones have been mineralized. They contain the lead and zinc mine at Eldorado, the Coggins gold mine, and a number of gold prospects.

### Jointing

Two major joint systems are developed in the Albemarle quadrangle. One strikes from N. 45° to N. 60° E. and dips N.W. at 85°; the other strikes approximately N. 60° W. and dips S.W. at 80°. Two minor joint systems are also noted. One strikes from N. 10° to 20° W. and dips from 80° to 86° S.E., and the other strikes N. 30° E. and dips from 78° to 85° N.W.

Jointing is poorly developed in the argillite unit. These rocks were evidently plastic and bent rather than broke when regionally folded. With the exception of the argillite, well developed jointing is present in all rocks of the quadrangle. It is probably best developed in the vitric tuffs of the Volcanic-Sedimentary sequence and the rhyolites of the Upper Volcanic sequence, both of which are dense, brittle rocks.

### Cleavage

Bedding plane cleavage is locally well developed throughout the quadrangle. Outside of shear zones, shear cleavage is poorly developed. Axial plane cleavage is best developed in the argillite unit and locally appears to parallel northwest trending minor folds developed perpendicular to the axis of the New London synclinorium, along its eastern limb. It is faintly developed, but discernible, in the tuffaceous argillite and graywacke units and parallels the axis of the New London synclinorium.

### Metamorphism

Metamorphism is of exceedingly low rank and would be classified as near the bottom of the green-

schist facies. Recrystallization has usually affected only the groundmass and for the most part has not greatly altered the mineral crystals in porphyrys and crystal tuffs. The major changes have been the development of sericite, kaolinite and chlorite, as well as complete devitrification of the volcanic glasses. General absence of alignment of secondary minerals is caused by lack of development of axial plane cleavage. Reconnaissance indicates that metamorphism and shearing increase markedly near the Charlotte Belt, west of the quadrangle; and increase gradually toward the Deep River Triassic basin, east of the quadrangle.

## Geomorphology

### Stage of Development

The area covered by the Albemarle quadrangle has reached a mature stage of development. Drainage is well integrated and approaching grade. Hills have a generally rounded appearance and most of the stream valley are in a late youth or mature stage of development. Their valley walls have diminished slope from the steep walled V-shape of youth and a few have begun to develop floodplains.

### Drainage Pattern and Development

Tributary streams which head and flow over areas underlain by rocks of the Upper Volcanic sequence have a generally random orientation, apparently because these rocks are essentially flat lying. In contrast, streams flowing over areas underlain by rocks stratigraphically below the Upper Volcanic sequence have developed a trellis pattern which is parallel with the northeast trending regional structure. The stream valleys have developed in the least resistant rocks leaving more resistant rocks holding up divides.

Drainage, in general, has been highly modified by stream capture. The major diversion of drainage was the capture of the Yadkin River by the Rocky River, (located southwest of the Albemarle quadrangle). Both of these rivers flow across structures and are antecedent streams. The Pee Dee River is thought to have once been a northeast flowing tributary to the Yadkin River. With the passage of time the Pee Dee eroded headward through the divide which separated the Rocky and Yadkin Rivers and diverted the Yadkin drainage into the Rocky River.

Almost all the northwest-southeast flowing tributary streams of the Yadkin and Pee Dee rivers have been offset by numerous, short, right angle captures. Several of the streams change direction of flowage

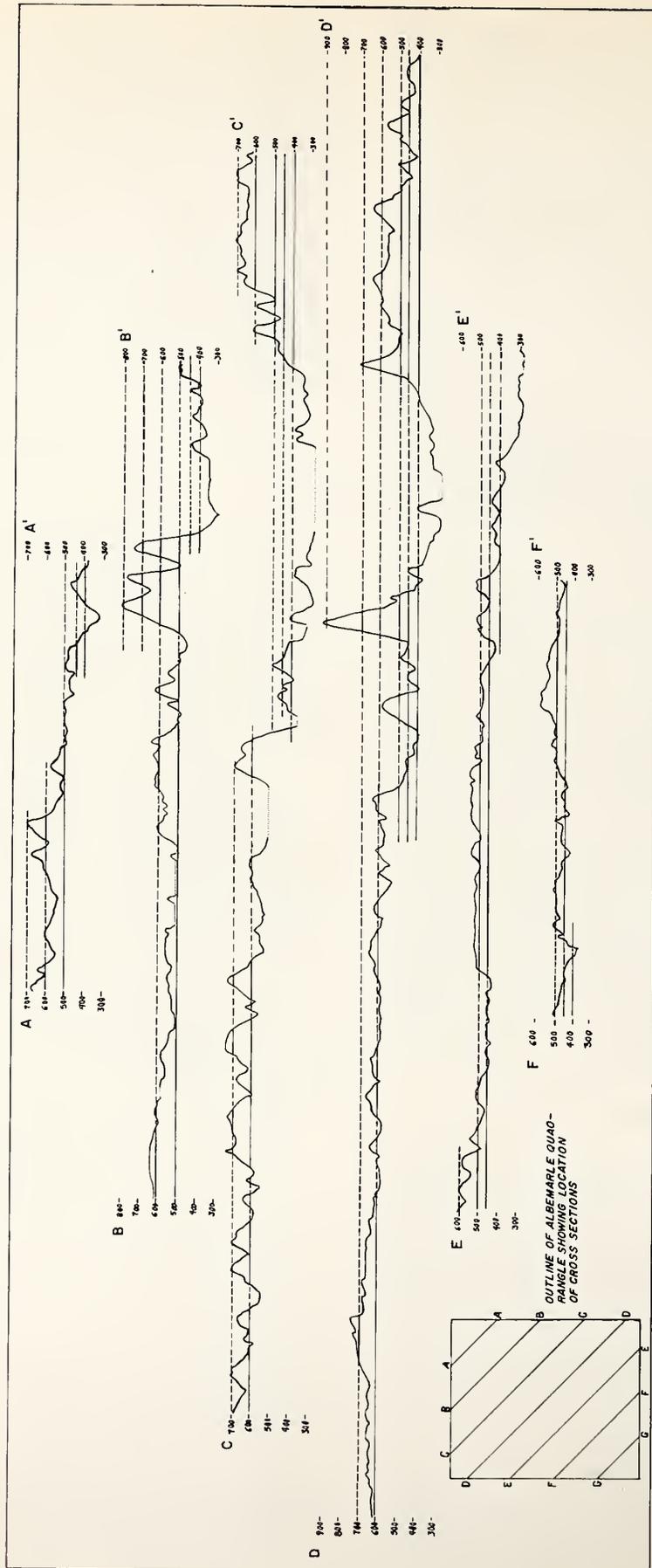


Fig. 2 - Topographic cross sections showing erosion surfaces at the 800, 700, 600, 500, 450, and 400 foot elevations

by this means a number of times before reaching the trunk stream. It is worth noting that tributaries flow into the trunk streams in either a northwest or southeast direction across structure, indicating that the trunk stream captured most of its tributaries. It is also interesting to note that both the Pee Dee and Uwharrie rivers flow in a southwesterly direction parallel to major northeast trending structures. Whereas, the Yadkin River flows in a southeasterly direction across structure and in places has cut through northeast trending ridges composed of differentially resistant dipping strata. This has produced several rather spectacular water gaps.

### Erosional Surfaces

A number of topographic cross sections across the Albemarle quadrangle indicate the presence of 6 erosional surfaces at elevations above present floodplains (see Fig. 2). These levels are found at the approximate elevations of 800, 700, 600, 500, 450, and 400 feet. The best developed surface occurs at the 500 foot elevation.

The upper two levels are primarily represented by hill tops. Surfaces below the upper two levels are represented by both rock terraces and hill tops.

Most of the erosional surfaces are products of stream capture and readjustment to new base levels. On the basis of present evidence, it is difficult to determine whether uplift in this area was a gradual slow process or a series of pulsations.

## ECONOMIC GEOLOGY

### Gold

#### Coggins Mine

The Coggins mine is located in northwestern Montgomery County, 1.4 miles north-northeast of Eldorado. The ore zone is located in the argillite unit. The country rock has been sheared into slate with a pronounced axial plane cleavage which strikes N. 45° E. and dips N.W., at 70° to 78°. The slate has been sericitized, chloritized, and silicified. This deposit is part of the mineralization which occurs along the shear zone which can be traced from the northern boundary of the quadrangle southwestward through Eldorado.

Some free gold occurs in the weathered zone, but with depth the ore is principally sulphides carrying gold. The ore is disseminated throughout quartz veins and adjacent country rock. Bryson (1936) stated that the mineralized zones are lenticular in outline and varied in width up to 50 or 60 feet.

Nitze and Hanna (1896) stated that there appears to be two ore bodies.

Bryson noted that the mine had been worked to a depth of 250 feet with drifts at the 50, 100, 200 and 250 feet levels. The assays of the ore ranged from \$1.00 to \$6.77 per ton, but certain zones from the 200 to 250 feet level gave values of approximately \$20.00 per ton with some high grade samples running as high as \$53.00 per ton. He stated that the mine was partially dewatered in 1933-1934, but no further exploration was done.

#### Morris Mountain Mine

The Morris Mountain mine (incorrectly located on the geologic map) is located .6 of a mile due north of Eldorado, just a few hundred yards northwest of the Eldorado-Coggins mine road. A concrete foundation of the mill, a trench, and a shaft are all that remain to indicate the existence of the mine.

The country rock is the argillite unit. The mode of occurrence of the ore is similar to that of the Coggins mine. Nitze and Hanna (1896) reported that the gold is occasionally concentrated in the joint planes. They gave two assays as follows:

Gold per ton.....	\$3.61	\$82.68
Silver per ton.....	.68	trace
	—————	
	\$4.29	\$82.68

#### Worth Placer Mine

Nitze and Hanna (1896) discussed the Worth placer mine, located near the junction of the Uwharrie and Yadkin rivers. This mine could not be located during the present field investigation.

#### Moratoek(?) Mine

Old mine workings, a few hundred yards north of highway N. C. 27 on the western edge of the Uwharrie Mountains, are thought to be the Moratoek mine. Nitze and Hanna (1896) located this mine 8 miles south of Eldorado and stated that the country rock is a highly silicified quartz porphyry and brecciated tuff.

The remnants of the old mine consist of two northeast trending caved open cuts approximately 200 feet long, a caved shaft, and the foundation of a building, probably the mill. The country rock is a slightly sheared felsic lithic crystal tuff of the felsic tuff unit. Quartz veins, a few inches to 10 inches in width, are exposed in the open cuts. They strike

N. 50° E. and dip N.W. at 50°. Nitze and Hanna stated that the gold occurred in the quartz veins. Some chalcopyrite, copper carbonate, and pyrite were noticed in the deposit. Nitze and Hanna reported that the pyrite assayed less than \$1.00 gold per ton.

A ten stamp mill equipped with a cyanide plant was erected on the property and operated until 1893. The failure of the venture was caused by ore of too low grade to be profitably worked.

### **Parker Mine**

The Parker mine is located at the western city limits of New London. The deposit occurs in the andesitic tuff unit near the contact with the overlying basaltic tuff unit. Nitze and Hanna (1936, page 83) stated, "numberless auriferous quartz stringer veins, from less than 1 to 18 inches in thickness, intersect the country rock in all directions. Besides these, several larger and more persistent veins occur. The quartz is imperfectly crystallized and often cellular. Weathering agencies have distributed the gold through the decomposed rock (soil) to depths of 10 to 20 feet". The ore was richest in the vein quartz, \$4.00 to \$6.00 per ton at pre 1934 prices; however, the most profitable part of the operation was the placer mining of old gravel channels whose values ran from \$.44 to \$3.20 per yard. It is reported that over \$200,000 in gold was produced from these gravels (Nitze and Wilkens, 1897).

The gold occurred as coarse nuggets, the largest found weighed 8 pounds 3 ounces and 2 dwts. Bryson (1936) reported that in 1935 a rich seam was encountered which contained nuggets weighing from 1 to 2½ pounds each.

The principal method of mining was hydraulicking the auriferous saprolite. However, Bryson (1936) stated that three shafts were sunk on the property; the "Ross shaft," 120 feet in depth; the "Crib shaft," 80 feet in depth; and another shaft, over 100 feet in depth. He reported that in 1935 the North Carolina Mining Corporation assumed control of the property and drove a 250 feet tunnel into the hillside. At 150 feet a quartz vein was encountered, and a shaft about 15 feet in depth was sunk on the vein. From this shaft about 15 or 20 pounds of large gold nuggets were removed.

### **Cotton Patch Mine**

The Cotton Patch mine is located approximately 2 miles east of New London. It has the same geologic setting as the Parker mine. The ore occurs as

free gold in a quartz vein approximately 18 inches wide. The gold nuggets are coarse, usually crystalline and range in size from 1/16 inch to over ¼ inch across. The major work carried out prior to 1865, was confined to placer mining a small creek which drains the property to the south. In 1958 interest was renewed and a crosscutting trench was bulldozed on the property. Sufficient reserves were not discovered and the mine was abandoned until 1961, when it was reopened to the public for mineral specimen collecting.

### **Gold Mine, Name Unknown**

A gold mine consisting of a series of open cuts and prospect pits is located on the south side of Big Island Creek, approximately 0.1 mile east of the junction of Big Island Creek with the Pee Dee River. A number of quartz veins cross this area, and mining seems to have been confined to the quartz veins and adjacent saprolite. If shafts were put down they are not caved and unnoticeable.

### **Dutchmans Creek and Island Creek Placer Mines**

Extensive dumps along the floodplains of both Dutchmans Creek and Island Creek attest to the fact that these areas were extensively placer mined. Nitze and Hanna (1896) stated that these and other mines along the western edge of the Uwharrie Mountains were profitably worked as long as the naturally concentrated material lasted and the proximity of water favored work.

### **Lead and Zinc**

A mine located approximately 100 yards northeast of the village of Eldorado was supposedly worked for lead, zinc, and gold. This locality is thought by local residents to be the site of the Henderson mine. It consists of a shaft of unknown depth and a series of northeast trending prospect pits. Galena, sphalerite and pyrite are prevalent on the dumps. The main shaft was dewatered in 1957, but mining was not activated.

### **Quartz**

Milky white vein quartz, used as a facing for ornamental exterior blocks in building construction, is being mined from a large quartz vein located approximately 0.8 mile northeast of Eldorado. Other large quartz veins which might be used for this purpose are: on the east bank of Richland Creek, on the hill west of White Crest Church; west of the road to Uwharrie, between the junction of Woods Creek and Big Island Creek with the Pee Dee River;

in the center of the village of Palmerville; and south of Halls Ferry Junction at the intersection of the Southern Railway spurline to Badin with the road connecting New London and Albemarle. These veins are variable in size throughout their exposure and a detailed investigation would be required before any type of mining could be commenced. In the event that architectural demands for milky vein quartz continues at its present rate, these veins might be exploited. Also, the iron content of these veins might be low enough to meet the specifications for manufacture of optical glass and metallic silicon. The feasibility of using vein quartz for this purpose is highly questionable because of the prohibitive cost of mining.

### Crushed Stone

The felsic lithic crystal tuff of the Lower Volcanic sequence was used in the construction of Highway N. C. 27 between the Pee Dee River and Troy. It is exceedingly hard and causes excessive wear on the jaw crushers, but was used because of its proximity to the road construction.

Several state highway quarries have been and some are presently in operation in the felsic tuffaceous argillite of the tuffaceous argillite unit. These rocks are easily quarried, crushed, and meet state highway aggregate specifications. One disadvantage is that the rock forms splinters which readily puncture tires when used as road gravel without an asphalt bond. However, it is satisfactory when cemented with a bonding agent and rolled until the splinter pieces lie parallel to the surface of the road.

Rhyolite of the Upper Volcanic sequence has not been quarried to any extent in the quadrangle, probably because it is a massive, hard rock, difficult to quarry and crush. For these reasons it is doubtful if it would be preferred in highway construction. Still, a possible use for this material might be in the manufacture of fine aggregate for composition roofing shingles.

Two rock types which have not been quarried or used for road aggregate in the Albemarle area are the basaltic tuffs of the Upper Volcanic sequence and gabbro sill-like bodies. Gabbro sills in the Albemarle area are similar to that satisfactorily used in road construction in Randolph County and should make an excellent road material. A second use for these rocks might be ornamental stone as they take a good polish and resemble verde antique. One of the better quarry localities would probably be Stony Mountain, which is composed of a large mass of relatively unweathered gabbro.

### Flagstone

Argillite which would apparently produce good flagstone occurs east of Blaine. This flagstone is on strike with that quarried by the Jacobs Creek Flagstone Company at their Nor-Carla Bluestone quarry north of Albemarle quadrangle. The argillites at Blaine have a closely spaced nearly perfect bedding plane cleavage, widely spaced jointing, and axial plane cleavage is absent. For these reasons, it appears that large masses could be easily quarried, and cleaved into structurally strong sheets varying in thickness from about 1/2 to 1 inch.

The argillites at the Nor-Carla quarry lie along the contact between the argillite and the tuffaceous argillite units. They appear to contain a small quantity of tuffaceous material, and on weathering take on a chalky appearance resembling the tuffaceous argillite. Because of this added tuffaceous material, the argillite at the Nor-Carla quarry is lighter colored, coarser bedded and upon metamorphism is more resistant to plastic flow, and development of incipient axial plane cleavage than are the argillites normally found in the argillite unit. As these rocks still contain graded bedding they are considered part of the argillite unit.

The argillite, which makes flagstone, can be traced southward along strike to the north shore of Badin Lake. Further south in the area around Badin the rock becomes a felsic tuffaceous argillite, and contains too much coarse bedding to split into flagstone.

A quarry in Morrow Mountain State Park has been opened in argillite. Stone from this quarry was used in constructing the rough flagging for the bridges and walls in the State Park. Fine bedding and incipient axial plane cleavage hampered splitting of the stone in other than rough angular blocks.

A quarry located on the west bank of the Uwharrie River south of Uwharrie was opened in a phyllite. The direction of shear was parallel to the bedding, causing the rock to split into thin fissile plates which might be used for roofing slate. Unfortunately, the rock contained a closely spaced joint system which substantially reduced the size of the material quarried and the venture was not a success.

### Brick Clay

Yadkin Brick Yards, at Isenhour is the only brick plant in the Albemarle quadrangle. Their clay pit is located in graywacke (gr) saprolite. This saprolite ranging from 10 to 20 feet in depth and consists of particles ranging in size from sand to clay. Upon

firing, an excellent red brick is produced from this material.

Stanly Shale Products, at Norwood, south of the quadrangle, produces brick from saprolite of the argillite unit (ar). The argillite unit is usually covered with a thick mantle of saprolite, and numerous brick clay pits could be opened in this unit in the Albemarle quadrangle.

Another possible source of brick clay is the saprolite of the felsic tuffaceous argillite (fta) of the tuffaceous argillite unit. This material might be used to manufacture buff burning brick and blended with other materials to produce lighter colored brick. Although no firing tests have been run, this saprolite appears to contain enough clay to give a bondable mixture. However, the tuffaceous argillites are not as susceptible to weathering as either the graywackes of the argillites and for this reason, reserves could be limited.

#### **Lightweight Aggregate**

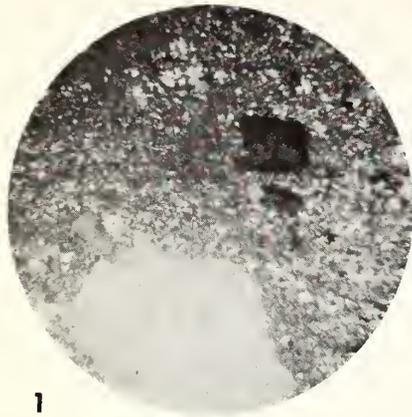
The Southern Lightweight Aggregate Corporation at Aquadale, just south of the Albemarle quadrangle uses felsic tuffaceous argillite to make a lightweight aggregate. Lightweight aggregate is produced by

heating this material until it reaches fusion temperature and expands as gases are released from decomposition of certain minerals such as calcite and pyrite within the rock. Maximum expansion is achieved when fusion and emission of gasses occur simultaneously. The process of bloating is aided by the decomposition of certain quantities of calcium carbonate. However, an excess of calcium drops the fusion temperature below the temperature at which gases are released and produces a vitreous slag (Burnett, 1960).

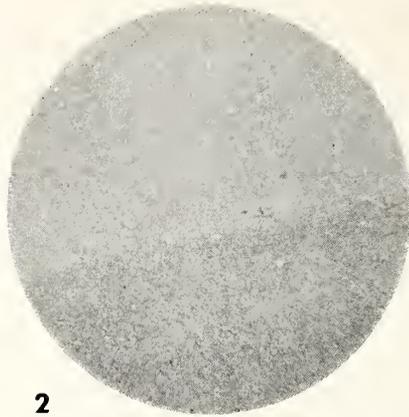
An excess of calcium carbonate could be a problem in bloating the felsic tuffaceous argillite because calcite nodules and thin beds of calcite, ranging in thickness from 1 to 3 inches, locally occur within the tuffaceous argillite unit. Excess calcium carbonate content could be controlled by selective mining.

During field mapping it was noted that the calcite beds thinned to the northeast, along the eastern flank of the New London synclinorium and almost completely disappeared north of Albemarle. This suggests that felsic tuffaceous argillite not containing an excess of calcium carbonate might be found in the area north of Albemarle.

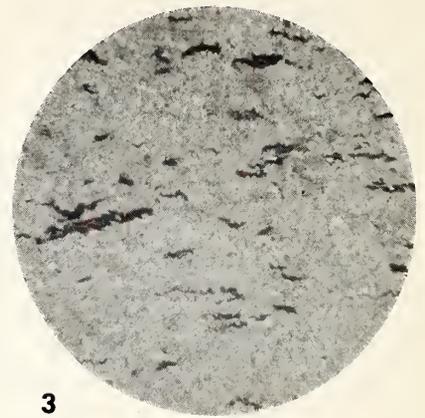




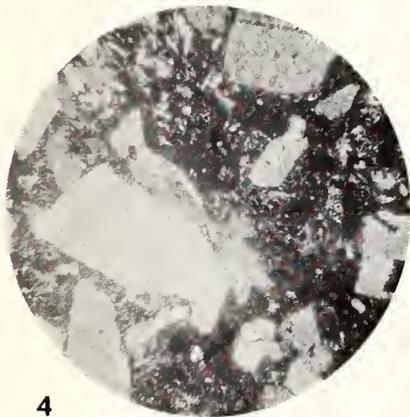
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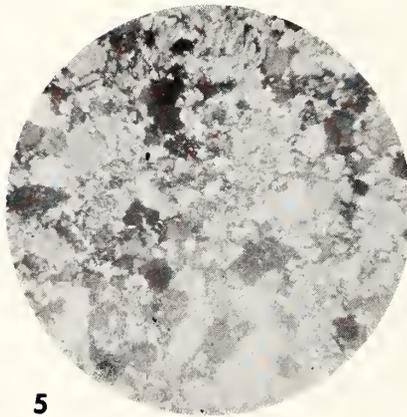
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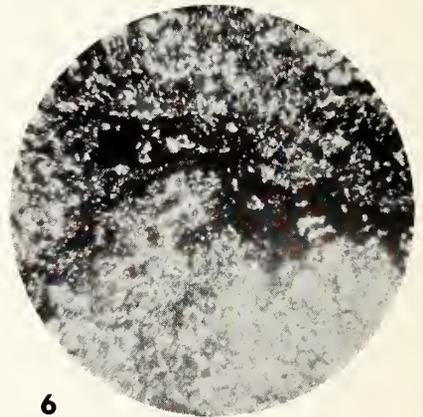
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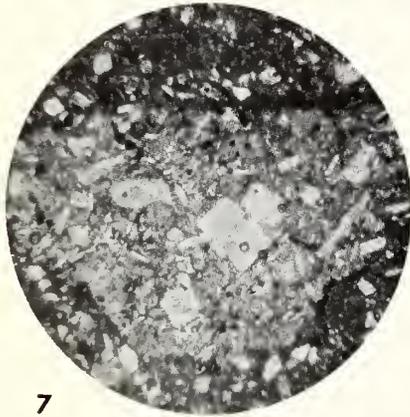
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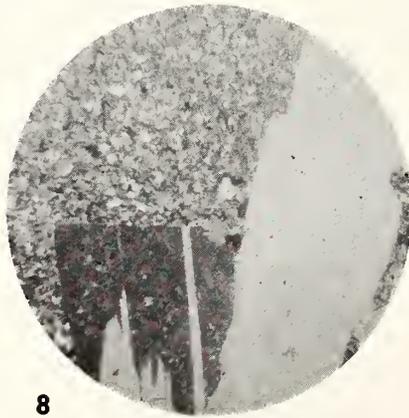
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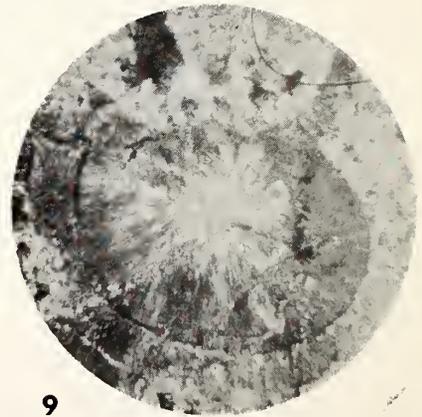
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Photomicrographs of Typical Volcanic Rocks

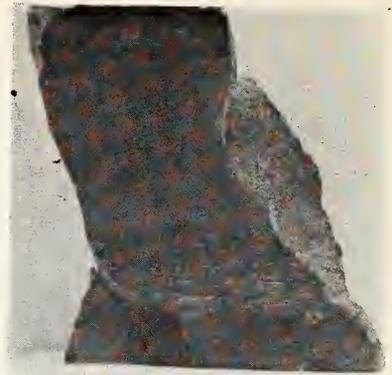
1. WELDED LITHIC CRYSTAL FLOW TUFF, felsic tuff unit, Diam. 2.5 mm., crossed nicols. Light colored lithic fragment and dark cloudy albite twinned feldspar crystals in a cryptocrystalline groundmass of quartz, sericite, and kaolinite.
2. ARGILLITE exhibiting graded bedding, argillite unit. Diam. 2.5 mm., crossed nicols. Graded bedding ranging in size from light colored coarse silt at the bottom to fine silt and clay at the top. The darker color of the fine grained portion of the bed is due to the increase in amount of chlorite in the matrix.
3. FELSIC TUFFACEOUS ARGILLITE, tuffaceous argillite unit. Diam. 2.5 mm., crossed nicols. Devitrified glass shards, now altered to kaolinite, in a cryptocrystalline groundmass.
4. FELSIC CRYSTAL TUFF, tuffaceous argillite unit. Diam. 2.5 mm., crossed nicols. Large broken feldspar laths in a matrix of fine crystals and other volcanic debris.
5. GRAYWACKE, graywacke unit. Diam. 2.5 mm., crossed nicols. Sand sized grains of quartz, feldspar, and rock fragments in a fine grained chloritic matrix.
6. ANDESITIC TUFF, andesitic tuff unit. Diam. 2.5 mm., crossed nicols. Dark colored, collapsed, scoriaceous fragment in a fine grained groundmass of volcanic debris.
7. LITHIC FRAGMENTAL TUFF, basaltic tuffs unit. Diam. 2.5 mm., plane polarized light. A large, lighter colored fragment composed of feldspar crystals in a fine grained groundmass completely surrounded by the rock matrix which is made up of broken feldspar crystals and chlorite.
8. RHYOLITE, rhyolite unit. Diam. 2.5 mm., crossed nicols. Untwinned orthoclase and albite twinned plagioclase crystals in a devitrified cryptocrystalline groundmass.
9. SPHERULITE in rhyolite, rhyolite unit. Diam. 2.5 mm., crossed nicols. Note the fibrous masses of quartz which are replacing the center of the spherulite.



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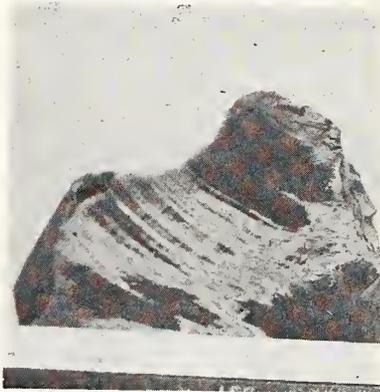
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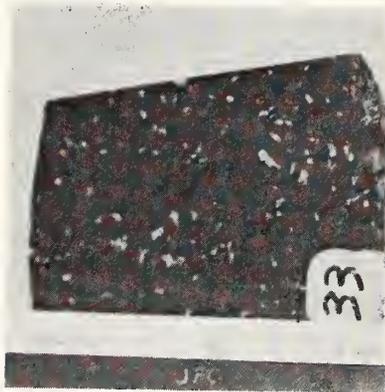
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Photographs of Typical Rock Specimens

1. Welded crystal flow tuff, felsic tuff unit.
2. Outcrop of argillite exhibiting graded bedding, argillite unit.
3. Massive bed of felsic tuffaceous argillite sandwiched between two beds composed of wispy, flattened masses of devitrified volcanic glass, tuffaceous argillite unit.
4. Felsic crystal tuff which occurs interbedded with the felsic tuff, tuffaceous argillite unit.
5. Vitric tuff of the type often interbedded with felsic tuff, tuffaceous argillite unit.
6. Graywacke containing crude graded bedding, graywacke unit.
7. Basaltic lithic tuff composed of dark green rock fragments in a lighter colored matrix, basaltic tuffs unit.
8. Porphyritic rhyolite, rhyolite unit.
9. Spherulitic rhyolite, rhyolite unit.
10. Amygdaloidal gabbro from a gabbro sill.

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