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FIELD TRIP GUIDEBOOK

GEOLOGY OF THE ALBEMARLE AND DENTON QUADRANGLES, NORTH CAROLINA

Featuring
Stratigraphy and Structure in
the Carolina Volcanic - Sedimentary Group

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GEOLOGY OF THE ALBERMARLE AND DENTON QUADRANGLES, NORTH CAROLINA

FEATURING STRATIGRAPHY AND STRUCTURE IN THE CAROLINA VOLCANIC-SEDIMENTARY GROUP

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INTRODUCTION

Location

The Albermarle and Denton quadrangles are located in the central Piedmont region of North Carolina, between 35 15’ and 35 45’ north latitude and 80 00’ and 80 15’ west longitude. The area is drained by the Yadkin and Uwharrie Rivers which join in the northeastern part of the Albemarle quadrangle to form the Pee Dee River. Most of the Denton and the eastern part of the Albemarle quadrangles contain the Uwharrie Mountains which contrast with the rolling Piedmont topography to both the east and west.

Purpose and Scop

The area of the two quadrangles is underlain by rocks of the “CarolinaVolcanic-Sedimentary Group,” also known as the Carolina Slate Belt. This group is a series of northeast trending low rank metamorphic rocks consisting of volcanic flows, pyroclastics and sediments; most of which are in part derived from volcanic rocks. Although recognized for over a hundred years, little is known about the stratigraphy and structure of these rocks. The present work on the two quadrangles was an attempt to map in detail the rocks of the area and subdivide the units as much as possible. From this mapping, it was hoped to establish a stratigraphic sequence and determine the structure of the area. The Albemarle quadrangle is being mapped by the North Carolina Division of Mineral Resources and the Denton quadrangle by the U.S. Geological Survey

Previous Investigations

Olmsted (1825) was one of the first to recognize the rocks of the group which he named the “Great Slate Formation”. This was followed by Emmons’ “Geology of the Midland Counties” (1856). He considered the rocks to be sediments, not recognizing that they were just in part composed of volcanic material. For his time, he made some very accurate observations of the structure of the area, recognizing both the large anticline near Troy and the syncline near New London. G.H. Williams (1894) was the first to discover the presence of volcanic rocks in the group. Following this there were several published descriptions of isolated areas. The most outstanding works, including areal geologic mapping of restricted areas, were by Laney (1910 & 1917), Pogue (1910) and Stuckey (1928). The most recent work has been a series of published economic studies by Broadhurst and Councill.

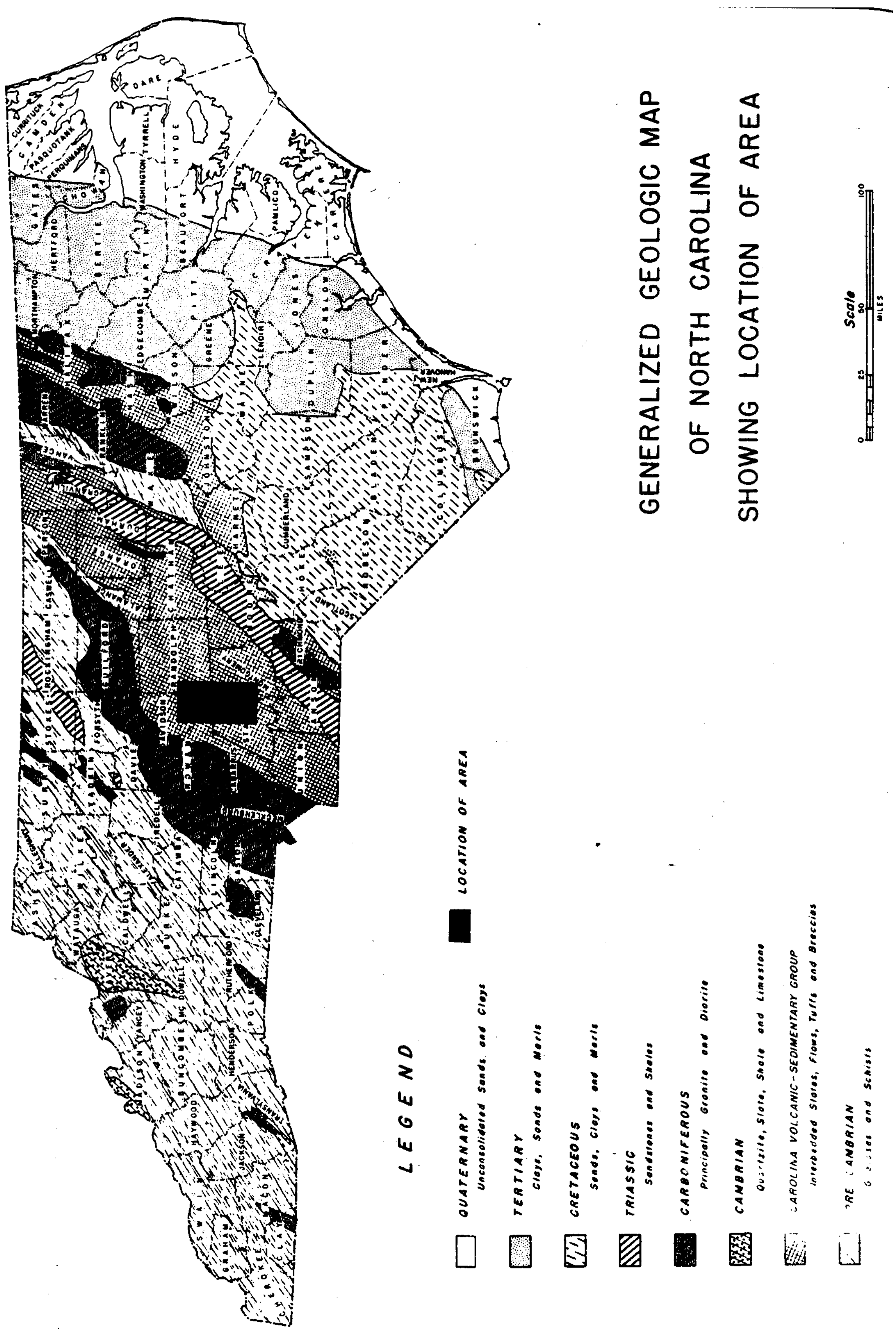
General Geology

The term “Slate Belt” which has come into popular usage is a misnomer which Broadhurst and Councill (1953) tried to correct by substituting “Volcanic-Slate Series”. Slate is not the predominant rock of the group. The southwestern part of the belt is mostly argillite with a well developed bedding plane cleavage. In contrast to the east, much of the material is compressed into phyllite with only occasional rocks showing a poorly developed axial plane cleavage of slate. The Slate Belt is not a belt as such, it is truncated by a complex of plutons to the west. However, Keith and Sterrett (1931) first reported pyroclastics in the Battle Ground schist of the Gafney-Kings Mountain folio and Griffitts (1958) discovered what appears to be an amygdaloidal basalt in biotite gneiss near Cherryville, North Carolina. These volcanic rocks in areas west of the Volcanic-Sedimentary Group, proper, might indicate that it was much more extensive, but has been metamorphosed beyond recognition. To the east, the group is covered by sediments of the Coastal Plain. Oil wells drilled as far east as Onslow and Camden Counties, penetrated rocks of the Volcanic-Sedimentary Group which form the basement in this area, indicating that they underlie the Coastal Plain for a considerable distance.

The Carolina Volcanic-Sedimentary Group is exposed in the central Piedmont from southern Virginia to Georgia. It is not continuous but is interrupted by the Sanford-Durha Triassic basin, and in the northeast it has been intruded by large granitic bodies which have metamorphosed the surrounding volcanic-sedimentary rocks into gneisses and schists.

Age

Fossils have not been recognized inthe Volcanic-Sedimentary Group in North Carolina and the age of the units is a subject of conjecture. Emmons and other early workers con-


GENERALIZED GEOLOGIC MAP
OF NORTH CAROLINA
SHOWING LOCATION OF AREA
Scale
0 25 50 100
MILES
LEGEND
LOCATION OF AREA
QUATERNARY
Unconsolidated Sands and Clays
TERTIARY
Clays, Sands and Marls
CRETACEOUS
Sands, Clays and Marls
TRIASSIC
Sandstones and Shales
CARBONIFEROUS
Principally Granite and Diorite
CAMBRIAN
Slate, Shale and Limestone
AROLINA VOLCANIC-SEDIMENTARY GROUP
Interbedded Slates, Flows, Tuffs and Breccias
ANBRIAN
and Schists

sidered the rocks to be of Precambrian age, but more recent authors have tended to place them in the Paleozoic. This is probably because the Arvonia and Quantico Slates of Virginia which contain volcanic beds have produced Ordovician age fossils (Watson 1911). In addition to this, volcanic ash beds occur in Ordovician (Lowville age) rocks in Tennessee, Kentucky, and Alabama (Nelson 1922). It is hoped that a more definite age can be placed on these rocks as soon as an age determination is completed by radiometic means.

Stratigraphy

In mapping the Albemarle and Denton quadrangles, a stratigraphic sequence has been recognized. The lowest member of the sequence is the lower volcanic unit. It is composed of acid lithic crystal tuff set in a matrix of very fine tuff, with interbedded rhyolite flows and intruded by rhyolite dikes. The lower volcanic rocks are conformably overlain by the “varved” argillite unit. The argillites are thinly bedded and usually show graded bedding and have been referred to in the literature as varved argillite (Theismeyer and Storm 1938). No glacial deposits have been found in the areas mapped and in this report “varved argillite” is a descriptive term for finely laminated argillite showing graded bedding. It does not imply seasonal bedding and glacial control, as the term was originally defined.

The varved argillites grade vertically into the coarsely bedded acid tuffaceous argillite unit. The basal section of this latter unit contains silt size quartz grains intermixed with flattened fragments now kaolinized, thought to be glass shards, as well as small lithic fragments and broken mineral crystals (usually feldspar) interspersed throughout the unit indicating a volcanic origin of the sediments. Interbedded with the acid tuffaceous argillites are basic tuffaceous argillites, acid tuffs, breccias and flows, and basic tuffs and breccias. The acid tuffaceous argillites are overlain by the graywacke unit. This unit is composed of graywacke sandstones with some graywacke siltstones and interbedded basic tuffs, breccias and conglomerates.

The upper volcanic unit uncomformably overlies the sedimentary units and is the youngest member of the sequence. It consists of basic tuffs and breccias, and one questionable flow. These are overlain by a series of rhyolite flows.

INTRUSIVES

The oldest known intrusives in the area are a series of rhyolite dikes intruding the lower volcanic unit. They are generically related to rocks of this unit and are thought to have been feeders which produced some of the volcanic rocks of this unit. Gabbro sills, at least younger than the acid tuffaceous argillite unit are found throughout the area. Conceivably, they may have been the feeders for the upper basic volcanic rocks. Small rhyolite dikes cut the basic tuffs of the upper volcanic unit but do not seem to intrude the overlying rhyolite flow. South of Morrow Mountain, one of these dikes is (almost) traceable into the over-lying rhyolite, suggesting that they were feeders for these later flows. Northwest trending diabase dikes probably of Triassic age cut across the structures of the Volcanic-Sedimentary Group. These dikes are very widespread and are found throughout the two quadrangles

STRUCTURE

The Volcanic Sedimentary Group has been regionally folded. Thus the area has been warped into a series of northeast trending snyclines and anticlines, the larger ones having wave lengths in the order of ten to twelve miles. At least one major fault has been mapped. Owing to the great thickness of the stratigraphic units, major faults of tremendous displacement could exist and show little or no signs of their presence.

Troy Anticlin

The southeastern part of the Albemarle quadrangle contains the nose of a southwest plunging anticline. This structure has been traced from Robbins in Moore County, in the east, to the Pee Dee River in the west, and from the southern part of the Albemarle quadrangle northward to Asheboro, Randolph County. Exposed in the center of the structure are the oldest rocks of the are mapped, the lower volcanic unit. This unit dips under the varved argillites along the western flank of the structure in the eastern part of the quadrangle and plunges under the argillites in the southern part.

New London Syncline

The northwestern part of the Albemarle quadrangle contains a large southwest plunging synclinal structure. The acid tuffaceous argillite wraps around this structure, whereas the younger graywacke unit is exposed in its center. The axis of the structure lies east of New London and can be traced in a southeastern direction out of the quadrangle.

Denton Anticline

The concealed axis of the Denton anticline parallels the regional trend, and from just south of the town of Denton passes southwestward through the west edge of the Denton quadrangle about 3 ½ miles north of the southwest corner of the quadrangle. The fold apparently plunges to the southwest at a low angle. This fold exposes only the acid tuffaceous argillite unit.

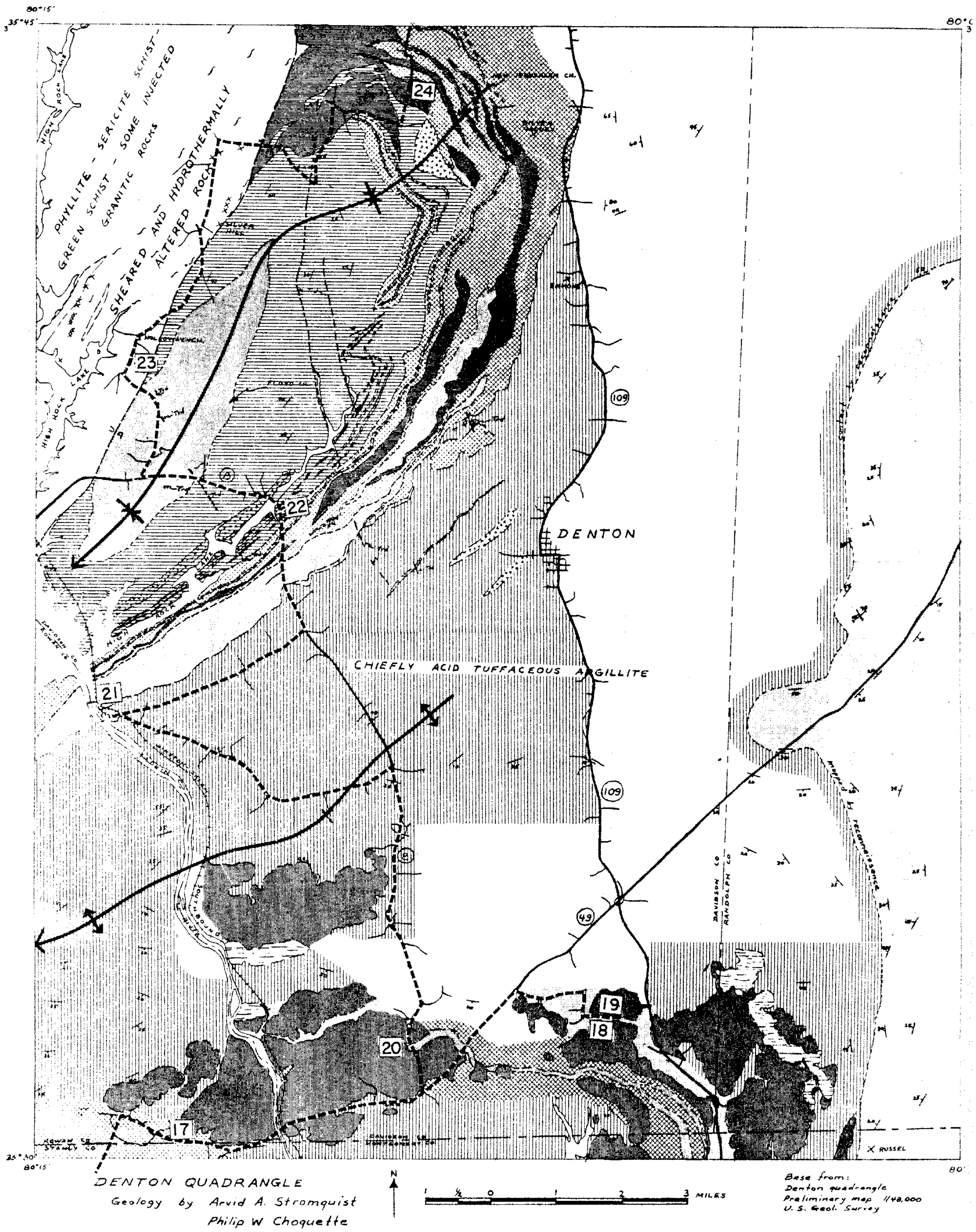
Floyd Church Syncline

The rocks of the northwestern corner of the Denton quadrangle were warped during regional deformation into northwest-trending folds. A probable syncline is the domi-

GEOLOGIC MAP
ALBEMARLE QUADRANGLE
GEOLOGY BY JAMES F. CONLEY

LEGEND

Rhyolite flows	UPPER VOLCANIC UNIT
Basic lithic crystal tuff	
UNCONFORMITY	
Graywacke	GRAYWACKE UNIT
Basic breccias and conglomerates	
Scoriaceous basic tuffs	
Acid tuffaceous argillite	TUFFACEOUS ARGILLITE UNIT
Basic tuffaceous argillite	
Acid tuffs and flows	
Basic tuffs and breccias	
Varved argillite	VARVED ARGILLITE UNIT
Acid lithic tuffs and conglomerates ?	LOWER VOLCANIC UNIT
Interbedded rhyolite flows	
Gabbro sills	INTRUSIVES
Rhyolite dikes	
Anticline	
Syncline	
ROUTE OF TRIP	
FIELD STOP	


80°15'
35°45'
80°0'
PHYLLITE - SERICITE SCHIST - GREEN SCHIST - SOME INJECTED GRANITIC ROCKS
SHEARED AND HYDROTHERMALLY ALTERED ROCK
HIGH ROCK LAKE
24
23
22
21
20
19
18
17
109
49
DENTON
CHIEFLY ACID TUFFACEOUS ARGILLITE
DAVIDSON CO
RANDOLPH CO
X RUSSEL
35°30'
80°15'
80°
DENTON QUADRANGLE
Geology by Arvid A. Stromquist
Philip W Choquette
N
MILES
Base from:
Denton quadrangle
Preliminary map 1/48,000
U. S. Geol. Survey

LEGEND

Rhyolite flows	UPPER VOLCANIC UNIT
Basic lithic crystal tuff	
UNCONFORMITY	
Undifferentiated graywacke, basic breccias and conglomerates	GRAYWACKE UNIT
Mudstone breccia in acid tuffaceous argillite; volcanic rubble breccia in acid fine grained tuff	TUFFACEOUS ARGILLITE UNIT
Acid-intermediate fine-grained tuff	
Acid-intermediate crystal lithic tuff, in part welded	
Rhyolite flow	
Basic agglomerate, breccias, and tuffs	
Acid and basic tuffaceous argillite, undifferentiated	
Acid tuffaceous argillite	
Varved argillite	VARVED ARGILLITE UNIT
Diabase dikes (TRd)	INTRUSIVES
Gabbro sills	
Interpreted fault (U/D)	
Concealed anticline	
Concealed syncline	
Strike and dip of bed (30)	
ROUTE OF TRIP	
FIELD STOP (21)	

nant feature. The axis of this syncline parallels the regional trend and passes west of Floyd Church and plunges to the southwest at a low angle.

The intensity of folding shows a marked increase from east to west. Thus attitudes of bedding show that the folds are probably gentle throughout the eastern three fourths of the northwest corner of the Denton quadrangle but become isoclinal in the northwestern one fourth. Folding is most intense along a northeast-trending belt a ½-mile or so wide. As a landmark for the reader Holloway Church is located in this belt. Whether this belt of isoclinally folded argillite marks the edge of a fault or fault zone toward the west is uncertain. Nevertheless, the zone immediately to the northwest of the isoclinally folded varved argillites is marked by mines and prospects and hydrothermally altered rock. Exposed in the center of this structure is the graywacke unit; wrapped about this unit is the tuffaceous argillite unit. From these relations and the presence of the varved argillite unit to the west it is almost certain that the east side of the varved argillite is marked by a fault.

Unconformity

An angular unconformity exists between the Upper Volcanic unit and the underlying stratigraphic sequence. The unconformity is found in eastern and east-central Albemarle quadrangle and across the southern part of the Denton quadrangle. This unconformity represents a major time break in the Volcanic-Sedimentary Group.

Minor Structure

The major cleavage of the area is a bedding plane cleavage. It is best developed in the varved argillites, is present in the acid tuffaceous argillites, and is poorly developed in the acid and basic tuffs, breccias and flows. A secondary northeast trending axis plane cleavage (or foliation) constitutes a regional structure throughout most of the area. This cleavage is fairly well developed and is closely spaced (¼ - 1 inch) in the argillites, which causes the rock to break into flat slabs and plates. This cleavage is poorly developed in the fine-grained tuffs and in much of the tuffaceous argillites is absent or present only as a rude foliation in the coarse-grained volcanic rocks. In the phyllonites and phyllites, however, the cleavage is very well developed and their fissility may be measured in microscopic dimensions. Platy minerals and rock fragments included in the phyllites and phyllonites are sheared and elongated parallel to this structure. Both the bedding and axial plane cleavages are absent in the upper volcanic unit. Two lineations are prominent: (1) intersection of cleavage and bedding planes occurs in the bedded sediments, (2) drawn out crystal, and rock fragments down the dip of the cleavage planes occur in the phyllonites and phyllites.

Joints

Two major joint patterns have been observed in the area. The most prominent of these strikes about N. 60 W. and a second system strikes N. 45 E. The dip of both systems intersect the bedding at approximately 45 causing the more massive rocks to weather out as rectangular blocks.

Metamorphism

The rocks in the area are of low grade metamorphis but attain the chlorite grade and greenschist facies. In the Denton quadrangle the metamorphic grade increases northwestward and reaches its peak in the northwest corner of the quadrangle where granitic rocks cut across (?) or are intercalated with green schists, sericite schists and phyllites. Some of the varved argillites in the northwest corner of the Denton quadrangle had chloritoid porphyroblasts that are now retrogressed to aggregates of biotite, chlorite and sericite. In the southeastern part of the Albemarle quadrangle the varved argillite grades northward from argillite to phyllite. The acid tuffaceous argillites and the acid and basic tuffs and flows to the area have been little affected by metamorphism except in isolated areas where they are sheared. The greatest change seems to have been devitrification.

ROAD LOG

General Instructions

1. Participants should have provided themselves with tickets for Saturday lunch and Saturday night banquet before assembling.
2. Cars should have full gas tanks before starting on Saturday morning. The total mileage for both the Saturday and Sunday trip is 117 miles and one tank of gas should be enough for both days.
3. The field trips on both days will leave the Hotel Albemarle parking lot promptly at 8:00 A.M. Cars and participants should reach the assembly point each morning in ample time to be in line and ready to go at 8:00 A.M. Those who arrive after the party has left can catch up with the caravan by following the road log.
4. In order to facilitate movement and parking of caravan on highways, it is requested that cars carry maximu number of passengers. “Extra” cars should be left in Albemarle, especially on the first day.
5. Please keep same position in line throughout each day. Stay as close behind car in front as safely possible. At road intersections, do not turn off until car behind is in sight. This applies to all except the last car, of course.
6. An average of 15 minutes is allowed at most excursion stops due to the crowded schedule. On arrival, please assemble promptly with excursion leader, but be patient, as he will not (unless forced) begin his talk until those at

the end of the line catch up.

ROAD LOG – SATURDAY TRIP

Mileage

0.0 **Stop 0. Assembly point**

Parking lot behind Hotel Albemarle. Parking lot faces West North Street. Drive east on West North Street for three blocks to where it dead ends.

0.3 Turn right on North Fifth Street and follow for one block.

0.4 Turn left on Pee Dee Avenue and drive eastward.

1.3 Junction with East Main Street; drive eastward on East Main Street (N.C. 740, 27 and 73).

1.8 N.C. 740A turns north via access approach. Stay on N.C. 740, 27, 73.

2.1 Junction with Albemarle by-pass, continue across by-pass and eastward on N.C. 27-73.

8.2 Cross Pee Dee River.

8.5 Bifurcation of N.C. 27 and 73. Keep to the left on Highway 27 and continue eastward.

9.5 Cross Uwharrie Road.

12.2 **Stop 1. Acid lithic tuffs of the lower volcanic unit**

These rocks are the oldest stratigraphic unit in the two quadrangles and are designated on the legend of the Albemarle quadrangle as the lower volcanic unit. They consist of acid lithic tuffs and crystal tuffs with interbedded rhyolite dikes. It is traceable from the southern part of the Albemarle quadrangle to north of Asheboro and from Robbins in the east almost to the Pee Dee River in the west. It occupies the center of a large southwest plunging anticlinal structure the axial plane of which lies near Troy. It is postulated that this unit represents an old land mass built up from the sea floor by a series of volcanic eruptions and flows.

Exposed in this road cut is an acid lithic crystal tuff composed predominately of fragments of rhyolite varying in size from 1/8 of an inch to two feet in diameter and crystal fragments of feldspar and quartz as well as rare basic lithic fragments. These fragments are set in a matrix of fine tuff. Some of the rhyolite fragments seem to be rounded while others are quite angular. Upon closer observation it is found that the outer surfaces of many of these rounded fragments are pitted; a phenomenon which is not common in water worn pebbles. It is thought that the rounded pebbles were originally liquid ejecta which received their shape during aerial flight. At this outcrop at least two spindle shaped rhyolite bombs have been discovered. It is thought that the angular rhyolite fragments were material already solidified and were ejected contemporaneously with the liquid material and fine ash which makes up the matrix of the rock.

Bedding is not very conspicuous in the deposit but is accentuated on weathering. Sorting is very poor to non-existent. Both of these suggest air laid rather than water laid deposits.

The glassy porphyritic rhyolite dikes here exposed cutting the acid tuffs contain bipyramydal beta-quartz phenocrysts, occasional orthoclase and rare plagioclase phenocrysts set in an aphanitic matrix. The rock is now completely devitrified and the glass has crystallized (probably due to slight metamorphism) into cryptocrystalline quartz and sericite. The presence of porphyritic rhyolite fragments containing beta-quartz phenocrysts in the lithic tuffs of this exposure suggest that the rhyolite dikes were feeders to the volcanoes which produced the tuffs.

The exposure contains three diabase dikes. These dikes are similar to those found in the Sanford Triassic basin and are considered of Triassic age.

Turn around and drive westward.

14.4 **Stop 2. Fine-grained, bedded tuffs of the lower volcanic unit**

This exposure contains fine-grained well-bedded and sorted tuffs. Well-sorted and stratified water laid tuffs thus far have been found only on the western edge of the unit near the contact with the overlying varved argillites. It is thought that this well-sorted and stratified material was deposited in shallow water along the margins of the old volcanic land mass.

The eastern end of the exposure and quarry on the south side of the road contains a glassy fragmental tuff which is associated with a discontinuous rhyolite flow which is traceable around the nose of the anticlinal structure in the south, and then northward almost to Uwharrie. This particular rhyolite contains spherulites which Emmons (1856) thought were fossils and named *Paleotrochis*.

Please stay out of the quarry as the walls are very dangerous!

15.0 Again cross Uwharrie Road.

15.2 **Stop 3 (A) Varved Argillites**

The caravan passed over the contact between the lower volcanic group and overlying varved argillite unit just before crossing the road to Uwharrie and is now in the basal part of the varved argillite unit. This unit is about 5 miles wide and is traceable from Union

County northward to west of Asheboro, Randolph County. The varved argillites are the most incompetent beds in the stratigraphic sequence and here have been tightly open folded. In the Denton quadrangle you will be shown isoclinal folding in the varved argillites. To the north, just south of Uwharrie in the Albemarle quadrangle and in the northwestern part of the Denton quadrangle they have been compressed into phyllites. The major cleavage at this exposure is the bedding plane type found in typical argillite, with an incipient axial plane cleavage present.

They are thinly laminated and show graded bedding with a silt layer on the bottom which grades upward into a clay layer. The cause of graded bedding in these argillites is not thoroughly understood. However, these beds must have had a pulsating source (Pettijohn, 1949, p. 139) and been deposited in quiet water below wave base to give time for settling out of the different size particles and produce graded bedding. The absence of ripple marks, current scour, intermixed coarser sediments, sole markings (hieroglyphic), cross bedding and the extreme small particles size making up the rock indicate that the sediments were not subjected to strong currents and settled in deep quiet water.

Fraser (1929) found from experimental studies that the maximum salinity permitting the formation of varves of coarse clay seems to be about 1/50 that of sea water. As these sediments vary from coarse clay to silt they might have formed in more saline waters, without flocculation. We are here probably dealing with very ancient sediments and as the salinity of the sea has been used as a criteria for determining the age of the earth, perhaps the sea was not very salty at the time of deposition. Pettijohn (1949) points out that graded bedding occurs in sediments from Precambrian to present and thinks that flocculation by sea water is a doubtful concept. Kuenen and Menard (1952) believe that graded bedding is caused by turbidity currents and can occur in normal sea water.

(B) Two highly weathered fine grained basic dikes continuing xenoliths of argillite.

(C) A slightly discordant zoned gabbro body

The upper and lower parts of the body contains crystals ranging from 1/8 to ½ of an inch in length, while the center of the body contains crystals up to 1 inch in length which are rosetted. It is cut by several very small aphanitic basic dikes which are not usually over 2 inches wide. The gabbro is composed of actinolite, and feldspar ranging from andesine to labrodorite, with minor amounts of olivine, ilmenite, magnetite, epidote, serpentine, calcite, chlorite and pyroxene.

(D) Fragmental argillite exposed in stream valley west of road cu

Fragments of rhyolite and argillite as well as beds of crystal tuff are often found in the basal varved argillite unit. This material is interpreted as ejecta which marks the waning phase of the volcanic activity which produced the lower volcanic unit to the east. Above its base the argillite unit contains little, if any, recognizable volcanic material and the unit is thought to indicate a time of quiescence. It is postulated that the source of the sediments was from the erosion of the volcanic land mass to the east, because the volcanics in the basal argillites indicates near source conditions. Each rainstorm which fell on this old volcanic landmass would have carried to the sea a new source of material, which upon reaching the basin would be more dense than the surrounding water. This would produce a gentle gravity current which would slowly move down the subaqueous slope of the old landmass and out into the center of the basin. Upon settling, this material would produce varved sediments.

16.0 Intersection with N.C. 73, turn left on highway N.C. 73.

17.1 Turn right on unpaved country road.

17.2 **Stop 4 Fragmental varved argillite showing slump bedding**

This exposure lies southwest of the nose of the large southwest plunging anticlinal structure explained at Stop No. 1, and about ¾ of a mile southwest of the contact between the lower volcanic unit and the varved argillites. The argillites at this stop show well developed graded bedding and contain fragments varying from sand size up to ½ of an inch in diameter. These fragments are usually concentrated along bedding planes. Slump bedding occurs in this exposure indicating that the sediments were deposited at an angle high enough to cause plastic flow and deformation of the deposits before compaction and lithification. Pettijohn (1949, p. 145) states, “These structures are confined to a single bed or zone between undisturbed beds. In many cases the disturbance is restricted to layers a mere inch or two thick. Such deformation is usually due to subaqueous slump or gliding. This structure seems most characteristic of the thick silt-shale sequences of graded beds which mark delta-like accumulations of geosynclines”. It is postulated that the varved argillites were deposited on subaqueous slopes of the old volcanic landmass to the east and slumped down these slopes.

17.3 Turn around.

18.1 Turn left on N.C. 73.

19.1 Intersection with N.C. 27; turn left on highway N.C. 27-73.

19.3 Cross Pee Dee River.

19.8 **Stop 5 Contact, base of gabbro sill with varved argillite**

At this stop is exposed a hairline contact between a gabbro sill and varved argillite. This is the same type of gabbro as seen at Stop 3, but is not as coarse grained and does not seem to be zoned. Stony Mountain to the northwest of this outcrop is another of these sill-like bodies in which the intruding magma has bowed up the roof into an elongate dome resembling a miniature laccolith. One of these laccolith-like gabbro bodies occurs in the north-central part of the Denton quadrangle and another lies southwest of Albemarle. These bodies are usually sills although all do not conform so perfectly with the bedding of the country rock as shown at this exposure. Some are amygdaloidal indicating that they were injected near the surface with a release of pressure allowing the formation of vesicles which were later filled with quartz. The presence of amygdules in this gabbro was probably first recognized by Bowman (1954).

In the Hawaiian volcanoes Eaton (Zahl, 1959, p. 815) has observed that before an eruption the country rock is bowed upward. This is explained by magma coming up from below entering sill like magma chambers and upwarping the overlying country rock. It is thought that these sills might represent magma which filled magma chambers, but was not squeezed out, and solidified in place. The small highly weathered basic dike at Stop 3 might represent a feeder from one of these bodies.

Continue westward.

23.0 Turn right onto Valley Drive (Road to Badin).

26.4 Turn left onto paved road.

27.4 **Stop 6 Acid tuffaceous argillite**

The caravan has crossed the upper contact of the varved argillites and is now in the acid tuffaceous argillite of the tuffaceous argillite unit. The contact between the two units is not distinct but is gradational over several feet. The acid tuffaceous argillites are coarsely bedded with individual beds varying from 3 inches to several feet producing an almost massive rock. It is composed of silt-sized angular particles of feldspar and quartz set in a groundmass of kaolinite and sericite with some epidote and chlorite. The rock is medium grey when fresh but on weathering becomes lighter grey, while in the final stages of decay it turns into brilliant reds and yellows. It is well jointed and breaks with a conchoidal fracture. Wis flattened particles occur in profusion along some bedding planes. These might be devitrified glass shards. This unit is probably made up of fine ash with some intermixed coarser volcanic ejecta and was deposited in water with very little reworking or sorting. This is indicated particularly by the angularity of the feldspar crystals, which are usually broken but not rounded.

In contrast to the varved argillites which were deposited in a time of quiescence the acid tuffaceous argillites were deposited during a time of renewal of volcanic activity from a new source. The old volcanic landmass to the east became dormant about the beginning of the time of the deposition of the varved argillites, never to revive. This new source was probably to the northeast near Flat Swamp Mountain. (A detailed study of the volcanic rocks of the Flat Swamp Mountain sequence will be made later in the trip.

Continue westward.

28.1 Turn left onto N.C. 740.

28.4 Turn left onto paved road.

30.1 **Stop 7 Rhyolite flow in the acid tuffaceous argillite unit**

The varved argillite-acid tuffaceous argillite contact lies approximately ¼ of a mile east of this stop. Exposed in this road cut is a rhyolite flow which has been an excellent horizon marker for the base of the acid tuffaceous argillite unit, because it can be traced as a continuous band from approximately two miles north of this outcrop southwest across the quadrangle. In the southern part of the quadrangle it accentuates a series of double plunging, northeast-southwest trending minor open folds.

The rhyolite is a light grey aphanitic rock. It emits a metallic ring when hit with a hammer and breaks with a conchoidal fracture. It is well jointed but does not show cleavage. Swirl flow bands are common and become more prominent on weathering. The rocks lying both above and below the flow are tuffs, and in other places are extremely fragmental. The rhyolite was probably originally a very glassy flow which is now devitrified. It is composed of cryptocrystalline quartz and sericite with occasional phenocrysts of orthoclase, plagioclase, biotite and quartz.

Continue eastward.

30.6 Turn left onto Valley Drive (Road).

32.6 Turn right onto Morrow Mountain State Park.

33.4 **Stop 8 Basic lithic crystal tuff of the upper volcanic unit**

In order to have lunch, it is necessary to deviate fro the order of the stratigraphic sequence at this point, and move into the youngest rocks of the area, the upper volcanic unit. At this stop the group will examine the basic tuffs which make up the lower part of the upper volcanic unit. It is believed that an angular unconformity exists at the base of this unit. Evidence for this unconformity is as follows:

1. The upper volcanic unit occurs as irregular erosional remnants capping the highest hills in the area and does not form elongate lenses or beds as do the volcanic rocks interbedded with the underlying units.

2. From east to west erosional outliers of the upper volcanic unit overlie and are in direct contact with the lower volcanic unit, varied argillite unit, and tuffaceous argillite unit.

3. In many places the basal beds of the basic tuffs, which form the lower member of the upper volcanic unit, contain rounded cobbles and pebbles derived from the underlying units, indicating erosion of the underlying units before deposition of the upper volcanic rocks.

4. Erosional windows in the upper volcanic rocks expose units of the underlying stratigraphic sequence, indicating that the upper volcanic unit overlies and is not interbedded with the underlying units.

5. The underlying units, in direct contact with the upper volcanic rocks, usually vary in strike, and dip more steeply (often in the opposite direction) than the overlying volcanic rocks, indicating that the structure is an angular unconformity.

6. Rocks of the underlying stratigraphic sequence usually have well developed bedding cleavage and incipient axial plane cleavage which are absent in the overlying volcanic unit, indicating the older rocks were folded prior to the deposition of the upper volcanic unit.

The above evidence indicates that these lower units had to be folded into their present structures and eroded almost to a peneplain before the upper volcanic unit was deposited.

The rock exposed at this stop is a basic lithic crystal tuff which shows faint bedding and is composed of actinolite, feldspar, chlorite, epidote, sphene and chlinozoisite. In hand specimen this rock is almost indistinguishable from the gabbro sills seen at Stops 3 and 5. The question is asked, “Could not the magma from which the sills solidified also have produced this tuff?”

34.1 Entrance to Morrow Mountain State Park.

35.0 Turn left at junction.

35.4 **Stop 9 (A) Rhyolite-basic tuff contact**

(You are now in Morrow Mountain State Park. Please leave hammers in cars!)

Rhyolite, the upper member of the upper volcanic unit, caps the hills surrounding this stop. The strea to the right has cut down through the rhyolite exposing the underlying basic tuff. This is the same basic tuff seen at Stop No. 8 and is the farthest east in this area that the basic tuffs are exposed, meaning either that this is the eastern edge of the deposit or an erosional unconformity exists between the basic tuffs and rhyolites of the upper volcanic unit and the basic tuffs to the east are eroded away. Only a few hundred yards east the rhyolite is exposed unconformably overlying the varved argillite unit.

(B) Rhyolitic lithic tuff which in some places underlies the rhyolite flows

(C) Rhyolite of the upper volcanic unit

The rhyolite at this locality is porphyritic. It contains orthoclase, occasional plagioclase and beta-quartz phenocrysts. The feldspars are usually clouded by inclusions which is thought to be primary rather than secondary alteration of the mineral. The groundmass is composed of cryptocrystalline quartz, sericite, and epidote. The rock was probably a porphyritic glassy flow, now devitrified. Flow lines are well preserved.

(D) Steeply dipping varved argillite overlain by rhyolite with contact covered

36.0 Turn right to Park Office and Lodge.

Turn around in parking lot.

36.3 Turn left onto paved road and continue back to junction.

37.0 Turn left up Morrow Mountain.

38.2 **Stop 10 Examination of rhyolite on top of Morrow Mountain and visit to Winchester firearms factory of pre-Columbian man**

The rhyolite which caps Morrow Mountain is a very dense rock and breaks with a conchoidal fracture. Before the coming of the white settlers it was quarried extensively by Indians for the manufacture of projectile points and other implements, and tons of rejects and chips are found on top of the mountain and down its sides.

From this vantage point one can see to the east the Uwharrie Mountains composed of the lower volcanic unit; varved argillite is exposed from east of the Pee Dee River to just below the top of the mountain. The western flank of the mountain is composed of basic tuff of the upper volcanic sequence. The valley west of the mountain contains varved argillite and the elongate hills further west are upheld by rhyolite flows interbedded with the acid tuffaceous argillite.

Incidentally, this is also a 45 minute lunch stop.

39.7 Turn left and continue to park entrance.

40.5 Turn right onto unpaved Falls Road.

43.4 Badin City limits, keep to the left, remain on Falls Road.

43.8 Intersection with Pine Street, continue straight ahead.

44.0 Intersection with N.C. 740, turn right on N.C. 740.

44.8 **Stop 11 Contact between varved argillite and overlying acid tuffaceous argillite**

The parking lot for Stop 11, is underlain by varved argillite which grades westward into the basal acid tuffaceous argillite. The road cut west of the railroad tracks contains a fairly thin bedded rock which is purplish-grey in color and seems to be composed predominately of fine volcanic ash. What appears to be flattened shards similar to those observed at Stop 6, lie in profusion along the bedding planes. In some beds of this outcrop they are the major constituent of the rock. The rock is composed of silt-sized quartz grains and broken feldspar crystals; however, the groundmass is now mostly kaolin and if the shards were originally composed of glass they are now altered to kaolinite. These rocks dip northwest toward the center of the New London syncline. They dip in this direction to the axis of the structure, about four miles from here.

Continue westward.

44.9 **Stop 12 Acid vitric crystal tuff**

At this stop we have our first introduction to the Flat Swamp Mountain sequence. The rock here exposed is a vitric crystal tuff, probably a welded tuff composed of feldspar fragments and devitrified glass. Notice the bedding or layering which is parallel to the regional trend. The rock is well jointed and breaks up into rectangular blocks. These blocks become spheroidal upon weathering.

This lithologic unit is a key horizon that has been traced by reconnaissance for over 50 miles. As can be seen on the Albemarle quadrangle map another unit of vitric crystal tuff lies northwestward of here. These tuff units hold up ridges, and can be traced around the New London syncline, up the western flank of the Denton anticline and around the nose of the Floyd Church syncline.

Continue westward.

47.3 **Stop 13 Graywacke**

We are now in the Graywacke unit with the tuffaceous argillite contact lying approximately two miles east of this point. The Graywacke unit overlies the acid tuffaceous argillite and occupies the center of the New London syncline. The axial plane of the structure lies about 11/2 miles west of this stop and west of the axis one can readily observe a change of direction of dip of the rocks from northwest to southeast.

The original term graywacke was applied to a sandstone composed of angular to subrounded grains of quartz, slate, phyllite and other rocks and in many cases feldspar all bound together in a fine-grained matrix. Although poorly stratified, they commonly show graded bedding. In some instances they grade upward into shale. Cross bedding is usually absent and if present is on a very small scale. Pyrite is generally present forming euhedral cubes. It is probably a product of peneconteperaneous diagenesis that is either caused by sulphur-reducing bacteria or decomposition of sulphur-bearing organic matter. Graywackes are usually confined to orogenic belts and are associated with pillow lavas and bedded cherts. The graded bedding indicates that they were deposited in still, deep water and many are associated with deep water faunas. They have no climatic significance and require only an environment of rapid erosion, transportation and deposition so that complete chemical weathering does not take place. Most graywackes are massive as shown by the dark color and pyrite indicating reducing environment. Association with pillow lavas and marine faunas also indicate a marine environment of deposition (Pettijohn 1957, p. 301-314).

The graywacke in this exposure is a rock composed of sand-size particles of quartz, feldspar, argillite and what appear to be ferro-magnesium minerals now altered to chlorite set in a fine groundmass. Pyrite cubes up to 2 inches across are found in the rock. It is usually coarsely bedded but shows grades bedding ranging upward from sand-size to silt-size grains. It also shows occasional cross-bedding. The fresh rock is greenish grey but turns brilliant reddish-maroon on weathering. Spheroidal weathering is pronounced in the partly decomposed rock.

Continue westward.

50.0 New London City limits, turn left on paved road.

50.2 Turn left and in 50 feet turn right.

50.5 Turn right.

50.6 **Stop 14. Scoriaceous lithic crystal tuff**

At this stop can be seen a faintly bedded lithic crystal tuff containing what appears to be fragments of scoria still showing recognizable vesicular structure. This material is in the graywacke unit and lies on the western flank of the New London syncline, and dips to the southeast. To the south and east the unit grades into graywacke while to the north it interfingers with basic tuff. It is greyish-purple when fresh but weathers deep maroon.

51.0 **Stop 14A. Ten minute rest stop in New London.**

51.4 **Stop 15. Bedded basic lithic conglomerate and breccia**

The rock here exposed is a well-bedded poorly sorted basic lithic conglomerate breccia composed of both angular and rounded basic volcanic rock fragments. These fragments are set in a groundmass of graywacke composition. This rock is interbedded with, and grades laterally into graywacke. To the north the rock covers a wide area around the nose of the New London syncline and coarsens in grain size. Along the Yadkin River it is a lithic conglomerate which shows occasional graded bedding. South of Tuckertown, current channeling has been observed between two beds of the conglomerate. The rock will occasionally grade laterally into a lithic breccia.

Because the basic lithic conglomerates and breccias usually have a groundmass of the same composition as the graywacke and grade laterally into graywacke it is thought that the graywacke unit was derived from rapid erosion and deposition of basic volcanic rocks, with little or no weathering of the parent rock. The lithic conglomerates and breccias become coarser to the north, suggesting that the source for these basic sediments was in that direction.

The presence of cross bedding within single beds in the graywacke, graded bedding in both the graywacke and the lithic conglomerates, and current channeling in the conglomerates suggest that powerful turbidity currents of the dense catastrophic type, triggered by submarine avalanche or earthquakes (Pettijohn 1957, p. 313) played a major role in the deposition of these sediments. The graywacke unit then represents rapid erosion and deposition of basic volcanic sediments with outbursts of volcanic activity as shown by the scoriaceous lithic tuffs. They constitute typical deposits of the orogenic or geosynclinal facies as described by Pettijohn (1957, p. 615).

Continue westward on U.S. 52.

51.7 Turn right on paved road.

54.2 Intersection with N.C. 49. Drive straight across highway and continue on gravel road.

54.25 Turn right on dusty dirt road.

54.8 **Stop 16 Acid tuffaceous argillite:**

We are now on the western flank of the New London syncline and in the acid tuffaceous argillite of the tuffaceous argillite unit, previously observed at Stop 6, on the eastern flank of the syncline. The rock is fine-grained, coarsely bedded and contains interbeds of coarse-grained acid crystal tuff. The regional northeasterly axial plane cleavage is poorly developed or absent and commonly the rock fractures conchoidally. The saprolites of this rock unit are typically in hues of white, orange grey to vermilion. This rock unit grades imperceptibly from a largely water-laid, fine-grained acid tuffaceous argillite stratigraphically downward to the coarser-grained acid crystal lithic lapilli tuff of the Flat Swamp Mountain sequence. It is believed that the coarser interbeds seen here were derived from the same volcanic activity that produced the Flat Swamp Mountain sequence.

Adjust dust masks and continue onward.

54.9 Rowan County Line.

55.0 Turn right onto paved county road.

55.8 **Stop 17 Coarse-grained acid crystal lithic tuff of the Flat Swamp Mountain sequence:**

We are still on the western flank of the New London syncline, stratigraphically below the rock at the last stop. Again, from the regional structural relations it is thought that these rocks belong to the Flat Swamp Mountain sequence. The rock is largely composed of fine-grained acid tuff with intercalations of coarse-grained acidic lithic tuff breccia. Notice that the rocks here are coarser-grained than those at Stop 16, as well as, containing lenses of crystal lithic lapilli tuff. This indicates that we are going from a largely water-laid fine tuff to a chiefly sub-aerial pyroclastic deposit. The coarser-grained fragments at this stop indicates that the rock is geographically closer to the source than are the acid vitric crystal tuffs observed at Stop 12, just west of Badin. Here, the acidic rocks dip about N. 50 W. and are unconformably overlain by greenstone (the lower member of the upper volcanic unit) that, as you can see, dips southwestward at a low angle.

56.4 Stanley County line.

56.8 Intersection with N.C. 49, turn left on N.C. 49.

57.5 Yadkin River Bridge.

61.0 Turn right on Slate Mine Road.

62.9 **Stop 18 Nor-Carla Bluestone, Jacobs Creek Flagstone Company**

Bluish grey to greenish grey argillite that because it is evenly laminated (varved), compact, and hard is quarried and marketed as flagstone. The principal minerals are quartz, orthoclase, albite or oligoclase, sericite, and chlorite; epidote, pyrrhotite, sphene-leucoxene, and biotite occur as minor accessories. Here, the argillite occurs as an inner beneath the unconformably overlying basic lithic breccia and tuff of the upper volcanic unit. Note the argillite fragment in a boulder from the basal section of the greenstone pyroclastic rocks.

A chemical analysis of the argillite shows it to be characterized by a high soda-potash ratio (Councill, 1954, p. 13). Published analyses of presumably similar argillites (Pogue, 1910, p. 41; Laney, 1910, p. 28 and Stuckey, 1928, p. 18) also show high soda-potash ratios. This led to the conclusion that volcanic debris makes up much of the argillites. However, other factors than volcanic debris, such as grain size and chemical immaturity, might influence the soda-potash ratio. For, according to Pettijohn (1957, p. 345) in the case of varved glacial sediments, summer silt contains a higher Na-K ratio than winter clay. We assume that this applies to non-glacial silt and clay as well. Also, clay deposited in a sea environment may gain potash as it becomes mature; thus, a high Na-K ratio may mean a chemically immature sediment (Pettijohn 1957, p. 345). Another possible interpretation for the cause of the high Na-K ratio is replacement or albitization (Pettijohn and Bastron, 1959, p. 593).

It should be noted that this varved argillite is correlated with the varved argillite unit at Stop 3. This correlation is based on the interpretation of the regional folds and has been traced northward to this point as a unit.

63.1 **Stop 19 Tour of Jacobs Creek Flagstone Quarry conducted by Mr. Woodward and Mr. Reynolds**

This is the last stop of the Saturday field trip. Turn around and drive to N.C. 49.

66.2 Turn left onto N.C. 49.

71.1 Turn left onto N.C. 8.

74.6 Turn left onto U.S. 52 at New London.

81.2 City Limits of Albemarle.

81.8 Turn left onto West North Street and follow for one half block.

81.9 **Stop 0 Hotel Albemarle parking lot.**

ROAD LOG – SUNDAY TRIP

Mileage

0 **Stop 0 Assembly point**

Hotel Albemarle parking lot, turn left out of parking lot and drive ½ block southward on West North Street.

Turn right onto North First Street (U.S. 52) continue northward on U.S. 52.

6.5 Southern city limits of New London.

7.3 Intersection with N.C. 8, turn right onto N.C. 8.

10.9 Intersection with N.C. 49, turn right onto N.C. 8-49.

12.1 Rowan County line.

12.4 Yadkin River Bridge.

14.8 Bifurcation of N.C. 49 and 8, turn left onto N.C. 8.

15.6 **Stop 20 Acid crystal lithic lapilli tuff on the Flat Swamp Mountain sequence**

After last night's elbow-bending exercises the chief purpose of this stop is to refresh our memories that we are still on the trail of the Flat Swamp Mountain sequence. We are new on the east flank of the Denton anticline. The rock here exposed is an acid crystal lithic lapilli tuff. It is largely composed of laths and fragments of orthoclase and plagioclase (orthoclase > plagioclase), scattered angular rock fragments, all in a devitrified groundmass of orthoclase, plagioclase, quartz, sericite, and minor accessories. As we have seen, these coarser tuffs grade vertically and laterally into vitric and fine crystal tuffs. This coarse facies of the Flat Swamp Mountain sequence is thought to be land deposited volcanic ejecta in contrast to the fine tuffs at Stop 16 which are probably water-laid deposits. Here the rock is exposed as an inlier through the unconformably overlying basic crystal lithic tuff breccia of the upper volcanic unit.

20.2 Turn left on Lick Creek Road.

25.0 Turn left on Bringleferry Road.

25.2 **Stop 21 Railroad cut through Flat Swamp Mountain showing the Flat Swamp Mountain sequence**

This section when pieced together with other partial sections in the area affords a volcanic history of how one volcanic disturbance "lived and died". How it started off by building up a landmass in part by Pelean cones and by hot avalanche deposits that probably issued from swarms of fissures. These discharges of crystal lithic tuffs were followed by collapse and slackened outbursts to form a thick sequence of fine-grained tuffs, layers or lenses of volcanic "rubble" breccias and volcanic "mudstone" breccias, after which the disturbance died and gave up exhaling material. The fine-grained acid tuffaceous argillite that surrounds the coarser facies of the Flat Swamp Mountain sequence (e.g. Stops 6 and 16), represent the fine ash that was deposited in the sea about the Flat Swamp Mountain landmass.

Going up the section northward along the railroad track we cross a sequence of bedded sericitic argillite and siltstone overlain by a complex of acid-intermediate vitric crystal lapilli tuff, vitric tuff, vesicular greenstone, acid to intermediate stratified tuff, lenses of rubble breccia, and finally the complex grades into a poorly bedded acid tuffaceous argillite that contain a few lenses of mudstone volcanic rubble breccias which will be seen at Stop 22.

The coarse crystal lithic lapilli tuff represents the initial outbursts of hot avalanches (nuee ardente) which swept down the slopes of the volcanic landmass and deposited this material at its base. Pettijohn (1957, p. 337) states that these hot avalanches are the aerial counterparts of turbidity flow and compares these deposits to turbidity-current deposited graywackes. The rock contains laths and fragments of orthoclase, plagioclase, essential (liquid ejecta), a few pre-consolidated rock fragments, fine grained aggregates of biotite-chlorite-feldspar that form irregular-shaped dark areas up to 30 mm. in size, all this is a devitrified matrix of orthoclase, plagioclase, and quartz, plus chlorite, sericite, and minor accessories.

Note the few angular aphanitic rock fragments and the thin lenticular elongated masses that parallel a crude stratification. The rock fragments very much resemble the aphanitic flows and vitric tuffs formed at the base of the belt in other parts of the area. It is postulated that they represent pieces from the initial flows and tuffs formed near the vents. Perhaps the thin lenticular masses are greatly fattened pumice lapilli or they may be concentrations of volatiles trapped during the emplacement of the rock. Note also, as you traverse the section, that the coarse tuff grades into an aphanitic rock at two places. These glassy rocks resemble flows but thin section studies show them to be glassy tuffs. In the southern-most exposure of glassy tuff the layering is to the north, and in the northernmost glassy rock the dip or layering is to the south. Does this mean repetition of the pyroclastic rocks by folding or do the glassy rocks herald the coming of a new avalanche? We think the latter

Note how the coarse tuff gradually “slackens off” northward forming only occasional lenses of coarse tuff in a largely fine-grained tuff of essentially the same composition, indicating a mellowing volcanic disturbance? Even the “intrusion” of a greenstone did not ruffle the old acid volcanic disturbance but calmly covered it with orderly bedded tuffs. Along the lake shore, when the water is low, one can see the scouring effect that the volcanic rubble breccia had a picking up fragments of the underlying bedded tuffs.

We shall see at Stop 22, how as these volcanic rubble breccias crossed the land-water interface, mud was incorporated as fragments with the volcanic debris. Finally, the mudstone breccias are overlain by poorly bedded tuffaceous argillites and the Flat Swamp Mountain volcanic disturbance has literally died.

Turn around the drive on Bringleferry Road to Healing Springs.

28.5 Healing Springs, turn left onto N.C. 8.

30.3 **Stop 22 Mudstone breccia**

The mudstone breccias intercalated with the acid tuffaceous argillites represent the last stages of the Flat Swamp Mountain disturbance. Some of the mudstone breccias persist for only a few hundred feet, others have been traced for more than 13 miles. The rock lacks much fresh ejecta but contains preconsolidated acid-intermediate rock fragments, a few basic rock fragments, and a fair abundance of argillite fragments. The argillite fragments are commonly bent but do not show evidence of heating. It is postulated that the mudstone breccias were formed from a slurry of volcanic debris that avalanched downslope from the Flat Swamp Mountain volcanic terrane into a basin to the west of the mountain. When the mudflow reached the basin it gouged out slabs of mud and incorporated them with the volcanic debris. It is possible that a mild volcanic explosion, one of the last gasps, so to speak, of the Flat Swamp Mountain volcanic disturbance may have triggered the mudflow avalanche – possibly assisted by rainfall.

30.6 Cross High Rock Lake.

32.8 Turn right onto Briggs Road.

35.1 **Stop 23 Isoclinally folded varved argillite**

This outcrop lies just west of the axis of the Floyd Church syncline which gently plunges to the southwest. The tuffaceous argillite unit lies along the eastern limb and around the nose of the structure. The younger graywacke unit is exposed in its center. We are on the upthrown side of a fault of probable great displacement which cuts across the synclinal structure and exposes the varved argillite underlying the tuffaceous argillite unit.

At this stop is exposed a bluish-grey thinly laminated (varved) argillite in which the varves grade in grain size from silt at the base to clay at the top. The average varve is 1-3 mm. thick. In this exposure the varved argillites are steeply dipping and isoclinally folded, whereas farther to the east the rocks show open folding. Does the intense folding indicate that the sediments were regionally folded then later pushed against the intrusives of the Charlotte belt to the west as a buttress, causing isoclinal folding as well as faulting?

Note the porphyroblasts that straddle the bedding planes. These are now aggregates of biotite-sericite-chlorite probably retrogressed from chloritoid. Their random orientation indicates that they formed after the beds were deposited. Also, their presence in the western belt and conspicuous absence in the varved belts to the east indicates that they are related to the northwestward increase in metamorphic grade.

The possible origin of varved argillites is a story in itself, as we learned yesterday at Stop 3. In review, were they formed by normal settling, proglacial deposition, tubidity, or what was the process? Do varved deposits necessarily indicate fresh water deposition on the assumption that salt water flocculates the clays?

We think that the varved argillites represent a period of quiescence between volcanic disturbances-settling in deep water at least below wave action. The more or less rhythmic bedding represents normal settling in a basin that possibly in Precambrian time had not acquired enough salinity to flocculate the fine sediments. Thus, the silty layers may be attributed to more or less recurrent rain falls that brought in coarser debris to the scene of deposition and gentle gravity currents produced a varved sediment.

37.5 Turn right onto (paved) Holloway Church Road.

38.9 Junction with Floyd Church Road, turn left at junction and stay on Holloway Church Road.

40.0 Silver Hill, turn right onto Bethany Road.

41.5 Bethany Church, turn right onto Shemwell Road.

42.4 Turn left onto Young Road.

43.5 Turn right onto the Jerusalem Road.

43.6 Road junction, continue to the left on unpaved Jerusalem Road.

43.7 Turn left on unpaved road.

44.3 **Stop 24 Basic volcanic agglomerate**

These greenstones are intercalated with acid pyroclastic rocks on the Flat Swamp Mountain sequence (Stop 20) and are a part of the tuffaceous argillite unit. They consist of basic volcanic agglomerate, lithic breccia and tuff that contain angular to subrounded lapilli and bombs of basaltic (?) ejecta. These fragments are generally aligned parallel to each other or lie along fairly distinct horizons so that bedding is faintly visible. An overall decrease in size of fragments southward suggests that the source of the volcanic ejecta was from north of the quadrangle.

This is the last field stop of the trip. Continue northward on this unpaved road to Old 64. Those going west, turn left on Old 64 to Lexington. Those going east, turn right on Old 64 and follow it to U.S. 64. Those going southward, turn right onto Old 64 and continue to the intersection with N.C. 109 and turn right and continue to N.C. 49.

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NOTES