May 23, 1949

To the Committee on Graduate Study:

I am submitting to you a thesis written by George David Swingle entitled "Petrography of the Chilhowee Group, Near Walland, Tennessee." I recommend that it be accepted for ten quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Geology.

Frank G. Snyder
Major Professor

We have read this thesis
and recommend its acceptance:

Paris B. Stockdale

L. Lee Collins

Accepted for the Committee

E. G. Watus
Dean of the Graduate School

PETROGRAPHY OF THE CHILHOWEE GROUP, NEAR WALLAND, TENNESSEE

A THESIS

Submitted to
The Committee on Graduate Study
of
The University of Tennessee
in
Partial Fulfillment of the Requirements
for the degree of
Master of Science

by

George David Swingle

June 1949

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Finally to Mr. Herman W. Ferguson of the Tennessee Division of Geology, under whose direction the field studies were made, the writer is deeply indebted. The keen interest and enthusiasm of Mr. Ferguson for this project cannot be overstated.

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CHAPTER I

INTRODUCTION

The Ocoee-Chilhowee Problem

Time and stratigraphic relationships of the Ocoee and Chilhowee groups have long been a problem in southern Appalachian geology. These rocks, now metamorphosed to varying degrees, outcrop over wide areas in the mountain region. Unfortunately, no one person has been able to study their problems in enough detail to unravel them and, as a result, many conflicting statements are in the literature.

Formations of the Ocoee and Chilhowee groups are largely composed of fine to coarse clastic sediments. In general, rocks of the Ocoee group lie to the southeast; those of the Chilhowee group to the northwest. The stratigraphic relationships of the two groups are difficult to determine. Standard methods of correlation are not applicable to this problem due to lack of fossil evidence, varying degree of metamorphism, and complex structure. In areas thus far mapped the groups are in fault relationship only, never in normal stratigraphic sequence. Lithologic units in the Ocoee group usually cannot be traced far laterally because of structural and metamorphic complexities. Units of the Chilhowee group, on the other hand, are only slightly altered by metamorphic processes and are more amenable to normal stratigraphic methods.

Early workers assigned these groups to various geologic periods ranging from pre-Cambrian to Silurian. More recently geologists are generally agreed that the groups are of pre-Cambrian and Lower Cambrian age.

This study is an attempt to apply heavy mineral techniques to some phases of the Ocoee-Chilhowee problem. Results may prove useful in supplementing field mapping in complex areas, in correlating units from one fault block to another, and in assisting in interpreting geologic history of the area.

Choice of Area

Formations of the Chilhowee group are in general well defined lithologic units; they are few in number; they usually occupy areas of only moderate structural complexity; and they exhibit only low rank metamorphism. Their comparative simplicity makes study of that group by detailed field and petrographic methods a logical approach to this classic problem. In order to obtain reliable data the area chosen for detailed study should be structurally simple, should include all formations of the Chilhowee group in normal sequence; should present ample outcrops for sampling; and should include if possible type localities of Chilhowee formations.

Location of Area

The area selected for study conforms to the above provisions. All formations of the Chilhowee group are present in normal sequence; outcrops are abundant; and beds have not been greatly altered by metamorphism. One type locality, Mount Nebo, is included in the area. Type localities of other Chilhowee formations are nearby.

The chosen area is approximately six miles long and two miles wide.

It represents a portion of Chilhowee Mountain in Blount County, eastern Tennessee. The village of Walland, Tennessee, is near the center of the area as shown in figure 1.

Previous Work

James Safford, second state geologist of Tennessee, described and named the Ocoee and Chilhowee groups in his now classic "Geology of Tennessee."

Arthur Keith, of the United States Geological Survey, in 1895 and later years sub-divided the groups into formations and mapped them over extensive areas. Keith's work was excellent; his maps are still the only ones available for many southern Appalachian areas. However, the complexity of formational names which he coined for different quadrangles accounts for a good deal of the present confusion in stratigraphic terminology of these units.

Crickmay (1936) studied the Ocoee group in northern Georgia. His conclusions differ markedly from those of Keith and others.

King and others (1944) were the first to map these groups in detail. Their work was in northeastern Tennessee.

Rodgers (1948) has mapped in detail a small area of Ocoee and Chilhowee rocks in Washington County, Tennessee.

Present Work

The writer's interest in this problem was stimulated while employed by the Tennessee Division of Geology during portions of 1946 and 1947 on

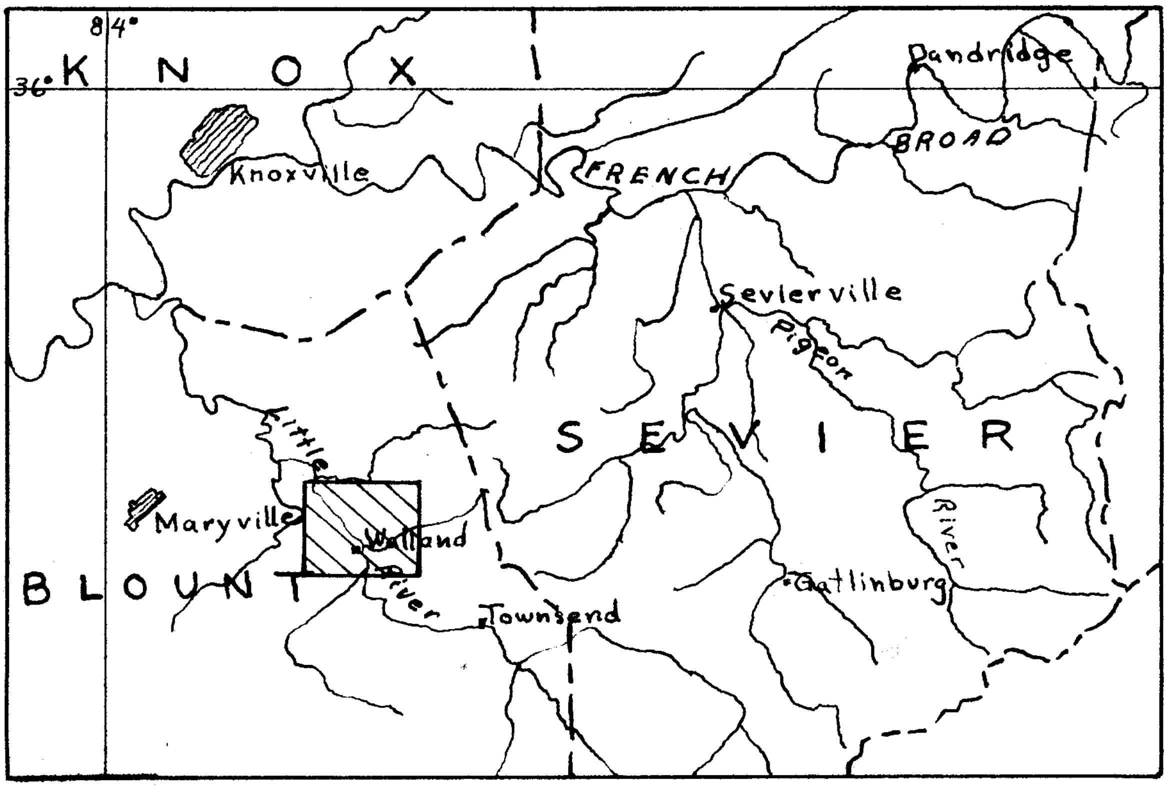

Figure 1.- Index map of east Tennessee, showing area covered by Plate I.

a joint areal mapping project of the Division and the United States Geological Survey in the Great Smoky Mountains area. The field experience in this joint mapping program brought first hand familiarity with the lithologic units and the many problems of the area as well as the privilege of working with men long acquainted with southern Appalachian geology.

Field studies in the Walland area were carried on during the fall of 1948 and the winter and spring of 1949. Petrographic studies of rocks from the area were made during the same period.

CHAPTER II

GEOLOGIC SETTING

Physiography

The area studied in this report is along the border of the Blue Ridge and Valley and Ridge physiographic provinces.

The Blue Ridge Province is a mountainous area extending from the state of Georgia northeastward into Pennsylvania. In eastern Tennessee and western North Carolina it attains a maximum width of seventy miles (Fenneman,1938) and at places along the Tennessee-North Carolina border, rises to elevations above 6000 feet. Rocks of the Ocoee group underlie these summit areas and much of the lower foothills country.

Chilhowee formations occur mainly as outliers which parallel the general northeast trend of the mountain chain. An excellent example of such an outlier is Chilhowee Mountain, extending for many miles along the western border of the Blue Ridge Province. In the area of this report it rises approximately 1000 feet above adjacent lowlands. As shown by photographs on the following pages, the mountain is relatively narrow and even crested.

Southeast of Chilhowee Mountain a synclinal limestone valley, known as Miller Cove, separates rocks of the Chilhowee group from those of the Ocoee group. The cove is elongate in shape and is surrounded by mountains and low hills. Although encircled by older rocks the cove is not a fenster like Tuckaleechee Cove and Cades Cove to the south.

System	Group	Formation	Symbol	Thickness	Description
CAMBRIAN		Shady dolomite	€sh	900±	Dolomite and limestone with chert and jasperaid.
	CHILHOWEE GROUP	Helenmode member	€eh	200±	Green siltstones and dolomitic sandstone.
		Hesse sandstone	€h	1000±	Massive white sandstone.
		Murray shale	€mr	500±	Grayish-blue sandy shale.
		Nebo sandstone	€nb	150±	Thinly bedded and massive white sandstone.
		Nichols shale	€nc	400±	Grayish-blue sandy shale.
		Cochran conglomerate	€ch	700±	Sandstone with scattered pebbles. Red sandy shale. Coarse conglomerate, quartz, and feldspar pebbles.
		Sandsuck shale	€s	1200±	Grayish-blue argillaceous shale with calcareous conglomerate lenses.

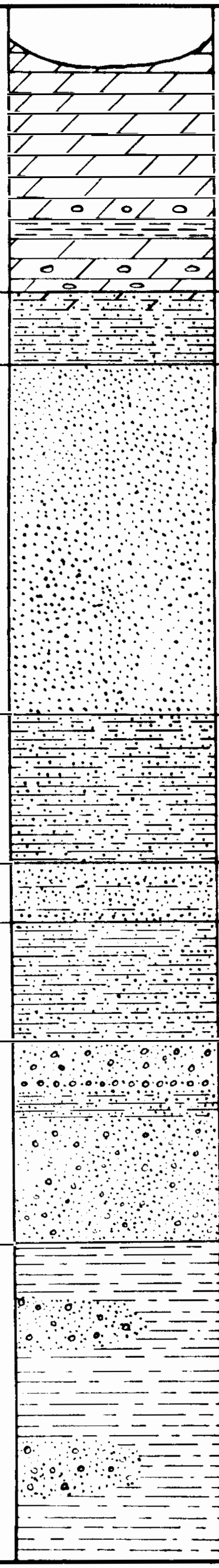

Figure 2.- Generalized section of geologic formations near Walland, Tennessee.

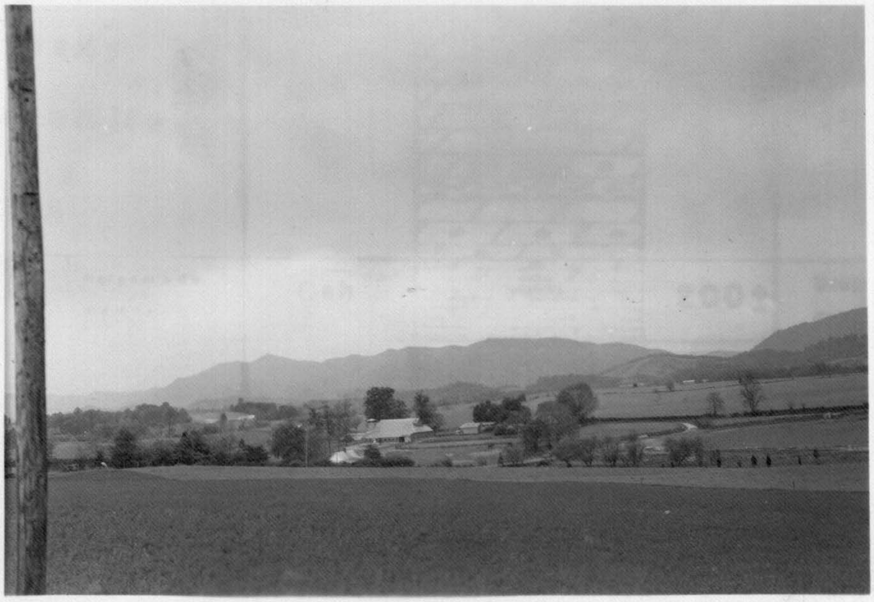

Figure 3. View Looking Southeast Toward Chilhowee Mountain

Figure 4. View of Chilhowee Mountain With Miller Cove in Foreground

Figure 5. View of Little River Gap Looking Southeast

Figure 6. View of Chilhowee Mountain From Miller Cove

To the northwest of Chilhowee Mountain lies the Valley and Ridge Province. Northeast-southwest structural trends produce alternate ridges and valleys which reveal the nature of orogenic movements that have so profoundly affected strata in the Blue Ridge Province. Familiarity with the geologic features of this region is essential to workers in the Blue Ridge Province because of intimate structural relationships. The often used term "Appalachian type structure" is exemplified in this province.

Regional Geology

Ocoee rocks form extensive outcrops in the mountainous belt. These strata consist largely of alternating fine and coarse clastic materials which were estimated by Keith (1895) to be about 16,000 feet thick. Keith (1895) subdivided the Ocoee group into seven formations, each variable in lithology and thickness. This group has a complex geologic history which is at present imperfectly understood. At least two orogenic movements have greatly altered these rocks.

Chilhowee formations underlie relatively small areas. This group, some 6000 feet thick, was divided by Keith (1895) into six formations of alternate shales and sandstones which are somewhat similar lithologically to Ocoee units. However, Chilhowee formations form more consistant lithologic units than those of the Ocoee group. Unlike the unfossiliferous Ocoee group, the Chilhowee group contains fossils in its uppermost formations.

In contrast with the Ocoee and Chilhowee groups, younger Paleozoic rocks in the Valley and Ridge Province consist largely of well-defined,

Figure 7. View of Miller Cove From East Side of Little River Gap. Blue Ridge Foothills in Background

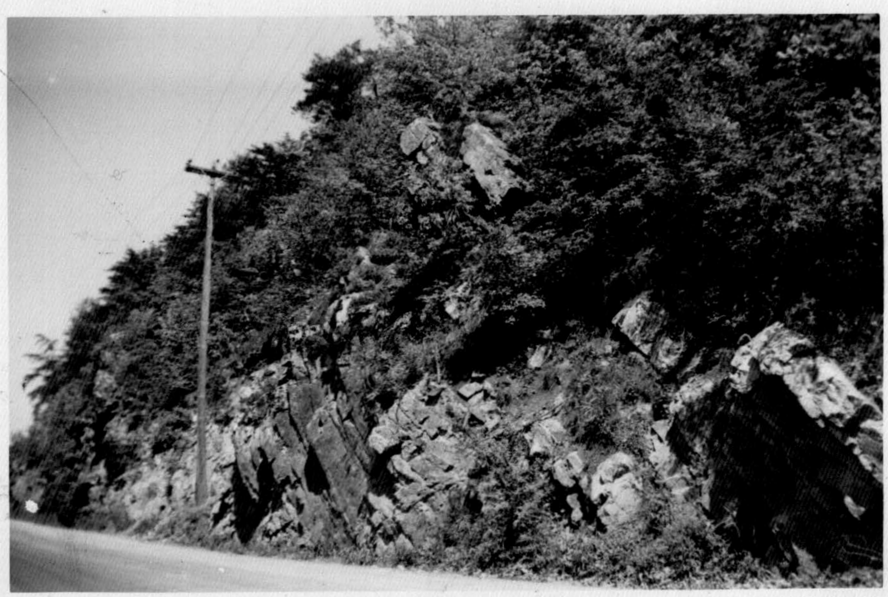

Figure 8. Cochran Conglomerate Exposed in Road Cut Along Highway 73 on East Side of Little River Gap

unmetamorphosed, fossiliferous formations. These strata are usually less complex stratigraphically and structurally than the older rocks.

Strata in the Blue Ridge Province, and to some extent younger beds in the Valley and Ridge Province, are often in complex structural attitudes. Outstanding among the tectonic features are the great overthrust faults which usually originate in the Blue Ridge Province and displace strata northwestward for many miles.

Typical of these faults is the Great Smoky overthrust along which Ocoee and Chilhowee rocks have overridden younger Paleozoic formations. Evidence in several fenster areas indicates this thrust sheet has moved a minimum distance northwestward of six miles. Chilhowee Mountain is a part of this thrust block and the area mapped in this report extends to the trace of the overthrust along the northwest side of Chilhowee Mountain. This thrust block is complicated by secondary faulting. Along the southeastern border of Miller Cove, Ocoee formations have been faulted against Chilhowee and younger rocks.

Folds of diverse trends are associated with the faults. Miller Cove syncline southeast of Chilhowee Mountain trends northeast. The structure is complicated by reverse faults. Shady dolomite (see figure 2) and a portion of the overlying Rome formation occupy the pit of the cove structure.

CHAPTER III

STRATIGRAPHY

General Statement

Formations of the Ocoee group are largely of sedimentary origin but thin flows of basic volcanic rocks are common in the lower part. The group rests unconformably on a basement of pre-Cambrian igneous and metamorphic rocks. Original clastic materials of the Ocoee group have largely been altered by metamorphic processes. As these beds are traced southeastward they become progressively more metamorphosed until many of the original features are obscured. In general, the lithology of the Ocoee group is such that detailed stratigraphic studies are difficult.

Unlike formations of the Ocoee group, Chilhowee units have not been intensely metamorphosed and original constituents of these rocks are discernible. Schistosity and other metamorphic features prevalent in Ocoee rocks are generally absent in this group. Variations in lithologic facies, common in the Ocoee group, are less apparent in the Chilhowee group, thereby simplifying stratigraphic studies. A generalized columnar section of Chilhowee formations is given in figure 2.

Fossils have never been reported from the Ocoee group; and, other than the worm tube *Scolithus*, are rare in Chilhowee formations. Walcott (1890) reports *Hyolithes Americanus*, *Isoxys chilhoweana*, and *Olenellus thompsoni* from the Murray shale. Keith (1895) also reported finding fossil fragments from the Murray shale. Butts (1926) reports *Olenellus* and brachiopods from the top of the Hesse sandstone. Resser (1938) has reported fossils from the Hesse horizon in other areas.

Various authors have placed the pre-Cambrian—Cambrian boundary at different horizons in the Ocoee and Chilhowee groups. The subcommittee on Cambrian Stratigraphy (1944) defined the base of the Cambrian as the base of the Hesse sandstone. The writer follows the United States Geological Survey correlation charts (Wilmarth 1929) in designating the entire Chilhowee group as Cambrian in age.

Chilhowee Group

The Sandsuck Shale

The name Sandsuck shale was applied by Keith (1895) to outcrops along Sandsuck branch of Walden Creek in Sevier County, Tennessee. The basal relationship of this shale with older rocks is not known. The Sandsuck shale is not present in its entirety in the Walland area. A wedge of this formation along the northwest side of the mountain is progressively faulted out to the southeast as shown on plate I. Estimated thickness of the shale present is about 1200 feet.

This formation in the Walland area is mainly drab-colored argillaceous and sandy shale with lenses of calcareous conglomerate. Quartz and feldspar pebbles in the conglomerate range in size from one-quarter inch to over one inch in diameter. Individual conglomerate lenses rarely exceed one hundred feet in thickness.

The Sandsuck shale usually occupies areas of low relief; outcrops occur only along stream valleys. Conglomerate lenses in the formation outcrop more frequently, usually forming low hills in the shale belt.

The Cochran Conglomerate

Overlying the Sandsuck shale are about 700 feet of typically conglomeratic beds to which Keith applied the name Cochran conglomerate from exposures along Cochran Creek, Sevier County, Tennessee. Pebbles of quartz and feldspar up to two inches in diameter are common in this formation. Although blue in color where fresh, decomposed feldspar grains give the rock a characteristic yellow-green color on the weathered surface. A thin zone of red arenaceous shale can sometimes be traced in the upper half of the formation. Above this zone the conglomerate beds give way gradually to beds of fine to coarse-grained sandstone.

The Cochran conglomerate forms massive cliffs along the northwest flank of Chilhowee Mountain.

The Nichols Shale

The Nichols shale was named by Keith (1895) from outcrops along Nichols branch of Walden Creek, Sevier County, Tennessee. In the area of this report the shale is about four hundred feet thick. The formation is predominantly sandy shale with thin beds of siltstone and fine grained sandstone. It is dark blue-gray when fresh, but weathers to a brownish-yellow color. Iron oxides often impart a purplish tinge to weathered outcrops.

This shale alters easily and does not form numerous outcrops. Topographically, its position can be determined by gentle slopes and low divides between sandstone ledges.

The Nebo Sandstone

The type locality of this unit is Mount Nebo in the mapped area.

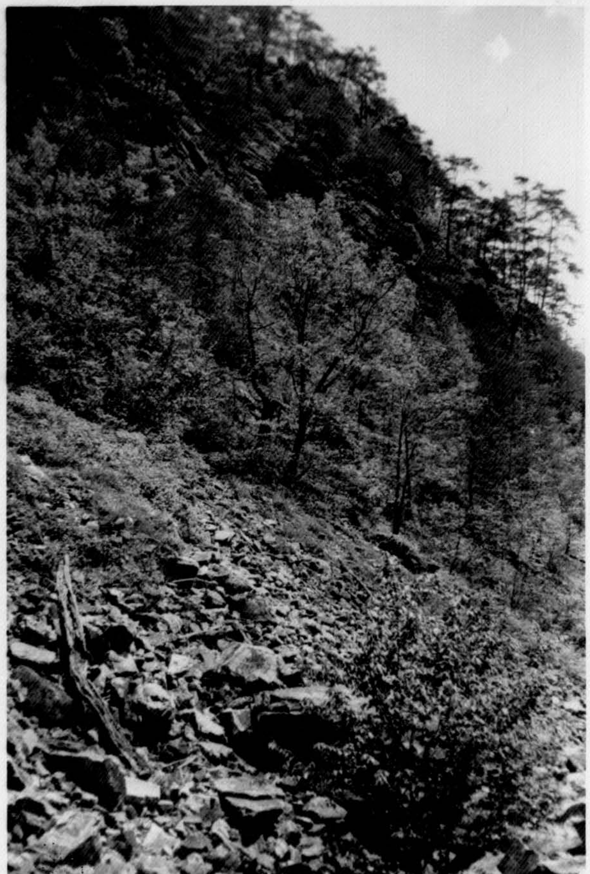

Figure 9. Talus Slope of Nebo Sandstone From Ledge in Background, East Side of Little River Gap

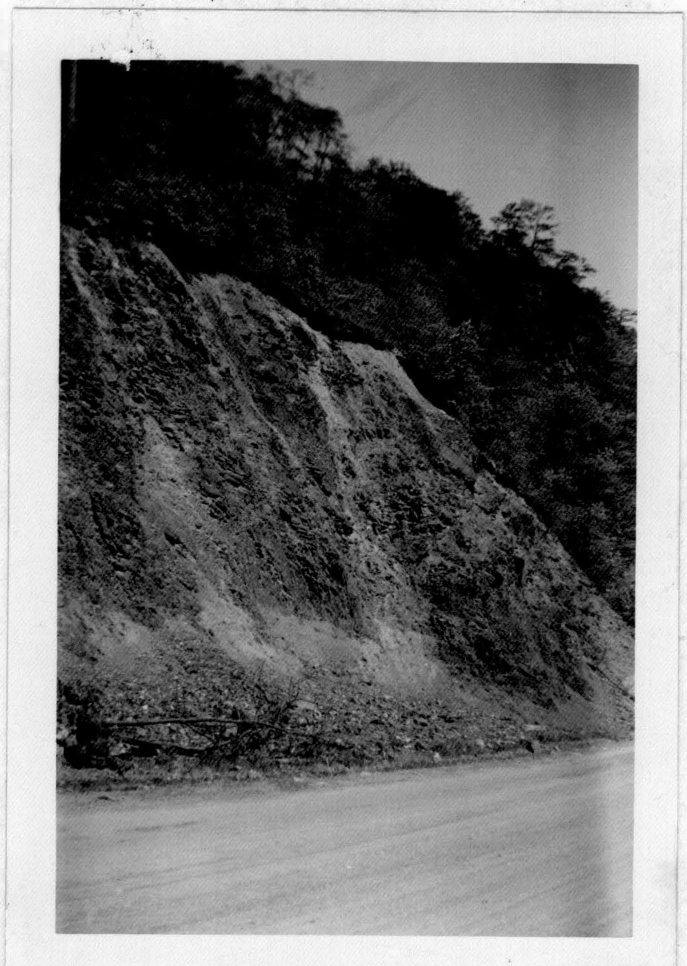

Figure 10. Nichols Shale Exposed in Road Cut along Highway 73 on East Side of Little River Gap

This formation was named by Keith (1895).

The Nebo sandstone consists almost entirely of fine to coarse-grained sandstone beds. Near the upper and lower limits of this formation thin siltstone beds occur. Fresh exposures of the sandstone are light brownish-blue to white.

Outcrops of Nebo sandstone are numerous, usually forming small ledges and cliffs. Rectangular blocks from weathered ledges of this formation commonly form large talus slopes.

This formation contains the worm tube Scolithus in its upper part. The Scolithus tubes are usually conspicuous; they average about one-quarter inch in diameter and several inches in length. Invariably the tubes are orientated perpendicular, or nearly so, to bedding planes.

The Murray Shale

The Murray shale, named by Keith (1895) for its occurrence along Murray branch of Walden Creek, Sevier County, Tennessee, overlies the Nebo sandstone. Its thickness in this area is estimated to be about five hundred feet. This formation is very similar to the Nichols shale; they are differentiated only on the basis of stratigraphic position.

Keith (1895) reported lingulellae and trilobite fossils in this formation from the crest of the mountain south of Montvale Springs, Tennessee, and from the east side of the Little River Gap.

The Hesse Sandstone

Above the Murray shale are the prominent white sandstone beds of the Hesse formation so named by Keith (1895) for outcrops along Hesse Creek, Blount County, Tennessee. This formation is composed of fine to coarse-grained sandstone which, when weathered, is very friable. Near the base of the sandstone is a thin zone of iron-cemented, coarse-grained sand which weathers into conspicuous red and purple masses.

The uppermost part of the Hesse formation has been designated the Helenmode member. King and others (1944) named this member from exposures at the Helenmode pyrite mine in Carter County, Tennessee. In the Walland area this member is mainly greenish siltstone with scattered lenses of yellowish sandstone. At the top of the member is a dolomitic, coarse-grained sandstone which on weathering leaves a residium of coarse quartz grains aptly termed "fish-egg" sand.

Scolithus tubes occur in the Hesse formation from about ten feet below the base of the Helenmode member almost to the base of the formation.

The thickness of this formation is about 1000 feet; the Helenmode member is approximately two hundred feet thick.

Shady Dolomite

Since this formation overlies the Chilhowee group, it was mapped at the Hesse-Shady contact. One exception to this is the small area of Shady dolomite residium south of Murray Gap. The position of the Hesse-Shady contact is easily located by the presence of residual jasperoid from the weathered dolomite. The formation has been well described by King and others (1944) and Rodgers (1948).

CHAPTER IV

STRUCTURE OF THE CHILHOWEE GROUP

Chilhowee rocks in this area have overridden younger Paleozoic strata along the Great Smoky overthrust. The younger beds are exposed along the northwest base of Chilhowee Mountain. It is estimated that the plane of this overthrust fault dips 20° to the southeast.

Chilhowee formations near Walland generally dip southeastward 30° to 50°, thus forming dip slopes on the southeast side of the mountain. This general dip is apparent southwest of Little River. To the northeast of this point the southeast dip is broken by a faulted syncline as shown on plate I.

Some warping and fracturing of the Chilhowee formations undoubtedly occurred simultaneously with the overthrusting. Such evidence is present in the gorge of the Little River at Walland where a northwest tear fault offsets the Great Smoky overthrust. However, the present attitude of these beds is probably due largely to post-overthrust movements.

High angle reverse faults are common in this fault block. Three of these faults occur near Walland. On Mount Nebo a small reverse fault cuts out the Murray shale, bringing the Hesse sandstone against the Nebo formation. Northeast of Walland, the fault which strikes toward Chestnut Flats (see plate I) breaks an incipient anticline. Displacement along this fault is only a few hundred feet. South of this fault is another conspicuous break which displaces Cochran conglomerate and Sandsuck shale against the Hesse sandstone. The plane of this fault can be seen in several stream valleys. The measured dip of the fault plane averages 75° to the southeast.

In addition to the reverse faults in this block, numerous normal faults of small displacement have been noted. The largest of these has been plotted on the areal geologic map, plate I. This fault strikes 45° northwest and dips 80° southwest.

Intricate folding and fracturing of the rocks along the fault zones is common. Much of this contortion is too localized to be accurately plotted. Deformation of the massive Cochran conglomerate beds along the Great Smoky overthrust is especially conspicuous. Frequently, slices of other formations are encountered along the fault zones, such as the wedge of Nebo sandstone along the high angle thrust south of Murray Gap.

CHAPTER V

PETROGRAPHY

Petrographic Techniques

Collecting Samples

During and following field mapping, samples were systematically collected from each Chilhowee formation. Collecting was handicapped in the shale formations due to lack of outcrop.

Composite samples were obtained by taking chips from each bed in a given stratigraphic interval. For the less well-exposed shale formations samples representing specific stratigraphic distances could not be collected. The exact stratigraphic position of the shale samples is necessarily an estimate.

Sample numbers plotted on plate I represent a series of closely spaced samples taken along one cross section line, rather than individual samples. This is necessitated by close spacing of samples in certain areas. Reference to table I indicates the number of samples collected from each formation and the stratigraphic interval each represents.

Crushing and Separation

Thirty-three composite samples, as shown in table I, were collected.

Each sample was crushed to minus 40 mesh size and screened on a 200 mesh sieve to eliminate very fine materials developed in the crushing process. The minus 40 mesh-plus 200 mesh fraction was split to give a sample of about ten grams. The ten gram sample was immersed in a 1:4 solution of hydrochloric acid for one-half hour. Immersion in acid removes iron stains which tend to mask the mineral grains. After the acid bath samples were washed twice with distilled water and dried.

For the separation procedure a battery of six funnels, each equipped with a short length of rubber hose and clamp to permit drawing off of liquid and minerals, was used. Bromoform having a specific gravity of about 2.85 was poured into the funnels. A ten gram sample was slowly poured into the heavy liquid and left for one-half hour. During this time sample and liquid were stirred slowly at frequent intervals.

Minerals having a specific gravity of plus 2.85 sink in the heavy liquid, while minerals of specific gravity minus 2.85, such as quartz and feldspar, remain suspended. Occasional stirring permits heavy grains trapped among the more abundant light grains to sink.

After separation was completed, the heavy fraction was drawn off on one filter paper; the light fraction on another. Samples and paper were washed free of bromoform with methyl alcohol, dried, and stored in small glass vials.

Pure bromoform was recovered from washings by mixing with water, shaking, and allowing to stand for several minutes after methods described by Ross (1926). In this procedure the water mixes with the alcohol; the bromoform settles to the bottom. Most of the water is decanted off. The remainder is poured into a separatory funnel, the bromoform is drawn off, filtered, and reused.

Identification of Minerals

Identification of the minerals was made with the petrographic microscope. After preliminary identification and determination of distinctive features, minerals could usually be recognized with a binocular microscope. During the course of the study, uncertain identifications with the binocular microscope were checked with the petrographic microscope.

Estimating Relative Abundance of Minerals

For estimation of the relative abundance of specific minerals in the heavy fraction the writer adopted the scale described by Milner (1940) and shown below. This is probably the most widely used scale of relative abundance employed by petrographers. The term flood is used when the heavy fraction is essentially one mineral; very rare when only one or two grains of a given mineral are present. Intermediate terms designate the estimated quantity of a given mineral present between these two extremes.

Term	Symbol
Flood	F
Very abundant	A
Abundant	a
Very common	C
Common	c
Scarce	s
Very scarce	S
Rare	r
Very rare	R

The Mineral Assemblage

Heavy Minerals

Barite occurs in a limited number of samples. Under the microscope the mineral is colorless. It is easily recognized as it is the only mineral in the suite with prominent cleavage. The mineral may be readily identified under the petrographic microscope by refractive index and optic sign. Barite in these samples is authigenic. This mineral is relatively abundant in the heavy fraction, but cannot be relied upon because of its authigenic origin.

Hematite appears in some samples as irregularly-shaped, dull red or black platy grains. It is distinguished from other opaque minerals by color and by its frequent alteration to limonite. Hematite in these samples is authigenic and unreliable.

Ilmenite is present in two forms in the samples examined; sometimes in the shape of ragged, irregular plates, sometimes in well-rounded grains. The mineral is characterized by its black color and metallic luster. Magnetite closely resembles ilmenite microscopically, but the two can be distinguished readily with a horseshoe magnet. Ilmenite in these samples is undoubtedly detrital.

Leucoxene is common as an alteration product of ilmenite. In reflected light it appears as white shreds in ilmenite plates, or frequently as rounded, yellow-white "snowballs" which sometimes have cores of ilmenite. Leucoxene is recognized by its white or yellowish-white color under the binocular microscope. In transmitted light it is opaque. Leucoxene in these samples is probably both detrital and authigenic in origin.

Pyrite is of frequent occurrence in sedimentary rocks, but was noted in only a few of the samples studied. It is easily recognized by its brassy color and metallic luster. Spherulitic pyrite resembling microscopic geodes, is abundant in some samples. It is undoubtedly authigenic in origin.

Tourmaline of various colors is frequently present in rocks of the Chilhowee group. It can be identified with the petrographic microscope on the basis of refractive indices, pleochroism, and optic sign. Under the binocular microscope it appears as colorless, pinkish, or light orange-colored grains. Lack of cleavage, elongation, and color usually distinguish it from similar minerals. Most of the tourmaline present is detrital.

Zircon is the most abundant and distinctive heavy mineral seen in the Chilhowee group. Three types of zircon, normal zircon, hyacinth, and malacon, have been recognized and used in sedimentary petrography studies. Malacon is distinguished from normal zircon by refractive index and other optical properties; hyacinth is distinguished from the others by its purplish color. The three types of zircon are probably present in these samples, but only normal zircon and hyacinth zircon are differentiated here. Malacon, if present, is classed with normal zircon.

Zircon is a very resistant mineral. It usually shows some of the original crystal faces after much abrasion and wear. Under the binocular microscope it can usually be recognized by its distinctive crystal form. Broken fragments may be recognized under the petrographic microscope by their high index of refraction and parallel extinction. In these samples

TABLE I

LOCATION OF SAMPLES

Formation	Sample number as given on table II	Stratigraphic interval represented by each sample	Sample locality number on plate 1
Helenmode member of Hesse sandstone	24	Random sample	1
	25	" "	2
	26	" "	3
	27	" "	4
Hesse sandstone	14	60-80 feet above base	5
	13	20-60 feet above base	
	12	basal 20 feet	
	15	800-900 feet above base	6
	16	700-800 feet above base	
	17	600-700 feet above base	
	18	500-600 feet above base	
	19	400-500 feet above base	
	20	300-400 feet above base	
	21	200-300 feet above base	
	22	100-200 feet above base	
	23	0-100 feet above base	
Murray shale	33	200-300 feet above base	7
	32	125-175 feet above base	
	31	0-100 feet above base	
Nebo sandstone	9	100-130 feet above base	8
	8	50-100 feet above base	
	7	0-50 feet above base	
	11	70 feet above base to top	9
	10	0-60 feet above base	
Nichols shale	28	Random sample	10
	29	" "	
	30	" "	
Cochran conglomerate	6	400-500 feet above base	11
	5	200-300 feet above base	
	4	100-200 feet above base	
Sandsuck shale	2	about 600 feet above base	12
	1	about 500 feet above base	

TABLE II

CHARACTERISTICS OF HEAVY MINERAL ASSEMBLAGE

Formation	Sample number	Barite	Hematite	Ilmenite	Leucoxene	Pyrite	Tourmaline	Zircon (normal)	Zircon (hyacinth)	Distinctive features of heavy mineral assemblage
Helenmode	24		s				C	s		Glauconite in the light fraction is characteristic
member of	25			s		r	c	c		of this member. Detrital grains are sub-rounded
Hesse	26			C	s		C	C	c	and abundant
sandstone	27			A	F		s	C		
	12		F	s	s			c		
	13			c	r		C	A	c	
	14			C	c		C	C	s	
	15			C	R		C	C	c	
Hesse	16			C			c	C	c	An abundance of ilmenite and leucoxene, and sphericity
sandstone	17			c	r		c	C	C	of detrital grains distinguish this formation from
	18			C	r		C	C	c	the Nebo sandstone.
	19			c			c	C	c	
	20			C	r		c	C	c	
	21			C	r		c	C	c	
	22			C	s		c	C		
	23			c	C		c	C	c	
Murray	31		c				c	a		Weathered samples are difficult to determine.
shale	32		c	A		c				Decomposed micas and iron oxides are abundant.
	33		c	A			c	a		
	7	c	a				s	C		Characterized by authigenic barite. Distinguished
	8	S	S				c	A	C	from the Hesse sandstone by scarcity of ilmenite
Nebo	9	s	C	c	c		S	C		and leucoxene. Detrital grains are much less rounded
sandstone	10	c		S			c	C	c	than those in the Hesse sandstone.
	11	S	S	c			C	C	c	
Nichols	28			c	c		c	c		Essentially similar to Murray shale.
sandstone	29			c	c	R	c	c		
	30			c	c		c	c		
	3			a	A		r	c	s	
Cochran	4		F				r	s		Distinguished from Sandsuck conglomerate lenses
conglomerate	5		a				c	r		by presence of detrital tourmaline, ilmenite, and
	6							F		leucoxene.
Sandsuck	1					A		c	s	
shale	2		c			A		c	s	Characterized by calcite content in light fraction.

normal zircon (and probably malacon zircon) are much more abundant than the hyacinth variety.

Light Minerals

The light fractions of only a few samples were examined. Quartz appears to be the most prominent mineral. Conglomerate lenses in the Sandsuck shale and beds of the Cochran conglomerate contain feldspar in addition to quartz. The Helenmode member of the Hesse formation contains abundant glauconite grains. Detailed study of light fractions might reveal distinctive inclusions within grains of light minerals.

Petrographic Characteristics of the Chilhowee Group

Sandsuck Shale

Heavy minerals are relatively abundant in this formation. Spherulitic pyrite grains, resembling minute geodes under the microscope, are common. Sub-rounded, normal zircon, and to a lesser extent, hyacinth zircon, are present. An abundance of authigenic pyrite also characterizes the heavy fraction.

Quartz, feldspar, and calcite are common in the light fraction. The feldspar is largely microcline and orthoclase.

Cochran Conglomerate

Zircon, ilmenite, leucoxene, tourmaline, and hematite largely comprise the heavy fractions of this formation. Grains are subangular to angular shaped. Platy ilmenite grains with leucoxene stringers are distinctive. Samples from the uppermost beds in the Cochran have better rounded grains than those from lower horizons. Angularity of grains and abundance of the heavy fraction distinguish this formation.

The light fractions of this formation are similar to conglomerate lenses in the Sandsuck shale, except for the absence of calcareous materials.

Nichols Shale

Samples from this formation were somewhat weathered. Decomposed micas, iron oxides, and other products are so abundant that identification of the heavy assemblage is difficult. Therefore, estimated percentage of a given heavy mineral in these samples is not too reliable. Reliable study should be based on mineral separation in a liquid of higher specific gravity than bromoform.

Nebo Sandstone

This formation is characterized by the presence of authigenic barite which was not noted in other formations. Detrital minerals in this unit are similar to those of the Hesse sandstone, however, the degree of rounding of grains is much less in the Nebo sandstone. Ilmenite is less in amount than in the Hesse formation; leucoxene, common in the Hesse, is almost entirely absent from this sandstone.

The light fractions of samples from this unit show that quartz grains are less well-rounded than those in the Hesse formation.

Murray Shale

Samples from the Murray shale are similar in many respects to those of the Nichols shale. Determination of the types and amounts of detrital minerals in these units is not reliable. More refined separation techniques should be employed on study of the shales.

Hesse Sandstone

The outstanding characteristic of this formation is the well-worn nature of detrital grains. This seems to distinguish the Hesse from other sandstone units. In addition, leucoxene, though usually present in small quantities, is common to most Hesse samples. Zircon and tourmaline, common in other formations, are also present in this unit.

Heavy minerals of the Helenmode member are similar in many respects to those of the rest of the Hesse sandstone. In some samples platy, authigenic hematite is present which is quite similar to the hematite found near the base of the Hesse sandstone. Ilmenite and leucoxene appear to be more abundant in portions of the Helenmode than in the underlying sandstone.

The characteristic feature which serves to distinguish the Helenmode member from the Hesse sandstone and other units is the presence of abundant glauconite in the light fraction. This mineral largely accounts for the green color of the fine clastic units in the Helenmode member.

CHAPTER VI

SUMMARY AND CONCLUSIONS

The simplicity of its heavy mineral suite is the most striking petrographic feature of the Chilhowee group. Among the many minerals which occur as detritals, only ilmenite, leucoxene, tourmaline, and zircon are common in the samples studied. Of these tourmaline, zircon, and to a lesser extent, ilmenite, are resistant allogenic minerals. That is, they may be preserved after having been exposed to extreme conditions of mechanical and chemical weathering. The other heavy minerals, barite, hematite, leucoxene, and pyrite may be either detrital or authigenic in sediments. The first three are probably authigenic in Chilhowee formations, while leucoxene is in part authigenic and in part detrital in origin.

This study indicates that in the Walland area, Chilhowee formations, such as the Nebo sandstone and the Hesse sandstone, can be differentiated in structurally complex areas by heavy mineral methods. The mineralogical differences in these formations near Walland may well persist throughout the entire belt of Chilhowee sediments. Further study of formations of this group, both to the northeast and to the southwest, will be necessary before wide scale application of the criteria is attempted.

In order to establish petrographic standards for the entire Chilhowee group similar studies of each Chilhowee formation should be made at frequent intervals along the strike of the formations. The method appears to have definite possibilities as a correlative tool, particularly in complex areas or between different fault blocks.

The mineralogical assemblage of the Chilhowee group strongly suggests that these formations were derived from other sediments not unlike themselves. Petrographers are in general agreed that certain minerals, such as apatite and olivine, are relatively unstable and are easily destroyed, while other minerals, such as garnet and kyanite, are very stable and persist through many generations of sediments. Tourmaline and zircon are stable minerals. While they occur mainly in acidic igneous rocks, the absence of unstable minerals common to acidic igneous rocks suggests that the Chilhowee formations represent sediments second or third generation removed from igneous rocks.

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GEOLOGIC MAP OF CHILHOWEE MOUNTAIN NEAR WALLAND, TENNESSEE

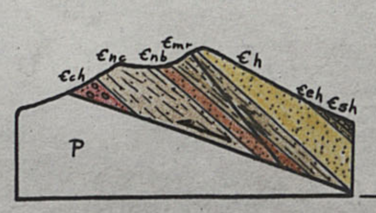
Topography from Kinzel Springs and Wildwood Quadrangles of USGS and TVA

Geology by George Swingle
Surveyed in 1948-49

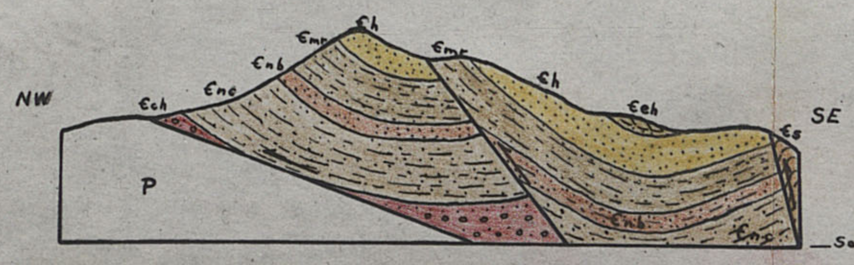
1 1/2 0 1 miles

Contour interval 20 feet

True North
Magnetic North



Section along line A-A'



Section along line B-B'