FINAL REPORT

ROBERT H. GRIFFIN
STUDENT TECHNICIAN, GEOLOGY

GREAT SMOKY MOUNTAINS NATIONAL PARK

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GEOLOGICAL CROSS-SECTION OF THE GREAT SMOKY MOUNTAINS NATIONAL PARK

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PART I

INTRODUCTION

1) Status of Geological Investigation.

For the most part geological study of the area occupied by the Great Smoky Mountains National Park has been carried on by the U. S. Geological Survey and lately by the National Park Service. By virtue of the Federal ownership, the area is not open to exploitation by private mining or quarrying enterprises. For this reason such companies and also, to a large extent, the geological surveys of North Carolina and Tennessee have done very little toward working out the geology of this complicated region.

Two folios of the Geological Atlas of the United States completely cover the park.. The Knoxville Folio, No. 16, published in 1895, covers the eastern half and the Mt. Guyot Folio, unpublished, the western half. Both folios are the work of Dr. Arthur Keith, of the U. S. Geological Survey.

At the present time the areal geology sheets of these adjoining quadrangles cannot be satisfactorily connected; the formation boundaries of one map cannot be projected in to the other.

In a typewritten"Report on the Geology of the Great Smoky Mountains National Park", submitted in 1935, D. K. Mackay, Associate Geologist with the Park Service, summarized the available knowledge concerning the geology of the park. Most of the information contained in his report is based upon the two above mentioned folios.

Drs. Stose and Jonas of the U. S. Geological Survey have done considerable work in the southern Appalachian and their findings are incorporated in the Geological Map of the United States, published in 1932, and in an article in the American Journal of Science.*

2) Project and Purpose.

Present knowledge of the Great Smoky Mountains indicates that this region is of very great geological interest. This report is the result of an attempt to work out in detail a small portion of the geology of the region and to make this information available to visitors. The project was to traverse and construct a detailed

*Jonas, A. I., Structure of the Metamorphic Belt of the Southern Appalachians, Amer. Jour. Sci., 5th Ser., Vol. 24, pp. 228-243, 1932.

cross section of the park from the junction of Tenn. Hwys. 71 and 73, near Gatlinburg, Tenn., along Tenn. Hwy. 71 and N. C. Hwy. 107, to the park boundary near Cherokee, N. C.

3) Plan of Development.

For the sake of convenience, in discussing the geology of this section, the formation descriptions will begin with the exposure of the Wilhite slate, near Gatlinburg, Tenn., and will proceed southeastward across the state line to Cherokee, N. C.

GEOLOGY

1) General Statement.

The Great Smoky Mountains are the eroded remnants of a huge uplifted and overthrust mass of rocks thousands of feet in thickness and varying in age from Pre-Cambrian to Ordovician.

The geology has been considerably complicated by folding, faulting, and metamorphism and the stratigraphy or the region has by no means been satisfactorily worked out. Different stratigraphic columns have been developed from the eastern and western halves of the park and so far it has not been possible to secure a clear and definite correlation between the two. Below is given a sequence of the formation seen in the traverse. These are not to be taken as complete stratigraphic columns for the entire park area. They show some of the suggested correlations:

	East Half*		West Half**
Cambrian	Hazel slate	- - - - - - - - - - - ? -	Nantahala slate
	Thunderhead conglomerate	- - ? -	Great Smoky Conglomerate
	Cades conglomerate		
	Pigeon slate	- - ? -	Hiwassee slate
	Citico conglomerate		
	Wilhite slate		
Pre-Cambrian			Snowbird formation Granite and gneiss

*Keith, Arthur, U.S.G.S. Folio #16, Knoxville Folio, 1895

**Mackay, D. K., unpublished, Rep. on Geol. G.S.M.N.P., 1935
Keith, Arthur, notes on unpublished Mt. Guyot Folio.

Description of these formations are given in some detail below. The thicknesses for the formations are approximations as are the formation boundaries themselves in many cases. For this there are several reasons:

(1) There is a lack of distinctive lithologic units and a masking of primary structures by metamorphism. The formations of the area traversed are, in the main, early Cambrian metamorphic rocks. They vary in composition very little in spite of frequent vertical changes in character. Individual beds differ mainly in relative size of mineral and rock fragments and in their relative abundance.

There seem to be few unconformities present in this series which embrace, generally, many thousand feet of alternating slates and quartzose rocks. There are no well defined rock units, and subdivision into formations is somewhat arbitrary. In some instances it seems to be based upon the most prevalent rock type in a section. Contacts are, therefore, just as arbitrary as are the formations.

(2) Also the excessive forest growth conceals to a large extent both formations and contacts. Exposures are best along roads and trails in artificial cuts, though outcrops are found in stream valleys in a number of places.

2) Geologic Events.

Below in tabular form are the main geologic events which have affected the area of the Great Smoky Mountains:

Time Scale and Geologic Events of the Great Smoky Mountains Area.

Era	Period	Geologic Events
Cenozoic	Pleistocene	Uplift and development of Somerville peneplane.
	Pliocene	Development of Harrisburg peneplane
		Uplift
Mesozoic	Cretaceous (Late)	Peneplanation - Schoolie or Cumberland.
Paleozoic		Uplift, folding, and faulting of Appalachian geosyncline. Formation of Appalachian Mts.
		Formation of Appalachian geosyncline - 25,000 feet of sediments deposited in geosyncline from surrounding land masses.
Pre-Cambrian	Late	Formation of land mass "Appalachia". Volcanic activity resulting in basaltic lava flows.
		Uplift and erosion
		Intrusion by igneous rocks forming crystalline complex.
		Formation of Carolina Gneiss.

3) Description of Section.

In traversing the Great Smoky Mountains from the Tennessee to the North Carolina side, the following formations are passed over in this order: Wilhite Slate, Citico Conglomerate, Pigeon Slate, Cades Conglomerate, Thunderhead Conglomerate, Hazel Slate, Great Smoky Conglomerate, Snowbird formation, and Carolina Gneiss. With the probable exception of the gneiss, all are of sedimentary origin but they have been extensively altered by both static and dynamic metamorphism.

The Carolina gneiss is considered to be pre-Cambrian ih age while the other formations are referred to the early Cambrian - the Wilhite, Citico, Pigeon, Cades, Thunderhead, and Hazel formation making up the Ocoee Series. The formations seem to be totally barren of fossil evidence so that age determinations have been based principally upon structure and degree of metamorphism.

From the point of view of the geologic section these formations may be divided into three units each of which seems to be separated from the adjoining one by a major fault. These are 1) the Carolina gneiss and Snowbird formation, 2) the Great Smoky Conglomerate, and 3) the Ocoee Series.

Correlation must doubtless be at least partially incorrect in view of the conclusion* reached by Drs. Jonas and Stose of the U. S. Geological Survey that the Great Smoky Conglomerate and Hiwassee Slate are pre-Cambrian in age.

It will be noted that in this report the Cambrian age of these above mentioned formations is assumed.

I. Wilhite Slate.

Near the junction of Tenn. Hwys. Nos. 71 and 73 is an excellent exposure of the Wilhite Slate. Here the formation is a very finely crystalline argillaceous slate, dark bluish to greenish in color. It exhibits little change laterally or vertically. The outcrop examined apparently has two slightly different aspects. Toward the north a slaty cleavage is slightly developed and the rock is hard and brittle; to the south, and separated from the other by a small zone of minor faulting, the rock is more massive, the beds are slightly thicker, and slaty cleavage poorly developed.

*Jonas, Anna J., Structure of the Metamorphic Belt of the Southern Appalachias, Amer. Jour. Sci., Vol. 24, pp. 228-243, 1932.

The thickness of the formation according to Mackay's report* varies from 0 to 1000'. In the area of the section it appears to be at least 1600' thick.

Bedding in the slate is well shown. The formation strikes N59°E-S57°W and dips S 33°E at an angle of 30°. The whole exposure is extensively jointed at an angle of 55° in the direction of dip and is crossed with numerous white calcite veins. These attain thickness up to 3 or 4 inches and show the greatest development in the vicinity of the small fault. The fault zone dips south at an angle of 55° and consists of a narrow zone of brecciated slate through which the calcite veins attain their greatest development.

The weathered slate is greenish brown to tan in color and is slightly softer than fresh rock. The formation forms steep slopes. Mantle rock and residual soil are thin.

II Citico Conglomerate.

According to the Knoxville Folio** the Citico Conglomerate is an entirely siliceous formation varying from a fine white sandstone to a coarse quartz conglomerate with a few thin beds of sandy slate.

Two exposures of this formation were examined. At these points the formation consists of medium light gray quartzites of fine grain size, very dense. These were parted by several very thin beds of hard black to dark gray argillaceous slate.

The Citico Conglomerate is not well exposed along the road at Newfound Gap. It crops out in several deeply weathered ledges at some distance from the road and along the branches. The quartzite beds which are very resistant to erosion, are composed of fragments of white quartz and some biotite. The formation strikes N50°E and dips SE at an angle of 15°. Two well defined systems of joints are present. One of these strikes N 85°E and dips at an angle of 57°S. The other strikes N10°W and dips at 85° toward the NE. Jointing has been well developed, the rocks breaking more readily along these than along the bedding planes which are very faint.

The quartzite weathers slowly to a tan colored slightly porous sandstone and is quite often iron stained along the joints. Its residual soil is thin and siliceous.

The formation is apparently about 1300 feet thick. It overlies the older Wilhite Slate conformably and unconformably underlies the younger Pigeon Slate.

* Mackay, D.K., Geol. G.S. M.N.P., 1935, NPS
** U.S.G.S. Folio #16, 1895.

III Pigeon Slate.

This formation consists of a thick series of bluish and greenish gray very finely crystalline argillaceous slates of great uniformity. Little variation is found horizontally and such as is found vertically consists of relatively narrow bands of coarser siliceous material.

According to the Knoxville Folio the slate is composed of quartz, feldspar, mica, and argillaceous matter.

The thickness is estimated as nearly 1300 feet.

The formation strikes N60°E/S60°W and dips S 30°E at an angle of 27°. A very clear set of joints cuts the exposure. This system strikes N40°E/S40°W and dips N50°W at 55°. Bedding is easily distinguished and the slaty cleavage deviates from it at an angle of a few degrees but is not uniform.

The weathered slate assumes a light yellowish gray color. In some beds, evidently more argillaceous than others, the slate scales off in thin sheets leaving elongated rounded masses and steep ledges.

The slate has been altered along joints and bedding by passage of ground water and formation of veins of white quartz. These result in the slate becoming schistose, notably softer, and discolored by the addition of muscovite mica and argillaceous material. The veins of white quartz vary in thickness from a fraction of an inch up to 6 or 8 inches.

Soils are excellent but thin, except on the flanks of the ridges where wash from higher ground produces a deeper soil.

This formation lies conformably below the Cades Conglomerate.

IV Cades Conglomerate.

The Cades Conglomerate formation consists of massive bedded gray conglomerates and quartzite alternating with thin partings of black and dark gray slates. The beds of quartzite and conglomerate vary from around 3 feet to as much as 20 feet in thickness while the subordinate slate partings are rarely more than 5 feet in thickness and usually less.

The quartzitic and conglomeratic beds are composed mainly of fragments of white and blue quartz, feldspar, biotite mica and argillaceous matter. Grain size varies from very fine to very coarse.

The coarser rock sometimes contains fragments of black slate. In some places a change in lithology from a light gray coarse quartzite or conglomerate to a fine black slate occurs in a single bed within a vertical distance of a few feet. The change is usually uniform but rapid. Grain size grows smaller, feldspar declines in prominence, and there is a gradual increase in biotite mica and argillaceous material.

Depending upon the grain size and the relative content of white feldspar, quartz, and biotite, the color of the siliceous beds varies from light to very dark gray. Lateral variations in color and composition and grain size are not so noticeable as are vertical variations.

The slate partings are medium gray to black in color and are usually very finely crystalline. Occassionally they are banded or spotted by scattered groups of biotite mica flakes. Cleavage deviates from bedding as much as 30° to 45° but is not always uniform.

The estimated thickness of the formation is 3400 feet.

The strike of the formation is approximately N60°E/S60°W while the dip S30°E varies from 39° to 15°. Jointing is irregular and not well developed. The most prominent jointing is vertical and strikes in the direction of dip of the formation.

Bedding is, by reason of the thin alternating beds, very obvious and distinct. Thin stringers of slate and of coarser material are often found within finer grained beds of quartzite.

When exposed to weathering the feldspar breaks down first leaving a pitted and slightly discolored surface. The rock is very dense and resists erosion well, forming steep high ledges and high mountains. In many cases the rock spalls off in thin layers leaving fairly fresh rock exposed.

A peculiar type of concentric weathering is noticeable in the quartzitic and conglomeratic beds. When exposed at the surface, the fresh rock occasionally displays a roughly circular concretionary structure slightly different in color from the surrounding rock and bounded by a thin stain of iron oxide. These concretions weather out in a few years time, forming shallow widely circular pits which often dot the face of massive beds. These concretions, which are epigenetic in origin, according to Mackay were formed in the following manner: During the deposition of the sands making up this formation, a fragment of some material perhaps organic, foreign to the substance of the surrounding material was deposited. Later when solutions percolated through the sand these solutions were met by solutions from the foreign material carrying different minerals and the result was that precipitation took place about the foreign material, forming a concentric shell or series of shells and prohibiting future mineralized solutions from passing through the concretion. The effect of this process was that the material inside the concretion was but loosely cemented. When exposed this loosely, cemented material is quickly weathered out leaving a circular pit in the surface of the rock.

Along some of the slate partings are thin veins of white quartz which have altered the slates and arenaceous slates to considerable extent,forming, by growth of secondary mica, rocks approaching mica schists. Both the slate and the siliceous beds have been altered slightly by seepages of ground water and compaction along bedding and jointing, resulting in the growth of secondary mica, quartz and clay minerals from the breakdown of the feldspars.

V Thunderhead Conglomerate.

This formation is not essentially different in any respect from the Cades Conglomerate formation. It consists of a series of thick, massive bedded gray quartzites and conglomerates alternating with thin partings of black and gray slates. The entire series aggregates 3000 feet.

The beds of slate, usually about 2 feet in thickness, are all of essentially the same character. They vary in color from dark gray to black. Some are more arenaceous than others and some more micaceous - approaching the phyllites.

There are some thin bedded, fine grained gray micaceous sandstones often banded by layers of muscovite and biotite mica. These are composed mainly of quartz and biotite. Some cleavage is developed as a result of the mica and argillaceous matter.

The massive beds of quartzite and conglomerate are various shades of gray in color dependent upon grain size and feldspar quartz content. They vary in grain size from the coarse fragments of quartz and plagioclase - sometimes 1/4" in diameter - in the quartzitic beds to very small grained quartzites. White, clear and blue quartz, feldspar minerals, and biotite make up the bulk of the rocks. In the coarse beds there are usually some partings and thin discontinuous layers ofslate.

Both fine and coarse grained beds are exceedingly compact with the exception of the occasional sandstone layers.

Sorting of sediments, seasonal variations in type and amount of sediment, and change in currents produced both lateral and vertical variations in the character of the rock. Coarse bands may be seen to pinch out laterally while vertical variations are produced by cross bedding and change in sediments, textures, and amounts. As in the Cades conglomerate changes from coarse quartzite to fine micaceous sandstones and slates are often found in a single bed within a vertical distance of 8 or 10 feet. The concretionary structure mentioned in connection with the Cades Conglomerate is noticeable in this formation also.

The strike of the formation varies from N78°E/S78°W to N45°W/S45°E. The dip is in a general south easterly direction and varies from 20° to 47°.

Jointing is not prominent. Exposures are generally fractured and weathered. Weathering is often accomplished by exfoliation in some of the more massive beds.

The formation expresses itself in broad divides and high mountains usually more than 4,000 feet in elevation. Slopes are rather steep and are characterized by numerous sheer bluffs and ledges. Soils are deep and strong and support a heavy forest cover.

It should be noted here that the two formations mapped as the Cades and the Thunderhead Conglomerates are strikingly similar. In the section they appear as a great series aggregating 5,400 feet in thickness of alternating massive beds of feldspathic quartzites and sandstones parted by numerous thin layers of slates, phyllites, and some mica schists. Aside from the relative abundance of the component minerals the mineralogical composition of the entire series consists mainly of quartz (abundant blue quartz), feldspar, mica, and argillaceous material.

The mineral and rock fragments incorporated in the rocks of these two formations were deposited in early Cambrian time in the narrow, shallow epicontinental sea occupying the Appalachian Geosyncline during times when sedimentation was far from being uniform ahd uninterrupted. Varying conditions of sedimentation such as seasonal changes in climatic conditions, fluctuations in the shore line, and changing currents are evident in the present rocks froned from these sediments. Massive siliceous beds alternate rapidly with thin argillaceous partings and layers throughout the vertical extent of these two formations.

In the section traversed the rocks of one formation are exceedingly similar to those of the other and no distinct line of separation of the formations was found so that a division into two distinct formations seems hardly justifiable

VI Hazel Slate.

There appears to be no distinct boundary between the Thunderhead conglomerate and the Hazel slate. It seems, rather, that slate becomes increasingly predominant and quartzite and conglomerates progressively subordinate above the arbitrary dividing line of these two formations.

Within the Hazel itself there is considerable variation. According to rock types it consists of a thick series of dark gray to black slates with thin bedded quartzites and conglomerates. In the lower division of the formation, the slate is very similar to that present as partings and thin beds in the two lower formations - the Cades and Thunderhead conglomerates. It is essentially a finely crystalline black slate, usually extremely hard and brittle. In some few places the slate seems graphitic. Beds of hard gray quartzite and conglomerate are no different from the same type beds in the underlying conglomerates, except in their proportion to the bulk of the formation. They are various shades of gray in color and are composed of small to coarse grains of quartz, feldspar, mica, and argillaceous material. Blue quartz is quite noticeable. In the coarser layers are fragments of black slate.

The bulk of this lower division is made up of the thick bedded black slates.

In the upper part of the formation the black slates and thin beds of gray quartzite become intermingled with thin layers of light silvery gray crystalline slates and softer argillaceous and micaceous iron stained sandstones. In the vicinity of Newfound Gap, on the State line, the formation consists of very thin, alternating beds of black, gray, and light gray slates, gray and tan quartzites. The tan quartzites attain great prominence on the North Carolina side of the State line ridge. Here the fine grained tan quartzite, composed mainly of white quartz and stained by clay minerals, makes up the bulk of the formation. Interbedded with them are thin layers of light, silvery gray, soft slates.

Above the tan quartzites the black and dark gray slates come again into prominence.

Bedding in the black slates is all but obliterated. It is more easily distinguished in the thin beds of quartzite and in the thin alternating beds of the upper part of the formation.

The general strike of the formation in N70°E. It dips to the southeast at angles of from 50° to 80°. There has been much deformation in the lower parts by tilting and crumpling. Certain exposures show small but well defined synclines and overturned folds.

Weathering of the formation is very slow because of a scarcity of soluble constituents. Argillaceous and feldspathic materials break down first, allowing the gradual crumbling of the rocks.

The formation expresses itself as steep narrow ridges and divides. The peaks and knobs formed by it are among the roughest in the entire park.

VII Great Smoky Conglomerate.

This formation embraces a thick series of gray quartzites, sandstones, slates, phyllites, and mica schists.

As in the conglomerates on the north side of the mountain, the argillaceous beds are present as thin layers or partings between the thick, massive siliceous beds.

The argillaceous beds have all been metamorphosed into either slates, phyllites, or mica schists. The slates are compact and very finely crystalline and dark gray to black in color. Cleavage is usually about 30° or 45° from the bedding. With the increase of mica present, the slates pass into the phyllites which are intermediate between the slates and the mica schists. The phyllites are usually dark gray in color. By insensible gradation with increase of quartz and mica, the phyllites pass into the mica schists. These are usually finely laminated and consist essentially of quartz, biotite and muscovite and are often accompanied by garnet crystals.

The siliceous beds are all composed of quartz and biotite mica. These minerals are sometimes accompanied by a very little feldspar and by muscovite. Grain size varies from fine and medium in the quartzite beds to coarse in the conglomeratic layers.

In color these beds vary from very light to dark gray, depending upon grain size and smoky quartz, white quartz and biotite content.

Massive beds of quartzite and conglomerate make up the bulk of the formation. Individual beds are separated by relatively thin partings of slate, phyllite, and schist.

No great vertical variations are found in the siliceous beds. They are fairly uniform and except for slight variations in grain size and mineral content, the different beds are hardly distinguishable. Irregular sedimentation resulted in the interbedding of argillaceous layers with the siliceous ores. These have all been metamorphosed greatly and bear little of their former characteristics. It seems that in the lower part of the formation the argillaceous layers have, in the main, been altered to mica schists, in the middle part to schists and phyllites, and in the upper part to slates. There is no definite segregation of the layers into these three vertical divisions. They are widely scattered but the preceding grouping is made on the basis of the most abundant rock types present.

The quartzites sometimes grade into dark gray mica quartzites or into softer micaceous sandstones with increase in mica and argillaceous matter. From these they merge into finely micaceous slates or into phyllites of gray or black color.

The presence of mica in the sandstones and quartzites indicates that alteration took place under static and/or dynamic metamorphism, that the quartzites were formed by recrystallization under conditions of great pressure and heat rather than by cementation, and that most of the feldspars were broken down under these conditions.

The formation strikes in general, NE/SW and dips at varying degrees usually toward the SE. Dips toward the NW indicate minor synclines. Outcrops are generally much fractured, jointed and usually deeply weathered. The color of the weathered surfaces is grayish white to tan. Being very compact and siliceous, the formation is resistant to erosion and forms a large expanse of rough mountainous ground.

VIII Snowbird Formation.

In general (from the Asheville Folio), the formation is composed of fine and coarse quartzite. With this are interstratified a few beds of conglomerate and subordinate layers of black and gray slate and schist. Some of the quartzite beds contain much feldspar in small grains, while others contain only quartz.

Above Cherokee, N.C., along N.C. Hwy. No. 107 the Snowbird formation outcrops in a few low scattered ledges. It is usually deeply weathered. Here it consists of dense light white to tan quartzites, tan micaceous sandstones and mica schists - some garnetiferous.

Quartzite is usually fine grained and banded by layers of muscovite, biotite and some iron oxide. Some beds contain much biotite and some muscovite well disseminated through the rock.

Beds of slate and schist are usually very thin. The schists consist of thin alternating layers of mica - mostly muscovite - and fragments of quartz. Some contain well developed small crystals of garnet. Usually these beds are gray or grayish brown in color.

The beds of sandstone are usually light tan in color, distinctly banded by micaceous layers and consist mainly of small grains of quartz and scattered flakes of biotite mica. They sometimes contain a little feldspar.

The strike of the formation is a few degrees east of north and the dip generally westward from 59° to 90°.

Rugged, mountainous country is formed by the Snowbird formation. Its siliceous nature enables it to resist erosion extremely well. Soils are thin, poor, and sandy and support a scanty growth of timber.

IX Carolina Gneiss.

The Carolina gneiss, named because of its great extent in North and South Carolina, is the oldest formation exposed in the park. In the Asheville quadrangle and in places in the Mount Guyot quadrangle, it is cut by younger igenous rocks and overlain by younger sediments.

In the Asheville Folio the gneiss is described as consisting of an immense series of interbedded mica schists, garnet schists, mica gneiss, garnet gneiss, and fine grained granetoid layers. Also associated with the gneiss are numerous pegmatite veins, beds of marble, and intrusive granites.

The thickness of the formation is uncertain as is its origin. It may be partly of igneous and partly of sedimentary origin altered to its present state through excessive metamorphism.

In the vicinity of Cherokee, N. C., the formation appears to be a mica gneiss. It is composed mainly of white and some rose quartz, and much biotite, and scattered apatite (?) grains. Predominant color is medium to dark gray. Segregation of quartz and biotite into light and dark colored flow bands and slightly developed augen-like masses is well shown. The rock is very uniform in character and seemingly contains little if any feldspar.

At the park boundary on N.C. Hwy No. 107 the gneissoid structure strikes approximately N/S and dips W at an angle of 57°. Just below Mingus Creek on the same road, within the park, the structure strikes N10°W/S10°E and dips S 80°W at an angle of 70°.

The exposures of the gneiss are usually fairly well jointed. The rock weathers deeply and becomes a dull light brown color on the weathered surfaces.

4) Structure.

General Statement: The prevailing strike of the formations, as indicated on the structure section sheet, is NE/SW and the dip is at varying degrees toward the SE.

It may be stated generally that the entire section represents the SE limb of a great overthrust anticline in which minor folds and faults have been developed. Evidence supporting the general statement is found in local variations in direction and degree of dip and in lithology of the formations.

Broad structures are best preserved in the heavy feldspathic quartzites and coarse sandstones while the slates, especially the Hazel slate, have been intensely deformed in many areas.

A threefold separation of the formations has been made in the area of the section by large scale faulting. These are, 1) the Ocoee series, consisting of the Wilhite, Citico, Pigeon, Cades, Thunderhead and Hazel formations which are separated by a major fault from, 2) the Great Smoky conglomerate which is separated from 3) the Snowbird and the Carolina Gneiss formation by a second major fault.

The planes or zones of these faults are not exposed, but there are several instances where minor fault planes are seen. Excessive forest cover and weathering has obliterated the exposures of the zones at the surface. Since the faults have been indicated by structural and lithological evidence, their locations are only approximate.

Fault between Ocoee Series and Great Smoky Conglomerate.

The zone of this fault lies between the outcrops of the Hazel Slate member of the Ocoee Series in Newfound Gap and those of the Great Smoky conglomerate below and on the North Carolina side of the divide. Apparantly the zone lies only a few hundred feet SE of the Gap, near the State line.

This zone may be localized between points 61 and 64. Between these points there are displaced masses of both formations which were involved in the faulting.

The characteristic rock types of the Great Smoky conglomerate in this vicinity are massive bedded, fine grained gray quartzites with subordinate layers of dark gray to black phyllites and slates. The predominant strike is NW/SE and the dip at 35° to 55° N and NE.

The Ocoee series, which is represented at this point by the Hazel Slate, consists of a series of thin bedded light gray to black slates and gray to tan colored quartzites, some of which contain fragments of blue quartz. Above the exposure at point 62 the Hazel Slate dips uniformly at 60° toward the S 60°E. The beds are not at all fractured or distorted as are those in and immediately below the zone of faulting. Some of the lower beds of the Hazel are massive light gray quartzites which contain abundant feldspar and blue quartz fragments. The uppermost beds of the Great Smoky conglomerate below the fault are massive light gray quartzites of fine grain size and contain considerable mica flakes but no blue quartz or feldspar.

The proximity of such distinctly different rock types coupled with their separation by an intensely fractured zone in which portions of both formations are exposed and the structure indicated by the strikes and dips of the formations clearly warrant the placing of a major fault at this point.

The Great Smoky conglomerate is on the upthrow side toward the SE and the Ocoee on the downthrown NW side.

Fault between Great Smoky Conglomerate - Snowbird and Carolina Gneiss:

At point No. 43 on the base map the strike of the Snowbird formation is N 10°E/S 10°W and the dip N80°W at an angle of 75°. The rock types are fine grained gray quartzites and quartz mica schists present in nearly equal amounts. At this point the formation is extensively fractured.

The strike of the Great Smoky Conglomerate, at a point 1225 ft. NE of 43 at point No. 44, is N40°E/S40°W and the dip S50°E at 35°. Here the exposure consists of massive bedded quartzites containing elongated fragments of white quartz and feldspar with some muscovite and biotite mica. These grade upward into finer grained micaceous quartzites and are distinctly different from the rocks exposed at point No. 43.

On the basis of this structural and lithological evidence a fault is indicated between these two points. ~~The upthrow side is~~ undoubtedly to the SE and the Cambrian Snowbird formation and the pre-Cambrian Carolina Gneiss lie on this side while the younger Great Smoky Conglomerate lies on the down-throw side toward the NW. The displacement of the fault has not been determined but is probably of great magnitude.

Folding:

Preceding, and probably the cause of the faulting, was the diastrophism which, at the end of Paleozoic time, resulted in the formation of the Appalachian Mountains. These diastrophic forces coming from the SE resulted in general uplift and crumpling of the formations making up the present mountain system. In the region occupied by the Great Smoky Mountains, the competent formations formed a large anticlinal structure with minor folds developed upon its flanks. As pressure from the SE continued the anticline broke at some flexure on its NW limb and the entire series of formations was pushed toward the NW over the surface for a distance estimated at from 25 to 30 miles.

The faults shown on the cross-section and other doubtless present in the region were probably formed at the time of this large scale overthrusting.

Due perhaps to the relieving of pressure by this thrust faulting folding has not been so well developed in the Smokies as in the Northern Appalachians. Of this folding, all that is shown on the section is the general dip toward the SE and several minor anticlinal and synclinal structures. Erosion has truncated and vastly reduced the theoretical total height of the folds. Indeed, the cove areas of the park are explained as due to differential erosion along the crest of this large anticline forming fensters or windows in the overthrust mass.

The absence of individual, well marked beds makes it difficult, if not impossible, to trace the structure by this method. However, the structure may be fairly accurately determined from strike and dip readings along the highway since the formations are usually well exposed.

CROSS SECTION OF BLUE RIDGE OVERTHRUST

Location.

Two and one-half miles SE of Townsend, Tennessee, and approximately 1300 feet outside the boundary of the Great Smoky Mountains National Park is an excellent exposure of the Blue Ridge Overthrust, known locally as the Great Smoky Overthrust.

Description.

The exposure on the east side of Tennessee Highway No. 73 is approximately 1050 feet long and consists of a large mass of the Wilhite Slate which has been thrust a distance of some 35 miles overriding the Knox Dolomite.

The fault plane is exposed and dips to the South at 48°. Large masses of the Knox have been picked up by the slate and carried along by it. Such masses are found in the slate for a distance of 600 feet from the actual contact of the Wilhite with the Knox.

As can be seen on the section, the slate is intensely fractured and slickensided and parts of the dolomite have developed closely spaced shear cleavages.

Apparently the faulting here occupies a considerable zone with numerous slipage planes in the slate and also in the dolomite.

Rock Types:

Wilhite Slate. - The slate exposed here is greenish brown in color, very uniform, finely crystalline and argillaceous. Cleavage is not uniform. There are numerous thrust joints vertical to the cleavage and the whole mass is broken into many small slickensided chips.

The formation is the basal member of the Ococee Series of early Cambrian age.

Knox Dolomite. - This formation is of Ordovician age. In the unaltered portions the dolomite is massive bedded dark gray compact dolomite. Many parts contain very small rounded quartz fragments and the whole formation is shot with numerous small calcite veins. A certain part of the dolomite has been extensively sheared by overthrusting. The altered rock is lighter gray in color and much softer than the unaltered material.

Fossils collected from the Knox, near the fault exposure in Tuckaleechee Cove by Dr. H. S. Ladd, of the National Park Service, and Dr. G. W. Crickmay, of the Georgia Geological Survey, were examined by Drs. Ulrich and Butts who concluded that the fossils were Stones River in age, the lithology of the rocks suggesting the Lenoir formation.

Conclusion.

This exposure of the Great Smoky Overthrust is one of the best seen in the area and should be connected up with a traverse along Tenn. Hwy. 73 from Gatlinburg, Tennessee. Although the exposure is outside the park boundary, a trailside exhibit explaining the process of overthrusting should be erected there in the future.

PART II

CROSS SECTION OF THE GREAT SMOKY MOUNTAINS NATIONAL PARK

Location and General Description.

The Great Smoky Mountains National Park includes an area of nearly 700 square miles which is divided almost equally between the states, Tennessee and North Carolina. The long axis of the park extends east - west for some 50 miles and the short axis north - south for 20 miles. The boundary between these two states lies on the divide of the Great Smoky Mountains which meanders through the park for a distance of 73 miles.

These mountains together with their numerous spurs isolated mountains, coves and foothills occupy the entire park area. The mountainous beauty and countless scenic attractions of the Park are due to factors of the geologic past which have resulted in the formation of the mountains and in their subsequent alteration.

Erosion.

Since their uplift many millions of years ago, the rocks forming the Great Smoky Mountains have been subjected to a ceaseless process of erosion. Countless seasons of heavy rainfall, of snow and ice, of freezing and thawing, and wind have resulted in the wearing away of thousands of feet of rock and in the carving of a huge mass of rock formations into the present rugged peaks and sharp divides of the Great Smokies. Indeed, from Newfound Gap on the State Line one sees a spectacle of erosion as vast as that which has formed the Grand Canyon.

GEOLOGY

General Statement.

The Great Smoky Mountains are the eroded remnants of a huge mass of uplifted and overthrust rocks. The mountains themselves are among the oldest in the United States and the rocks underlying them are likewise among the most ancient exposed in the United States.

The rocks of the formations exposed along the line of the traverse vary in age from pre-Cambrian to early Cambrian. Rocks of far younger age formerly overlaid these old formations but all traces of them have been removed by erosion.

The Pre-Cambrian rocks consist of gneisses, probably of igneous origin but which have been extremely altered since their formation by heat and pressure. These rocks are exposed on the North Carolina side of the park, near the park boundary. Other formations consist principally of thick layers of quartzite and thinner layers of slates and schists. Originally these were sedimentary rocks but like the gneisses they have been altered or metamorphosed.

It may be seen from the accompanying structural cross section of the mountains that the layers of rock dip at varying angles toward the southeast. There are exceptions to this for in certain areas they dip toward the northwest. These variations indicate minor flexures or folds in the rocks. At several other places the rocks have been fractured and one mass shoved for some distance up over another. These breaks are known as faults and have played a very important part in the formation of the mountains.

Geologic History.

From a study of the rock types and the present structure of the rocks a fairly detailed geologic history of the region may be formulated.

In early Pre-Cambrian time the Carolina gneiss was formed, probably solidifying from a molten mass of rock material deep within the earth. After many periods of intrusion by other molten rocks the land was slowly uplifted and deeply eroded. By the end of the pre Cambrian there was formed along the present Atlantic seaboard a large land mass or continent, Appalachia, probably very mountainous. At the same time there was formed west of this land mass a broad trough extending hundreds of miles along the eastern parts of the United States. As the land forming this trough slowly sank, the ocean water poured into it forming a long shallow epicontinental sea, known as the Appalachian Seaway.

By the agents of erosion which are acting today just as they were in the dim geologic past the rocks of the land mass Appalachia were broken down and their fragments were carried by streams into the Appalachian sea. Here they were deposited in this great natural basin in a series of horizontal layers eventually totalled 25,000 feet.

This process of erosion, transportation and deposition took place throughout the Paleozoic Era and the sediments laid down consisted of fragments and of chemically precipitated materials derived from the weathering of the adjacent land areas. The first sediments were generally coarse fragments of quartz, feldspar minerals, and clayey minerals. By the later parts of the Paleozoic Era massive beds of limestones and other chemical precipitates were deposited along with the other clastic sediments.

Deposition was not uniform. Varying climatic conditions, periods of increased rainfall, changing shore currents and the general lowering of the land areas surrounding the sea led to deposition of alternating layers of coarse and fine materials which were later compacted and cemented together to form layers of rock.

At the end of Paleogoic time powerful mountain building forces began acting on the area from the east and southeast. These forces resulted first in the general uplift of the eastern areas of the United States and the consequential disappearance of the shallow Appalachian sea. As the forces built up greater pressures, broad folds began to develop in the rocks of the area. These folds became tighter and tighter and a huge mass of folded and crumpled rocks was piled up along the course of the Appalachian Mountain system. At last when pressures became so intense that the rocks were no longer able to withstand them, there occurred numerous fractures along which some of the rock material was shoved. This movement of rock masses, over other rocks along such breaks is known as thrust faulting. In the vicinity of the Great Smoky Mountains there occurred one such fault, traceable for several hundred miles in longitudinal extent, along which rocks have been shoved over from the southeast for some 25 to 35 miles. Major faults were often accompanied by secondary faults all of which served to release the pressures built up by the diastrophic forces.

At the end of this period of movement, the Great Smokies as well as others of the Appalachian System existed as broad rounded areas of high elevation. Weathering and erosion, which had begun their work upon the rocks immediately after their emergence from the sea, through the millions of years that have elapsed since that time have worn down and carved this mass of rocks into the mountains seen in this region today.

Cross Section.

The accompanying cross section of the mountains extends from the junction of Tennessee Highways, 71 and 73 along 71 to Newfound Gap and from there along North Carolina 107 to the park boundary near Cherokee, N. C.

As one proceeds from Gatlinburg, Tennessee, southeastward across the mountains the following formations are passed over in this order: Wilhite Slate, Citico Conglomerate, Pigeon Slate, Cades Conglomerate, Thunderhead Conglomerate, Hazel Slate, Great Smoky Conglomerate, Snowbird Formation, and Carolina Gneiss.

The first six formations named are members of the Cambrian Ocoee Series and consist essentially of massive beds of slates in the slate formations and of dense, massive gray quartzites and sandstones parted by thin beds of dark gray to black slates and schists in the conglomerate formations.

The Great Smoky Conglomerate, also of Cambrian age, consists of a great thickness of similar beds of quartzite and sandstone with interbedded layers of slates and mica schists which sometimes contain abundant small crystalline garnets.

The Snowbird formation of Cambrian age is composed mainly of white to tan colored quartzites with associated beds of sandstones and mica schists.

The oldest rock exposed in the park is the Carolina Gneiss which is Pre-Cambrian in age. This formation consists, in the park, of gray colored, massive, banded mica gneiss and contains much quartz and mica flakes.

The formation composed mainly of massive quartzites form the bulk of the Smoky Mountains, and the mountains underlain by these rocks are usually the highest in the park area. The slaty formations form usually lower ground. A notable exception to this is found near the state line where the Hazel Slate forms what is probably the roughest topography in the park. The slate in this case, however, is both underlain and overlain by the quartzites.

Structure.

As can be seen on the cross section the rocks dip at generally low angles toward the southeast. There are several gentle folds imposed upon this general dip and at several places, notably at Newfound Gap and near Cherokee, North Carolina, there occur faults. In both of these faults the rocks from the southeast have been shoved up over those to the northwest.

Conclusion:

A brief survey of the geology of the Great Smoky Mountains National Park is sufficient to show that the geology of the region is very complex and not easily understood by the layman without additional study. It is hoped, however, that certain points of great geological interest may be pointed out and sufficiently explained so as to give some idea of the rocks which make up the Great Smoky Mountains, the factors which caused their formation and subsequent alterations which have affected them, and, finally, to induce some speculation as to the future geologic history of an already much disturbed region.

SUGGESTIONS

As indicated in the previous section, the complete geology of the park has not yet been worked out. Therefore, while it is inadvisable to attempt the publication of any comprehensive report on this subject, it is urged that the Park Service attempt the encouraging of geologic interest in the park, which should certainly not be neglected, by the publication of brief general articles on cross section traverses and by the erection of simplified geological markers stressing erosion, rock types, geological processes, etc.

It is certainly advisable to conduct the program of geological investigation so that it, like the other naturalist programs, will be completed on or before the park is fully developed and officially opened.

PART III

PROGRAM FOR FUTURE GEOLOGICAL WORK IN
THE GREAT SMOKY MOUNTAINS NATIONAL PARK

Before a complete and accurate report of the geology of the park can be made available, either to scientific circles or to the public, considerable work remains to be done.

The entire park area is covered by two folios of the United States Geological Survey.* Although the areal geology sheets of these two adjoining quadrangles do include the whole of the park, a complete satisfactory map of the park has not yet been assembled. This is due to the fact that formations in the Mount Guyot Folio cannot be projected into the Knoxville Folio and also to the fact that correlation of the formations of the two folios has not been accomplished.

It is very necessary that a complete areal geology map of the park should be made. Either the two existing sheets should be adjusted after additional field work, or an entirely new map should be worked out. The latter course seems the more advisable since the formation boundaries on the existing maps are for the most part concealed or only approximations. More extensive development of roads and trails will enable more accurate location of contacts, determination of structure, and lithologic characteristics of the formations exposed.

There appears to be considerable difficulty in arriving at definite formation boundaries in the series on either side of the mountain. This may be accounted for by the lack of distinguishing characteristics in a vertical section. Both series appear to consist of many feet of alternating quartzitic and argillaceous beds deposited without noticeable interruption. Hence definite formation boundaries may have to be located after careful laboratory work. This same general characteristic of the series makes for a lack of key horizons and accurate structural determinations.

The areal geology sheet should be accompanied by numerous sections preferably along the roads or trails which would give accurate pictures of the structural geology.

Leaflets containing brief articles concerning the geology of the park with detailed sections along the roads and the areal geology map should be made available to visitors and to persons requesting geological information about the park.

*Knoxville Folio, No. 16, 1895, with geology by Dr. Arthur Keith.
Mt. Guyot Folio (unpublished) by Dr. Keith.

In the section of the Natural History Museum devoted to geology should be placed characteristic rock samples of all formations exposed in the park and in addition, samples showing features of especial geological interest such as fossils, peculiar or well developed minerals, shear and slaty cleavage, etc. Here, also, should be placed a large scale relief model of the park showing the areal geology and the structure, by sections, along the exposed sides.

It is to be expected that students and geologists who visit the park on field trips will have considerable knowledge of the geology of the park if publications are made available for them. However, the usual visitors will have little or no knowledge of geology and for their benefit, as well as for the others, simplified geologic signs and markers should be erected at suitable locations giving by means of brief statements and simplified diagrams, a clear impression of rock types, processes, structures, etc.

Some evidence has been gathered which would indicate the presence of a major fault in the vicinity of Newfound Gap, but there remains still the accurate tracing of this fault as well as the one near Cherokee, North Carolina, in other sections of the park. The difficulty of correlation, if correlation is needed, remains, as does the important problem of age determination of the two series and the working out of a complete stratigraphic column for the entire area.

These problems must affect changes in several other folios of the United States Geologic Survey which cover adjacent quadrangles.

By way of a brief summary, some of the more important problems may be enumerated as follows:

1) A detailed study of the Blue Ridge (Great Smoky) Overthrust Fault and of associated faulting in the vicinity of Newfound Gap and elsewhere, of slicken-siding, shearing, jointing, and metamorphism caused by overthrusting. The fenster topography of the cove areas should be more carefully studied in this connection. What is the relation of the faults at the Gap and at Cherokee to the Great Smoky Overthrust? How may the outcrops of the formation designated as Nantahala Slate on the North Carolina side be accounted for? Imbricate faulting as a result of overthrusting?

2) Examination of the supposed Knox Dolomite for fossils and the identification and preservation of these for display and the accurate determination of the age of the dolomite. Some work has already been done on this problem.

3) The working out of a complete stratigraphic column for the park area showing the character, thickness, topographic expression, age, and correlation of all formations exposed in the park. This, as mentioned previously, will necessitate, possibly, some changes in adjoining folios.

4) The construction of an accurate and complete geologic map of the park with accompanying cross sections along the major roads through the park.

REPORT ON ROCK SAMPLES
from
CHEROKEE - GATLINBURG SECTION
GREAT SMOKY MOUNTAINS NATIONAL PARK
By

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Specimen #1 — Cherokee - Newfound Gap Road at point 10.35 miles from Cherokee bridge.

Hand Specimens: Collection includes fine-grained grey mica schist, mica quartzite (greywacke of #13), and micaceous conglomerate. This is the typical Great Smoky lithology.

Thin-Sections: A) A course-grained aggregate of quartz, calcite, muscovite, and chlorite. Section also includes some sodic plagioclase (close to Albite), biotite (generally surrounded by and interlayered with chlorite), zircon. The calcite, in part at least, has been introduced and occupies veinlets. The rock appears to represent a thoroughly metamorphosed argillaceous sandstone, perhaps originally calcareous.

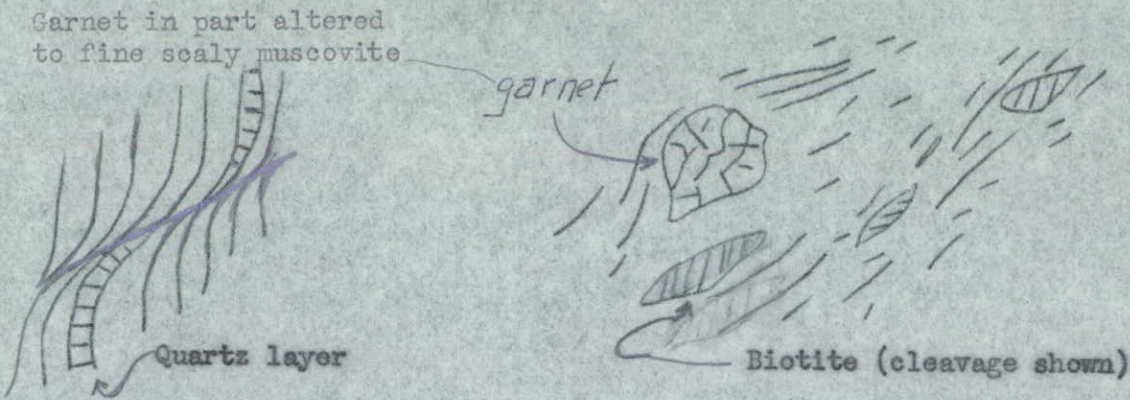
B) The section is a fine-grained schist made up of biotite, quartz, muscovite, feldspar, and crowded with innumerable opaque specks. The biotite has pleochroic halos. Biotite is not distinctly but has ragged margins. This rock appears to be a completely metamorphosed shale.

Specimen #2 — On Cherokee - Newfound Gap Road at point 15.5 miles from Cherokee bridge.

Hand Specimen: A dark shiny grey phyllite with well marked double cleavage.

Thin-Section: The section is made up of muscovite and quartz with a marked parallelism of the former. The section contains layers made up mainly of quartz. The quartz layers contain much biotite. Biotite is also present in the muscovitic parts but has been sheared into lenses with dimensional parallelism. (The biotite in this rock is earlier than development of schistosity, not later as in #9). Epigenetic crystalloblasts of chloritoid are common.

The sections show remarkably well a strong double cleavage. There has undoubtedly been some movement along this secondary cleavage for biotite flakes have been shredded giving an aggregate pleochroism to the rock, nevertheless the matching of quartz layers on either side of secondary cleavage shows that the movement has been very small.



Rock #9 shows no sign of retrogression although I count as unusual the large crystalloblasts of garnet in an extremely fine-grained phyllite. The biotite crystalloblasts are epigenetic and may have resulted from effect of igneous intrusion later than time of metamorphism. Rock #2 is strongly suggestive of retrogression for it evidently contained biotite and garnet before last metamorphism; these minerals have been deformed cataclastically, that is cracked, broken and drawn out into lenses. There is no evident retrogression of minerals. The common retrogressive change of garnet and biotite to chlorite is not in evidence.

Specimen #3 — On Cherokee - Newfound Gap Road at point 9.3 miles from Cherokee bridge.

Hand Specimen: Collection contains both fine-grained biotite gneiss (greywacke type of #13) and fine-grained silvery mica schist with slightly crenulated schistosity.

Thin-Section: Apparently of the biotite gneiss; contains quartz, muscovite, and biotite with some apatite and zircon. Biotite has pleochroic halos. The rock appears to be a thoroughly recrystallized sandy shale.

Specimen #4 On Cherokee - Newfound Gap Road at point 3.95 miles from Cherokee bridge.

Hand Specimen: This is a feldspathic garnet-biotite gneiss. It differs from the preceding specimens in being coarser and in being very feldspathic. The feldspar is in irregular blotches and lenticular eyes. It is also not as distinctly layered as the other specimens.

Thin-Section: Contains feldspar (in part myrmikitic - also some crystals have sodic margins), biotite, muscovite, quartz, apatite (very abundant and in large crystals) calcite, epidote, zircon. This is the general mineralogy of the other sections and thus there is here nothing to set this rock apart from the others. It has a somewhat more "igneous-appearance" but there is no evidence against it being a highly metamorphosed sediment.

Specimen #5 On Cherokee - Newfound Gap Road at point 4.2 miles from Cherokee bridge.

Hand Specimen: Biotite gneiss. This, of all the specimens is typical of the rock called by Keith Greywacke, a fine-grained grey biotite quartzite generally having a somewhat gneissic texture. The term "quartzite" is not very good because the rock is so feldspathic; on the other hand, the term "biotite gneiss" gives a somewhat false impression of a banded or foliated rock. This dilemma appears to have promoted the term greywacke.

Thin-Section: Contains quartz, plagioclase (this seems to be albite but may be microcline; part of it is in the form of an intergrowth resembling myrmikite), biotite, muscovite, and apatite. No strong parallelism of micas is seen in the section. I suspect that this, like most or all of the preceding, is a sedimentary gneiss.

Specimen #6 On Cherokee - Newfound Gap Road at point 9.4 miles from Cherokee bridge.

Hand Specimen: A crenulated mica schist with a semblance of secondary cleavage across schistosity due to coincidence of tiny folds (puckered schistosity).

Thin-Section: Is made up almost entirely of muscovite, biotite and quartz, with marked parallel alignment. Schistosity is sharply folded, mica scales are bent but not broken. This appears to be a thoroughly metamorphosed shale.

Specimen #7 On Cherokee - Newfound Gap Road at point 5 miles from Cherokee bridge.

Hand Specimen: A medium-grained biotite-garnet schist with thin feldspathic streaks.

Thin-Section: Made up of plagioclase (probably close to An30), biotite, muscovite, quartz, and garnet (strongly cracked and in part surrounded by chlorite and very fine muscovite), chlorite and apatite. In the series of slides this is the first in which feldspar is a good deal more calcic than albite and also the first in which feldspar is the most abundant mineral. There is no good indication of its origin but the rock does not differ greatly (except dominance of feldspar and coarseness of grain) from previous biotite gneisses. In other words, as far as the thin sections go, it is not possible to substantiate a claim that this belongs to a series definitely older than the preceding sections.

Specimen #8 On Cherokee - Newfound Gap Road at point 8.15 miles from Cherokee bridge.

Hand Specimen: Mica gneiss with bright silvery flakes of muscovite on cleavage surfaces.

Thin-Section: The thin-section is apparently cut parallel to cleavage and thus does not show any marked schistosity (also contain innumerable basal sections of muscovite and biotite). The main minerals are quartz, muscovite, and biotite. Apatite and zircon present. Feldspar is rare and may be absent (a few untwinned grains with poor cleavage were all that could belong here). The rock is thought to be a strongly metamorphosed shaly sandstone.

A noteworthy feature is the very dark nearly opaque pleochroic halos which surround zircon where it is included in biotite.

Specimen #9	On Cherokee - Newfound Gap Road at point 15.8 miles from Cherokee bridge.
Hand Specimen:	A dark gray shiny phyllite with good even cleavage. Small crystalloblasts can be seen with eye.
Thin-Section:	Made up mainly of muscovite and quartz. Muscovite is in very fine scales all perfectly aligned. The section contains innumerable opaque specks, possibly in part graphite. There are a few strongly cracked colorless garnets. Biotite is present as crystalloblasts oriented athwart the schistosity. It is evidently later than development of schistosity.
Specimen #10	On Cherokee - Newfound Gap Road at point 4.25 miles from Cherokee bridge.
Hand Specimen:	Garnet biotite schist with fine-grained siliceous layers very similar to #13. Schistosity is more even than #7 and the rock lacks the thin feldspathic streaks common in #7.
Thin-Section:	The section is made up of quartz, feldspar, biotite, muscovite, garnet, epidote, and apatite. It is crowded with opaque specks, probably mainly metallic ores. The biotite has many good halos in it. The feldspar is plagioclase probably close to An30 as in #7. The quartz is characterized by parallel streaks of dustlike inclusions.
Specimen #11	On Cherokee - Newfound Gap Road at point 6.8 miles from Cherokee bridge.
Hand Specimen:	This is a medium-grained gneiss of the type generally put in the Carolina. It is a siliceous biotite gneiss with feldspar porphyroblasts.

Thin-Section: The section contains quartz, feldspar (probably albite - the ref. index is low), biotite, muscovite, apatite, zircon, and calcite. Only a very rough parallelism of micas is seen in the section and the quartz grains have no dimensional parallelism such as shown by section #3. Feldspar occurs mainly as large porphyroblasts. I judge this rock to be a sedimentary gneiss like those above because its mineralogy and texture is similar.

Specimen #12 Cherokee - Newfound Gap Road at point 11.4 miles from Cherokee bridge.

Hand Specimen: A finely crinkled biotite-muscovite schist with porphyroblasts of feldspar (these are very small and give the rock a speckled appearance in section at right angles to cleavage).

Thin-Section: The section contains muscovite, biotite, quartz, and albite (possibly oligoclase), opaque iron oxides. The micas, which predominate, are in perfect alignment giving a well marked cleavage. This primary schistosity is crenulated but is not nearly as deformed as in #2. The albite occurs as porphyroblasts which are cracked. This rock is similar to #13 but evidently originally more argillaceous. The original schistosity has been puckered by later movement but no mineral grains have been crushed.

Specimen #13 Cherokee - Newfound Gap Road at point 13.1 miles from Cherokee bridge.

Hand Specimen: This is a mica quartzite, - a hard, fine-grained siliceous rock of a type generally miscalled greywacke.

Thin-Section: The rock contains the following minerals named in order of abundance: Quartz (with strong strain shadows)
Biotite (random orientation)
Calcite (irregular grains)
Muscovite (random orientation)

The following are minor constituents: Feldspar, iron oxides, zircon, tourmaline, apatite, epidote?, titanite?. The minerals in this rock show no common orientation. The rock is interpreted to be a highly metamorphosed argillaceous sand.