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The Geology of the Graveston Quadrangle, Union and Knox Counties, Tennessee

John Franklin Spangler
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To the Graduate Council:

I am submitting herewith a thesis written by John Franklin Spangler entitled "The Geology of the Graveston Quadrangle, Union and Knox Counties, 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.

P. B. Stockdale, Major Professor

We have read this thesis and recommend its acceptance:

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Vice Provost and Dean of the Graduate School

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August 1, 1949

To the Committee on Graduate Study:

I am submitting to you a thesis written by John Franklin Spangler entitled "The Geology of the Graveston Quadrangle, Union and Knox Counties, Tennessee." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Geology.

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We have read this thesis
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THE GEOLOGY OF THE GRAVESTON QUADRANGLE
UNION AND KNOX COUNTIES, 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

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by

John Franklin Spangler

August 1949

PREFACE

This thesis, entitled "The Geology of the Graveston Quadrangle, Union and Knox Counties, Tennessee" is one in a series being undertaken by graduate students in the Department of Geology and Geography, University of Tennessee. The area under study had been mapped previously by Arthur Keith (U.S.G.S. Maynardville folio, no. 75, 1901) on a scale of 1:125,000. The geologie mapping by the present writer was done on the Tennessee Valley Authority base map (Graveston Quadrangle, 146-NE) which has a scale of 1:24,000.

The reconnaissance field work was undertaken in the fall of 1948 using the Maynardville folio for purpose of general information. Field work was delayed during the late winter and early spring months due to inclement weather conditions. During late spring and early summer the field work was renewed and subsequently completed in July, 1949.

The writer is indebted to Dr. P. B. Stockdale, Head of the Department of Geology and Geography, University of Tennessee, for his guidance in the preparation of this manuscript and his advice concerning field problems. He is obligated to the entire faculty and graduate student body of the department for their interest in the problem and the many suggestions offered. He is equally indebted to his wife, Nancy, for her assistance and encouragement in the preparation of the entire manuscript.

J.F.S.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF PLATES

CHAPTER I

INTRODUCTION

Location and Size of the Region

The Graveston Quadrangle is located in the western part of the Valley and Ridge Province in eastern Tennessee. The southeastern corner is approximately nine miles northeast of the city of Knoxville. It includes parts of Union and Knox Counties. It extends from 83°45' to 83°52'30" west longitude and from 36°07'30" to 36°15' north latitude. The area of the quadrangle is slightly more than 60.2 square miles.

Topographic Conditions of the Region

The topography of the Graveston Quadrangle is typical of the southern part of the Valley and Ridge Province. It consists principally of alternating parallel ridges and valleys which trend northeast-southwest. The ridges are supported by sandstone or by cherty dolomite or limestone. Those ridges formed from Rome sandstone are narrow, steep sided, and sharply defined. They are relatively even-topped with many wind gaps and water gaps which have been cut perpendicular to the strike of the beds. These gaps have been a major factor in the cultural development of the quadrangle. The arteries of transportation follow the strike valleys between the ridges and the minor county roads follow the gaps across them. Ridges formed from the Knox dolomite create a different topographic expression in the form of belts of elongated, rounded and irregular knobs. In the case of Copper Ridge, in the central part of the quadrangle where its width is greatest, the Knox dolomite forms a rolling upland instead of a sharp ridge.

The maximum relief of the quadrangle is 860 feet. The point of maximum elevation, 1,820 feet, is on an unnamed knob on Comb Ridge located one mile southwest of Hamilton Gap in the extreme northeast corner of the quadrangle. The lowest elevation, 960 feet, is located on Flat Creek along the eastern margin of the quadrangle, one-half mile north of House Mountain. The local relief is up to 500 feet.

The stream pattern in the quadrangle is largely trellis, following an old and well established drainage system. The several water gaps across the ridges suggest the likelihood of the larger streams being antecedent or superimposed. Drainage is accomplished in some small part by subsurface solutions channels developed in the relatively soft and soluble calcareous formations.

No master stream crosses the quadrangle which is drained by three small creek systems, namely, Raccoon,

Figure 1

Water gap through Pine Ridge

Bullrun, and Flat Creeks. In general, Raccoon Creek drains the area north of Buffalo Ridge, Bullrun Creek drains Comb Ridge and Copper Ridge, and Flat Creek and other minor systems drain the area south of Copper Ridge. Flat Creek has the best developed flood plain which ranges in width from 100 yards where developed in the Moccasin limestone to 400 yards where formed in the Sevier shale.

Climate

The climate of the region is the northern phase of the humid subtropical type. The average annual rainfall of 48.28 inches has a distribution throughout the year favorable for agriculture. The summers are relatively long and warm, while the winters are generally mild and short. July, the hottest month, has an average mean temperature of 77.4°F, and January, the coldest month, has an average of 39.2°F. The mean annual temperature is 58.6°F. The agricultural development of the region is aided by a frost-free season of approximately 209 days, from about April 3 to about October 29.

Topography is a considerable factor in the determination of the climate. Two important climatic controls are the Cumberland Plateau on the northwest and the Great Smoky Mountains to the southeast in the Blue Ridge Province. The former retards and modifies the northwestern cold waves and the latter diverts some of the hot southern winds coming from the

Atlantic coast. The winds are mild and variable with the southwesterlies prevailing as a result of the local topographic influences. The average annual wind velocity is six miles per hour.

Vegetation

The Graveston Quadrangle supports a profuse vegetative cover. Because the ridge area does not have a large population, much of the land has not been cleared for farm use or for grazing. A small portion of the virgin timber, however, has been cut for fence rails, home construction, and firewood, and has subsequently been replaced by a second growth. The valleys are thickly populated and an almost complete destruction of timber has followed in creating farmland with intensive agriculture preventing its regrowth. However, many homesites have a stand of timber about them reminiscent of the quantity that once filled the valleys.

The soil types, the geological formations, and the types of trees present an almost coincident areal pattern. On Knox dolomite ridges oak and hickory are predominate while giant poplars are present in the shale valleys. Soils developed from argillaceous limestones of the Lenoir formation support in particular dense growths of cedar trees. Walnut, cherry, and ash are found here and there throughout the valley and ridges, with dogwood and redbud trees forming a considerable part of the underbrush.

Two major all-weather highways, State Routes 33-61 and 33-71, serve the area. They follow strike valleys across the northwestern and southeastern corners of the quadrangles. Forming a trellis pattern with these major routes of transportation are numerous unpaved county roads that dissect the ridges and form a more complete communication system.

There are no special recreational areas within the limits of the quadrangle. The people rely mostly upon those facilities provided by their own social groups meeting at the many small churches and schools within the region.

Other than in the two villages, Maynardville and Corryton, most of the population is widely dispersed along the roads of the quadrangles. Generally, at the intersections of the more widely used roads, small settlements have developed. However, until some possible future industrialization occurs there will quite likely be no centralizing of population.

Culture

The culture of the Graveston Quadrangle is a direct result of the geological and climatic forces of the region. Farming is the major occupation, but the location and quality of the farms are determined by the underlying soils, in turn dependent upon the geologic formations. Those farms located on the soils derived from limy and dolomitic rock strata or on the flood plain alluvium of the streams are the more fertile and productive.

Because the area is located in the northern portion of the humid subtropical climatic type near the area of the continental long summer type, the crops are quite diversified. The primary group includes: (1) wheat, (2) tobacco, (3) corn, (4) oats, and (5) hay. Winter wheat and tobacco are the principal sources of cash income. The grains are grown mainly on the valley flats and rolling uplands, while tobacco is grown on the steeper slopes, thus utilizing profitably the less valuable and more abundant land surfaces. Generally associated with the corn are small crops of beans, pumpkin, and squash, usually destined for the family use.

The lack of large areas of land for suitable pasturage prohibits the development of the dairying industry, but small herds of cattle are present serving individual family needs. Similarly, there are no sizeable swine or poultry farms, although most homesteads possess a few for their own use.

CHAPTER II

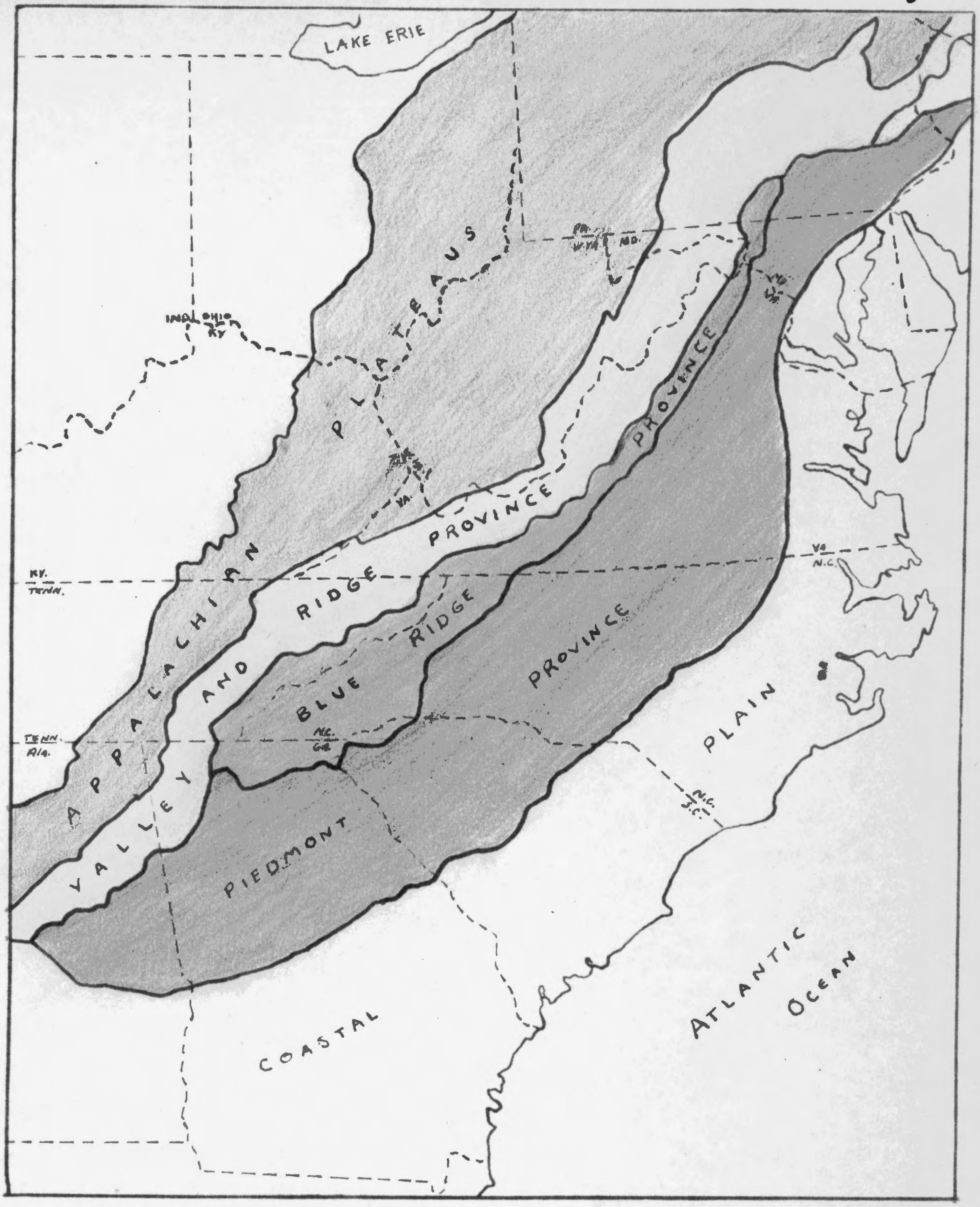
PHYSIOGRAPHY

General

In the map of the Physical Divisions of the United States prepared by Fenneman and Johnson (1946), East Tennessee lies within the Appalachian Highlands Division. There are seven physiographic provinces included in this division. Three occur in Tennessee. Although the Graveston Quadrangle lies entirely within the Valley and Ridge Province, it is necessary to present a brief description of all three in order to further a better understanding of the physiographic history of the quadrangle.

Valley and Ridge Province

This province extends 1,200 miles northeast-southwest from the St. Lawrence River to the Gulf Coastal Plain in central Alabama. It is approximately eighty miles wide at Harrisburg, Pennsylvania, sixty-five miles wide in northern Virginia, and about forty miles in East Tennessee and southward. It is bounded on the east in Tennessee by the Blue Ridge Province and on the west by the Appalachian Plateaus Province.



(after Fenneman)

Figure 2

Physiographic regions of eastern United States

The province is divided into three physiographic sections. The boundary between the northern and middle segments is arbitrarily assigned as the Delaware River, the approximate southern limit of continental glaciation. The divide between the New and Tennessee Rivers is taken as the boundary between the middle and southern sections.

Fenneman (1938) defines the province as a lowland surmounted by long, narrow, parallel ridges. These valleys and ridges are the result of differential erosion of folded strata of varying resistance. The crests of the ridges are generally even, but with no broad areal extent. The valleys in general are developed in limestone and shale formations while the ridges are supported by more resistant sandstone and more or less cherty dolomite.

The pattern of drainage of the province is variable. To the north of the New River-Tennessee River divide, the general trend is transverse to the structural development of the region. With the exception of the New River, which flows north to the Ohio River, all other streams flow eastward to the Atlantic Ocean. South of the divide, the Tennessee River and its main tributaries follow the general southwest trend of the valleys until the Tennessee River turns west through the gorge across Walden Ridge near Chattanooga. The region south of Chattanooga is drained by the Coosa River and its tributaries which flow southward to the Gulf of Mexico.

Several notable levels of accordant ridge tops are apparent in the region near Knoxville. The highest, locally, are on the top of Clinch Mountain and its remnant, House Mountain, which are slightly over 2,000 feet. At an elevation between 1,300 and 1,400 feet another level of ridge tops is apparent which is questioned as the post-Miocene Harrisburg erosion surface, more clearly defined farther north. The extensive flats covered in most places by alluvium are believed to be intimately associated with the Coosa erosion surface.

Blue Ridge Province

This mountainous province extends from the Susquehanna River in Pennsylvania to northern Georgia along the eastern edge of the Valley and Ridge Province. The boundary is regarded as the limit of overthrusting of the metamorphosed rocks of the Blue Ridge Province on the unaltered sedimentary formations of the Valley and Ridge Province. The eastern boundary separating it from the Piedmont Province is arbitrarily defined as at the foot of the mountains. The province is divided into two distinct physiographic segments by the Roanoke River in central Virginia.

The northern segment is approximately fourteen miles in width, forming a belt of even-topped, rounded knobs averaging 1,500 feet in elevation. Some few of the knobs reach a maximum of 4,000 feet, and although most of them have a heavy vegetative cover, some few evoke interest in that they are completely barren and have thus earned the name, "the balds". South of the Roanoke River, the province widens to a maximum of seventy miles and the elevation increases with many peaks exceeding 5,000 feet.

The Blue Ridge Province is formed of resistant Pre-Cambrian crystalline and metamorphosed Cambrian sedimentary rocks and presents a rugged topography. The exact age relationship of the rocks and the details of their complex structural development are not as yet completely clarified, but the area is at present under study by both the United States Geological Survey and the Tennessee Division of Geology. Along the western side of the province are many fensters or "coves" which, serving as windows in the over-thrust sheet, expose the underlying Paleozoic rocks.

Appalachian Plateaus Province

The Valley and Ridge Province is bordered on the northwest by the Appalachian Plateaus Province, an upland area of varying width. The province extends from central New York to central Alabama and is called the Allegheny Mountains in the northern portion and the Cumberland Plateau in the southern. The eastern boundary of this province is a sharply defined, east-facing escarpment called the Allegheny Front to the north and the Cumberland Escarpment to the south. There are generally a series of faults at the base of the escarpment.

The elevation of the province ranges from 500 feet in Alabama to 3,500 feet in central Tennessee, 3,000 to 4,000 feet in West Virginia, and 2,000 feet in Pennsylvania. The points of highest elevation according to Keith (1901) are located along the eastern escarpment from which both the rock strata and the surface of the plateau slope gradually westward.

In Tennessee the lower Pottsville shales and sandstones form the surface and much of the mass of the Cumberland Plateau. Because the underlying strata are almost horizontal, a dendritic drainage pattern has developed in contrast to the trellis pattern developed on the folded structure of the Tennessee portion of the Valley and Ridge Province.

The northern portion of the province has lost many of the features of a plateau due to the mature dissection by stream action and appears to be mountainous; hence, Allegheny Mountains. This is most apparent in West Virginia and farther north. From Kentucky to central Alabama, the province retains many of the characteristic plateau features.

Special Features of the Graveston Quadrangle

Although not restricted to the Graveston Quadrangle alone, three physiographic features are noteworthy; i.e., valleys and ridges, wind gaps and water gaps, and karst topography.

The valleys and ridges, though characteristic of the province as a whole, are well defined within the quadrangle. The valleys have been formed in the shale and limestone formations, which attests to the susceptibility of these formations to erosion and solution. Little, Possum, Texas, and Potato Valleys have been eroded into the Conasauga shale and Raccoon Valley is formed in the Chickamauga limestone. The ridges of the quadrangle are capped either by resistant sandstones or cherty dolomites. Pine and Comb Ridges are capped by Rome sandstone, and Hinds, Buffalo, and Copper Ridges are capped by Knox dolomite. The sandstone ridges are generally higher and more irregular than the rounded, rolling dolomite ridges. Low, knobby ridges are formed by the erosion of the Maryville limestone as in the Miller Knobs.

Water gaps are numerous throughout the quadrangle, but the best developed are Ailor and Stover Gaps in Comb Ridge incised by Bullrun Creek and its largest tributary. High level wind gaps are more common in Comb Ridge than in the dolomite ridges but are unnamed and their appearance is only striking when considering their effect in creating a serrate outline to the summit of the ridge.

Approximately thirty good-sized sinkholes are present in the Knox dolomite of Hinds and Copper Ridges. They are roughly circular and have a maximum depth of fifty feet. The majority are due to surface solution and the insoluble chert residue left in their outlet permits easy drainage. They are, therefore, seldom filled with water except during periods of heavy precipitation or when the chert residue completely clogs the outlet.

Campbell Cave is an interesting example of karst topography within the quadrangle. It underlies approximately one acre of land and is formed along the bedding plane of the Holston marble. A small, nearby sink which drains the immediate vicinity is clearly a part of the cavern roof which has collapsed. The water, however, is diverted through a series of small solution channels and not through the major passageway of the cave. No dye tests were conducted by the writer, but a part of the subsurface water probably joins the water of Tabler Branch two-tenths of a mile to the southeast.

CHAPTER III

STRATIGRAPHY

Geologic Column in General

The stratigraphic range of rocks within the limits of the Graveston Quadrangle is from Lower Cambrian through Middle Ordovician. The oldest formation exposed is the Rome, composed of shale and sandstone; the youngest is the Sevier shale. The strata between these two formations consist of limestones, sandstones, shales, and "marbles". There are no igneous rocks in the Graveston Quadrangle.

The Graveston Quadrangle was a part of the Appalachian Geosyncline that existed from the beginning of the Paleozoic to the time of the Appalachian Revolution. As the geosyncline subsided slowly, materials derived from the higher lands to the east and west were deposited within it so that the sedimentary record is at present sufficiently complete to give a reasonably accurate picture of the conditions existing at the time of deposition.

From evidence that has been obtained from elsewhere within the Valley and Ridge Province, it may be readily assumed that the Graveston Quadrangle was once covered by rocks representing the entire Paleozoic era with the exception of the Permian period. Rocks of Mississippian age are known from nearby localities. According to W. D. Johnson (1931), a Cretaceous cover capped the Paleozoic formations before widespread peneplanation began. However, no evidence is visible within the quadrangle to support this theory.

Within the southern Valley and Ridge Province, there are many stratigraphic problems, several of which are seen in the Graveston Quadrangle. These will be developed in connection with the individual formations as they are described below. At the present writing, the entire problem of Ordovician stratigraphy of the southern Valley and Ridge Province is under study by Dr. John Rodgers of Yale University.

Because of the intense folding and faulting of the strata within the area, the thicknesses assigned to the formations are necessarily only approximations and more accurate thickness determinations must await some later, more exhaustive study.

A stratigraphic section of the formations included in the Graveston Quadrangle is presented on page 18.

Cambrian System

The oldest rocks exposed in the Graveston Quadrangle are of Cambrian age; namely, the highly contorted sandstones

Figure 3

GENERAL STRATIGRAPHIC SECTION

OF THE GRAVESTON QUADRANGLE

SYSTEM	SERIES	CORRELATION		GRAVESTON QUADRANGLE
Ordovician	Middle	Trenton		Sevier shale
		Chazy-Black River		Moccasin limestone
				Holston marble
			Chickamauga (Restricted)	Lenoir limestone
				Mosheim limestone
	Lower	Beekmantown		Knox dolomite
Cambrian	Upper	Croixian		
				Nolichucky shale
	Middle	Albertan		Maryville limestone
				Rogersville shale
				Rutledge limestone
	Lower	Taconian		Rome formation
				not exposed

and shales of the Rome formation, the shales and limestones of the Conasauga group, and the massive dolomites of the lower part of the Knox dolomite.

Rome Formation

The Rome formation was named by C. W. Hayes (1894) for the 3,000 to 4,000 feet of alternating shales and sandstones exposed south of Rome, Georgia. It is exposed in northwestern Georgia, northern Alabama, western North Carolina, eastern Tennessee, and southwestern Virginia.

As exposed in the Graveston Quadrangle the Rome is made up of red, green, yellow, and brown shales and reddish, calcareous sandstones. Locally, thin beds of limestone and dolomite are found. The sandstone members of the formation average about four feet in thickness, and massive sandstones rarely exceed twenty feet in thickness. These sandy members are frequently marked with primary structural features such as oscillation ripple marks and mud cracks. The sandstones are prominent ridge forming rocks in the area. Comb Ridge is capped by the formation. The less competent shales are highly contorted.

There are two outcrop belts of the Rome formation within the quadrangle. One belt is marked by Comb Ridge, striking about North 60°East across the northern portion of the area. The general dip of the formation is to the

Figure 4

Nearly vertical sandstones and shales of the Rome formation southeast. However, as a result of intense folding, the dip of the strata ranges from southeast through vertical to folds that have been overturned to the northwest. To the south and southeast of Comb Ridge, the Rome formation is in conformable contact with the overlying Rutledge limestone. However, to the north, thrust faulting has thrown the Rome formation up against the Knox dolomite, the Nolichucky shale, and the Chickamauga limestone. In the northwest portion of the area the Rome formation is exposed in Pine Ridge. To the south it is conformably overlain by the undifferentiated rocks of the Conasauga group. On the north it is faulted against the Chickamauga limestones of Ordovician age. The belt of outcrops follows the general regional strike of approximately North 60°East. Due to the intricate folding of the formation an accurate determination of the thickness was impossible to ascertain. However, for the general vicinity of Knoxville, the thickness has been estimated to be approximately 1,000 to 1,200 feet.

The few fossil remains that are included in the formation have been identified by other workers as _Olenellus_, _Paterina_, _Obolus_, and _Lingula_. Because of the relative scarcity of fossils and the fragmental nature of those that are found, no collection was made by the writer. C. E. Resser (1938) assigned the Rome formation to the upper part of the Lower Cambrian (Taconian).

The red to reddish brown soil formed from the weathering of the formation is sandy and, in most parts, is unsuited for agriculture. Because of the resistance of the sandstone, the highest points and the most rugged topography within the quadrangle are developed where the sandstone is exposed.

Rutledge Limestone

The Rutledge limestone was named by Keith (1894) for the 250 to 500 feet of massive limestones and basal shales exposed at Rutledge in Grainger County, Tennessee. The name was first used by Campbell (1894) in the U.S.G.S. Estillville folio. The formation is exposed in northeastern Tennessee, southwestern Virginia, and western North Carolina.

The Rutledge formation as exposed in the Graveston Quadrangle is made up of dark gray, massive, siliceous limestones that grade downward through green and yellow calcareous shales to the underlying Rome formation. The formation is poorly exposed in the quadrangle. It is highly soluble and thus is present in the low valleys or as slopes adjacent to the more resistant Rome formation.

Two outcrops of the formation were found within the area of the Graveston Quadrangle. The limestone forms the northern side of Texas Valley. It strikes about North 60° East across the entire quadrangle and dips to the southeast at an average of 35 degrees. On the north it conformably overlies the Rome and to the south and southeast it, in turn, is overlain conformably by the Rogersville shale. A second outcrop is exposed in a syncline in the northeast end of Comb Ridge and is present as an inlier within the Rome formation. The thickness of the formation in the Graveston Quadrangle is approximately 300 feet.

Although Schuchert (1943) states that a Glossopleura fauna is typical, no fossils were found by the writer in the Rutledge limestone. Resser (1938) assigned the Rutledge to the lowest Middle Cambrian (Albertan). The limestone and shale of the formation weathers to a rich red clay that is suited mostly to grazing with some few areas under cultivation.

Rogersville Shale

The Rogersville shale was named by Keith (1894) for the 70 to 250 feet of green calcareous shale exposed at Rogersville, Hawkins County, Tennessee. The name was first used by Campbell (1894) in the U.S.G.S. Estillville folio. The formation is exposed in northeastern Tennessee, southwestern Virginia, and in western North Carolina.

The Rogersville shale as exposed in the Graveston Quadrangle is a green calcareous shale with occasional red, sandy shale and thin limestone lenses. There is but a single outcrop belt of the shale in the quadrangle, namely, along the lowest levels of Texas Valley. It conformably overlies the Rutledge limestone and is conformably overlain by the Maryville limestone. The formation strikes approximately North 60°East and dips on an average 30 degrees to the southeast. The thickness of the formation is about 250 feet in the area under study.

Although only fragmental, unidentifiable fossil remains were found by the writer, Schuchert (1943) reports Obolus, Wimanella, Acroteta, and Ehmaniella as typical fauna. Resser (1938) assigned the Rogersville shale to the Middle Cambrian (Albertan).

The greenish brown soil developed from the weathering of the shale is relatively fertile and, although limited in extent, is used intensively and extensively for agriculture in Texas Valley and Potato Valley.

Maryville Limestone

The Maryville limestone was named by Keith (1894) for the 150 to 500 feet of massive blue limestone which outcrops near Maryville, Blount County, Tennessee. The name was first used by Campbell (1894) in the U.S.G.S. Estillville folio. The formation is exposed in northeastern Tennessee, southeastern Kentucky, southwestern Virginia, and western North Carolina.

The Maryville limestone as exposed in the Graveston Quadrangle is a blue-gray limestone with occasional siliceous bands. It is generally constant in appearance vertically and horizontally. The formation is characterized by the low knolls and the shallow sink holes which have been developed as a result of its relatively high solubility.

The Maryville limestone outcrops in three belts within the quadrangle. In the northwestern corner of the area the formation underlies the series of low knolls adjacent to Little Valley and strikes approximately North 60°East. To the south and southeast of the highway (33-61) the formation makes up the low rounded knolls known as the Miller Knobs. The northern contact of the formation is faulted against the Chickamauga limestone, but to the south it is conformably overlain by the Nolichucky shale. The third outcrop belt of the formation makes up a series of low hills to the south and southeast of Bull Run Creek in Texas Valley. In the first two outcrop belts, the thickness is approximately 400 feet. By calculation, the Texas Valley outcrop is about 600 feet thick. This greater thickness is explained by Keith (1894) by the presence of an intraformational fault. This fault is included in the accompanying areal map (Plate III) and is based on topographic, not lithologic evidence. The Little Valley and Texas Valley outcrop belts conformably succeed the Rogersville shale and are conformably overlain by the Nolichucky shale.

Because no fossils have been found in the type locality, correlation of the formation has been problematical. However, Resser (1938) regards the Maryville limestone as latest Middle Cambrian (Albertan). Walcott (1914), on faunal evidence collected from a lithologically similar formation, considers it to be Upper Cambrian in age. No fossils were collected by the writer from the Maryville formation within the Graveston Quadrangle.

The formation is covered in most places within the quadrangle by a residual, dark red soil. The hummocky nature of the topography where underlain by the Maryville limestone prohibits extensive agriculture.

Nolichucky Shale

The Nolichucky shale was named by Keith (1894) for the 400 to 750 feet of calcareous shale and shaly limestone exposed along the Nolichucky River in Greene County, Tennessee. The name was first used by Campbell (1894) in the U.S.G.S. Estillville folio. The formation is exposed in eastern Tennessee, western North Carolina, and southwestern Virginia.

The Nolichucky formation as exposed in the Graveston Quadrangle is composed of calcareous shales, shaley limestones, and some massive blue-gray limestones. The shales are blue or blue-gray in color, but weather to red, yellow, brown, and green. The thin-bedded shales in some parts of the outcrop weather to small rhomboids measuring approximately one inch on the side. The upper portion of the formation as mapped by the writer is a massive limestone. C. R. Oder (1934) names this the Maynardville formation and considers it to be a basal unit of the Knox, but Resser (1938) includes it in the Nolichucky shale formation. Resser's usage is followed in this paper.

The Nolichucky shale is a weak formation and found in three lowland belts within the quadrangle. In the northwest corner of the area the formation is found in Little Valley, creating a lower level between the conformably underlying Maryville limestone to the north and the conformably overlying Knox dolomite to the south and southeast. It is exposed further south in Possum Valley where it is in conformable relation to the overlying and underlying formations. However, at the end of Possum Valley the shale is faulted against the Rome sandstone. To the north of Copper Ridge the Nolichucky shale comprises the low level between the Knox belt on the ridge and the Maryville limestone knolls to the north. All three of the belts of exposures strike approximately North 60°East and dip approximately 40 degrees to the southeast. The thickness of the Nolichucky shale in the Graveston Quadrangle is estimated to be about 500 feet.

Schuchert (1943) reports a rich assemblage of fossils from the formation, but only a few unidentifiable, fragmental specimens were collected by the writer. Resser (1938), by including the uppermost massive limestone (Oder's Maynardville formation) within the Nolichucky, regards the entire formation as Upper Cambrian (Croixian).

The yellow to greenish brown soil derived from the Nolichucky shale is quite fertile and where it is not developed as the concave slopes of the Knox ridges, is suitable for extensive agriculture. The slopes must necessarily be used for intensive agriculture (primarily tobacco) or for grazing purposes.

Ordovician System

The rocks constituting the Ordovician system in the Graveston Quadrangle are predominately calcareous. Some are pure limestones (Mosheim and Holston formations), some dolomitic limestones and dolomites (Knox formation), some calcareous siltstones (Moccasin limestone), and some calcareous shales (Sevier shale).

The Ordovician system begins with the upper part of the Knox formation. However, because this formation is a time transgressing unit (the basal portion is Upper Cambrian), the formation is included here under the Ordovician system and the problem of the Cambrian-Ordovician boundary is discussed below. The upper stratigraphic limit of the

Ordovician rocks within the quadrangle is marked by the Sevier shale. The Ordovician rocks are areally the most prominent ones within the quadrangle.

The age relationships and correlation of the formations above the Knox dolomite are much disputed and present one of the major problems of the stratigraphy of the southern Valley and Ridge Province. The units of Ordovician stratigraphy present in the Graveston Quadrangle in ascending order are: the Knox dolomite; the Mosheim limestone; the Lenoir limestone; the Holston formation; the Moccasin limestone; and the Sevier shale. Since their original description by J. M. Safford (1869) they have been subject to numerous discussions and revisions and the problem is still unsettled.

Knox Dolomite

The name Knox dolomite was proposed by Safford (1869) for the 4,000 feet of dolomite exposed in Knox County, Tennessee. The name was first used by him in his "Geology of Tennessee". Exposures of the formation are found in Tennessee, western North Carolina, and northwestern Georgia. It is areally the most widespread unit in the southern Valley and Ridge Province.

The Knox dolomite as exposed in the Graveston Quadrangle is made up of massive-bedded, fine-grained dolomites or magnesium limestones with some shale and sandstone present

THREE CLASSIFICATIONS OF THE KNOX DOLOMITE

	CHICKAMAUGA GROUP			
	U.S.G.S.	ODER	HALL-AMICK	
ORDOVICIAN	Mascot dolomite	Jefferson City	Thorn Hill	KNOX GROUP
	Kingsport limestone	Cotter-Powell	Forked Deer	
	Longview dolomite	Nittany	Nittany	
	Chepultepec dolomite	Chepultepec		
CAMBRIAN	Copper Ridge dolomite	Copper Ridge	Copper Ridge	
	CONASAUGA GROUP			

Figure 5

in lesser amounts. Some of the layers are silieeous in the form of chert nodules or banded masses. The lower strata of the formation are marked by heavy beds of oolitic limestone.

Two factors have caused a series of detailed studies of the Knox dolomite. Because it is time transgressing (it transcends the Cambrian-Ordovician boundary), it has been viewed academically in order to correlate it with other formations. Because the formation contains commercial quantities of sphalerite in the Mascot-Jefferson City district to the southeast, it has been studied from the economic aspect. As a result of the detailed consideration given the formation, there are three generally accepted classifications of the Knox group. They are listed here in order of their publication and not by any other manner of preference: (1) the Hall-Amick classification (Hall-Amick, 1934); (2) Oder's classification (Oder, 1934); (3) the U.S.G.S. classification (Rodgers and Kent, 1948). There has been no attempt to date at a detailed correlation to prove the equivalency of the rocks. Because local names have been used for the stratigraphic members, the U.S.G.S. classification is generally used in preference to the other systems.

In the Graveston Quadrangle it was not feasible to map the individual members of the Knox group. A complete fresh section of the formation is not exposed and were it so, it would have been exceedingly difficult to trace and correlate

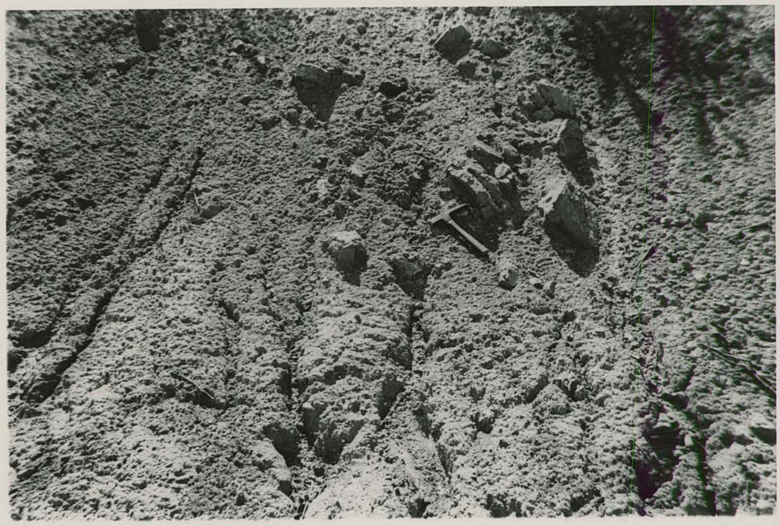


Figure 6

Sandstone marking the Cambrian-Ordovician Knox boundary

Figure 7

Muddy laminae in Knox exposed by differential weathering it with the nearest described section which is approximately thirty miles to the northeast. However, an attempt has been made by the writer to divide the Knox group into its Cambrian and Ordovician members on the basis of a thin, but prominent, sandstone at the base of the Chepultepec member.

Within the Graveston Quadrangle, the Knox finds topographic expression in three ridges which parallel the general northeast-southwest strike of the region. The Knox dolomite formation constituting these ridges has a 30 to 40 degree dip to the southeast. These are Hinds Ridge, Buffalo Ridge, and Copper Ridge. They are low, rounded knobs and ridges which contain numerous sink holes where the calcium content of the rock is higher. Upon weathering, the exposed formations create a physiographic appearance known as "pinnacle weathering". Complete weathering forms a dark red, clayey soil that is in most places covered or imbedded with the more resistant residual chert. The red coloration results from the oxidation of small amounts of pyrite that were present in the original rock. The less cherty members of the Knox form a soil that is suitable for agriculture. However, those soils with a heavy covering or imbedding of chert residuum are usually reserved for pasture to eliminate the impractical job of clearing the fields.

The Cambrian portion of the Knox dolomite was named the Copper Ridge by Ulrich (1911) for its exposures at Copper

Figure 8

Chert debris remaining from weathering of Knox dolomite

Ridge (Thorn Hill) northeast of Knoxville. The Copper Ridge member is about 900 feet thick at the type area (Rodgers and Kent, 1948). The basal beds of the Cambrian member are a gray dolomite with inclusions of dark, coarse oolite. The dark gray, granular dolomite with its interbedded thin lighter-colored, finer-grained dolomite persists throughout much of the member. The darker-colored dolomite gives off an asphaltic odor in a fresh sample. However, because members of the Ordovician portion of the Knox similarly have this characteristic, it is not a diagnostic feature. The upper portion of the Copper Ridge member is a lighter-colored dolomite with considerable quantities of oolitic chert. Fossil remains in the Cambrian member of the Knox are limited, with Cryptozoon being present in the lower part.

The Ordovician portion of the Knox (U.S.G.S. classification) consists of the Chepultepec dolomite, the Longview dolomite, the Kingsport limestone, and Mascot dolomite. From the base of the Chepultepec, the formation was mapped by the writer as Ordovician Knox with no attempt being made to subdivide the formation further. The Copper Ridge-Chepultepec boundary as drawn by Rodgers and Kent (1948) is at the base of the lowermost prominent sandstone bed. This contact was drawn by the writer in Graveston Quadrangle with some uncertainty because the deep weathering of the formations in the oolitic and dolomitic zones had obscured the sandstone in most places with float and residual soil.

The members of the Ordovician portion of the Knox are chiefly light-gray, fine-grained dolomite with interbedded thick limestones and coarse-grained dolomite. Silty laminae present in some of the members commonly stand out in relief upon differential weathering. A soil which is thickly covered with residual chert attests to the high silica content of the middle Knox (Ordovician) members. The contact between the Kingsport limestone and the Mascot dolomite is marked by a chert-matrix sandstone, which was not found in place in the Graveston Quadrangle. However, this contact is of importance in the Mascot-Jefferson City vicinity. It is along this contact that much of the sphalerite mineralization has occurred in that area. Fossils are similarly scarce in the Ordovician portion of the Knox and although none were collected by the writer, a varied fauna has been reported by Oder (1934).

Chickamauga Formation

The Chickamauga formation was named by Hayes (1891) for the 1,200 to 1,800 feet of blue limestone exposed along Chickamauga Creek east of Chattanooga, Tennessee, and was designated to include all the rocks occurring between the top of Knox dolomite and the base of the Rockwood (Ordovician-

Silurian) shale. The formation is exposed throughout east Tennessee, northern Alabama, northwestern Georgia, and southwestern Virginia. The Chickamauga has subsequently been divided into several smaller formations, and the original term is used in a general or restricted sense only. In this paper the "Chickamauga" is regarded as a group and the "Chickamauga formation" pertains to the lower formations of the group; i.e., the Mosheim and Lenoir limestones. Thus, by the restricted definition, the Chickamauga extends from the top of the Knox dolomite to the base of the Holston formation.

The basal unit of the Chickamauga, the Mosheim limestone (Ulrich, 1911), is a dense, blue, fine-grained limestone that is distinctively marked by "eyes" and veins of pure calcite. The formation is highly soluble and, as a result, is found primarily in the lowlands. Karst topography is associated with the formation. Campbell Cave, southwest of Graveston, has been developed in this formation. It has abundant fossil remains of the coral Tetradium.

The Mosheim limestone is conformably overlain by the Lenoir limestone, a more resistant and more highly fossiliferous formation which includes sponges, gastropods, and cephalopods. The gastropod, Maclurites, is especially common in the Lenoir formation. The lenoir weathers to a nodular, earthy, light gray rock.

Figure 9

Steeply dipping Chickamauga limestone

Figure 10

Sink hole formed in Chickamauga limestone. Note the growth of cedars on the limestone soil.

The Mosheim is found unconformably overlying the Knox dolomite, and is conformably overlain by the Lenoir limestone. However, the two formations often grade into one another suggesting that they both are facies of the same formation. In some localities the Mosheim is absent and the Lenoir lies unconformably over the Knox dolomite. Although the age of the two formations is debatable, they are most generally accepted to be Chazy.

There are four areas mapped as Chickamauga within the Graveston Quadrangle. One area is in the extreme northwest corner where the formation extends into the adjacent quadrangles. The southeastern contact is a faulted one against the Rome formation. Paralleling the highway (33-61) and constituting the underlying rock of Raccoon Valley is another belt of Chickamauga. It is unconformably underlain by the Knox formation. To the south and southeast the fault contact is obscured in most part. Wedges of the Rome, Maryville, Nolichucky, and Conasauga formations have been faulted against the Chickamauga. The third belt of exposures is in the lowland south of Copper Ridge. It is unconformably underlain by the Knox formation and conformably overlain by the Moccasin formation. Included within the Chickamauga is a lentil of the Holston "marble" which occurs with various relationships to the Chickamauga formation. The fourth area of the Chickamauga occurs in the southeastern portion of the area where the exposure pattern further indicates the facies nature of the Chickamauga. The interfingering character of the Chickamauga, Moccasin, and Holston formations is best shown here.

Holston Marble

The Holston marble was named by Keith (1895) for the exposures of variegated marbles along the Holston River, Knox County, Tennessee. The name was first used by him the same year in the U.S.G.S. Knoxville folio. The formation is exposed in eastern Tennessee, western North Carolina, and western Virginia. By geological definition, the formation is a coarsely crystalline limestone, but common quarrying terminology has become generally accepted and the Holston is referred to as a marble. It is mapped as a separate formation from the Chickamauga group because of its distinctive appearance and its economic importance.

The formation as exposed in the Graveston Quadrangle is a highly calcareous, fossiliferous, and coarsely crystalline rock. The color grades from a white or gray in the lower limits to a dark pink in the upper part. The upper limits are marked by a grading of color back to gray or white. Stylolites and slickensides are common, but bedding is indistinct. Fossil remains of brachiopods, crinoids, and gastropods are well preserved and their unaltered appearance gives evidence to support a recrystallization hypothesis without benefit of heat-pressure metamorphism.

The Holston marble is considered by most workers as a bioherm or reef-like deposit. It has a facies relationship with the Chickamauga formation (here regarded as including the Mosheim and Lenoir formations) and this condition is well illustrated in the Graveston Quadrangle where it forms an included lentil. The Holston marble is a highly controversial lithological and stratigraphic formation. In a general geologic section it is regarded as unconformably overlying the Lenoir and is considered to be Chazy in age.

Two belts of Holston marble traverse the quadrangle. The first is a relatively straight belt which parallels the regional strike, passing through the community of Graveston and continuing to the northeast as a part of the Luttrell belt. The second area of exposures enters the quadrangle to the south from the John Sevier Quadrangle and, though bifurcating, also parallels approximately the regional strike. The end of the outcrop is near the town of Corryton. The peculiar facies relationship of the Holston marble is illustrated near its southern limit in the quadrangle. It is found along the highway (33-71) unconformably overlying the Knox dolomite. However, farther to the northeast it is contained within the Chickamauga formation. The thickness of the formation is difficult to determine because it is a reef deposit, thinning in all directions from Clinch Mountain and showing only indistinct bedding and direction of dip.

Since the Holston is a soluble formation its outcrop is frequently marked by karst topography. The rock weathers readily to a fertile, dark red soil. Where the formation is capped by the more resistant Lenoir formation, it forms low, knobby hills.

Moccasin Limestone

The Moccasin formation was named by M. R. Campbell (1894) for the 500 feet of red, argillaceous limestone above the blue Chickamauga limestone and below the Sevier shale exposed along Moccasin Creek in Virginia. The name was first used by him in that year in the U.S.G.S. Estillville folio. The formation is exposed in northeastern Tennessee and western Virginia. Keith (1895) interpreted the Moccasin as a shale facies of the Tellico sandstone to the southeast. Thus, the Moccasin would be a deposit formed in the deeper seas, whereas the Tellico would be a near-shore deposit. Raymond (Schuchert, 1943, p. 324) has correlated the Moccasin with the Lowville of New York.

As exposed in the Graveston Quadrangle, the Moccasin is a red, calcareous siltstone. Some members are highly argillaceous limestones with some light colored shales present.

The Moccasin, like the Rome formation, occasionally exhibits shallow water, primary structural features such as oscillation ripple marks and mud cracks. The formation was mapped as a separate unit because of its ready identification by its distinctive color. The basal members are white or gray siltstone immediately overlain by the red members.

There are three areas of the formation in the Graveston Quadrangle. One is a belt south of Copper Ridge, paralleling the general strike of the region. It is in conformable relationship with the underlying Chickamauga formation and with the overlying Sevier shale. The thickness of the belt is approximately 500 feet. A second area of outcrops occurs in the region to the east and southeast of Corryton. The rocks have been much disturbed and the formation has been thrown into a series of anticlinal and synclinal folds. As a result its stratigraphic position is somewhat confused. It has a conformable relationship with the adjoining formations to the west, south, and east, but is unconformable to the north. To the west and south it is conformably overlain by the Sevier shale. To the east it is underlain by the Chickamauga formation. However, to the north it is faulted against the Sevier shale. A third area of outcrops is exposed west of Rockydale Church in the south-central section of the region. This exposure is unusual in that it presents

Figure 11

Gently dipping, thin-bedded Moccasin limestone a northwest strike, the only one in the quadrangle. It is overlain by the Sevier shale and to the southeast it is faulted against the Chickamauga limestone.

The formation is completely barren of fossils within the quadrangle. The formation outcrops as low hills and it is relatively soluble as evidenced by the presence of several sink holes. It weathers readily to a dark red, clayey soil.

Sevier Shale

The Sevier shale was named by Keith (1894) for the 1,000 feet of calcareous, yellow shale exposed in Sevier County, Tennessee. The name was first used by Campbell (1894) in describing rocks in southwestern Virginia. The formation is exposed in eastern Tennessee, western North Carolina, and southwestern Virginia.

As exposed in the Graveston Quadrangle, the Sevier is a yellow-weathering shale with interbedded strata of fossiliferous limestone. The appearance of the shale is uniform with little or no variation throughout the exposures. The general trend of the three outcrop belts within the quadrangle seems to indicate that they may be parts of a broad uninterrupted belt of the shale to the east.

The broadest belt of Sevier shale in the Graveston Quadrangle parallels the regional strike and has a general dip to the southeast, although the highly contorted beds assume various attitudes. The northern contact is conformable with the underlying Moccasin formation. The southern limit is along a fault where the Sevier shale is adjacent to the upthrown Knox dolomite, Holston marble, Chickamauga limestone, and Moccasin limestone. West of Corryton, a small area of Sevier shale is in conformable relation to the Moccasin limestone. In the extreme southeastern corner of the quadrangle the Sevier shale is exposed in conformable relation with the Moccasin limestone. It here outcrops on the northwest flank of House Mountain which is capped in the John Sevier Quadrangle by Clinch sandstone (Maher, 1948, unpublished manuscript).

As with most of the Ordovician stratigraphy in the southern Valley and Ridge Province, age determination and correlation of the Sevier shale is in question. Schuchert (1943, p. 324) regards it as Early Cincinnatian in age. Wilmarth (1938) apparently accepts Raymond's ideas that the Moccasin correlates with the Lowville of New York since she gives the age of the Sevier shale as late Chazy.

The Sevier shale is the youngest stratigraphic unit exposed in the Graveston Quadrangle. From field observations it seems reasonable to assume that although most of the Ordovician strata exposed in the Graveston Quadrangle have a facies relationship, sedimentation continued uninterrupted from the base of the Mosheim limestone to the top of the Sevier shale.

CHAPTER IV

GEOLOGIC STRUCTURE

Structure of the Valley and Ridge Province

Following the Paleozoic deposition in the Appalachian Geosyncline, the sediments were subjected to intensive compressive forces originating from the south and southeast. The widespread geosynclinal deposits then became a more narrow anticlinal structure intricately folded to form an anticlinorium. Although it is not possible to describe the exact nature of the forces, it is possible to describe the evident results, i.e., the folds and faults.

Rock textures, confining strata, and distance from the loci of force produce varying degrees of complexity of the structural effects. In the northern portion of the Valley and Ridge Province the rock strata are compressed into open folds. Faulting in the competent rocks is rare. In the southern section of the province, however, the competent rocks are sandwiched between the incompetent strata. During the deformational processes the rock strata in the southern Appalachians reached their elastic limit earlier so that faulting was more common.

There is a general uniformity to the structure of the southern Valley and Ridge Province. Most of the strata strike approximately North 60° East and dip to the southeast. Folds of the area are close and some are accompanied by faults which segment the structure into fault blocks. Overturned folds to the northwest are common. The faults, in most cases, are thrust faults, i.e., low angle reverse faults, with the trace running northeast and the fault plane dipping to the southeast at an angle approximating that of the bedding planes. In some localities, minor cross faults occur.

Both the eastern and western boundaries of the southern Valley and Ridge Province are marked by major thrust faults. The Great Smoky Overthrust fault on the east has moved the Pre-Cambrian and Lower Cambrian rocks westward over the Cambrian and Ordovician formations of the Valley and Ridge Province to a distance of twenty miles. On the west, a fault-line scarp separates the Valley and Ridge Province from the Appalachian Plateaus Province. In east Tennessee this scarp is known as the Cumberland Escarpment. The Valley and Ridge strata have been lifted with respect to the Carboniferous rocks to the west.

Special Structural Features of the Graveston Quadrangle

General

The structural features exhibited in the Graveston Quadrangle are characteristic of those in the entire Valley and Ridge Province. All the sedimentary rocks underlying the quadrangle have been folded and faulted. Subsequent erosion has truncated the structures. Most of the strata strike approximately North 60°East with dips which have been observed in various directions and amounts. The average dip is approximately 35 degrees to the southeast.

All of the mapped faults of the quadrangle are thrust faults whose traces are approximately parallel to the regional strike of the strata and whose fault planes dip at an angle approximating the same as that of the regional dip. By reconstructing the folds and observing the nature of the faults, it can be shown that the deforming forces originated to the southeast and that the pressure was transmitted northwestward across the southern Valley and Ridge Province.

Many minor folds and faults were observed in the field in the incompetent members, but are not represented on either the included areal geological map or the structure section because of the limitations of the scale used. However, their presence is important in determining the major structures and the direction of forces that created them.

Folds

Portions of both broad, open folds and tightly closed folds are to be found within the Graveston Quadrangle. Also, there are folds that have been faulted as well as those of incompetent rock materials that have withstood the compressive forces and have yielded to overturning without faulting. The southeast portion of the quadrangle is underlain by the limestones, siltstones, and shales of Middle Ordovician age. These incompetent units were irregularly folded and overturned to the northwest without faulting.

In the vicinity of Buffalo Ridge there is evidence indicating a small faulted syncline with portions of both limbs remaining. To the south of Buffalo Ridge the rocks constituting Comb Ridge, Texas Valley, and Copper Ridge appear to be the southeastern limb of a vast overturned anticline. Both limbs of the oldest formation involved in the structure (the Rome formation) are partly present. The rocks constituting Pine Ridge, Little Valley, and Hinds Ridge are dipping to the southeast without clear evidence as to their relation to the structure. It may be inferred that it is a limb of an overturned structure.

Many small structures are present in the shales, thin limestones, and sandstones. The flexures in these incompetent strata give further evidence of the intensity of the deformational forces which acted upon the region. The Rome formation, the Sevier shale, and the Conasauga shales and thin limestones show a multiplicity of minor flexures within the major folds.

Comb Ridge is composed of a series of major and minor folds. Near the northeastern end of the ridge in the quadrangle, a small syncline is exposed, revealing the Rutledge limestone in the center of the structure.

Faults

Five major faults are present in the Graveston Quadrangle. They are all thrust faults with the stratigraphic throw varying from a few feet (in the case of the intraformational thrust fault in the Maryville limestone south of Comb Ridge) to several thousand feet in the northwestern portion of the area where the Rome sandstone of Pine Ridge is faulted against the Chickamauga limestone. The fault in the Maryville limestone dies out southwest of Bull Run School. Because the fault has such a limited stratigraphic throw, it was impossible to infer its presence except by topographic evidence. In the Pine Ridge fault there is a stratigraphic loss of both the Conasauga group and the Knox dolomite.

South of Raccoon Valley a major fault runs parallel to the highway (33-61) where the Maryville limestone, the Rome formation, the Nolichucky shale, and the Conasauga shales are faulted over the Chickamauga limestones. Fault topography is well illustrated at the Maryville-Chickamauga contact where a fault scarp is visible. The soluble nature of the Maryville limestone has caused the partial destruction of the fault scarp in the development of the knolls of Miller Knobs. The fourth major fault of the area is topographically distinct along the southern limit of Buffalo Ridge. The Rome shale has been overthrust upon the Knox dolomite where subsequent erosion has created a fault-line scarp. The trace of the fault turns northeast to unite with the fault in Raccoon Valley.

The fifth major fault of the area is topographically indistinct. The Knox dolomite and units of the Chickamauga group are overthrust upon the Sevier shale. A fault of limited extent and of uncertain stratigraphic throw occurs near the northeast corner of the area at the southern boundary of Comb Ridge. At this locality, the Rome shale is overlain conformably by the Conasauga shales. The southern limit of outcrops of the Conasauga is at a fault contact where the Rome shale lies on top of the Conasauga.

Other Minor Structural Features

The ridges of the quadrangle occur as a direct response to both lithology and structure. They are underlain by tilted strata, in most cases, and are either capped by or entirely made up of more-resistant rock. The single exception to this hogback structure is Comb Ridge which is a result of complex folding of the sandstones and shales of the Rome formation.

The strike valleys which run parallel to the regional trend of the strata are underlain by the less resistant shales and soluble limestones. Faults in association with the weaker strata have played an important role in determining the position of some of the valleys. For example, the site of Raccoon Valley is determined by both the presence of the relatively weak limestones of the Chickamauga formation and the thrust fault along the southern limit of the valley. Similarly, the course of Bull Run Creek in Texas Valley is determined by both the weak shales and soluble limestones of the Conasauga group and by the fault within the Maryville limestone.

The Rome formation offers a variety of primary structural features. Throughout Comb Ridge, every outcrop exhibits either ripple marked or mud cracked surfaces on the bedding plane. Less obvious is a thin shale unit near the base of the formation which shows raindrop impressions.

Figure 12

Ripple marks exposed in the Rome formation

CHAPTER V

GEOLOGIC HISTORY

General

The geologic history of the Graveston Quadrangle as well as of the entire Valley and Ridge Province can be deduced from the evidence shown by the lithology, paleontology, stratigraphy, and structure of the rock strata. One area of such limited extent cannot show or prove the facts of the history of the entire region, but both local and widespread indications can be combined to give a more complete and accurate presentation.

In Pre-Cambrian time, a mountainous, unstable landmass, Appalachia, existed to the east and southeast of this area. Appalachia no longer exists, but the locality is directly represented by the Piedmont Province, the Coastal Plain Province, and the Continental Shelf. No Pre-Cambrian rocks of a westward extension of Appalachia are exposed in the Graveston Quadrangle.

To the west of Appalachia in Pre-Cambrian and Paleozoic time lay a broad (70 to 100 miles) trough extending from Canada to central Alabama, occupied by a shallow sea which advanced and withdrew many times. Into this shallow sea were deposited the eroded materials from Appalachia and the more stable interior of the continent, forming the earliest Paleozoic sedimentary strata. Coarse clastic sediments were in abundance in the earliest portion of the sedimentation cycle, but as the streams reduced their divides and subsequently their loads, the mineral matter in solution came into prominence. The chemical reaction of fresh water streams entering a marine body brought about the precipitation of these soluble materials and created vast calcareous and dolomitic deposits.

Appalachia was highly unstable as shown by the character of the sediments in the geosyncline. Formations of chemical precipitates are overlain by coarse clastic sediments indicating a transition from a time of little erosive activity to one of great diastrophism in conjunction with intensive and extensive erosion.

The Appalachian Geosyncline was similarly unstable. Following periods of subsidence in a direct response to isostatic adjustment, there would be a rise in the elevation permitting sub-aerial erosion. Later subsidence and deposition would be separated from the earlier by the erosional unconformity developed.

These movements were culminated in a vast uplift with the geosynclinal sediments warped into a mountain range, the ancestral Appalachian Mountains. This uplift is accepted as marking the close of the Paleozoic era.

Since the close of the Paleozoic era, the history has been that of a series of peneplanations and uplifts, which destroyed the ancestral Appalachian Mountains and formed the present ones with at least three erosion surfaces marking periods of extensive erosion or interrupted peneplanation (Fenneman, 1936).

Cambrian History

The oldest stratigraphic unit exposed in the Graveston Quadrangle is the Rome formation, the basal member of the Cambrian period. The presence of notable primary structural features, i.e., mud cracks, oscillation ripple marks, and rain drop imprints, indicates clearly its deposition in a quiet and, at times, in an extremely shallow sea. Faunal studies have shown that the sea advanced from the north. This shallow sea withdrew and a period of sub-aerial erosion closed the Early Cambrian deposition.

The readvancing sea was changeable in its nature; at times clear and shallow enough to permit the development of a varied invertebrate life. The great thicknesses of chemical precipitates and the lenses of shales, indicate, respectively, deep, clear seas and deep or shallow muddy phases. The three formations constituting the Middle Cambrian sedimentation, the Rutledge, Rogersville, and Maryville, are generally conceded to be facies deposits in the same marine body but under changing geographic and/or climatic conditions. Then, with no erosional unconformities present, they are necessarily differentiated on lithologic and faunal evidence.

Because the earliest Ordovician deposits lie conformably upon the youngest Cambrian formation (the basal member of the Knox dolomite being Late Cambrian in age) the unanswered stratigraphic question of an exact, widespread Cambrian-Ordovician boundary has arisen.

Ordovician History

The deposition of dolomitic limestone that began during the Cambrian continued uninterrupted throughout the Early Ordovician, developing a great thickness of sedimentary material in the stable Appalachian Geosyncline. A broad uplift and subsequent erosion before subsidence created an easily recognizable boundary marker between Early and Middle Ordovician time.

The Middle Ordovician deposits constitute a complex stratigraphic problem yet to be solved. They are considered to be facies deposits in the same sea whose presence and nature were determined by existing conditions of geography, climate, and the sea, locally. The Holston marble deposits are considered to be reef deposits formed in shallow, clear water where an abundance of invertebrates could thrive. Changing conditions of the sea could alter or deter the reef development and, in the case of a deepening of the water, prohibit any further growth and bury it beneath the Moccasin or, possibly, the Sevier facies, the youngest unit exposed in the Graveston Quadrangle.

The Appalachian Geosyncline was slowly rising late in the Ordovician period and deposition became less prominent. This uplift was culminated by the Taconic Disturbance of the northeastern Appalachian region and with a general emergence elsewhere on the continent. An unconformity marks the Ordovician-Silurian boundary in some areas.

Post-Ordovician History

Deposition continued in the Appalachian geosyncline with minor diastrophic activity developing time boundary markers between some formations. At the close of the Permian period, pressures exerted from the south and southeast compressed the sediments of the geosyncline into a series of sharp folds and created numerous faults. Along the axis of the geosyncline, these folded and faulted Paleozoic sediments were developed into a mountain range. Since the time of the

Appalachian Revolution, no further marine deposition has occurred and the history of the area has been resolved to a series of cycles of erosion and uplift (Schuchert and Dunbar, 1944).

CHAPTER VI

MINERAL RESOURCES

General Statement

The mineral resources of the Graveston Quadrangle are limited to marble, crushed stone, and ground water. Ground water is the most valuable of the three and the only one utilized at the present.

Marble

The Holston marble of this quadrangle is an extension of the Luttrell belt to the northeast. Two narrow belts cross the southern portion of the Graveston Quadrangle, but neither is worthy of exploitation. In most portions of the belts, the marble is concealed by a mantle of dark red residual soil. Thus, a complete and accurate knowledge of the physical characteristics and the limit of its extent is difficult to attain.

Where outcrops are available for study, the marble appears as a medium to coarse grained, calcic rock. The color ranges from white to dark pink, and the weathered surface is gray in color. Invertebrate fossils are present in limited numbers and most can be identified only with difficulty due to partial destruction resulting from the recrystallization of the calcium carbonate rock. The term "marble" has been adopted from the commercial usage denoting a calcic rock that will take a polish. The Holston formation is regarded by geologists as a coarse grained, recrystallized limestone.

The last commercial attempt to procure dimension stone for structural purposes was made in 1927. The extreme jointing, solution channels, and the high water table caused the project to be abandoned. No active quarrying is being pursued at the present writing.

Crushed Stone

The dense, massive limestone and dolomitic members of the Chickamauga and Knox groups were used primarily as road metal. All of the quarries indicated on the topographic and geologic maps of the quadrangle are no longer in operation, but most were developed in these formations in the past in order to produce this material. The surfacing material for the secondary roads is now being brought in from quarries operating in the Chickamauga formation near Luttrell, Tennessee.

Ground Water

Ground water constitutes the most valuable single mineral resource of the quadrangle. All of the inhabitants of the area are dependent upon wells and free-flowing springs for their water supply.

Because of the nature of the rock strata, most of the water is obtained from solution channels and joints in calcareous and dolomitic rocks of the Chickamauga and Knox groups. Some of the supply comes from bedding planes and fault planes of these and other formations.

The Ground Water Division of the United States Geological Survey is at present conducting a program to determine the ground water conditions and the reserve in East Tennessee. Upon completion of this project, a more accurate evaluation of the ground water conditions of the Graveston Quadrangle can be formulated.

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APPENDICES