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The Geology of the Blockhouse Quadrangle, Blount County, Tennessee

James Edward Ricketts
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To the Graduate Council:

I am submitting herewith a thesis written by James Edward Ricketts entitled "The Geology of the Blockhouse Quadrangle, Blount County, Tennessee." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Geology.

Paris B. Stockdale, Major Professor

We have read this thesis and recommend its acceptance:

H. C. Amick, R. Lee Collins, J. S. Walls

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Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

July 27, 1942

To the Committee on Graduate Study:

I am submitting to you a thesis written by James Edward Ricketts entitled "The Geology of the Blockhouse Quadrangle, Blount County, Tennessee." I recommend that it be accepted for nine quarter hours credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Geology.

Paris B. Stockdale

Major Professor

We have read this thesis
and recommend its acceptance:

R. Lee Collins

H. C. Amick

J. G. Walls

Accepted for the Committee

Dean of the Graduate School

THE GEOLOGY OF THE BLOCKHOUSE QUADRANGLE, BLOUNT COUNTY, 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

James Edward Ricketts

August 1942

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PREFACE

It is the purpose of this report to describe the major geologic and geographic conditions of the Blockhouse Quadrangle, Blount County, Tennessee, based upon field studies of the writer. This area, a relatively small portion of the Tennessee Section of the Valley and Ridge Province, is typical of the East Tennessee Valley and the adjacent Blue Ridge Province. Since field study constituted a large part of the work, much of the written information was taken from field notes. Maps, charts, and photographs are interspersed throughout the text thus aiding in a better understanding of the subject at hand.

Since the creation of the Tennessee Valley Authority in 1933 there has been careful mapping of much of the territory included in the development program. The maps, by quadrangles, have been masterpieces of workmanship and represent the first intensive program of remapping done in the area since the turn of the century. The Blockhouse Quadrangle, chosen as a research project, was contoured and the map brought up to date by the Authority in 1941.

CHAPTER I. INTRODUCTION

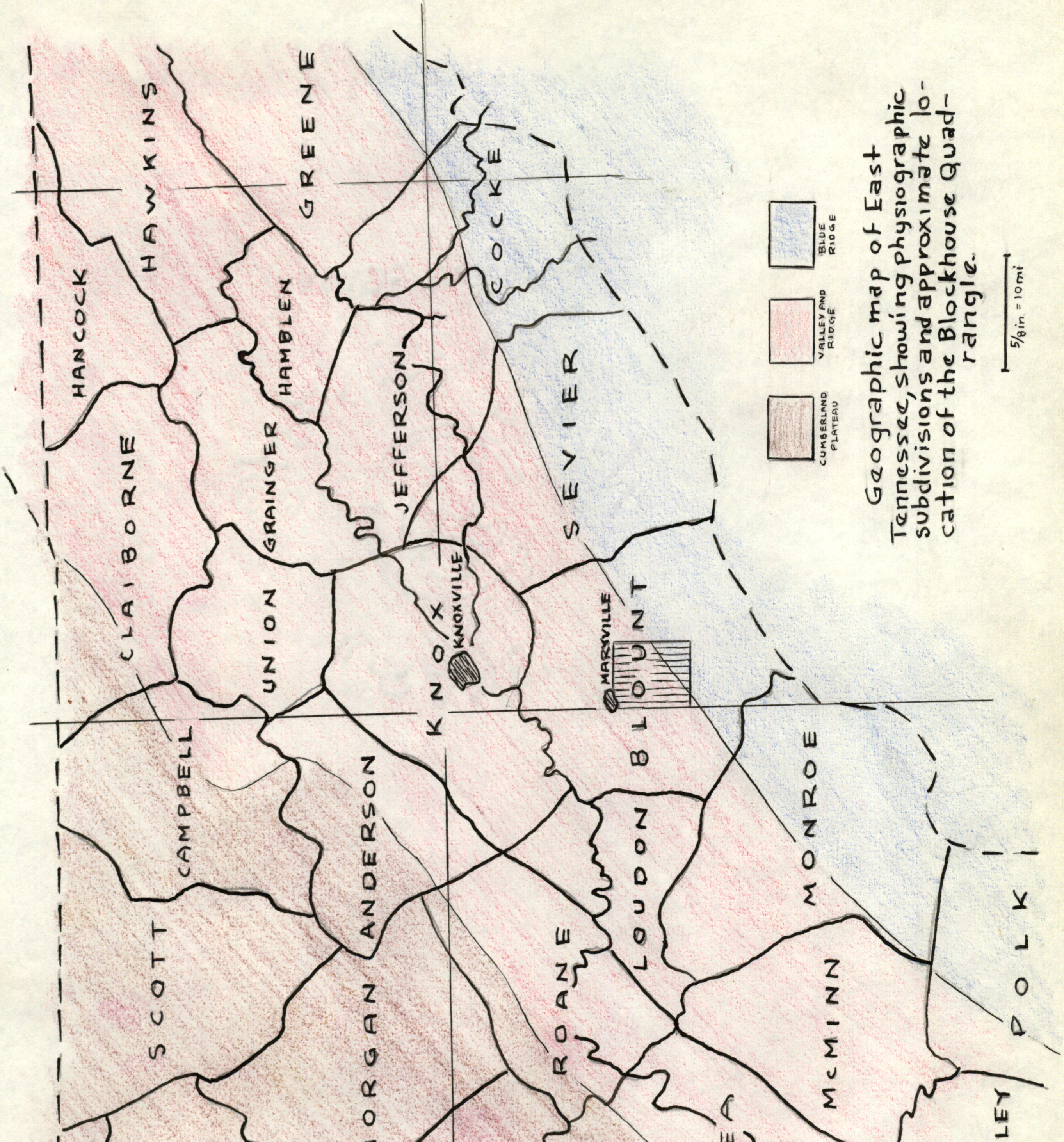
LOCATION AND SIZE OF THE AREA

The Valley and Ridge Province, which in its southern extent includes eastern Tennessee, is part of the larger Appalachian Highlands Division of the eastern United States (Fenneman, 1938, p. 265). The province is bounded by the Cumberland Plateau on the west, the Coastal Plain on the south, the Great Smoky Mountains of the Blue Ridge Province on the east, and the Virginia Segment of the Valley and Ridge on the north. The Tennessee Section of the Valley and Ridge Province (Valley of East Tennessee) as bounded above is approximately 200 miles long, 55 miles wide and covers an area of 9200 square miles (Case, 1925, p. 1). The Blockhouse Quadrangle, in Blount County, Tennessee includes a typical portion of this section (Pl. 8). Located south and east of the city of Maryville, this quadrangle has an area of 74 square miles, being ten and five-eights miles in length and seven miles in width. Latitude limits are 35°37'30" on the south and 35°45'30" on the north. Longitude boundaries are 83°52'30" on the east and 84° on the west.

The southeastern portion of this quadrangle is included within the Great Smoky Mountains of the Blue Ridge

PLATE 1

CONTINENTAL SHELF
COASTAL PLAIN
PIEDMONT PROVINCE
BLUE RIDGE
APPALACHIAN VALLEY
APPALACHIAN PLATEAUS
INTERIOR LOW PLATEAUS
1b
1c
1d
2
3a
3b
3c
3d
4a
4b
5a
5b
6a
6b
8d
8e
8f
11a
12d
GULF OF MEXICO
ATLANTIC
KENTUCKY
TENNESSEE
NORTH CAROLINA
SOUTH CAROLINA
GEORGIA
ALABAMA
MISSISSIPPI
FLORIDA
OHIO
WEST VIRGINIA
VIRGINIA
89°
87°
85°
83°
81°
79°
77°



Geographic map of East Tennessee, showing physiographic subdivisions and approximate location of the Blockhouse Quadrangle.

Province. Since this western portion of the mountain province is distinct from, and subordinate to the Valley and Ridge area its complex structures are given only limited consideration.

CULTURE

The area between Maryville and Chilhowee Mountain to the east has few good roads, with only a small portion, perhaps 10 or 15 percent, hard surfaced. All-weather roads total some 70 miles in length while several miles of unimproved roads and trails penetrate to the less densely populated areas of the quadrangle.

Highway development has been retarded in this section because of two factors: (a) the barrier effect of Chilhowee Mountain which has forestalled east-west highway construction, and (b) north-south highways connect with the larger cities which lie to the northwest of the area of this report.

No significant population centers occur within the immediate region east and southeast of Maryville. Settlements consist only of the essentials for a rural population, namely, the church, school, and general store. The following listing gives the names of a majority of the settlements, many of which take the name of the local church:

Name of Community	Location
Forest Hill	Two miles south of Maryville
Chilhowee View	Three miles southeast of Maryville
Blockhouse	Three and one half miles southeast of Maryville
Old Piney	Four and one half miles southeast of Maryville
Sixmile	Six miles south of Maryville
Montvale	Seven and one half miles south of Maryville
Laws Chapel	Five and one half miles east of Maryville

Although the small community at Montvale at the present time consists of only a few families it is interesting to note that the springs and recently destroyed hotel were quite famous in the last century. The resort declined in significance but nevertheless continued to be frequented during the first three decades of the twentieth century. Listed among its distinguished visitors were such men as Sidney Lanier and Sam Houston.

CLIMATE, AGRICULTURE, AND VEGETATION

The climate of the southern portion of the Valley and Ridge Province is the humid warm temperate type. This is characterized by hot summers and cool winters. The rainfall ranges from 40 to 60 inches per year, the average for the Blockhouse area being 50 inches. January temperatures average 40 degrees while July readings average 77 degrees. The combination of the above factors and the location, especially latitude, gives this eastern Tennessee sector a growing season of 190 to 200 days which is the ideal condition for the cultivation of most crops. (Parkins, 1938, p. 44.)

With ample rainfall and an extensive growing season it is only natural for much of the land to be utilized for crops. Between 70 and 80 percent of all land is in farms and of this a substantial portion is cultivated, while the rest is used for grazing and timber growth.

Approximate percentages of cultivated land are divided among four major crops, as follows (Case, 1925, p. 21-26):

Corn	30 percent
Hay and Forage	30 percent
Wheat	20 percent
Clover and Timothy	7 percent

Timber resources have largely been destroyed in this area, especially in the western, or valley portion, but many varieties are represented in the remaining stands. In the mountainous, eastern part of the quadrangle the following trees predominate: birch, basswood, hickory, white pine, maple, red oak, white oak, buckeye, and cherry. Undergrowth consists of hornbeam, holly, beech, dogwood, andwitchazel. (Hall, 1910, p. 24.)

In the valley portion black oak, black gum, short leaf and scrub pine predominate on the higher areas while on the slopes the characteristic trees are red oak, white oak, and yellow poplar. Hickory, maple, butternut, and walnut are also present along with many other hardwoods. Sumach, sassafras, huckleberry, and blackberry form the underbrush. Pines are perhaps the most abundant of the present uncut timber reserves of the Blockhouse area. (Hall, 1910, p. 23-24.)

CHAPTER II. PHYSIOGRAPHY

TOPOGRAPHIC CONDITIONS

The topography east of Maryville is, perhaps, not as typical of the Valley and Ridge Province as is that of areas farther west. This condition is probably due, in part, to the abundance of limestone southeast of Maryville. There are three distinct ridges which deserve mention, one of which is partially developed on limestone. The first of these is Pea Ridge, a short northeast-southwest trending area lying to the southeast of the city. Its greatest elevation is 1160 feet above sea level, and the local relief is generally less than 100 feet. The ridge is developed on the Nolichucky shale and the Knox dolomite. Slopes at no place exhibit a gradient of over 120 feet per 1000 feet, as along an eastern slope two miles northwest of New Providence Church.

Southeast of Pea Ridge is a pronounced northeast-southwest belt of hills called Black Sulphur Knobs (Pl. 3, Fig. 1-2). They are well-rounded, irregular hills of sandstone, some connected, others isolated, which range in elevation from 1250 feet to 1400 feet. Slopes on the Knobs, in contrast to the lower ridge previously mentioned, are as much as 300 feet per 1000 feet. This steep gradient, when

Figure 1. Black Sulphur Knobs
The Black Sulphur Knobs, one and one half miles southwest of Blockhouse, Blount County, Tennessee. Note the rolling land in the foreground, developed on the Athens shale, and the contrasting knobbed topography in the background, developed on the resistant Tellico sandstone.

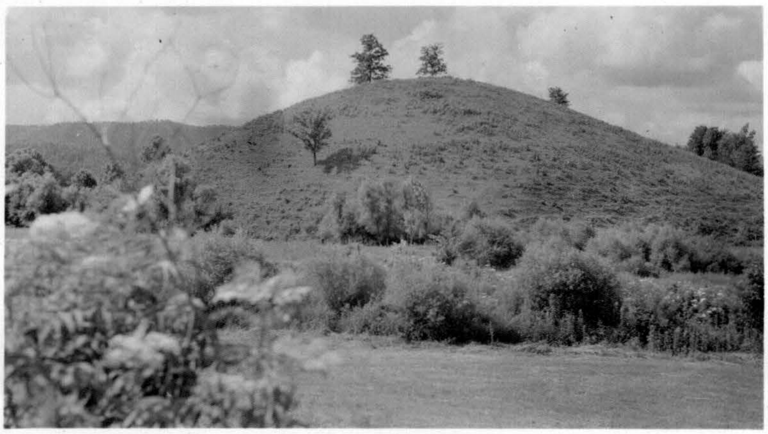


Figure 2. Black Sulphur Knobs
A well-rounded hill of the Black Sulphur area, one fourth of a mile northwest of Birchfield Church, Blount County, Tennessee. Note the Chilhowee Front in the background.

thought of in terms of drainage, is partially responsible for the minute dissection of the Black Sulphur Knobs.

Fronting Chilhowee Mountain on the west and lying to the east of the Black Sulphur Knobs is Little Mountain, a ridge whose maximum elevation is 1500 feet (Pl. 4, fig. 1).

At the western margin of the Blue Ridge Province is Chilhowee Mountain, the southeasternmost, loftiest, and most prominent ridge of the Blockhouse Quadrangle (Pl. 4, fig. 2). A characteristically steep western slope (as much as 500 feet per 1000 feet) and a more gentle eastern slope are notable features of the mountain. The ridge is composed of resistant Cambrian formations of quartzite, sandstone, and conglomerate. Three well known gaps occur within the quadrangle limits, namely, (a) Murray Gap, southeast of Montvale Springs, (b) Woldpen Gap, northwest of Flat Creek, and (c) Emerine Gap, one mile south of Greasy Cove.

Of unusual topographic interest are the broad flats which occur chiefly to the west of the Black Sulphur Knobs. The largest of these is developed on the Knox dolomite along the upper course of Flag Branch, northeast of Lutheran Church (Fig 1, p. 8). This flat is, in all probability, a result both of solution in the dolomite and filling from shale wash from the west. It is three-eights of a mile wide and one mile long.

Figure 1. Little Mountain
Westward view from the Emerine Gap trail. Butterfly Gap in the foreground, the Black Sulphur Knobs in the background.

Figure 2. Chilhowee Mountain
View from a point one half of a mile southwest of Old Piney Church. Note the persistence of the crest of Chilhowee Mountain.

A similar flat, developed on the Athens shale, lies along one of the tributaries of Crooked Creek southeast of Pine Level Church (Pl. 7). It is one half mile in length and approximately one fourth mile in width.

At several points just east of the Black Sulphur Knobs there are broad fertile stream valleys which are quite impressive since the area as a whole lacks such featureless topography.

Figure 1. A Knox dolomite flat
Relatively featureless topography near Lutheran Church, Blount County, Tennessee. Pea Ridge in the background.

Elevation of selected places within the scope of this study are as follows:

Name	Elevation
Blockhouse	972 feet
Black Sulphur Knobs	1300 feet
Chilhowee View School	982 feet
The Flats	2040 feet
Forest Hill......................	1100 feet
Little Mountain	1500 feet
Look Rock	2650 feet
Maryville	980 feet
Montvale Springs	1220 feet
Old Piney Church	1059 feet
Sixmile	984 feet

There are no major streams within the area of the Blockhouse Quadrangle. Small northeast-southwest flowing streams serve as tributaries to Little River and Little Tennessee River respectively. Permanent streams are well developed largely because of the numerous constant flowing springs.

In a broad sense the drainage pattern is trellised. Small tributary streams, however, are characterized by a dendritic pattern which is somewhat obscured in the mountain region where they flow more or less at right angles to the master streams.

In relation to topography the streams uphold the geological principle that trellised stream patterns tend to be developed on tilted strata. Here the beds have a characteristic dip of 45 degrees to the east-southeast. Sandy shales and sandstones are the principle resistant formations which hold up the ridges, while the valleys are developed on limestone, a relatively soluble sedimentary rock.

The following chart lists the chief streams of the Blockhouse area:

Name	Approximate length within the limits of the report	Flow	Drains into
Cane Creek	4 miles	NE	Little River
Crooked Creek	15 miles	NE to N	Little River
Browns Creek	2 miles	NW	Little River
Flat Creek	4 miles	NE	Little River
Little Ninemile Creek	3 miles	SW	Little Tennessee River
Flag Branch	3 miles	NE	Little River
Pistol Creek	7 miles	NW	Little River
Sixmile Creek	5 miles	SW	Ninemile Creek

VALLEY AND RIDGE PROVINCE
(TENNESSEE SECTION)

The Valley and Ridge Province in its entirity is a long, relatively narrow belt. "It borders the Older Appalachians and the New England province on the west, reaching to theCoastal Plain at the south and the St. Lawerence Valley at the north" (Fenneman, 1938, p. 195). It is approximately 1200 miles long and has a maximum width of 80 miles. "The extreme width in East Tennessee is 40 miles, which is near the average of its southern half" (Fenneman, 1938, p. 195).

Geologically speaking, the province lies within the area formerly occupied by the eastern margin of the Paleozoic sea. It is a belt of alternating lowland and ridge topography, prevailing northeast-southwest, developed upon a succession of parallel folds and thrust faults. The Tennessee Section extends from southwestern Virginia to central Alabama. Valleys widen and ridges become correspondingly smaller in this section. Ridges are numerous and average 2500 feet in elevation while the valley lands rise northward from 800 feet in southeastern Tennessee to 2500 feet near the Tennessee-Virginia line. Relief features of the Knoxville-Chattanooga segment are for the most part of a low order, that is, carved from the valley floor. Low ridges, knobs, and stream valleys are typical examples of this topographic condition.

BLUE RIDGE PROVINCE
(SOUTHERN SECTION)

The Blue Ridge Province as a whole consists of a belt of high and rugged mountains between the Piedmont Province on the east and the Valley and Ridge Province on the west. The mountain belt gradually widens from 14 miles at the north to 70 miles at the south. Rocks of the province are primarily old, crystalline and resistant, and exceedingly complex in structure. "They represent an ancient land mass repeatedly raised into mountains and continuously eroded while the interior sea washed its western coast throughout most of Paleozoic time . . ." (Fenneman, 1938, p. 164). The western front from Georgia to Pennsylvania, although similar in origin to the Folded Appalachians, belongs to the Blue Ridge when geographic boundaries are considered.

The Blue Ridge Province is divided into two sections, the boundary being drawn at Roanoke Gap in south-central Virginia. Southward from this boundary line the mountains spread over a maximum width of 70 miles and rise to an elevation of 6684 feet at Mount Mitchell in western North Carolina. "There are said to be 46 peaks and 41 miles of divides above the level of 6000 feet, also 288 more peaks and 300 more miles of divide above 5000 feet" (Fenneman, 1938, p. 171-172).

The highly metamorphosed rocks of the Blue Ridge Province are closely folded and faulted along lines which agree in direction with the general trend of the province. The western boundary of the mountains is largely determined by the limit of overthrust of early Cambrian sandstone and quartzite formations over the limestone of the Great Valley. It is this overthrust faulting (Great Smoky Overthrust) and subsequent erosion which is responsible for the many coves of the Great Smoky Mountain district.

CHAPTER III. STRATIGRAPHY

GEOLOGIC COLUMN

All bedrock involved in this study is of Paleozoic age. Given below is a listing of the geologic formations which are exposed within the limits of the Blockhouse Quadrangle:

System	Formation
Mississippian	Newman limestone
Mississippian	Grainger shale
Mississippian	Chattanooga black shale
Silurian	Clinch sandstone
Ordovician	Bays sandstone
Ordovician	Sevier shale
Ordovician	Tellico sandstone
Ordovician	Athens shale
Cambro-Ordovician	Knox dolomite
Cambrian	Nolichucky shale
Cambrian	Maryville limestone
Cambrian	Hesse sandstone
Cambrian	Murray shale
Cambrian	Nebo sandstone
Cambrian	Nichols shale

System	Formation
Cambrian	Cochran conglomerate
Cambrian	Pigeon slate

CAMBRIAN FORMATIONS

Pigeon Slate

The Pigeon slate, oldest outcropping formation in the Blockhouse area, takes its name from exposures along Little Pigeon River, Sevier County, Tennessee. It is quite uniform in appearance and ranges from 1300 to 1700 feet in thickness. (Keith, 1895, p. 2.)

In its unweathered state the rock has a blue-gray appearance. Upon weathering it changes to a gray-yellow. The slate is composed chiefly of argillaceous material supplemented by quartz, mica, and feldspar. The presence of but small quantities of one weak mineral, feldspar, accounts for the resistance the formation offers to weathering and the development of ridges and divides. Exposures are best seen in the Cane Creek locality two miles south of Emerine Gap.

Cochran Conglomerate

This conglomerate is named for Cochran Creek, on the southern slope of Chilhowee Mountain, in Sevier County, Tennessee. Its basal portion is composed of some 500 feet (as much as 700 feet in some areas) of coarse, greenish-white conglomerate. The middle portion of the formation consists of 100 feet of blue-gray shales, while the upper 600 to 900 feet is made up of light colored sandstones. (Keith, 1895, p. 2.)

The basal conglomerate beds are composed of quartz, feldspar and argillaceous shale. The shale in the Cochran formation is argillaceous, micaceous, and slightly sandy. The upper sandstone beds are composed of grains and small pebbles of white quartz. This quartz material occurs as float along many of the lower slopes of Chilhowee Mountain.

The Cochran conglomerate generally overlies the Sandsuck shale (absent in the Blockhouse Quadrangle) and underlies the Nichols shale. It forms the basal formation of the famous Chilhowee Group of rocks as conceived by Arthur Keith. (Keith, 1895, p. 2.)

Nichols Shale

The Nichols shale, also a formation of the Chilhowee Group, consists of blue, sandy, micaceous, and argillaceous rocks. It is of uniform composition and ranges in thickness from 550 to 800 feet. It was named after Nichols Branch of Waldens Creek, on the eastern slope of Chilhowee Mountain, in Sevier County, Tennessee.

The Nichols shale overlies the Cochran conglomerate and underlies the Nebo sandstone. It is of early Cambrian age and occurs in eastern Tennessee and western North Carolina. Topography developed on the Nichols strata is characterized by steep slopes, many of which are bare of a soil cover and vegetation.

Nebo Sandstone

The Nebo sandstone is included in the Chilhowee Group of rocks and is of early Cambrian age (Pl. 5). It is found both in eastern Tennessee and western North Carolina, and takes its name from Mount Nebo Springs, Blount County, Tennessee.

The sandstone is light colored, usually white, and fine grained. It has a thickness of some 500 feet in the area southeast of Montvale Springs. The formation overlies the Nichols shale and underlies the Murray shale. Soils developed on the Nebo sandstone are relatively thin due to the resistance to weathering processes. The Nebo sandstone forms the backbone of Chilhowee Mountain at the south side of the Blockhouse Quadrangle (Pl. 8). Huge blocks of the sandstone frequently break away and clog the many small west flowing streams.

Murray Shale

The Murray shale, early Cambrian in age, belongs to the Chilhowee Group of rocks. Named for Murray Branch of Waldens Creek in Sevier County, Tennessee, it is found widely distributed in easternmost Tennessee and western North Carolina. The Murray shale is gray-blue, sandy, micaceous, and calcareous. Its lithologic character, it will be noted, is quite similar to other shales previously mentioned but the formation can be distinguished by establishing the proper stratigraphic sequence.

Above this shale is the Hesse sandstone and beneath is the Nebo sandstone. Thicknesses average 300 feet in the Happy Valley-Chilhowee Mountain area. The gentle slopes on the southeast side of Chilhowee Mountain, in the southern portion of the Blockhouse Quadrangle, are developed on the Murray shale.

Hesse Sandstone

The Hesse sandstone is at the top of the Chilhowee Group of rocks. Keith originally described it as a sandstone although in later reports it was occasionally referred to as the Erwin quartzite (Keith, 1895, p. 3).

This formation is also early Cambrian in age. It makes up much of the eastern slope of Chilhowee Mountain east of Montvale Springs, Tennessee, and is responsible for the high (2000 feet above sea level) level area around Flat Creek, known as "The Flats." The type locality is along Hesse Creek, Blount County, Tennessee. The sandstone is 600 feet in thickness, and can be recognized by its fine, white, and massive appearance. It contains numerous well-rounded small quartz pebbles. The Murray shale lies beneath the Hesse, but the rock in normal stratigraphic position above is faulted out.

Maryville Limestone

The Maryville limestone, similar in many respects to the Rutledge limestone in Grainger County, Tennessee, is named from exposures near Maryville, Blount County, Tennessee. It has a total thickness of 500 feet, is quite massive, blue, finely banded and contains a few shaly beds. This limestone forms a lens-like area extending from the headwaters of Duncan Branch, two and one fourth miles south of Maryville, to a point outside the southwest limits of the quadrangle. The formation is succeeded on both sides by the younger Nolichucky shale. As to the specific stratigraphic sequence in the Blockhouse Quadrangle, the next oldest formation is the Hesse sandstone which occurs several miles to the east in the Cambrian strata of the Chilhowee

Mountain region. Soils of the decayed Maryville limestone are similar to the weathered Knox dolomite beds but lack the abundant chert content of the latter.

A fine exposure of this limestone was studied two miles south of Maryville near the community of Forest Hill, where quarrying operations have begun in the formation (Fig. 2, p. 20). Weathered exposures were noted a few hundred yards north of these operations.

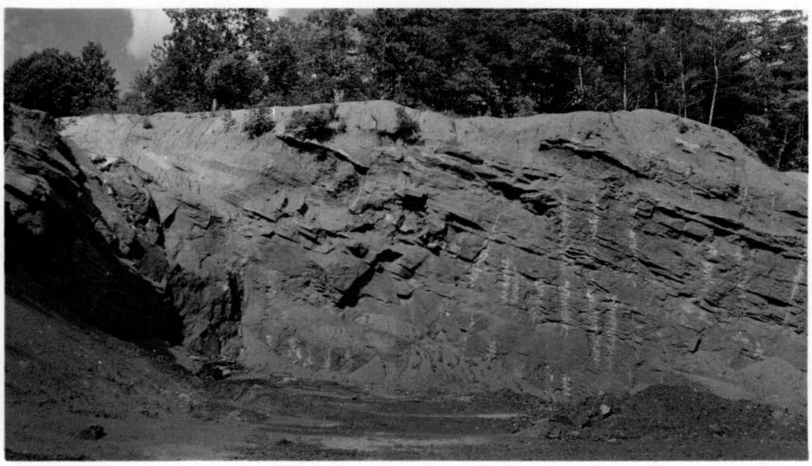


Figure 2. Maryville Limestone Formation Exposure near Forest Hill, Blount County, Tennessee. Note the low eastward dip of the beds.

Nolichucky Shale

The Nolichucky shale, of late Cambrian age, takes its name from exposures along the Nolichucky River in Greene

County, eastern Tennessee. In the Blockhouse Quadrangle the shale extends for a distance of six and one half miles along a belt 800 feet wide. Variations in the width of this belt are due to erosion and dip. The Nolichucky beds consist largely of calcareous shales and shaly limestone. In the weathered condition it is brightly colored, usually some shade of yellow, olive green, red or brown, chiefly the first. The wide extent of the yellow shales is implied in the abundance of yellow soils in the vicinity of Pea Ridge. This late Cambrian formation is also found in the western part of North Carolina and in southwestern Virginia.

CAMBRO-ORDOVICIAN FORMATIONS

Knox Dolomite

The topography of the area as a whole adheres closely to underlying structures and resistance of formations. Valleys are developed largely on less resistant and more soluble strata such as the Knox dolomite, which is the most widespread formation of the Great Valley. However, where chert is abundant and the beds are inclined the Knox formation is responsible for low ridges. Since the cherty materials within the beds do not weather so readily the soil usually contains a considerable percentage of this oxide, which directly influences agricultural possibilities.

The Knox dolomite has an estimated thickness of 4000 feet. The upper portion is especially well represented in the northwest section of the Blockhouse Quadrangle. The Knox dolomite covers over 25 percent of the area between Maryville and Chilhowee Mountain. In its unweathered state it is gray-blue in color and is massive. Weathered, the Knox beds form a typical buff to red soil, relatively rich in iron oxide. Its characteristic color and chert fragments are a valuable aid in the identification of the formation.

The Knox dolomite is commonly divided into the following subdivisions (Oder, 1934, p. 469-497):

Ordovician System
- Canadian (Beekmantown) Series
  - Cotter-Powell beds
  - Jefferson City formation
  - Nittany dolomite
  - Stonehenge limestone

Cambrian System
- Ozarkian Series
  - Chepultepec
  - Conococheague-Copper Ridge
  - Maynardsville limestone (new)

The Cotter-Powell subdivision of the Knox dolomite is widespread in the Blockhouse locality. Charles Oder (1934, p. 488-489) states that these upper Knox beds are

> "said to correlate with the Cotter and Powell formations of Missouri and Arkansas, the Upper Arbuckle limestone of Oklahoma, and, in part, with the higher beds in the Ellenburger limestone of Texas. It has affinities with the upper part of the Newala and the whole of the Odenville limestone in Alabama, and, in part, with the Bellfonte dolomite of Virginia and Pennsylvania."

A typical Knox exposure is found about one mile south of Maryville. The usual characteristics are present, mainly cherty weathered material and gray, dolomitic limestone bedrock. Oolitic chert occurs on some of the weathered slopes. The beds are quite thick and massive, surface exposures of which are much darker than the fresh rock. No fossils were found in support of the conclusion that the formation in this area belongs to the upper Knox division. However, at the same apparent horizon farther north, near Maryville, typical upper Knox fossils were collected.

ORDOVICIAN FORMATIONS

Athens Shale

The Athens shale, of Early Ordovician age, lies next above the Knox dolomite. The normally intervening Stones

River beds and the Holston marble are absent in the Blockhouse locality, although present in the Knoxville vicinity a few miles to the north. On top of the Athens shale is the Tellico sandstone. The Athens shale gets its name from exposures near Athens, McMinn County, Tennessee. This shale lies along the western foot of the Black Sulphur Knobs and extends in a northeast-southwest direction for a distance of 10 miles, within the quadrangle limits. The thickness of the formation varies, with an average of 3000 feet. The Athens shale ranges from argillaceous to calcareous, is thinly bedded, and has a blue-gray color which turns deep gray upon weathering. Soils developed from the formation are distinctly yellow thus enabling the Knox dolomite-Athens shale contact to be established where actual outcrops are missing.

Athens shale belts extend into northern Alabama, western Virginia, and western North Carolina. Based upon research by Charles Butts in the Appalachian Valley of Virginia the United States Geological Survey now recognizes "Athens shale" across the Appalachian Valley of Virginia from Tennessee on the south to the western Virginia line.

Fine exposures of the formation occur north of Little Ninemile Creek, southwest of the village of Blockhouse, and southeast of Chilhowee View School.

Tellico Sandstone

The Tellico sandstone, of Middle Ordovician age, forms the Black Sulphur Knobs of the Blockhouse area. The formation is widespread throughout the southeastern part of the Valley and Ridge Province in Tennessee. Its distinctive deep red-brown color and its resistant qualities are characteristics. The presence of iron, as a coloring agent, and of calcite, frequently in veins, are common features of this massive, fine grained sandstone. Maximum thickness of the Tellico sandstone is 1000 feet. The formation derives its name from exposures along the Tellico River, near Tellico Plains, Monroe County, Tennessee. The trend of the sandstone beds is similar to that of adjacent formations, Athens shale below and Sevier shale above. An unusual surface indication of this sandstone is the abundant growth of pines.

Good esposures of the Tellico sandstone were noted near Liberty Church, northwest of New Providence Church, and near Old Piney Church.

Sevier Shale

The Sevier shale lies above the Tellico sandstone and in turn is succeeded by the Bays sandstone. It crops out along the eastern foot of the Black Sulphur Knobs and is quite similar to the Athens shale except in color. Whereas the Athens shale is grayish, the Sevier is more distinctly yellow. Thickness average is 1500 feet. The Sevier shale is characteristically calcareous with some shaly limestone zones which weather to a shaly appearance. This shale belt represents one of the three basins which existed in the remote geologic past, the other two being in the vicinity of Knoxville, Tennessee (Keith, 1895, p. 5).

Butts, Stose and Jonas (1932, p. 15) describe the Sevier shale as having

> "lower beds which are black, fissile and graptolite bearing, and upper beds which range from black compact, rather thin bedded limestones with black shale partings that produce a banded structure, to thick bedded greenish arkosic coarse grained sandstone with shale partings and graptolite carrying beds."

Excellent exposures were noted near Sixmile Church (Fig. 3, p. 27), and near Old Piney Church. Several heavy beds of sandy shale and calcareous sandstone were observed northwest of Montvale Springs. These sandy beds closely resemble the Tellico sandstone of the nearby Knobs. Two calcareous beds were noted approximately one mile southeast of Chilhowee View School, near the contact with the Tellico layers. Both of these occurrences seem to be only of local importance.

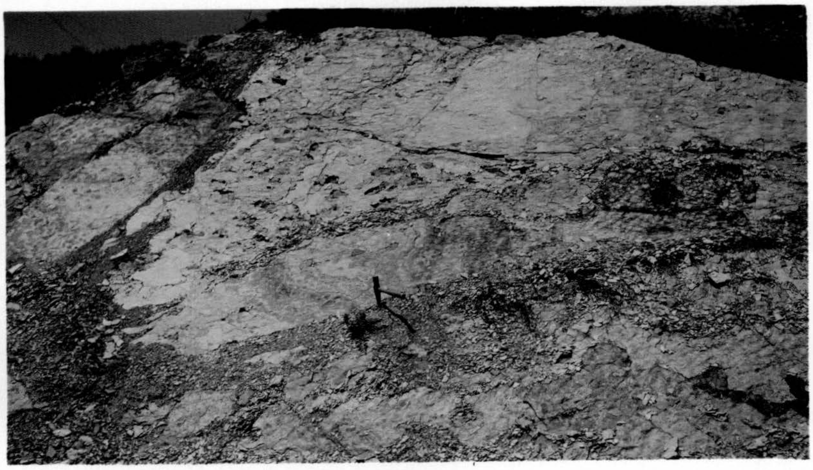


Figure 3. Sevier Shale
Exposure near Sixmile Church, Blount County, Tennessee. Note the ripple marks on the less weathered surface.

Bays Sandstone

The Bays sandstone crops out along the western foot of Little Mountain, where it underlies the Clinch sandstone and overlies the Sevier shale. It is found throughout eastern Tennessee and southeastern Virginia, and takes its name from exposures along Bays Mountain, Hawkins County, Tennessee. The formation has a characteristic pinkish-red color which is readily distinguishable even in the soils which come from the disintegrated rock. The beds are calcareous and argillaceous, and have a uniform thickness of 1100 feet. Low ridges and knobs are the major topographic forms developed on the Bays sandstone.

Excellent exposures were observed along Clear Creek southwest of Montvale Springs, near Butterfly Gap, and near Sixmile School (where the contact with the Sevier shale was seen) (Fig. 4, p. 28).

Figure 4. Sevier Shale and Bays Sandstone
Contact between the Sevier shale (left) and the Bays sandstone (right). Note the massiveness of the latter.

SILURIAN FORMATIONS

Clinch Sandstone

The only Silurian formation in the Blockhouse area is a thin bed of Clinch sandstone in the Little Mountain section. It belongs to the Albion Series of rocks (Born, 1936, p. 29). This sandstone is easily distinguished from the Bays by its white or light gray instead of reddish color. The name was taken from exposures on Clinch Mountain, Grainger County, Tennessee. The formation is thick bedded, and generally fine grained in texture. One thin conglomeratic bed was noted in the only exposure of this formation three-fourths of a mile east of the junction of Clear and Sixmile Creeks. Thickness of this sandstone at the above locality is not more than 10 feet. The contact between the Bays and the Clinch sandstones is transitional though quite distinct (Fig. 5, p. 29).

Figure 5. Bays and Clinch Sandstones
Contact of the Bays sandstone (left) and the Clinch sandstone (right), one mile west of Montvale Springs, Blount County, Tennessee.

MISSISSIPPIAN FORMATIONS

Chattanooga Black Shale

Overlying the Clinch sandstone and succeeded by the Grainger shale is one of the most discussed formations in East Tennessee, namely, the Chattanooga black shale. Its age and origin are still being pondered by some of the foremost geologists of the United States. Stockdale (1939, p. 48) states that

> "although for years considered as of undisputed Devonian age, a swing toward assignment of early Mississippian age started with the writings of Grabau (1906) and was given strong impetus in the writings of Ulrich (1912;1915). Subsequent studies, especially those of Swartz (1924;1927; 1928), Butts (1926), Pohl (1930), Bassler (1932), and Klepser (1937), have resulted in general acceptance of the early Mississippian age for at least a major portion, if not all, of the Chattanooga shale in Tennessee."

As to origin Clarke prescribes a deep sea as essential for the accumulation of black shales in general. Schuchert concluded they were formed in closed arms of the sea. Ulrich believed thin shales were deposited during times of cool climate and graptolite-bearing currents.

The age of the Chattanooga black shale is now generally accepted as Mississippian, except possibly the lowest portion and is included in the Kinderhook Series of rocks. Named for Chattanooga, Hamilton County, Tennessee, the main outcrops of the formation extend north and south from that locality. It is exposed on the western slope of Little Mountain in the area of this report. The shale is black, fissile, and carbonaceous (contains 13-15 percent carbon). A dark basal sandstone member is generally present. This shale is one of the thinnest formations in the Valley of East Tennessee, being only 10 to 50 feet thick, but is persistent throughout its extensive linear distribution.

The only exposure studied is along Big Spring Branch, near Montvale Springs, Tennessee where the beds have a maximum thickness of 35 feet.

Grainger Shale

The Chattanooga shale is succeeded by the younger Grainger shale which is, in turn, overlain by the Newman limestone. The Grainger formation is Mississippian (Osage Series) and was named from exposures in Grainger County, Tennessee. It occurs throughout the length of Little Mountain and is responsible for the prominence of this particular ridge. The formation has a relatively wide areal extent, being found in southwestern Virginia, North Carolina, and Tennessee. Lithologically the Grainger shale is chiefly sandy shale and shaly limestone, the sandstone content being responsible for its resistance to weathering. The beds are blue-gray, turning greenish-gray upon disintegration. Thickness ranges from 400 to 1200 feet, the latter figure being represented in the Butterfly Gap locality.

Typical Grainger exposures were noted where Clear Creek flows south from Montvale Springs through a gap in Little Mountain, along Spring Branch one half of a mile north of Montvale Springs (Fig. 6, p. 32), and in Butterfly Gap. An unusual conglomeratic bed occurs in the Spring Branch locality. This bed, less than one foot in thickness, is composed of rounded quartz pebbles some of which are several inches in diameter.

Figure 6. Grainger Shale
Exposure along Spring Branch, one half of a mile north of Montvale Springs, Blount County, Tennessee. Thin fossil bed and conglomerate bed found at this point.

Newman Limestone

The Grainger shale is succeeded by the Newman limestone, Mississippian in age, and the youngest bedrock occurring in the Blockhouse Quadrangle. The Newman beds normally underlie the Pennington shale. The formation farther north is divided into the following, listed from youngest to oldest: (a) Glen Dean, (b) Gaspar, (c) Ste. Genevieve, (d) St. Louis, and (e) Warsaw. These five beds are known collectively as the Greenbriar, near Bluefield, West Virginia (Butts, Stose, Jonas, 1932, p. 23).

This limestone derives its name from exposures along Newmans Ridge, Hancock County, Tennessee. It makes up a portion of the flat, rolling area around Montvale Springs. The formation, in its basal part, is made up of 100 feet of massive blue limestones, these beds succeeded by some 500 feet of gray, calcareous shaly limestones. Red soils normally develop over the formation but these are usually obscured by wash from the higher ridges and mountains nearby.

One excellent exposure of the upper shaly beds was studied, especially for its fossil content, one fourth of a mile southeast of Montvale Springs, along the Look Rock trail.

CORRELATION CHART

Systems (left margin, top to bottom): PENN. – MISSISSIPPIAN – SILURIAN – ORDOVICIAN – CAMBRIAN

SAFFORD

- COAL MEASURES
- MOUNTAIN LIMESTONE
- SILICEOUS GROUP
- BLACK SHALE
- DYESTONE GROUP
- CLINCH MT. SANDSTONE
- TRENTON AND NASHVILLE SERIES
- TRENTON, LEBANON AND MACLURIA LIMESTONE
- KNOX DOLOMITE
- KNOX SHALE
- KNOX SANDSTONE
- CHILHOWEE SANDSTONE
- OCOEE GROUP

KEITH

- BRICEVILLE SHALE
- LEE CONGLOMERATE
- PENNINGTON SHALE
- NEWMAN LIMESTONE
- GRAINGER SHALE
- CHATTANOOGA BLACK SHALE
- ROCKWOOD FORMATION
- CLINCH SANDSTONE
- BAYS SANDSTONE
- SEVIER SHALE
- TELLICO SANDSTONE
- ATHENS SHALE
- HOLSTON MARBLE
- CHICKAMAUGA LIMESTONE
- KNOX DOLOMITE
- CONASAUGA SHALE:
  - NOLICHUCKY SHALE
  - MARYVILLE LIMESTONE
  - ROGERSVILLE SHALE
  - RUTLEDGE LIMESTONE
- ROME FORMATION
- APISON SHALE | GROUP SHEET: NOTTELY QUARTZITE, ANDREWS SCHIST, MURPHY MARBLE
- HESSE SANDSTONE | CHILHOWEE – NANTAHALA: VALLEYTOWN FM.
- MURRAY SHALE | BRASSTOWN
- NEBO SANDSTONE | TUSQUITEE
- NICHOLS SHALE | NANTAHALA SLATE
- COCHRAN CONG.
- SANDSUCK SHALE
- GREAT SMOKY CONG. (KEITH) / GREAT SMOKY FM. (LaFORGE):
  - CLINGMAN CONG.
  - HAZEL SLATE
  - THUNDERHEAD CONG.
  - CADES CONG.
- HIWASSEE SLATE:
  - PIGEON SLATE
  - CITICO CONG.
  - WILHITE SLATE

WILMARTH

- CLINCH SANDSTONE
- BAYS SANDSTONE | JUNIATA
- SEVIER SHALE:
  - BLUE, GRAY, AND RED SHALES. CALC. SLATES
  - VESTAL LIMESTONE -- 30-200 ft. -- TYPE
  - CALC. SANDSTONE AND SHALE -- 500-600 ft.
  - CALC. SH. | OTTOSEE SH.
- TELLICO SANDSTONE | TELLICO SANDSTONE | HEISKELL SHALE
- CHICKAMAUGA L.S. of some areas 1100 ft. | HOLSTON MARBLE | ATHENS SHALE | HIATUS ULRICH | BLOUNT GROUP of E.O. ULRICH
  - CHICKAMAUGA L.S. of some areas
  - HOLSTON MARBLE LENTIL -- 90-400 ft. VARIAGATED
  - HIATUS-BUTTS
  - LENOIR L.S.
  - HIATUS-BUTTS
  - MOSHEIM L.S.
  - BLUE LIMESTONE AND GRAY ARGILLACEOUS L.S. 500-700 ft.
- KNOX DOLOMITE 3500 ft. TYPE IN KNOX. SHEET | E.O. ULRICH -- 1924:
  - UPPER CANADIAN | 2000
  - LONGVIEW DOLOMITE
  - CHEPULTEPEC ABSENT
  - COPPER RIDGE (TYPE IN KNOXVILLE SHEET) | 1000
  - LOWER KNOX -- 0 to ?
- NOLICHUCKY SHALE
- MARYVILLE LIMESTONE
- ROGERSVILLE SHALE
- RUTLEDGE LIMESTONE
- ROME FORMATION / R. FM. SANDSTONE
- BEAVER LIMESTONE
- APISON SHALE
- ABSENT

ODER

- ATHENS SHALE
- HOLSTON MARBLE
- ?
- LENOIR LIMESTONE
- LOWER STONES RIVER
- MOSHEIM LIMESTONE
- COTTER POWELL BEDS
- JEFFERSON CITY FORMATION
- NITTANY DOLOMITE
- STONEHENGE LIMESTONE
- CHEPULTEPEC
- CONOCOCHEAGUE
- COPPER RIDGE DOLOMITE
- MANARDVILLE LIMESTONE
- NOLICHUCKY SHALE

BUTTS

- NEWMAN LIMESTONE
- GRAINGER SHALE
- CHATTANOOGA BLACK SHALE
- BAYS SANDSTONE
- SEVIER SHALE
- TELLICO SANDSTONE
- ATHENS SHALE
- HOLSTON MARBLE
- LENOIR LIMESTONE
- MOSHEIM LIMESTONE
- KNOX DOLOMITE
- NOLICHUCKY SHALE
- MARYVILLE LIMESTONE
- ROGERSVILLE SHALE
- RUTLEDGE LIMESTONE
- WATAUGA SHALE
- SHADY LIMESTONE
- CHILHOWEE GROUP

ULRICH

- BAYS SANDSTONE
- SEVIER SHALE: LOWVILLE; OTTOSEE SHALE
- TELLICO SANDSTONE
- ATHENS SHALE
- HOLSTON MARBLE
- ?
- LENOIR LIMESTONE
- ?
- MOSHEIM LIMESTONE
- UPPER CANADIAN { JONESBORO L.S.
- LONGVIEW DOLOMITE
- CHEPULTEPEC DOLOMITE
- COPPER RIDGE DOLOMITE
- GREENVILLE DOLOMITE

CHAPTER IV. PALEONTOLOGY

CAMBRIAN FOSSILS

No Cambrian fossils were found within the limits of the Blockhouse Quadrangle despite the fact that several formations of that age are known to contain relatively rich faunas in other localities. The Nolichucky shale beds carry an abundant assemblage of brachiopods and trilobites among the most common of which are *Crepicephalus texanus* and other species of this genus, *Coosia* sp., *Kingstonia* sp., and the widely distributed *Dicellomus politus*. All of these forms are Upper Cambrian in age.

The Maryville limestone contains fragmentary evidence of such trilobites as *Maryvillia*, *Blountia* and *Kingstonia* (Upper Cambrian).

The early Cambrian formations in this area are not known to contain fossils, this being a result of metamorphic processes, such as heat and pressure, which altered the former sediments. The Murray shale is the only rock east of the Chilhowee Mountain, in the Blockhouse sector, known to contain fossils.

KNOX DOLOMITE FOSSILS

The Knox dolomite contains relatively few fossils, but the ones which do occur within the Blockhouse region were quite helpful in establishing the true stratigraphic relation in the thick Knox beds. The opercula of the gastropod <u>Ceratopea</u>, probably <u>robusta</u> and <u>subconica</u>, were found about 300 feet below the contact with the overlying Athens shale. This distance was checked with Oder's report on the Knox dolomite (Oder, 1934, p. 490) and it was found that both fossils and lithologic characteristics corresponded roughly to his descriptions. The upper Knox rocks belong to the Cotter-Powell beds of the Ordovician System. Examples of <u>Ceratopea</u> were found in weathered beds near the city of Maryville and near the headwaters of Ninemile Creek several miles eastward. Since these two localities are relatively far apart it was surmised that a structure deviating from the simple eastward dipping formations exists. This structure later proved to be a broad syncline, the younger limbs of which contain the index fossil <u>Ceratopea</u>.

Ceratopea fragments were found only in these upper Knox beds where they occur associated with the highly weathered, light colored, and angular chert fragments which are so characteristic of this dolomite. These small forms are one half to one and one half inches in length, concentrically striated, and horn shaped. They are believed to be the plates which closed the apeture of ancient gastropod shells. Their chitinous or calcareous composition made them especially favorable for preservation. Other shells (small and spiral) found in the same vicinity, near the headwaters of Ninemile Creek, were tentatively identified as belonging to the gastropod order Aspidobranchia.

Oder (1934, p. 488) lists the following forms in his discussion of the Cotter-Powell beds:

Barrandeoceras sp
Ceratopea calceoliformis
C. capuliformis
C. compressa
C. corniformis
C. cuneata
C. curvatum (Ruedemann)
C. keithi (Ulrich)
Coelocaulus linearis (Billings)
Deltatreta sp.
Endoceras champlainense
Ophileta
Oraspira small sp.
Orthoceras
Piloceras canadense
Platycolpus
Pliomerops?
Schroederoceras
Taffia sp.
Turritoma acrea

ORDOVICIAN FOSSILS

The Athens shale contains a graptolite fauna, through the aid of which the formation has been correlated over a wide area. Graptolites occur in the upper 60 feet of limey beds of the formation. Fossils of the characteristic world-wide species, Nemograptus gracilis, were found in abundance at one locality, directly north of Little Ninemile Creek. It belongs to the Coelenterata phylum, and to the group Graptozoa ("written animal"). The above species represents only one of hundreds of varieties of this extinct, colonial, and marine group. In the process of fossilization of graptolites all of the chitin ingredients except the carbon content disappeared thus leaving a carbonaceous film resembling a saw blade. (Twenhofel, 1935, p. 87.) Other forms found include species of bryozoans, crinoids, and brachiopods.

The graptolite fauna of the Athens shale has been correlated with the Normanskill formation of New York, the Glenkiln shale of Scotland and part of the Llandeilian formation of England and Wales (Butts, Stose, Jonas, 1932, p. 15).

Butts, Stevenson, Cooke, and Adams in their report on the Geology of Alabama list the following species of graptolites as occurring in the Athens shale:

Climacograptus scharenbergi	Dicranograptus spinifer
Dicellograptus moffatensis	Diplograptus foliacens
D. smithi	Glossograptus ciliatus
	Nemograptus gracilis

No identifiable species were found in the Tellico sandstone, but small fragments of crinoids and brachiopods were seen in the less weathered portion of the formation.

The Sevier shale contains numerous branching graptolite forms many of which were found on the weathered surfaces of an excellent exposure at Sixmile Church (Fig 3, p. 27). This outcrop shows an abundance of well-developed ripple marks. Fossils in the lime phases of the Sevier shale are similar to those of the Chickamauga limestone (Mosheim and Lenoir limestones near Knoxville, Tennessee).

One mile southeast of Chilhowee View School an exposure was found which contains numerous brachiopods, ranging in size from one fourth of an inch to over one inch in diameter, trilobite plates (?), bryozoans, crinoid stems and rings, and branching graptolites. This was the only Sevier shale exposure noted where fossils were abundant. The beds consist of soft, light brown, argillaceous shale and shaly limestone.

The Bays sandstone was found to contain a small fauna of linguloid brachiopods and numerous ostracods near the middle of the formation. The linguloids differ in size with an average of one fourth of an inch in length, and the ostracods, in the same beds, range from a millimeter or two to over one inch in length. Species were not determined but descriptive characteristics were studied. Lingula forms belong to the phylum Brachiopoda and the order Atremata.

Ostracods belong to the Arthropoda phylum and to the subclass Ostracoda. The body of the latter is contained within a bivalved calcareous shell. The animals moved in great swarms, preferred shallow water, and were scavangers by habit. (Twenhofel, 1935, p. 436.)

MISSISSIPPIAN FOSSILS

The Chattanooga shale is characterized by typical linguloid forms similar to those of the Bays sandstone. An exposure of the Chattanooga black shale, on the east bank of Spring Branch, one mile northeast of Montvale Springs, was studied. Fossils were found only in the upper two feet of the shale which at this locality is approximately 30 feet thick.

The Grainger shale exhibits two or three interesting beds. Throughout the lower portion of the formation a characteristic fossil, namely, _Taonurus_ (_Spirophyton cauda-galli_) occurs in great abundance. _Taonurus_ consists of concentric, brush-like markings which were "originally regarded as a plant, also interpreted as mechanical markings by basally attached plants moved by wind; interpreted by Sarle as packings of successive burrows" (Grabau and Shimer, 1910, p. 248). "The structure most likely resulted from the many successive tracks of a large worm which crawled back and forth from a central opening in the muds where the animal lived for a considerable time. Bucher has suggested that the structure may have resulted from movement of the siphon of a large pelecypod" (Stockdale, 1939, p. 68). Specimens of this unusual fossil, collected by the writer, range from a few inches to over one foot in diameter. Two localities exhibiting the above form are, (a) three-fourths of a mile northeast of Montvale Springs, and (b) in Butterfly Gap, five and one half miles southeast of Maryville, Tennessee.

In the upper Grainger beds, one half mile north of Montvale Springs, a rich Mississippian fauna occurs that includes trilobites (Phillipsia and others), bryozoans, brachiopods, and crinoids.

In the Newman limestone, one half mile east of Montvale Springs along the Look Rock trail, a fossil bed was noted. The calcareous shaly-limestone of these upper Newman beds contain numerous forms of bryozoans, brachiopods, and crinoid stems. The specimens, however, were so badly broken that definite species could not be established.

CHAPTER V. GEOLOGIC STRUCTURE

Structurally the Blockhouse area involves both the newer Folded Appalachians and the older, crystalline Appalachians, the former comprising the major portion of the quadrangle. The principle geologic structures exhibited in the Valley and Ridge Province are folds and thrust faults, the former more numerous perhaps than the latter especially in the Tennessee Section of the Great Valley. (Pl. 6, fig. 1-2.)

Folds have a characteristic northeast-southwest trend. Many of the crests are at the same height and expose identical formations. Broader warps are best seen in heavy-bedded rock, such as the Knox dolomite, while in the thin-bedded contorted shales, such as the Nolichucky, Athens and Sevier, an infinite number of small insignificant folds appear. This intricate minor folding has had little effect on the topography. Close folding in thin-bedded incompetent formations is characteristic since they yield readily to the slightest pressure.

Folds in this area strike north 45 degrees to 60 degrees northeast. The northwest limbs of anticlines are steeper than the southeast limbs, and the axial planes are inclined to the southwest, thus indicating a force from the southeast. (Fig 7, p. 42.)

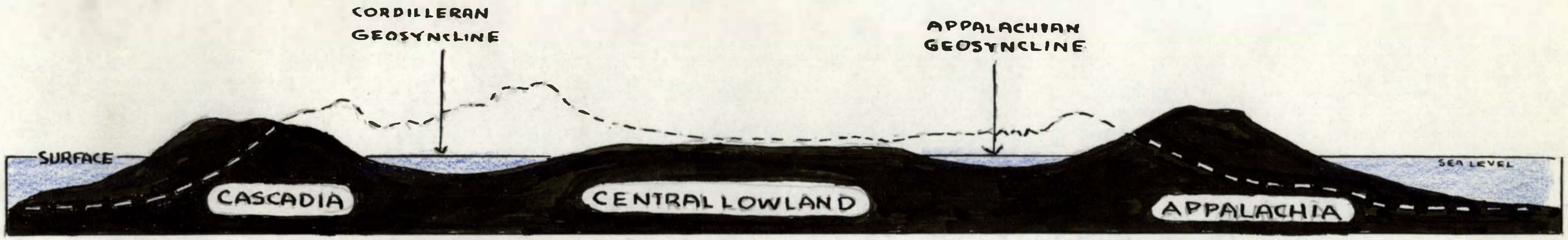


Figure 1. Profile across the North American Continent in Cambrian time (black) to show the relations of the geosynclines and borderlands to the modern continent (broken line). Vertical scale exaggerated. (After Schuchert and Dunbar, 1941, p. 127.)

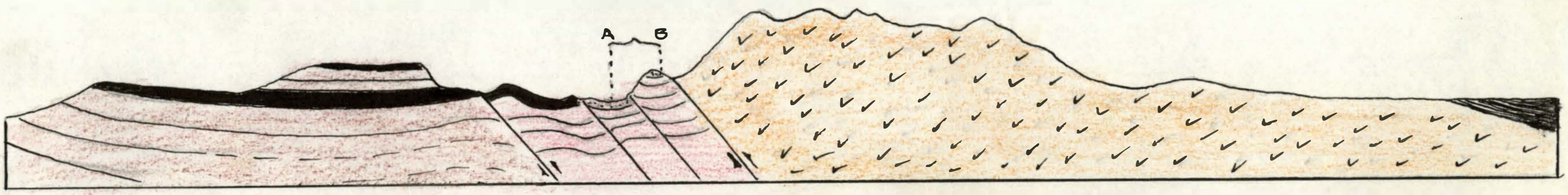
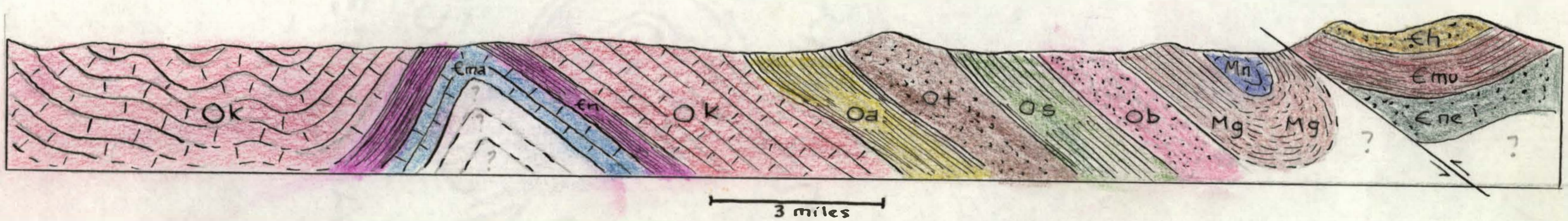


Figure 2. Generalized structure section taken on a line from the Coastal Plain to the Nashville Basin showing the folds and faults of the Great Valley. Lines A-B indicate approximate area covered in this report. (After Fenneman, 1938, p. 164.)

PLATE 6



Structure section across the Blockhouse Quadrangle from northwest to southeast. Symbols and colors same as those on geology map (Plate 8) in pocket.

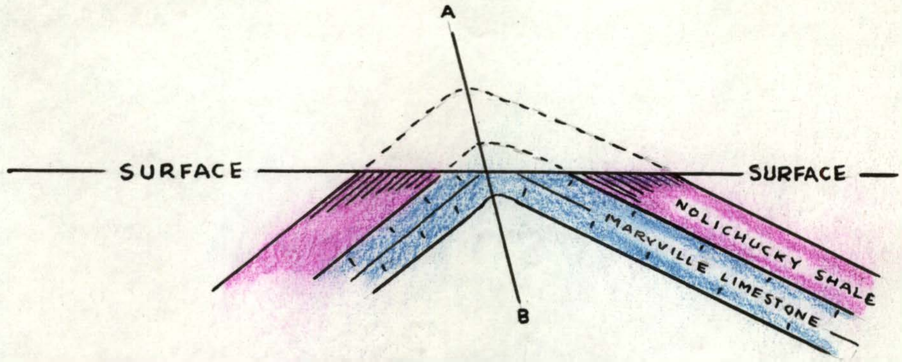


Figure 7. Structure section of Nolichucky shale and Maryville lime stone showing the anticlinal nature of the formations. Axial line indicated by A-B.

There is a notable increase in the amount of folding and faulting from north to south in the Valley and Ridge Province as a whole, and while there is no lack of folding in the Blockhouse Quadrangle there is a marked decrease in the number of faults. A major displacement was observed along the western edge of Chilhowee Mountain where the Murray shale, Cambrian in age, is thrust up adjacent to the Grainger shale of Mississippian age. The hanging wall, developed here on the Murray shale, has been shoved upward and toward the west, over the foot wall on the Grainger shale (Fig. 8, p. 43). Subsequent erosion made the two adjacent formations appear as a simple contact, but on close observation, based largely on the rock character, the ages of the respective beds has been definitely established.

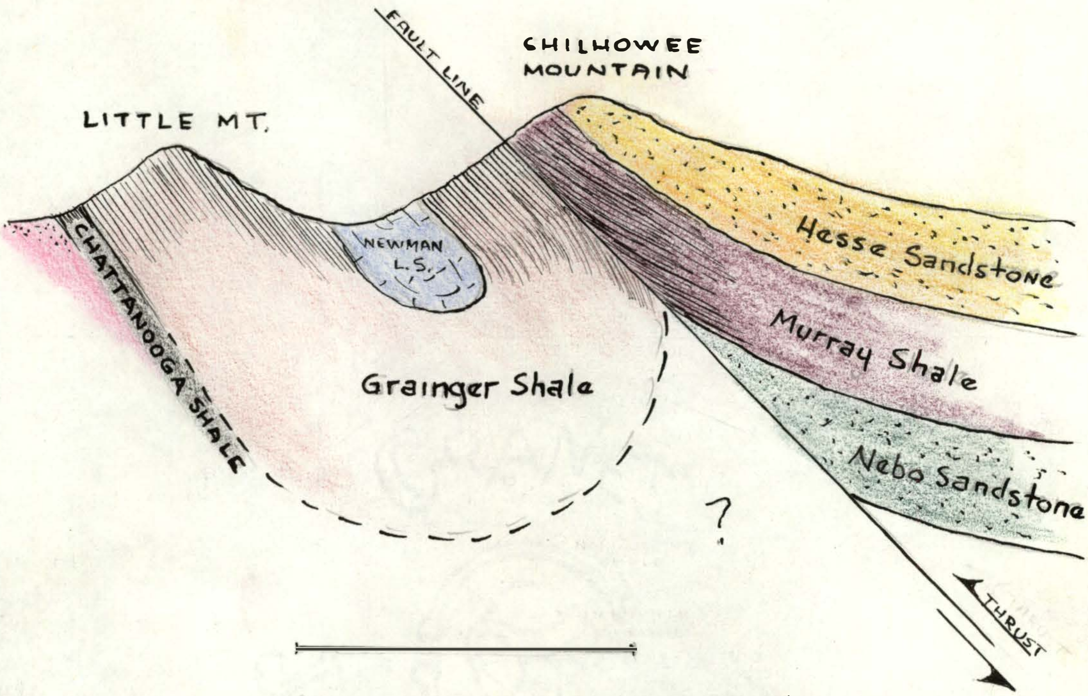


Figure 8. Cross section from the base of Little Mountain, one half of a mile southeast of Old Piney Church to Ellis Butt showing thrust fault along Chilhowee Mt.

Beside the compressive forces there has been vertical movement which raised and depressed the land surface. The vertical force covered a broader area than did the compressive movements and were less intense, the result being a gentle warping rather than folding and faulting. Some 10 periods of oscillation have been established in the Valley and Ridge Province since the beginning of the Paleozoic. (Keith, 1895, p. 5.)

Rocks in the Maryville area have been considerably disturbed since their original deposition. Folds are long and straight and the axial planes are off the vertical. The fault planes near Chilhowee Mountain are much nearer the horizontal than those near Maryville, the latter being outside the limits of this report.

A general structure section of the Blockhouse Quadrangle reveals the following features from northwest to southeast:

The Knox dolomite underlies much of the area between Maryville and the Black Sulphur Knobs. It strikes N. 65° E. and dips 55° SE (railroad cut two miles south of Maryville). The outcrop belt is synclinal. The western flank lies west of the city of Maryville while the eastern flank rises adjacent to the Nolichucky shale about three miles southeast of the city limits. The Nolichucky shale and the Maryville limestone have anticlinal positions. The Maryville beds, on the eastern flank, strike N 40° E and dip 28° SE (Fig. 2, p. 20). These two formations interrupt the wide Knox dolomite belt which appears again on the eastern limb of the Nolichucky shale and extends to the contact with the Athens shale farther to the southeast (Pl. 7). Structural features were intrepreted by the writer largely through a study of the strike and dip of the beds, but paleontological and stratigraphic data were likewise a distinct aid.

The structure between the upper Knox beds and the Chattanooga black shale, from the Black Sulphur Knobs to Little Mountain departs little from the common southeast dip. Next above the Chattanooga shale lies the Grainger sha which is exposed throughout the Little Mountain belt. This shale lies in a synclinal structure with the Newman limestone occupying the shallow depression between the two limbs. The entire southeastern side of the syncline is demarcated by a major fault. In the Emerine Gap locality this fault lies between the Grainger and Murray shales. Near Montvale Springs the adjacent formations are the Grainger shale and the Cochran conglomerate. The dips recorded on the Grainger do not definitely prove the existence of a synclinal structure but the limestone and the reoccurrence of the formation on the eastern flank suggest such a structure, and Keith shows in the structure section of the Knoxville folio (1895, p. 10) that a syncline does occur along the Chilhowee Front.

The formations east of the Grainger shale, in the Blockhouse area, are all synclinal with the one exception of the dolomitic limestone exposed in the Flat Creek locality. They have a characteristic low eastward dip and strike in a northeast-southwest direction. Identical formations do not come in contact along the Chilhowee fault line due to the variations in displacement. The upturned, westernmost limits of this syncline, consisting chiefly of the resistant Nebo and Hesse sandstones, account for the height of Chilhowee Mountain (Pl. 7-8).

In the extreme southeastern part of the quadrangle the early Cambrian Pigeon slate has been thrust up into contact with the Hesse sandstone (early Cambrian but younger than the Pigeon slate).

Fensters

An unusual structural feature partially within the limits of the Blockhouse Quadrangle, and included within the Blue Ridge Province, is the low cove-like area one half of a mile east of Emerine Gap. The floor of the cove lies at an elevation of 1100 feet while the enclosing mountains are several hundred feet higher. Topographically, this is not an unusual occurrence. However, careful examination shows that the floor of this cove is developed on the Knox dolomite (Pl. 8), Cambro-Ordovician in age, while the surrounding steep slopes are carved on much older rocks, chiefly early Cambrian sandstones and slates. Thus the stratigraphic sequence is reversed, with the older formations overlying the younger beds. This is due to a great low-angle thrust fault, known as the Great Smoky Overthrust. "The plane of this overthrust dips gently and is deformed by later folds and faults of great size. Erosion through the thrust plane now exposes Ordovician rocks in windows surrounded by the overlying Cambrian. No less than 10 windows form a chain in the Great Smoky Mountains on a northeast-southwest anticline through Cades, Tuckaleechee and Wears Cove" (Keith, 1927, p. 154). Such features are known as fensters.

Most of the overthrust mass is of early Cambrian age. Underlying limestones are not metamorphosed, and only near the surface is it broken even by small faults. This shows the ease of sliding of the overthrust material which in this case consisted of many miles of Paleozoic rocks. (Keith, 1927, p. 155.)

CHAPTER VI. GEOLOGIC HISTORY

PALEOZOIC EVENTS

The geologic history of the Blockhouse area involves that of the entire Appalachian Highlands Division. The conditions prevailing during past geologic time were quite similar along the site of the entire Valley and Ridge Province. The sedimentary record serves as a principle guide on which the geologist bases his conclusions as to the events of the geologic past. Since the rocks of the Province are primarily sedimentary a fairly complete record of geologic history can be compiled from such deposits. It has been estimated that at least 40,000 feet of sediments were deposited in the geosyncline which covered the Appalachian area during Paleozoic time. The sediments comprising the rocks of the Blockhouse Quadrangle were derived principally from the great mountainous land mass, Appalachia, which lay to the east of the site of the present Blue Ridge Province, the latter bearing little resemblance to the ancient mountains which were several times higher. All westward drainage was into the huge trough, known as the Appalachian Geosyncline, in which accumulated sediments of several geological periods, from Cambrian to Mississippian in this case.

The chemical make-up and appearance of the sediments give some indication as to the depth of water in which they were deposited. Many shales, such as the Sevier, and sandstones show distinct ripple marks which indicate shallow water, near shore conditions. Limestones, such as the Maryville, indicate a rather deep, clear water deposition. Conglomeratic materials, such as comprise the Cochran conglomerate, indicate shallow water deposition and the rounded pebbles suggest water movement for considerable distances. The sandstones of the area, such as the red-brown Tellico, indicate a revival of erosion on old land surfaces which for untold centuries had been exposed to the processes of weathering (Keith, 1895, p. 1). As a result of these weathering processes a deep residual soil developed which was easily carried away during a time of activated erosion. This process is well borne out in the Cambrian and Silurian rocks of the Tennessee Section of the Valley and Ridge Province.

The vast geosynclinal sea in which the sediments of Appalachia were deposited extended from Newfoundland to the Gulf of Mexico. "In Virginia and Tennessee it probably coincided in location with the present Appalachian and Blue Ridge Province" (Butts, Stose, Jonas, 1932, p. 4). The area here under discussion lay near the eastern extremity of the geosyncline, thus its characteristic near shore deposits, such as the conglomerates and shales. The exact locations, of course, cannot be made but it suffices here to say that East Tennessee was near the eastern limb of this great sea.

The stratigraphic column gives evidence of at least four cycles of sedimentation in this area. The first that we have definite knowledge of began with the deposition of gravels, sands, and muds in the early Cambrian time. These deposits were laid down as the sea encroached upon the sides of Appalachia. Undoubtedly this transgression was slow in its landward movement and waters were shallow, tending to restrict the accumulation of lime material. (Keith, 1895, p. 2.) Generally sandstones and shales indicate near shore deposition.

As the land of Appalachia was gradually reduced by erosive and diastrophic processes the sediments became finer and finer finally resulting in the dolomitic deposits which show little trace of near shore materials. The accumulation of the Knox dolomite thus represents a long period during which Appalachia was quite low and not, as a result, furnishing much sediment to the sea. After a long period of quiet the area was elevated as shown by the coarse rocks. Elevation continued until the middle of the Silurian at which time large areas of recently deposited materials were lifted above the sea. This ended the first great cycle. (Keith, 1895, p. 2.)

A second depression initiated the next cycle and it was during this time that the black shales (Chattanooga) accumulated. On these, sandstones and shales were deposited, thus recording a minor uplift of the land. The uplift was of little significance in the Southern Appalachians but increased in intensity northward. (Keith, 1895, p. 2.)

The third cycle saw renewed depression during which time the Carboniferous (Mississippian and Pennsylvanian) limestones were deposited. Renewed uplift brought this limestone deposit into shallow water and on it were laid the Pennsylvanian sandstones and the coal beds of the Cumberland Plateau. A depression of unknown age was responsible for the encroachment of the sea on the mountain region and the subsequent deposition of the coarse and varied deposits now found there. (Keith, 1895, p. 2.)

The fourth and last cycle saw renewed uplift at the end of the Carboniferous which ended deposition in the Appalachian Province. (Keith, 1895, p. 2.)

The Paleozoic was terminated by a profound physical disturbance, known as the Appalachian Revolution. It has been termed Appalachian Revolution "because at that time the Appalachian Mountain Range was born out of the sea by upheaval and folding of the strata" (Miller, 1937, p. 178). The thousands of feet of sediment which had accumulated in the Appalachian Geosyncline were compressed, folded, faulted, and uplifted. No doubt this mass was much higher than the present Valley and Ridge and Blue Ridge Provinces but its exact elevation at the close of the disturbance cannot be definitely established.

Movement was not confined to the Permian time but began in the preceding Pennsylvanian and did not fully die out until the Mesozoic (Triassic) time. The activity at the close of the Permian lay the "groundwork" of our present topographic forms, now worn down to maturity by geologic processes during the countless intervening ages.

POST PALEOZOIC EVENTS

Post Paleozoic deposition was notably absent in the Southern Appalachians. The region did, however, undergo extensive erosion during the Mesozoic and Cenozoic eras. Some Triassic rocks were deposited in a trough which lay between old Appalachia and the newly formed Appalachian Mountains. The waters from this trough receded and by late Triassic the eastern United States was entirely above the sea, and the deposited sediments were upwarped, tilted, and faulted. The United States, in its eastern extent, remained above the sea until late Cretaceous time when the greatest Mesozoic sea invaded the continent. The last semblance of Appalachia disappeared under these waters. Although much of the eastern interior of North America remained high during this time, however, a huge arm of the sea extended from northern Canada to Mexico over the western interior states. These waters extended eastward over parts of the Gulf states and the eastern seaboard. Western Tennessee was inundated during this Mesozoic invasion, but the central and eastern parts of the state had sufficient elevation to prevent encroachment. Erosion continued until, by the end of the Mesozoic, most of the land of eastern North America was reduced to a peneplain.

Cenozoic deposition did not materially affect the Valley and Ridge and Blue Ridge Provinces, deposits being limited to the east coast area, the western states, and the Gulf Coast region. A small Eocene sea invaded the Gulf states, waters extending as far north as southern Indiana. Parts of the east coast were submerged at this time but not to an extent comparable to the Paleozoic invasions. (Miller, 1938, p. 336.)

Sculpturing of the Appalachians during the interim between the close of the Paleozoic and the beginning of the Cenozoic had proceeded to such an extent that nearly all the mountains had reached a state of peneplaination "exceptions being a chain of monadnocks as much as 2000 feet high along the border between eastern Tennessee and North Carolina... These unreduced areas form the crest of the modern Great Smoky Mountains..." (Schuchert and Dunbar, 1941, p. 390.)

The flat erosion surface of the Appalachians was known as the Schooley Peneplain, and it is still preserved in some of the higher ridges of the Valley and Ridge Province and possibly in the summits of the Allegheny Plateau farther north. This old surface dipped eastward and would, if present today, underlie the coastal plain beds. (Schuchert and Dunbar, 1941, p. 390.)

The present elevation and the local relief are both due to such primary causes as regional upwarping and erosion. Late in the Cenozoic further upwarping was followed by the development of incised streams and the subsequent formation of lowlands. This flat land surface has been termed the Harrisburg Peneplain because of its development in the Harrisburg, Pennsylvania area. Still further uplifts followed causing the Harrisburg surface to be warped and causing the streams to again be incised. Present relief has been carved from streams flowing over these old surfaces. (Schuchert and Dunbar, 1941, p. 390.)

CHAPTER VII. MINERAL RESOURCES

The mineral resources of the Blockhouse area are limited in comparison with those of the Valley and Ridge Province as a whole. A few of the valuable resources to be found within the Great Valley include marble, zinc, barite, and manganese. Of these the Maryville-Chilhowee Mountain section contains only manganese, which occurs in small amounts in the Knox dolomite.

In addition, brown iron ore (limonite) is known to occur in several localities, chiefly in the limestones, but its value and extent are not such that mining operations could be undertaken on a profitable scale. "No deposits have been discovered that will certainly support a modern furnace for any considerable time" (Case, 1925, p. 63). "The East Tennessee limonites occur as compact, shapeless masses in the foothills, spurs and valleys associated with clay and chert" (Born, 1936, p. 66).

Small limonite deposits occur about one mile south of Forest Hill School in the Knox dolomite and in the Newman limestone both north and south of Montvale Springs. The Tellico sandstone, which is quite extensive in the Blockhouse area, contains a small percentage of iron which the early settlers are purported to have utilized in the making of plow shares and horseshoes. Hayes (1909, p. 73) summarized the uncertainty of the quality and quanity of the brown iron ore in this eastern belt as follows

> "The brown ores are extremely variable in depth and horizontal extent. Surface indications are thoroughly unreliable, and those most experienced in such deposits are practically unamious in the opinion that no deposits can be estimated safely until every ton of ore has been mined. Under such circumstances, estimates given of ore remaining in this class of deposits can only be regarded as having a degree of accuracy represented by a factor varying between 7 per cent and 30 per cent."

Traces of gold occur as placer deposits in the streams flowing from Chilhowee Mountain. Its source is not definitely known but is believed to be from the "metamorphosed shales and sandstones of Cambrian or Pre-Cambrian age" (Born, 1936, p. 61).

The Knox dolomite has been widely used for structural purposes, such as bridge abutments, its chief qualities being its compactness, its resistance to frost and heat, and its ease of quarrying. It offers future possibilities for the chemical industry and as a source of magnesium, these developments depending upon a number of conditions. The Knox dolomite contains the chief zinc deposits in the state, at Mascot and Jefferson City, Tennessee, but the beds in the Blockhouse Quadrangle are not known to contain this valuable mineral resource.

The Maryville limestone is used for road metal and is only of local importance. Its limited thickness, and the use of other more desirable formations has prevented any extensive development.

The Newman limestone, Grainger shale, and the Chattanooga shale, offer possibilities for cement industries at certain other localities within the Valley of East Tennessee, and although all three occur within the limits of this report no development has taken place.

It should be noted that the largest aluminum rolling mill in the world, that of the Aluminum Company of America, is located just outside the limits of the Blockhouse Quadrangle, and several hundred of the employees of this plant reside in this locality. About 40 percent of the United States supply of finished aluminum comes from these huge mills at Alcoa, Tennessee (World Almanac, 1942, p. 508). Raw materials, bauxite, are first sent to one of the several processing centers, and the ore is then shipped to the Alcoa reduction and rolling plants. At first glance this plant would appear out of place but such factors as hydroelectric power and a good labor supply, chiefly the former, make the East Tennessee Valley region ideal for this growing industry.

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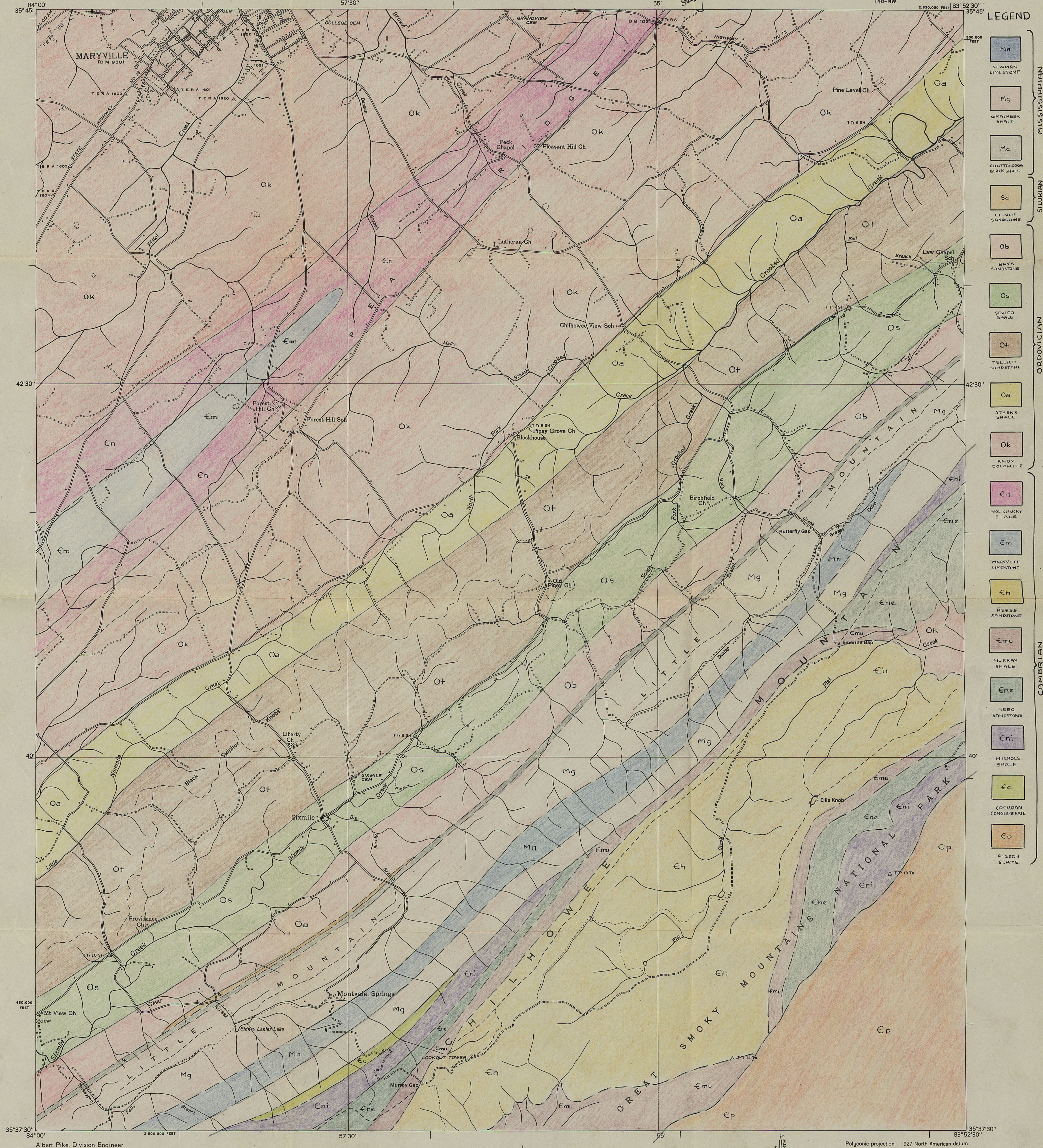
DEPARTMENT OF THE INTERIOR
U. S. GEOLOGICAL SURVEY

TENNESSEE VALLEY AUTHORITY
ARTHUR E. MORGAN, CHAIRMAN AND CHIEF ENGINEER
CARL A. BOCK, ASSISTANT CHIEF ENGINEER

Advance sheet Subject to correction

TENNESSEE
(BLOUNT COUNTY)
BLOCKHOUSE QUADRANGLE
148-NW



Albert Pike, Division Engineer
Compiled by U. S. Geological Survey from aerial photographs
Control by U. S. Geological Survey and Tenn. Ell. Rel. Adm.
Field examination in 1935

Scale 1/24,000
2 Miles
5,000 0 5,000 10,000 Feet

Datum is mean sea level

APPROXIMATE MEAN DECLINATION, 1935

Polyconic projection. 1927 North American datum
10,000 foot grid based on Tennessee rectangular coordinate system

Ridge line
Trail
Sinks

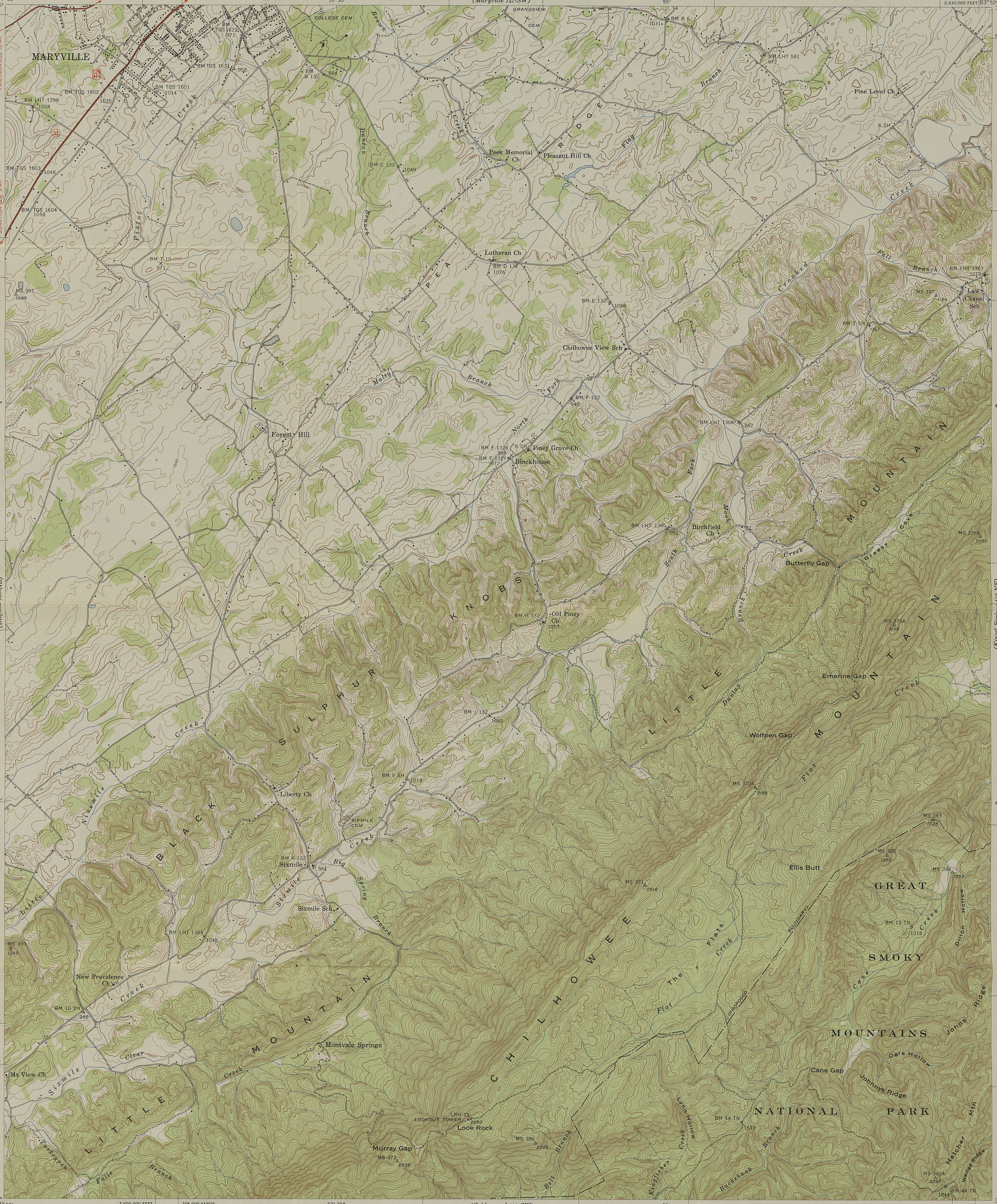
BLOCKHOUSE, TENN.
148-NW

Ricketts

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

UNITED STATES
TENNESSEE VALLEY AUTHORITY
MAPS AND SURVEYS DIVISION

TENNESSEE
(BLOUNT COUNTY)
BLOCKHOUSE QUADRANGLE
148-NW



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Control by USC&GS, USGS, and TVA
Topography by Geological Survey from aerial
photographs by stereophotogrammetric methods
Field examination by Tennessee Valley Authority - 1941

Maps distributed by the Geological Survey

TRUE NORTH
MAGNETIC NORTH
APPROXIMATE MEAN
DECLINATION, 1941

Scale $\frac{1}{24000}$

1 ½ 0 1 2 Miles
5000 0 5000 10000 Feet
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Engraved and printed by the Coast and Geodetic Survey

(Great Smoky Mts. Nat. Park 1:62,500)

Polyconic projection. 1927 North American datum
10,000 foot grid based on Tennessee
rectangular coordinate system
5,000 yard grid based on U. S. zone system, B

ROUTES USUALLY TRAVELED
HARD, IMPERVIOUS SURFACES
OTHER SURFACE IMPROVEMENTS
411 U. S. ROUTE
33 STATE ROUTE

BLOCKHOUSE, TENN.
148-NW
Edition of 1942

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