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Stratigraphy and Structure of the Millican Creek Area, Sevier County, Tennessee

James R. Marie
University of Tennessee, Knoxville

To the Graduate Council:

I am submitting herewith a thesis written by James R. Marie entitled "Stratigraphy and Structure of the Millican Creek Area, Sevier 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.

R. E. McLaughlin, Major Professor

We have read this thesis and recommend its acceptance:

Harry J. Klepser, George D. Swingle

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Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

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

August 9, 1963

To the Graduate Council:

I am submitting herewith a thesis written by James R. Marie entitled "Stratigraphy and Structure of the Millican Creek Area, Sevier County, 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.

R. E. McLaughlin
Major Professor

We have read this thesis and recommend its acceptance:

Harry J. Klepser

George D. Swingle

Accepted for the Council:

Hilton A. Smith
Dean of the Graduate School

STRATIGRAPHY AND STRUCTURE OF THE MILLICAN CREEK AREA, SEVIER COUNTY, TENNESSEE

A Thesis

Presented to

the Graduate Council of

The University of Tennessee

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

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by

James R. Marie

August 1963

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CHAPTER I

INTRODUCTION

Location and Size of the Millican Creek Area

The Millican Creek area, named for a small stream which traverses the region, is located in the northeastern portion of Sevier County, Tennessee, approximately twenty miles east of Knoxville (Figure 1). The area is situated within the Tennessee section of the Valley and Ridge physiographic province (Fenneman, 1938, pp. 265-276) about eight miles northwest of the foothills of the Great Smoky Mountains. The mapped area (Plate 1), which encompasses about twenty-five square miles, is represented within the Kykers Ferry (156-NE) 7-1/2 minute topographic map published jointly by the Tennessee Valley Authority and the United States Geological Survey.

Local Topography and Drainage

The topography of the Millican Creek area is typical of that developed upon rocks of the eastern clastic phase of the Middle Ordovician sequence in East Tennessee. The topographic expression is characterized by lines of high elliptical knobs and elongate ridges aligned parallel to the strike of the bedrock. The rock is composed chiefly of interbedded sandstones and siltstones. These knobs and ridges are quite asymmetrical, the slope of the scarp face far exceeds

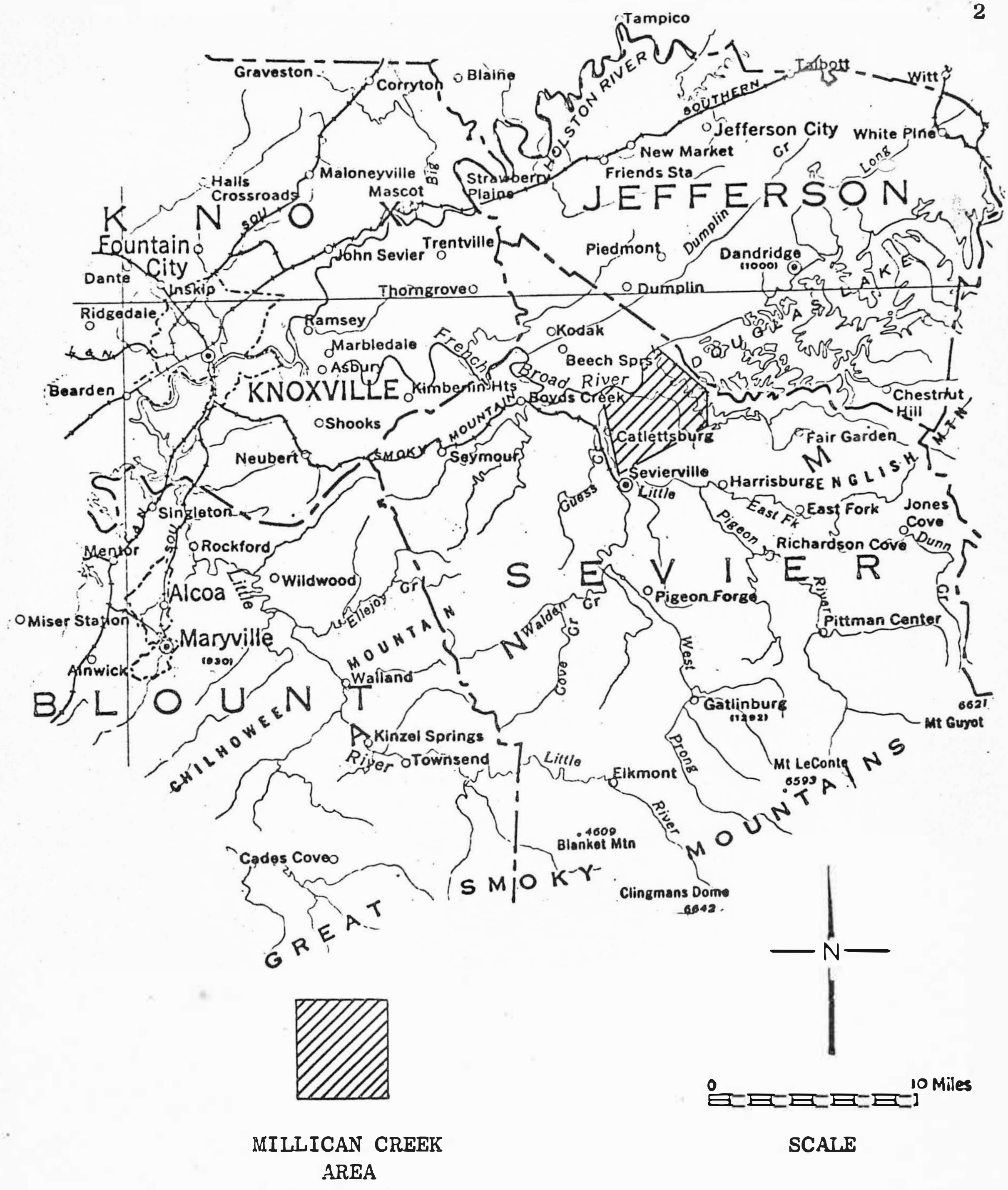

Figure 1. Location of the Millican Creek Area.

that of the dip face. Interspersed with these knobs and ridges are exceedingly steep-sided ridges and spurs that are elongated at right angles to the strike of the beds. These beds are predominantly shale and interbedded calcareous siltstone. Here it appears that erosion has been controlled to a great degree by steeply dipping joints which trend parallel to the dip of the bedrock. The narrow, deep valleys which lie parallel to the strike of the beds are formed on the erosionally weaker beds or along fracture zones.

In sharp contrast to the knobby country of the central and southern portions of the area, a rather subdued, slightly rolling, and moderately karst topography is developed in the argillaceous limestones and dark-gray shales in the extreme northern part of the area.

In the north central portion of the mapped area there is a large abandoned meander of the French Broad River. Most of the floor of the meander scar is underlain by a relatively thick blanket of terrace material ranging in size from clay to cobbles. Other isolated terrace deposits occur throughout the mapped area; however, they are more abundant in the northern section.

The maximum relief within the area is about 400 feet.

The region is well drained by the French Broad River and many of its tributaries, most of which are deeply intrenched.

Previous Investigations

The Millican Creek area was mapped by Keith (1895) as a part of the Knoxville Folio in the Geologic Atlas of the United States.

Keith's stratigraphic section within the Millican Creek area consists of the Chickamauga Limestone, the Athens Shale, the Tellico Sandstone, and the Sevier Shale (Figure 2).

The area was also included in the geologic map of the Douglas reservoir by the Tennessee Valley Authority (1943) with geology by H. Wedow. Wedow mapped three units within the area: (1) the Lenoir Limestone, (2) the Athens Shale, and (3) the Sevier Formation (Figure 2).

Rodgers (1953, pp. 76-82) described a number of units from this strike belt, but "proposes to return to the original meaning of the term Sevier and apply it to the whole mass of shale where undivided" (p. 78). Rodgers states (p. 78) that he believes the Sevier thus defined includes equivalents of the typical Lenoir, Holston, Athens and Ottosee units.

Laurence (1944) described an Early Ordovician sinkhole about 300 feet deep in the extreme northern portion of the area at Douglas Dam. The sinkhole is developed in the upper part of the Knox Group and is filled with volcanic ash and shaly dolomite.

Bridge (1955) mapped a section of the Ordovician strata which crops out along the north shore of Douglas Lake approximately one mile northeast of the present mapped area. Bridge described seven stratigraphic units within that area (Figure 4).

Neuman (1955) mapped the Tellico-Sevier belt which adjoins the Millican Creek area on the southwest. Neuman described eleven formations and members within this belt, but only eight of these presumably extend into the present mapped area (Figure 4).

Keith, 1895	Wedow, 1943	Present Report
Sevier shale	Sevier formation	Yellow Weathering Shale Sequence
Tellico sandstone		Dark Siltstone and Sandstone Sequence Upper Shale Unit Middle Sandstone Unit Lower Shale Unit
Athens shale	Athens shale	Dark-gray Shale Sequence Sandstone Unit Cobbly Limestone Unit Dark-gray Graptolite Bearing Shale Unit
Chickamauga limestone	Lenoir limestone	Limestone Sequence Pyritic Facies Argillaceous Bedded Limestone Facies Argillaceous Cobbly Limestone Facies
	Mosheim member	Calcarenite Facies Calcilutite Facies Dolomite Facies Basal Clastic Facies

Figure 2. Classification of Middle Ordovician rocks of the Millican Creek Area.

Purpose of the Present Investigation

The purpose of the present study was two fold. First, and most important, was to determine if less generalized mappable units than had been previously described could be defined within the Middle Ordovician section. Secondly, if subdivision was possible, a geologic map and related cross-sections were to be constructed showing the areal extent of the mappable units and the interpretation of the relationships of these units.

Present Investigation

The present investigation was undertaken in March, 1962 and was continued intermittently until July, 1963. Field data were gathered by employing accepted geologic methods and by following the general plan as outlined below:

1. A search and subsequent study of the literature was made in order to gain an understanding of the broad features of the geology and geography of the area.

2. A general reconnaissance was made along all of the public roads within the area.

3. A traverse was made on foot along both banks of the Flat Creek embayment. An additional traverse was made by boat along Flat Creek to examine otherwise inaccessible outcrops.

4. Supplementary traverses were made between the initial road traverses and the Flat Creek traverse in order to obtain further control.

5. All stratigraphic units and possible major fault zones were walked out along strike where possible.

CHAPTER II

STRATIGRAPHY

Local Stratigraphy in General

The rocks exposed within the Millican Creek area are of sedimentary origin and range in age from Early to Middle Ordovician. The rocks of Early Ordovician age are assigned to the upper part of the Knox Group and consist chiefly of interbedded bluish-gray, very fine-grained limestones and pale-gray, fine-grained dolomites. The rocks of Middle Ordovician age range from relatively pure limestones through very fine-grained clastic rocks to coarse-grained sandstones. All of the clastic rocks, which form the bulk of this sequence, are calcareous to a degree.

A very prominent disconformity marks the boundary between the Early and Middle Ordovician. This disconformity, herein named the Bridgean Disconformity in honor of the late Josiah Bridge who studied this feature in considerable detail, represents a time of undetermined length during which the rocks of Early Ordovician age were subjected to subareal erosion prior to the deposition of the Middle Ordovician rocks.

Rocks Underlying the Middle Ordovician Section

The rocks underlying the Middle Ordovician section were not studied in detail during this investigation; however, they are assigned to the Mascot Formation (Bridge, 1955, pp. 725-726) which is the upper unit of the Knox Group. The Mascot Formation is of Early Ordovician age. It consists chiefly of interbedded bluish-gray, very fine-grained to aphanitic limestones; pale-gray, fine-grained dolomites; beds of "ribboned" dolomite and limestone; and thin, discontinuous zones of fine-grained, well rounded and frosted quartz sands cemented within a calcareous matrix.

The contact between the Mascot Formation and the overlying Middle Ordovician rocks is marked by the prominent disconformity noted previously. This disconformity is characterized by a distinct change in lithology; that is, from relatively uniformly bedded, pure limestones and dolomites below to extremely unevenly bedded, rubble and chert conglomerates, dark-gray to black shales and dolomites, and fine-to coarse-grained calcareous sandstones above.

The Mascot Formation is about 525 feet thick in this general region (Bridge, 1955, p. 726); however, only the upper few hundred feet are included within the mapped area.

The Middle Ordovician Section

At present there is much controversy concerning the stratigraphy of the Chickamauga and equivalent rocks in the Southern Appalachians. This controversy has run the gamut in both subdivision and correlation. Rodgers (1953, pp. 64-68) has ably outlined the various views concerning this problem and their historical development.

Differences of opinion regarding Chickamauga subdivision and nomenclature stem from the particular stratigraphic emphasis employed by various workers. Some geologists (Rodgers, 1953) consider the stratigraphy of the Chickamauga from a lithologic view point; others (G. A. Cooper, 1956) have developed systems based largely upon paleontologic evidence; while a few geologists (Neuman, 1955) have attempted to assimilate both kinds of evidence into a more reasonable approach to the solution of the problem. Workers employing these three approaches have introduced many stratigraphic names into the literature (Figures 2 and 4) and as a result have created much confusion and debate.

In view of this controversy and the complexity of resulting nomenclature, the present investigator has elected to describe the stratigraphic units in the Millican Creek area independently of previous terminology and to tentatively correlate these units with existing named formations and members.

Limestone Sequence

The Limestone Sequence which forms the lower stratigraphic unit of the Middle Ordovician rocks of the area exhibits extremely complex facies relationships (Plate 2). Seven distinct lithofacies are known within this unit: (1) Basal Clastic Facies, (2) Dolomite Facies, (3) Calcilutite Facies, (4) Calcarenite Facies, (5) Argillaceous Cobbly Limestone Facies, (6) Argillaceous Bedded Limestone Facies, and (7) Pyritic Facies. All of these units may be seen at the head of a small valley about 2,000 feet south-southeast of Douglas Dam (Tennessee rectangular coordinates 2,730,050E-578,350N). Except for the Basal

Clastic Facies and the Pyritic Facies, these lithofacies are quite variable in thickness, lateral variation, and stratigraphic position within the Limestone Sequence. The Basal Clastic Facies is as the name implies a clastic unit resting upon the disconformity. The Pyritic Facies, on the other hand, forms the uppermost unit in the Limestone Sequence in every outcrop in which it was observed. The Argillaceous Cobbly Limestone Facies and the Argillaceous Bedded Facies usually compose about 70 per cent of the sequence. The total thickness of the Limestone Sequence ranges from approximately 35 to 110 feet, but averages about 80 feet.

Basal Clastic Facies. This unit contains several rock types: (1) a chert or limestone-pebble conglomerate in a matrix of limestone or dolomite; (2) a dark-gray, sandy dolomite; (3) a light-to dark-gray, sandy limestone; and (4) a dark-gray fissile shale.

The chert conglomerates are of two general types. One is a dark-gray, fine-grained, thick bedded dolomite containing angular fragments and/or large weathered masses of chert which stand in high relief upon the surface of the weathered rock. The other is a dark-to light-gray, fine-to medium-grained, thick bedded, arenaceous limestone also containing angular fragments and/or masses of chert. This arenaceous limestone weathers to a light-gray, granular appearing rock with the chert standing in high relief upon its surface.

The dark-gray to gray-black shales form local interbeds less than one inch thick throughout the basal unit and also occur as breccia and fracture fillings a few feet stratigraphically beneath the top of the Mascot Formation.

None of the occurrences of this unit are well enough exposed along strike to permit defining their exact relations; however, the deposits are assumed to be lenticular and to lie in depressions upon the erosional surface of the Knox Group as suggested by Bridge (1955, p. 727). All of the units of the Basal Clastic Facies grade vertically into the overlying lithofacies of the same unit or into overlying units. This facies ranges from a feather edge to about eight feet in thickness.

A few small _Lingula-type_ brachiopods were observed in the dark-gray shales.

Dolomite Facies. The dolomite of this facies is dark-to light-gray, thick bedded, and locally arenaceous. Except for the absence of chert, it is similar to the dolomites of the underlying Basal Clastic Facies. This unit is very thin and lenticular and grades laterally and vertically into other members of the sequence.

A high-spiraled gastropod _?Subulites regularis_ Ulrich and Scofield was observed at several localities.

Calcilutite Facies. The Calcilutite Facies is a massively bedded, dove-gray, aphanitic limestone. Locally, this limestone contains numerous small isolated calcite crystals and gastropod molds filled with crystalline calcite. The unit is rather thin and lenticular and grades both laterally and vertically into the other members of the sequence.

The gastropod Maclurites magnus? Lesueur was found in almost every outcrop of this unit.

Calcarenite Facies. The Calcarenite Facies is composed of two distinct rock types. One type is a pink to gray, coarsely crystalline calcarenite containing abundant brachiopod fragments. The other is a dark-gray, coarsely crystalline, fossiliferous, limonitic calcarenite. Both lithofacies are quartz free. The pink calcarenite generally occurs stratigraphically below the darker facies where both are present in the section. The calcarenites form lenses a few feet thick which grade laterally and vertically into the adjoining lithofacies.

Fragments of brachiopods, gastropods, and crinoid columnals were observed in the dark-gray calcarenite; but only fragmental brachiopods were found within the pink variety.

Argillaceous Cobbly Limestone Facies. This unit is a light-to dark-gray, fine-to coarse-grained, argillaceous, locally pyritic, cobbly limestone which contains abundant fragmental organic debris. Upon weathering, the cobbles are generally freed from the shaly matrix and litter the surface of the ground over large expanses of the outcrop belt. This lithofacies commonly comprises about 50 to 60 per cent of the Limestone Sequence, and appears to grade both laterally and vertically into adjacent lithofacies.

The fauna of this facies is large and diverse. Brachiopods, cephalopods, trilobites, ostracods, and bryozoans and crinoidal debris are quite abundant. Excellently preserved specimens of Pliomerops *canadensis* Billings (A. R. Palmer, written communication, 1962) were collected about 2,000 feet east-southeast of Douglas Dam (T. R. C. 2,731,150E-579,350N) within a zone about two feet thick and approximately two feet stratigraphically above the Bridgean Disconformity. Species of *Maclurites magnus?* Lesueur were observed at a number of localities within this lithofacies as were *Valcourea* sp. A number of specimens of *Bimuria superba?* Ulrich and Cooper were collected from the upper portion of this facies.

Argillaceous Bedded Limestone Facies. This member is a dark-to light-gray, argillaceous, locally micaceous and hematitic, fossiliferous limestone that occurs in thin, even beds. The rock is extremely hard and compact, and upon weathering breaks into large flagstone-like blocks. The upper few feet of this member weather to a compact orangish-yellow saprolite in which there is an abundance of well preserved molds of fossils. Locally within the saprolite there are small pockets and lenses of medium-to coarse-grained, heavy mineral-bearing sands. These sands are composed mainly of quartz (both clear and rose varieties); but also contain zircon, tourmaline, hornblende, magnetite, and garnet.

These thin-bedded limestones contain numerous cephalopods *(?Orthoceras)*, brachiopods (*Oligorhynchia* sp.), and bryozoans and crinoidal debris.

Pyritic Facies. The Pyritic Facies where present forms the upper lithofacies of the Limestone Sequence. Characteristically it is a dark-gray, fine-grained, argillaceous, locally conglomeratic, fossiliferous, pyritic limestone which weathers to a conspicuous rusty ledge. This member averages about one foot thick at a point approximately 2,000 feet south of Douglas Dam, but thickens toward the northeast along strike. A few miles to the northeast of the thesis area, its thickness has increased to about six feet and numerous prospect pits mark its trace. Where outcrops are scarce, this bed may be easily traced along strike by the large blocks of manganiferous limonite float which are produced as a result of weathering.

The contact between the Pyritic Facies and the overlying dark-gray, graptolitic shale generally appears gradational; however, at one locality (T. R. C. 2,731,250E-579,050N) the contact is disconformable (Figure 3). At this locality a channel about ten feet deep has been eroded through the Pyritic Facies and subjacent members and into the Argillaceous Cobbly Limestone Facies. Cobbles of the Pyritic Facies, as well as cobbles of numerous other beds within the Limestone Sequence, and blocks of light-gray dolomite which are lithologically similar to the underlying Mascot Formation are incorporated within the shale which fills the channel.

Dark-gray Shale Sequence

Overlying the Limestone Sequence is 600 to 700 feet of dark-gray shale; lenses of dense, gray limestone; and thin-bedded, fine-grained sandstone. These rocks collectively form a mappable unit, which can be subdivided into three distinct lithofacies zones. The lower zone consists of shale. The middle zone contains interbedded limestone and

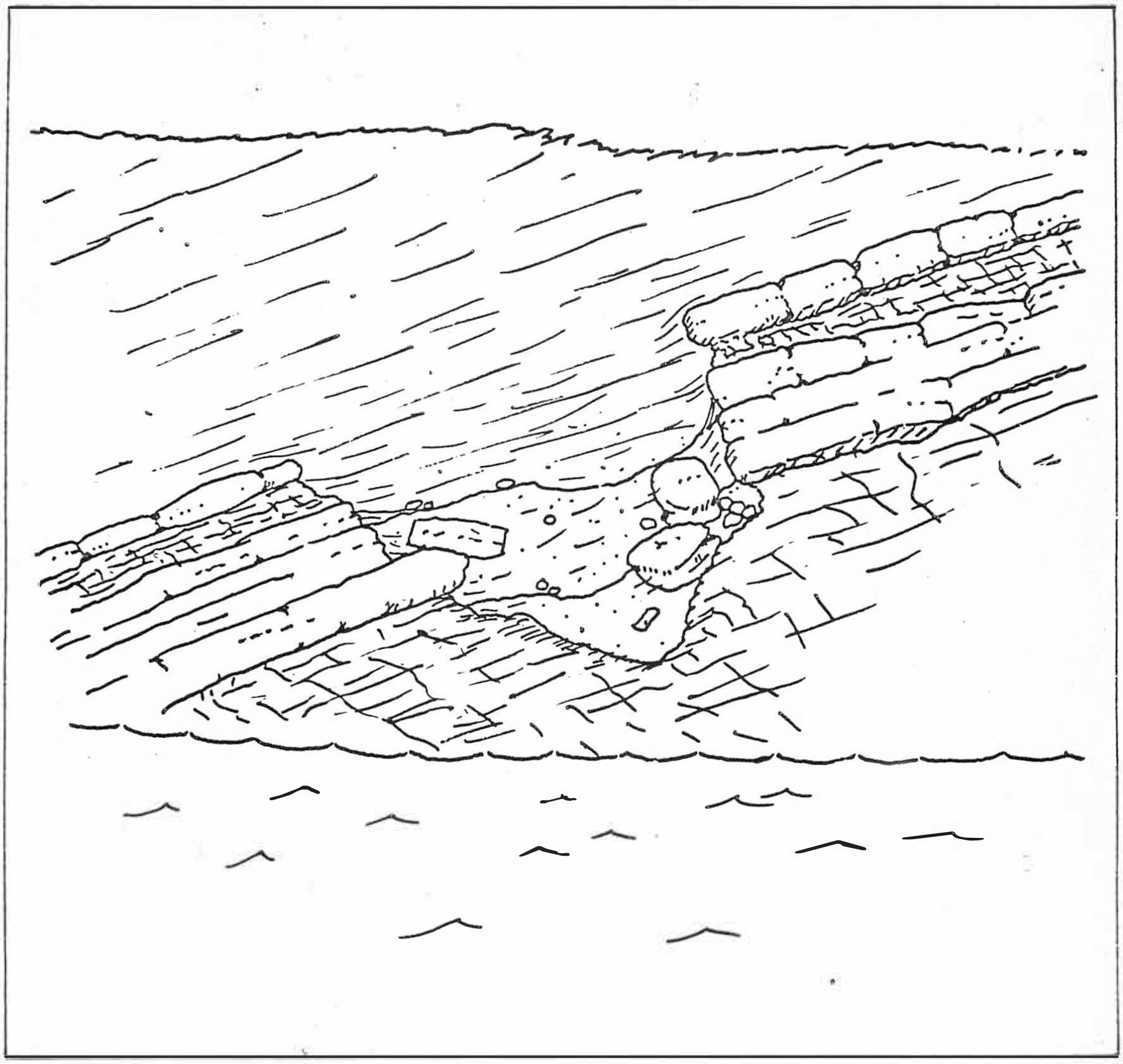

Figure 3. Generalized sketch of channel defining the disconformity between the Dark-gray Shale Sequence and the Limestone Sequence, south side of Douglas Lake, Tennessee. The sketch shows the ten foot deep channel as it is exposed when the lake is at an elevation of 940 feet. The view is toward the southeast.

shale. The upper zone is composed of interbedded sandstone and shale.

Dark-gray, Graptolite Bearing Shale Unit. The dominant rock type of the Dark-gray Shale Sequence is a finely laminated, micaceous, graptolite-bearing shale. The weathered shale is gray-brown or chocolate brown, thinly fissile, and extremely brittle. The member grades laterally and upward into the overlying Cobbly Limestone Unit. The shale is quite contorted and fractured.

Graptolites of the Athens or Normanskill type are abundant throughout the shale; however, the greatest number of well preserved individuals occur in a zone about sixty feet below the top. Three identifiable genera, *Climacograptus*, *Dicellograptus*, and *Diplograptus*, are present in this zone.

The thickness of this unit was calculated from field data and found to be approximately 800 feet. The present author considers this thickness to be excessive in view of the numerous folds and faults occurring throughout the unit, and would suggest that the true thickness is probably closer to 500 or 600 feet.

Cobbly Limestone Unit. The Cobbly Limestone Unit forms a zone about fifteen to twenty feet thick in which numerous thin beds and lenses of dense, fine-grained, gray limestone are interbedded with dark-gray, graptolite bearing shales identical to those of the subjacent member. This member is quite persistent and may be traced along strike for a considerable distance.

These limestone beds are sparsely fossiliferous and have yielded no identifiable material.

Sandstone Unit. This unit forms a zone about fifty feet thick consisting of thin beds of dark-gray, calcareous, fine-grained sandstone alternating with thin beds of dark-gray, silt-free shale similar to those composing the main body of the Dark-gray Shale Sequence. The proportion of sand increases upward until individual sandstone beds attain thicknesses of three to four feet and the shales form only thin intervening partings.

This member represents a transition zone between the shale beds below and the siltstone and sandstone beds above. Any contact chosen between these two larger units would be an artificial one; however, for mapping purposes the boundary was selected at the highest occurrence of dark-gray shale.

Dark Siltstone and Sandstone Sequence

This sequence is composed of gray, silty, calcareous shales; fine-to coarse-grained, calcareous sandstones; and gray, silty to sandy, limestones and calcarenites. A thick sandstone zone near the middle of the sequence roughly divides this larger unit into three members: (1) the Lower Shale Unit, (2) the Middle Sandstone Unit, and (3) the Upper Shale Unit. These rocks are intricately folded and faulted, thus making an accurate determination of thickness impossible. Along strike to the southwest where these rocks are much less contorted, they have been studied in detail by R. B. Neuman (1955). Neuman (1955, p. 155) states that they aggregate a thickness of from 2,700 to 4,500 feet. Cross-sections of the thesis area constructed by the present investigator suggest a maximum thickness of approximately 3,500 feet for this sequence.

Lower Shale Unit. Light-gray, sandy, calcareous shales and siltstones form the bulk of this member. These rocks weather to yellowish to buff, irregular slabs which range from about one-quarter to one-half inch thick. The slabs show very closely spaced bedding laminae when viewed on edge. Thin-to thick-bedded, fine-grained, light-gray calcareous sandstone is interbedded with the shale and siltstone. Upon weathering most of the carbonate is leached from the rock producing a yellow brown to reddish brown, fine-grained, evenly textured, very cohesive sandstone. Individual sandstone beds range from a few inches to several feet in thickness.

Fossils are generally rare in the rocks of the Lower Shale Unit. The graptolites *Dicellograptus* sp. and *Callograptus* sp. are the most abundant, occurring locally in the shales. The trilobite *Isotelus* sp. was observed at a few localities, predominantly in the sandy zones. The sandy zones also yielded a few ostracodes. Locally, however, the siltstones abound in specimens of the trace fossil *Fucoides.*

Middle Sandstone Unit. The predominant rock type of this unit is a gray to bluish gray, fine-to medium-grained, evenly textured sandstone. The rock weathers to a yellowish to reddish brown, dense, ferruginous sandstone in which fossil fragments appear as limonitic molds.

These sandstones form lenses a few feet to over a hundred feet thick in which occur thin beds of brownish weathering, gray, fossiliferous siltstones and yellowish weathering, gray shales. Thin beds and lenses of gray, quartzose calcarenite occur throughout the unit.

Only fragments of a large trilobite similar to Isotelus, fragmental brachiopods, bryozoans, and crinoidal debris were observed within this unit.

Upper Shale Unit. This member is quite similar to the Lower Shale Unit, except that the rocks are much lighter in color and contain considerably less coarse clastic material. Light-gray, locally silty, calcareous shales and thin-bedded siltstones are the major rock types. Zones of dark-gray, slightly silty, fossiliferous, calcarenites and argillaceous, cobbly limestones are quite abundant throughout the member, but are thicker and more persistent near the top. Lenses of fine-grained, calcareous sandstone occur locally in the lower portion of the unit.

Fragmental brachiopods and trilobites were the only fossils found within this unit. The graptolites which dominate the fauna of the lower clastic units are conspicuously absent in the Upper Shale Unit.

Yellow Weathering Shale Sequence

This sequence is composed of light-gray, yellow-weathering shales and thin, interbedded siltstones, and is essentially devoid of the coarse clastic material which is so characteristic of the underlying units. Thin zones of gray, very argillaceous, nodular limestone occur near the top of the sequence. These limestones are extremely fossiliferous, containing abundant bryozoan and crinoidal debris, and fragmental brachiopods and trilobites.

Any statement as to the thickness of this sequence would at best be only an estimate, because the entire unit is highly folded, cleaved, jointed, and faulted.

Correlation of the Middle Ordovician Units

The tentative correlations (Figure 4) of the rocks of Middle Ordovician age in the Millican Creek Area are based upon paleontologic and stratigraphic evidence set forth in preceding sections of this chapter. The pertinent information concerning these correlations may be summarized as follows:

1. The Basal Clastic Facies and the Dolomite Facies of this report are correlated with the Douglas Lake Member of the Lenoir (Bridge, 1955, pp. 727-728) on the basis of lithologic similarity and stratigraphic position. No diagnostic fossils were found within these rocks.

2. The Calcilutite Facies is correlated with the Mosheim Member of the Lenoir Formation on the basis of lithologic, stratigraphic, and paleontologic similarities. Specifically, the gastropod Maclurites magnus? Lesueur (Chazyan) was associated with this member throughout its extent.

3. The Calcarenite Facies and the lower portion of the Argillaceous Cobbly Limestone Facies are correlative with the Lenoir Limestone on the basis of lithology and stratigraphy, but more precisely by the faunal assemblage of Valcourea sp., Maclurites magnus? Lesueur, and Pliomerops canadensis Billings.

4. The upper portion of the Argillaceous Cobbly Limestone Facies, the Argillaceous Bedded Limestone Facies, and the Pyritic Facies are correlated with the Whitesburg Limestone Member of the Blockhouse Shale (Neuman, 1955, pp. 148-154) by lithology, stratigraphic position, and the occurrence of the brachiopods Bimuria superba? Ulrich and Cooper and

Douglas Lake Section (Bridge, 1955)	Present Report	Tellico-Sevier Belt (Neuman, 1955)
Not in Report	Yellow Weathering Shale Sequence	Tellico formation
	Dark Siltstone and Sandstone Sequence Upper Shale Unit Middle Sandstone Unit Lower Shale Unit	
/ / / / / / / / / / / / / / Athens shale with limestone member at base	Dark-gray Shale Sequence Sandstone Unit Cobbly Limestone Unit Dark-gray Graptolite Bearing Shale Unit	Blockhouse shale Dark shale member
	Limestone Sequence Pyritic Facies Argillaceous Bedded Limestone Facies Argillaceous Cobbly Limestone Facies	Whitesburg limestone member
Lenoir limestone nodular limestone aphanitic limestone Douglas Lake member	Calcarenite Facies Calcilutite Facies Dolomite Facies Basal Clastic Facies	Lenoir limestone Argillaceous limestone Mosheim member Douglas Lake member

Figure 4. Tentative correlation of Middle Ordovician rocks of the Millican Creek Area with the Tellico-Sevier belt and the Douglas Lake Section.

Oligorhynchia? which are restricted to the Whitesburg and higher units (Cooper, 1956).

5. The three described units of the Dark-gray Shale Sequence are all correlative with the Blockhouse Shale (Neuman, 1955, pp. 148-154) or Athens Shale of older terminology. This correlation is based upon lithologic and stratigraphic similarities and upon the occurrence of the graptolites *Climacograptus*, *Dicellograptus*, and *Diplograptus*, which are all of the Normanskill aspect.

6. The units stratigraphically above the Dark-gray Shale Sequence form a massive lithofacies and are tentatively correlated with the Tellico Formation as defined by Neuman (1955, pp. 154-157) on the basis of lithology and stratigraphy. All fossils observed within this sequence are either long-ranging types or are not well enough preserved to permit identification.

CHAPTER III

STRUCTURE

Regional Structure

The structural framework of the southern Appalachians has been described by many writers, notably, King (1950, 1959), Miller (1945), Rich (1934), Rodgers (1949, 1950, 1953a, 1953b), and Woodward (1957). The following, therefore, is intended only as a brief summary.

The Appalachian structural system, which consists of three broad, sweeping curves, each convex to the northwest, extends from the Gulf of St. Lawrence southward across eastern North America to and beneath the younger rocks of the Coastal Plain. The system may be divided longitudinally into three belts: (1) the Appalachian Plateau belt, (2) the Valley and Ridge belt, and (3) the Blue Ridge-Piedmont belt. This does not, however, imply the existence of three such distinct and separate structural zones.

The Blue Ridge-Piedmont belt embraces the complex zone of metamorphosed igneous and sedimentary rocks which lies between the Valley and Ridge belt and the Coastal Plain. The Valley and Ridge belt consists almost entirely of unmetamorphosed, but intensely folded and faulted, sedimentary rocks. The Appalachian Plateau belt, which lies on the northwest flank of the system, is composed of rocks which are nearly flat, except for outlying folds (Sequatchie anticline) and faults (Pine Mountain fault).

These belts, as mentioned above, are not distinct structural units, but grade into one another. As pointed out by Cloos (1947, pp. 901-910), Kesler (1940, p. 281), and King (1947), the continuous Blue Ridge overthrust of Jonas (1932, pp. 232-233), which supposedly separated the Valley and Ridge from the Blue Ridge, does not exist. These men recognize, in the respective area described, only a northwestward decrease in the nature of the deformation. Likewise, the Cumberland structural front which is supposedly defined by the Cumberland Escarpment and separates the Valley and Ridge from the Appalachian Plateau belt does not exist. The structures of the Valley and Ridge and the Cumberland Plateau merge (Swingle, and others, 1956, p. 1758).

The Appalachians are truly a structural system. All of the geologic events--vulcanism, metamorphism, folding, faulting, erosion, and sedimentation--bear upon the product. The system, therefore, should not be dismembered and its parts examined without a consciousness of their broad relationships with the system.

Structure of the Valley and Ridge Province in General

In East Tennessee, most of the Valley and Ridge province is made up of imbricate fault slices and asymmetrical or northwestwardly overturned folds. Many of the major fault slices are great masses of rock which have been thrust for miles over the underlying rocks along extremely low-angle fault zones. Some of these great sheets of rock, such as those defined by the Saltville and Pulaski faults, may be traced for hundreds of miles along strike. On the other hand, some of the fault slices are merely simple breaks on the flanks of anticlines, resulting when stresses applied to the folds became too great to be withstood by the strata involved.

Two schools of thought have developed in recent years concerning the depth of which the Appalachian deformation extends in the Valley and Ridge province.

The first school, or basement theory, insists that the folds and faults occurring in the Paleozoic sedimentary rocks are simply reflections of adjustments in the underlying Precambrian basement rocks. This theory, as elaborated by Ver Wiebe (1936), holds that each major anticline appearing in the sedimentary column is the direct result of a major upwarp in the basement and that each major thrust fault in the sedimentary rocks is merely the continuation of a similar fault from the basement. In short, the deformation occurred in the basement rocks.

Adherents of the second school (Rich, 1934) suggest that the folds and faults are independent of the basement and that a great portion of the sedimentary rocks have been stripped off the basement along great bedding plane thrust faults by forces acting wholly within the sedimentary rocks. Further, the structures of the Valley and Ridge are only marginal to the greater deformation which occurred to the southeast in the Blue Ridge and the Piedmont.

In recent years, increasing geological and geophysical data indicate that the major portion of the deformation in the Valley and

Ridge province is shallow, and does not extend into the basement, or even into the lowest Paleozoic rocks of the area. There are also indications that the basement rocks are involved both on a local and a regional scale. This suggests that neither of the above mentioned concepts are completely right nor completely wrong. The present writer considers both the "basement" and the "no-basement" theories as the possible extremes, and would suggest that the true Appalachian structural picture lies somewhere between these concepts.

Local Structure in General

The Millican Creek area lies on the northwestern limb of a broad, shallow syncline. The syncline is quite asymmetrical; the rocks of the northwestern limb dip gently to the southeast, while the rocks of the southeastern limb are overturned and dip steeply to the southeast. The sandstones and shales composing the core of the syncline are complexly folded and faulted; whereas, the underlying dolomites and limestones show only minor, broad flexures. The boundary between the rocks of Early and Middle Ordovician age is marked by the Bridgean Disconformity.

The Guess Creek fault extends in a northeasterly direction through the region approximately along the southeastern boundary of the mapped area.

A gentle swing in the regional strike, occurring between Douglas Dam and Kykers Ferry, broadly defines a large anticline which trends across the strike. The relations of this structure are obscure, but it is suggested that the significance of this feature is of a regional rather than a local nature.

Bridgean Disconformity

The prominent Bridgean Disconformity marks the boundary between the rocks of Early and Middle Ordovician age. This disconformity represents a time of undetermined length during which the rocks of Early Ordovician age were subjected to subaerial erosion prior to the deposition of the Middle Ordovician rocks. The disconformity also marks a major regional change in the tectonic environment and probably reflects a major orogenic episode. Prior to Middle Ordovician time the source of the clastic fraction of the Paleozoic sediments lay generally to the west of the present area. On the other hand, during Middle Ordovician time the clastic portion of the rocks was derived from the east.

The disconformity is rarely well exposed, but can commonly be located within a distance of a few feet as it is generally marked by a distinct change in lithology. The Lower Ordovician rocks are uniformly bedded, limestones and dolomites; whereas, the overlying Middle Ordovician rocks are unevenly bedded rubble and chert conglomerates, dark-gray shales, and calcareous sandstones.

The maximum relief present upon this paleo-erosion surface is suggested by Bridge (1955, p. 727) to be about 140 feet. The present writer believes the relief within the Millican Creek area is comparable. This opinion is based upon constructed cross-sections of the disconformity, the lenticularity of the basal clastic units of the Middle

Ordovician sequence, and the great variance in the thickness of the Limestone Sequence (35 to 110 feet).

The disconformity is exposed at a number of localities within the present area. The outcrops most clearly showing the disconformity are located approximately 2,000 feet east-southeast of Douglas Dam (T. R. C. 2,731,150E-579,350N) and about 2,400 feet south-southwest of the dam (T. R. C. 2,728,950E-577,700N). At both localities a thin, sandy to conglomeratic limestone lies upon dolomite.

Guess Creek Fault

A prominent fault zone, extending along the southeastern boundary of the present area, marks the strike extension of the Guess Creek Fault as mapped by Neuman (1955). Neuman mapped the fault across the Pigeon Forge quadrangle (adjoining the thesis area on the south) to the boundary of the Kykers Ferry quadrangle, or to a point approximately one mile west of the southern boundary of the Millican Creek area. Based upon the work of Neuman, Rodgers (1953, Plate 9) extends the fault into the present area for a distance of about three miles. Detailed field work by the present investigator clearly indicates that the fault extends across the Millican Creek area.

The Guess Creek Fault in the Millican Creek area occurs within rocks of Middle Ordovician age. Rocks of the Middle Sandstone Unit of the Dark Siltstone and Sandstone Sequence are thrust upon rocks of the Upper Shale Unit or the Yellow Weathering Shale Sequence. The stratigraphic displacement is believed to be about 1,500 feet at the southern boundary of the area and to decrease in a northeastwardly direction. The trace of the fault zone is marked by numerous small drag folds, calcite and quartz filled fractures, and mylonite zones. The beds of the footwall block are highly contorted; whereas, the beds comprising the hanging wall are relatively undisturbed and dip to the southeast.

Minor Folds and Faults

Small, generally asymmetric folds occur within all of the units stratigraphically above the Dark-gray Shale Sequence. The axes of the anticlines and synclines strike N 40°-70° E, or approximately parallel to the regional trend. The axial planes dip steeply and usually to the southeast. Small, southeastwardly dipping thrust faults are locally associated with these folds. The displacements along these faults range from a few inches to a few feet.

Several folds of larger amplitude also occur within these rocks. The geometry of the folds is basically the same as that described in the preceding paragraph. Numerous southeastwardly dipping faults are associated with these larger folds, and their displacements are proportionally greater than those associated with the smaller folds.

Numerous examples of the folds and faults which occur within the mapped area are clearly displayed along both banks of the Flat Creek embayment.

A relatively small dextral wrench fault occurs a short distance southwest of Kykers Ferry. The rocks involved in this faulting include the Mascot Formation, the Limestone Sequence, and the Dark-gray Shale Sequence.

Cleavage and Jointing

Both slaty and fracture cleavage (Billings, 1954, pp. 336-361) occur within the rocks of the Millican Creek area; however, they are best developed in the rocks of the Upper Shale Unit of the Dark Siltstone and Sandstone Sequence. Fracture cleavage is also well developed in the folds of the Middle Sandstone Unit about 1,000 feet northwest of Catlett School and on the west bank of Flat Creek immediately southeast of Kerr Knob.

A prominent joint pattern is developed over most of the area. This fracture system is essentially vertical and parallel to the dip of the rocks. The strike of the pattern ranges from N 20° E at Ewing on the west edge of the area to about N 40° W at Kerr Knob on the east. The joint system appears to be related to the large anticlinal structure causing the swing of the regional strike.

CHAPTER IV

MINERAL DEPOSITS

The Millican Creek Area is not known to contain mineral deposits of present economic value; however, isolated occurrences of limonite, manganese, and sphalerite were noted (Plate 1).

A few shallow, overgrown pits immediately south of Douglas Dam record an early attempt to recover sphalerite from the upper portion of the Mascot Formation. No bedrock is exposed within these pits, but the dump area contains fragments of brecciated dolomite in which occur veinlets of sphalerite and coarse recrystalline dolomite with blebs of sphalerite. To the northeast of these pits a single occurrence of sphalerite was observed associated with recrystalline dolomite within a brecciated pinnacle of the Mascot.

Float blocks of limonite mark the trace of the Pyritic Facies as stated previously. The limonite is most abundant at the northeasternmost locality indicated on Plate 1. No exploration trenches or pits were observed in the area in association with this mineral.

Two small, inactive rock quarries are located within the thesis area. One was developed within the Limestone Sequence at a point about one quarter mile southwest of Kykers Ferry. The other, north of Millican, was opened in a thin argillaceous limestone occurring in the Upper Shale Unit.

Small residual nodules of manganiferous limonite were noted just east of Millican. The nodules appear to be derived from a thin limestone bed within the Yellow Weathering Shale Sequence.

CHAPTER V

SUMMARY

Sedimentary rocks of Early and Middle Ordovician age are exposed within the Millican Creek area. These rocks include dolomite, limestone, shale, siltstone, sandstone, and conglomerate. The Bridgean Disconformity separates the predominately carbonate rock sequence (the Mascot Formation) of Early Ordovician age from the overlying, chiefly clastic, sequence of Middle Ordovician age.

The Middle Ordovician rocks may be grouped into four major stratigraphic units: (1) the Limestone Sequence, (2) the Dark-gray Shale Sequence, (3) the Dark Siltstone and Sandstone Sequence, and (4) the Yellow Weathering Shale Sequence. These four units are tentatively correlated with the Lenoir Limestone, the Blockhouse or Athens Shale, and the Tellico Formation, as illustrated in Figure 4.

The Guess Creek Fault extends through the Millican Creek area and essentially defines the southeastern boundary of the mapped area. Numerous minor folds and faults occur throughout the clastic rock sequence of Middle Ordovician age.

There are no known mineral deposits of present economic value occurring within the thesis area.

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PLATE I

GEOLOGIC MAP AND STRUCTURE SECTIONS OF THE MILLICAN CREEK AREA, SEVIER COUNTY, TENNESSEE

BY

JAMES R. MARIE

1963

EXPLANATION

QUATERNARY

Pleistocene ?

Qa — Alluvium

UNCONFORMITY

ORDOVICIAN

Middle Ordovician

Oy — Yellow Weathering Shale Sequence

Osu / Osm / Osl — Dark Siltstone and Sandstone Sequence
Osu, Upper Shale Unit, Osm, Middle Sandstone Unit, and Osl, Lower Shale Unit

Og — Dark-gray, Graptolite Bearing Shale Sequence

LOCAL DISCONFORMITY

Ol — Limestone Sequence

DISCONFORMITY

Lower Ordovician

Oma — Mascot Formation

Contact
Dashed where approximately located, dotted where concealed.

Fault
Dashed where approximately located.
T, upper plate. ↑, relative movement.

Fold
Showing axis and direction of plunge.
Dashed where approximately located.

Anticline

Syncline

Strike and dip of beds
Generalized where no value is given.

30
normal

25
overturned

vertical

Localities from which fossils were collected

x

Mineral occurrences

xZn

Quarries and prospect pits

Topography by Geological Survey from aerial photographs by stereophotogrammetric methods.
Field examination by Tennessee Valley Authority, 1940.

10,000 foot grid based on Tennessee rectangular coordinate system

APPROXIMATE MEAN DECLINATION, 1940

Scale 1/24000

1 ½ 0 1 2 Miles

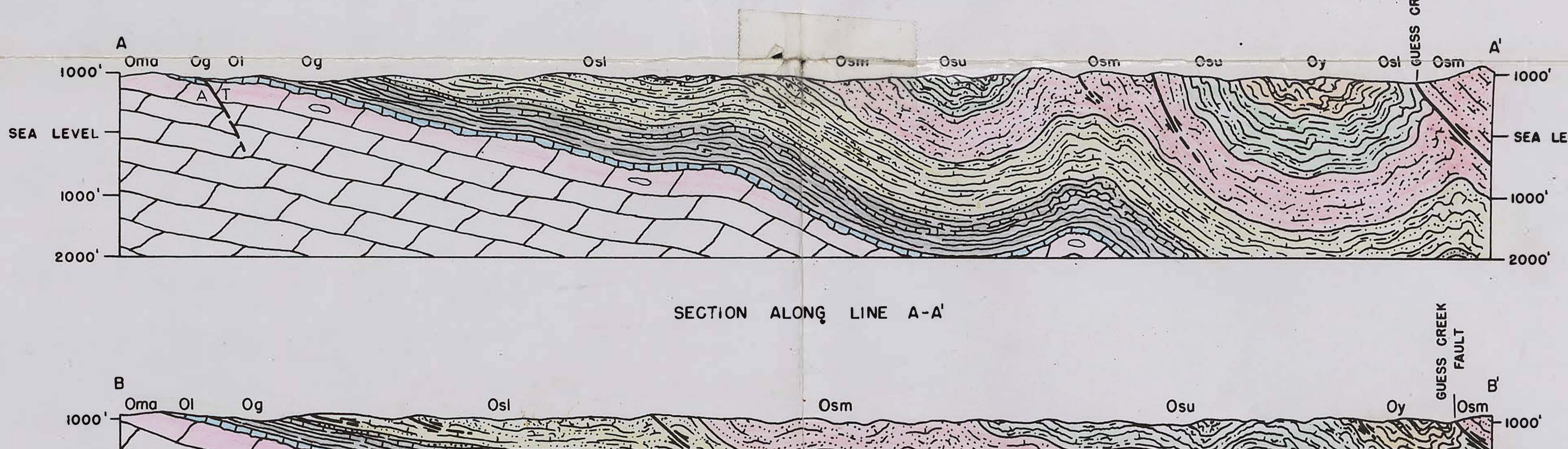
5000 0 5000 10000 Feet

1 ½ 0 1 2 Kilometers

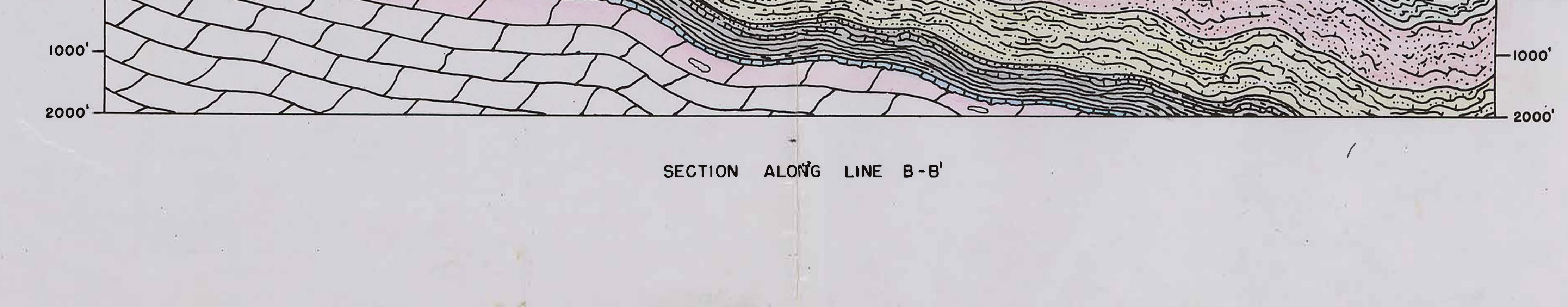
Contour interval 20 feet with 10 foot contours shown by broken line
Datum is mean sea level

TENNESSEE
KYKERS FERRY QUADRANGLE
156-NE

QUADRANGLE LOCATION



SECTION ALONG LINE A-A'



SECTION ALONG LINE B-B'

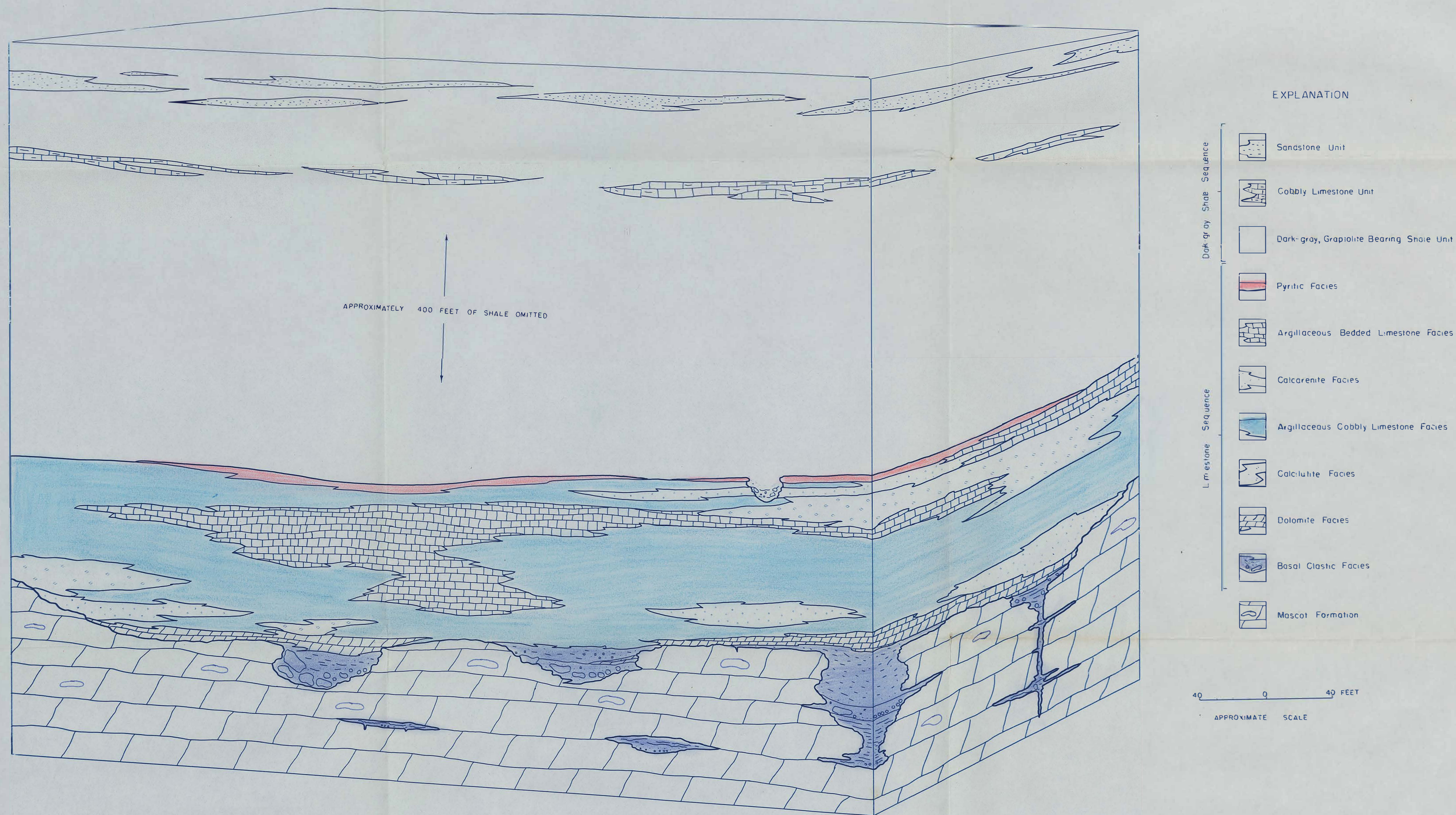
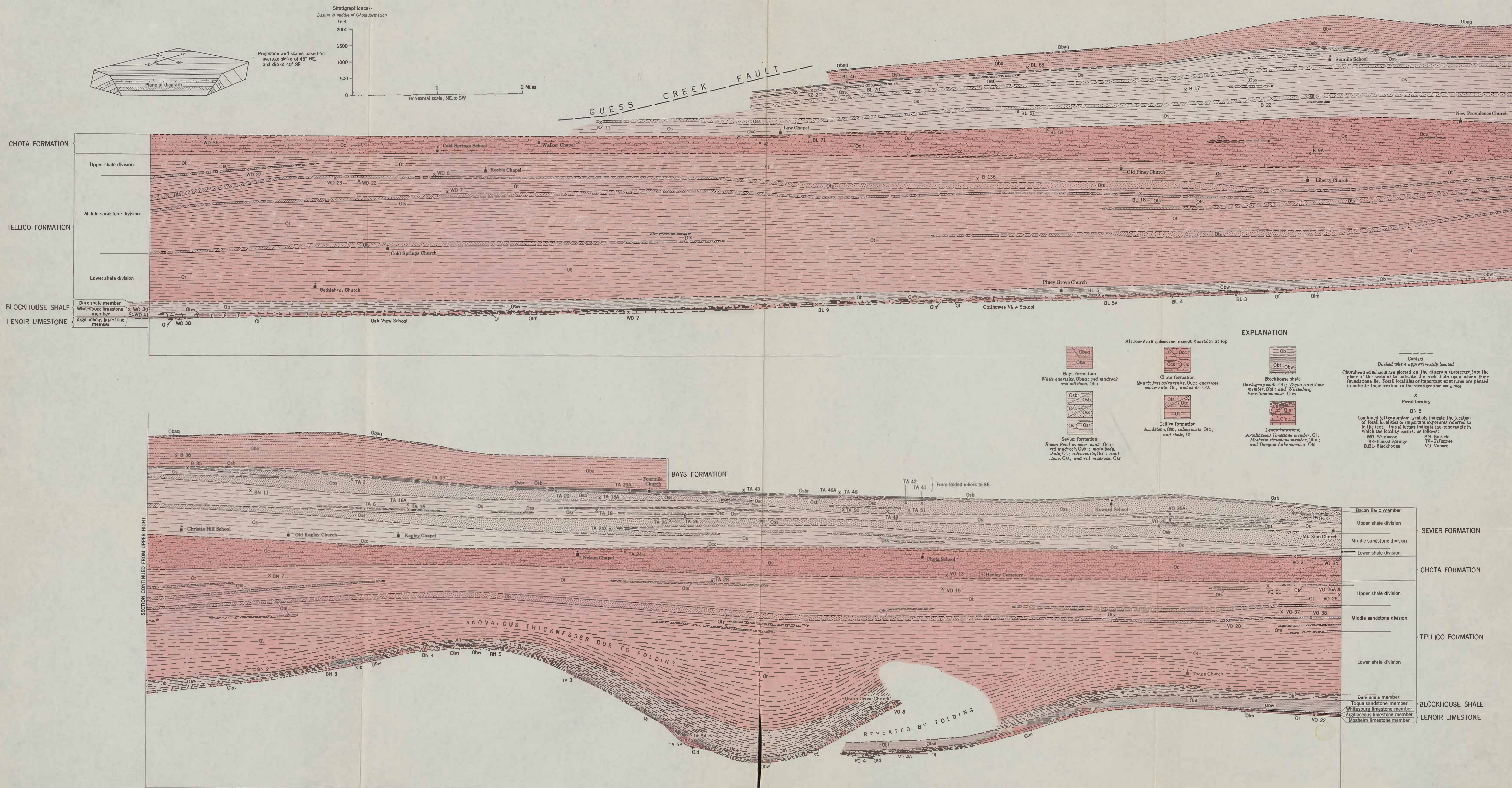


PLATE 2. GENERALIZED LITHOFACIES DIAGRAM OF THE LOWER MIDDLE ORDOVICIAN SECTION

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY



Planimetry from U. S. Geol. Survey-TVA 7½-minute topographic quadrangle maps

INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D. C.

Geology by R. B. Neuman, 1949–52

STRATIGRAPHIC DIAGRAM OF MIDDLE ORDOVICIAN ROCKS IN THE TELLICO-SEVIER BELT, TENNESSEE

THE DIAGRAM WAS PREPARED NORMAL TO THE DIP OF THE ROCK TO SHOW RELATIVE THICKNESS, LITHOLOGIC CHARACTER, AND LATERAL VARIATION OF THE ROCK UNITS