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GARLAND PEYTON, Director

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GEOLOGY AND MINERAL RESOURCES OF THE NORTHWEST QUARTER OF THE COHUTTA MOUNTAIN QUADRANGLE

By

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LETTER OF TRANSMITTAL

Department of Mines, Mining and Geology

Atlanta, January 1, 1962

His Excellency, S. Ernest Vandiver
Governor of Georgia and
Commissioner Ex-Officio
State Division of Conservation
Atlanta, Georgia

Dear Governor Vandiver:

I have the honor to submit herewith Georgia Geological Survey Bulletin No. 71, "Geology and Mineral Resources of the Northwest Quarter of the Cohutta Mountain Quadrangle, Georgia," by Dr. John W. Salisbury. This report which was done at small expense to the State was submitted as a doctor's dissertation for the degree of Doctor of Philosophy at Yale University.

The report is a contribution to the geology of northern Georgia near the Tennessee line and discusses critical features connected with the rocks of that district. It is particularly involved with the structure and petrography of the rocks, including any minerals which are known to be of economic importance. The work will be of particular value when geologists reconsider the rocks of the State for the preparation of a new State Geologic Map.

Very respectfully yours,

Garland Peyton

Director

ABSTRACT

The northwest quarter of the Cohutta Mountain quadrangle falls almost entirely within Murray County, Georgia, except that along the northern boundary it includes a narrow strip of Polk County, Tennessee. It is bounded by parallels 34°52′30″ and 35° N. and meridians 84°37′30″ and 84°45′ W.

The rocks of the area are divided structurally into three main fault blocks by the Great Smoky and the Alaculsy Valley faults. The Great Smoky fault runs approximately north-south near the western margin of the area, and the Alaculsy Valley fault runs from the northeastern corner of the area southwestward to its junction with the Great Smoky fault. West of the Great Smoky fault lie unmetamorphosed Paleozoic rocks of the Valley and Ridge province, ranging in age from middle Cambrian to middle Ordovician. The sequence, oldest to youngest, is: Conasauga shale, Knox dolomite, Newala limestone, Athens shale, and Chota formation. The Conasauga shale and Knox dolomite are thrust over the Athens shale and Chota formation by a minor fault. Other than the minor fault, there is little deformation of the Paleozoic rocks, which maintain a relatively constant NNE. strike and 25° to 75° SE. dip.

East of the Great Smoky fault lie the metamorphosed Precambrian rocks of the Blue Ridge province. A sequence composed of phyllite, quartzite, and metasubgraywacke crops out north of the Alaculsy Valley fault. The rocks are tightly folded; the folds trend NE.-SW., plunge NE., and are overturned to the northwest. The quartzite and metasubgraywacke are two facies of the same unit, and the whole sequence (approximately 1700 feet thick) is designated as the Sandsuck (?) formation.

A sequence composed of phyllite and metagraywacke crops out south of the Alaculsy Valley fault. The rocks are less tightly folded than those north of the Alaculsy Valley fault and, although the folds trend NE.-SW. and plunge NE., they are commonly not overturned. Slaty cleavage maintains a relatively constant strike and dip independent of the folding, except locally where the rocks are highly contorted. The sequence is divided into two formations. A phyllite section at the base, ranging in thickness from 2000 to 6000 feet, is designated the fine-grained part of the Ocoee series. The overlying

section of interbedded phyllite and metagraywacke, ranging in thickness from 2900 to 5100 feet, is designated the coarse-grained part of the Ocoee series.

Sedimentary structures preserved in the metamorphic rocks were instrumental in determining structure and sequence of the units. Graded bedding, cross-bedding, and scour channels can be observed.

Iron, manganese, and limestone deposits are described.

GEOLOGY AND MINERAL RESOURCES OF THE NORTHWEST QUARTER OF THE COHUTTA MOUNTAIN QUADRANGLE[1]

INTRODUCTION

Location and Size of Area

The northwest quarter of the Cohutta Mountain quadrangle falls almost entirely within Murray County, Georgia, except that along the northern boundary it includes a narrow strip averaging three-quarters of a mile in width of Polk County, Tennessee (fig. 1). It is bounded by parallels 34°52′30″ and 35°00′ N. and meridians 84°37′30″ and 84°45′ W.

The dimensions of the area are approximately 7.2 (east-west) by 8.7 (north-south) miles—an area of about 62.6 square miles.

The Louisville and Nashville Railroad runs from ¾ to ¼ mile east of, and essentially parallel to, the western boundary of the area. All important communities are located along U. S. Highway 411, which parallels the railroad.

Dalton, Georgia, the nearest city of any size (population 16,000), is located in the southwest corner of the adjacent Dalton quadrangle about 25 miles by road from Cisco.

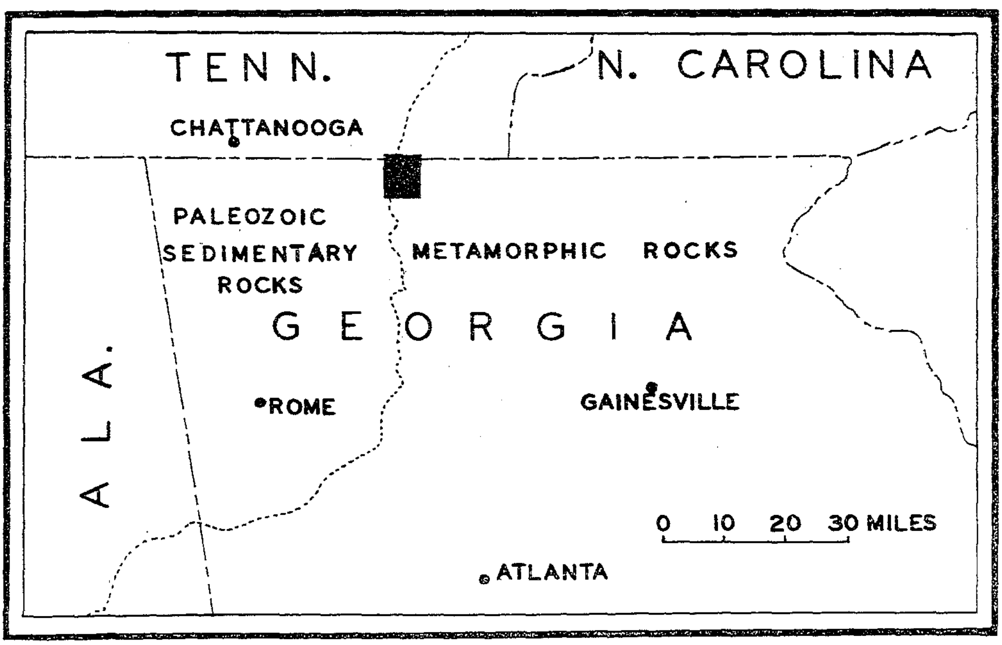


Figure 1. Index map showing location of the northwest quarter of the Cohutta Mountain quadrangle (black rectangle).

[1] A dissertation presented to The Faculty of The Graduate School of Yale University in candidacy for the degree of Doctor of Philosophy.

The sole industry within the area is the Ross chenille factory at Tennga, although talc and shale are mined in the Cohutta Mountains nine miles south of the area and a lumber mill is in operation one mile to the north. The major occupation is farming, but good farmland is limited to the few open valleys. Densely overgrown ridges cover most of the area, making access difficult. At one time extensive logging operations provided easy access and local job opportunities. Now, however, the logging roads and railroads have been destroyed and most of the second-growth trees, choked by underbrush, are fit only for pulpwood. These forests do represent, however, a valuable potential resource in years to come.

Topography

The northwest quarter of the Cohutta Mountain quadrangle occupies portions of two physiographic provinces—the Valley and Ridge province on the west and the Blue Ridge province on the east. These two provinces will be referred to in this report as the Valley and the Mountains, respectively. James M. Safford described these natural subdivisions of the Appalachian region in his Geology of Tennessee (1869, p. 8-9; Part I, Physical Geography, was first published in 1861). The names of the provinces were standardized in 1928 by a committee appointed by the Association of American Geographers (Fenneman, 1928, p. 274-275).

The mountain chain forming the northwestern boundary of the Blue Ridge province—which begins at Bent Mountain southwest of Roanoke, Virginia and ends at Cohutta Mountain east of Chatsworth, Georgia—is usually referred to as the Unaka Chain (Fenneman, 1938, p. 173-174). Mountains within the northwest quarter of the Cohutta Mountain quadrangle may be considered part of this chain. These mountains stand from 1000 to 1500 feet above the level of the adjacent Valley. The difference in elevation between the two provinces is due to differences in rock type and degree of metamorphism. Major rock types of the Mountains are quartzite, metagraywacke, and phyllite. Valley rocks are less resistant limestone or dolostone, limy sandstone, and shale. Although some metamorphic recrystallization has occurred in the Valley rocks near the mountain front, comparable rock types of the two provinces, such as shale in the Valley and phyllite in the Mountains, show a definite difference in their resistance to weathering and erosion. The greater resistance to weathering of the Mountain rocks is largely a result of their greater degree of metamorphism.

Topographic detail in both provinces is a function of rock type and structure. In the Mountains, quartzite beds characteristically crop out as steep linear ridges, whereas phyllite forms valleys and low spurs. The resulting linear topography is best developed northwest of the Alaculsy Valley where quartzite beds alternate with phyllite. Structure may also control topography; thus the Alaculsy Valley seems to be the result not only of rock type but also of brecciation along the Alaculsy Valley fault.

Only two ridges occur in the portion of the Valley contained within the area—Sumac Ridge just west of U. S. Highway 411, and an unnamed ridge just east. Both are best seen in the vicinity of Cisco. Sumac Ridge reflects underlying beds of resistant sandstone and siltsone, and is of the type referred to by Safford (1869, p. 45) as "comby." The unnamed ridge is more accurately a series of generally conical knobs reflecting the underlying more quartzose phases of the Chota formation. Valleys are developed on limestone, dolostone, or shale exposed between the ridges. Subparallelism of the ridges and valleys results from erosion of strata with rather uniform strike and dip, but varying resistance to erosion, exposed in alternating belts. Relief is generally less than 400 feet.

Drainage

Stream patterns within the Valley are, for the most part, controlled by the less resistant rocks. Although the portion of the Valley seen within the area is too limited to show it well, trellis drainage has developed in which the master streams are longitudinal subsequents and tributaries join the trunk streams by means of transverse water gaps. The best local example of this drainage pattern is, unfortunately, not within the area. Sumac Creek cuts through Sumac Ridge to join the Conasauga River immediately to the west of the area in the Dalton quadrangle.

The principal river draining the Mountains is the Conasauga River. It is an entrenched, meandering stream, as is common for the major streams crossing the Mountains. Portions of

Sumac Creek also show these characteristics. Their tributaries and all other minor streams within the Mountain area have a simple dendritic drainage pattern.

Previous Work; Purpose of This Investigation

Although the northwest quarter of the Cohutta Mountain quadrangle has never been the sole subject of a geologic map, it has been included in many generalized and small-scale maps covering substantial portions of the Appalachians. On such maps, the Paleozoic sedimentary rocks of the Valley have received more attention and been better understood than the more complicated and inaccessible metamorphic Precambrian rocks of the Mountains. The Paleozoic geology of Georgia was first outlined by Hayes (1891), and all subsequent publications have followed his outline. Butts and Gildersleeve (1948, p. 4-5) presented a complete list of such publications and prepared the most detailed map to date of the Paleozoic sedimentary area in northwest Georgia. They recognized all the Valley formations found within the northwest quarter of the Cohutta Mountain quadrangle except for the poorly exposed Knox. A more detailed map of the adjacent Dalton quadrangle was prepared by Munyan (1951), and his additions and corrections bring the geology to the west into agreement with that found in the writer's area. A similar agreement prevails to the north (Rodgers, 1953). Thus, little difficulty was encountered in mapping the Paleozoic Valley rocks of the northwest quarter of the Cohutta Mountain quadrangle.

The metamorphic rocks of the Mountains, as indicated above, are more complicated in stratigraphy and structure, more inaccessible, and less well understood than the Valley rocks. These rocks have been mapped chiefly to the north and east of the Cohutta Mountain quadrangle, but several generalized and small-scale geologic maps cover the crystalline rocks within the area. All maps, except one prepared by the Stoses (Stose and Stose, 1944, p. 321), show the metamorphic rocks of the northwest quarter of the Cohutta Mountain quadrangle to be solely Ocoee, Talladega, or related crystallines (Geologic Map of Georgia, 1939; Geologic Map of North America, 1946; Jonas, 1932, p. 231; Crickmay, 1936, p. 1373; Crickmay, 1952, p. 6). Stose and Stose (1944, p. 371) show the Alaculsy Valley as a window in the overthrust Ocoee, through which can be seen the Paleozoic rocks of the Valley. In a later map (1949, p. 267) they show both the Valley Paleozoics and the Chilhowee group exposed in the window. Rodgers (1953, p. 156), on the other hand, has interpreted the extension of the Alaculsy Valley lineament in Tennessee as a thrust fault (Sylco Creek fault). Hayes (1895, p. 3) mapped the same lineament as a breached anticline. Kesler, in his report on the Cartersville district (1950), has even thrown doubt on the existence of the Cartersville overthrust (Great Smoky fault) along the western edge of the Mountain rocks in Georgia. Further, marked differences of opinion have arisen concerning the ages and stratigraphic relations of the crystalline rocks mapped.

The Georgia Geological Survey, in an effort to unravel the many structural and stratigraphic problems in the Mountains, has instituted a program of detailed (out-crop) geologic mapping. The purpose of the present investigation, which is a part of that program, is to attempt to:

(1) determine the existence or non-existence of a thrust fault separating the crystalline rocks of the Mountains from the sedimentary rocks of the Valley in extreme northern Georgia;

(2) discover whether the structure within the Alaculsy Valley is a window or a simple thrust fault;

(3) determine the detailed structure of the crystalline rocks of the Mountains so that the stratigraphy can be worked out without fossils;

(4) determine the relationships of the cliff-making quartzite beds in the northwest portion of the Alaculsy Valley fault block to the metasubgraywacke beds in the northeast portion of the Alaculsy Valley fault block;

(5) place stratigraphically the rock units north and south of the Alaculsy Valley, and determine their relations to each other;

(6) investigate all mineral resource possibilities within the area.

Field Work

Field work was done during the summer months of 1956, 1957, and 1958.

Aerial photographs (scale 1:12,000) were used for the initial geologic mapping, and the data were transferred from these to the topographic base map (scale 1:20,833) using a method described by Lovejoy (1956, p. 1117). The base map is the northwest quarter of the Cohutta Mountain topographic sheet of 1913 enlarged three times. Because there are few natural landmarks in the area to which to refer in describing rock units and their structure, a coordinate system was superimposed on the base map. The upper left- hand corner of the map is taken as zero, the north-south edge of the map is taken as the ordinate, and the east-west edge of the map is taken as the abscissa. Each of the coordinates is referred to by its direction from the zero point (e.g., S. 21, E. 30), and each unit of measurement marked off on the map is equivalent to 880 feet.

So that color descriptions might be more objective, the color chart prepared by the Rock-Color Chart Committee (distributed by the Geological Society of America) was used. Following each color name is a symbol in parentheses, which is a coded reference to the hue, value, and chroma of the color, and which corresponds to a color chip on the chart.

Laboratory Work

Laboratory work was done during the winter months of 1957-59 at Yale University. It consisted of petrographic study of 40 thin sections and 17 rock slabs.

Acknowledgments

The Georgia Department of Mines, Mining, and Geology, under the direction of Captain Garland Peyton, sponsored the field work. Dr. A. S. Furcron and Dr. Vernon J. Hurst, geologists for the State, participated in the initial reconnaissance, pointed out the main stratigraphic units, and indicated features to be particularly studied. Dr. Hurst later visited the area at various times to instruct the writer in mapping techniques best suited to different parts of the area and to specific geologic problems.

The writer is also indebted to the Faculty and fellow students of the Geology Department of Yale University. Thanks are owed particularly to Professor Karl Waage and B. S. Norford, F. G. S. who cheerfully identified badly distorted fossil specimens; and to Professor John Rodgers, under whose supervision this study was made, who gave freely of his deep knowledge of Appalachian structure and stratigraphy, and by his continued guidance and perceptive criticism made possible the writing of this report.

Finally, the writer wishes to acknowledge the aid of his wife, Lynne Salisbury, for her assistance in the field, typing of the manuscript, and unfailing encouragement.

STRATIGRAPHY

General Features

Rocks of the northwest quarter of the Cohutta Mountain quadrangle fall structurally into three groups: 1) rocks west of the Great Smoky fault (see Tbl. 1); 2) rocks east of the Great Smoky fault and north of the Alaculsy Valley fault; and 3) rocks east of the Great Smoky fault and south of the Alaculsy Valley fault. Such a division is also stratigraphic in the sense that certainty of correlation becomes progressively less from group to group. Thus, rocks of the first group probably can be correlated with well-known and thoroughly investigated sedimentary rocks to the north and west, whereas rocks of the second group less probably can be correlated with less well-known and sparsely investigated crystalline rocks to the north. The third group cannot be correlated with any degree of certainty with any rocks in any direction.

In the interest of clarity, the natural rock groupings indicated above will be used in describing the rocks of the area,

<table>
<tr><th>Salisbury, 1959</th><th>Neuman, 1955</th><th>Rodgers, 1953*</th><th>Munyan, 1951</th></tr>
<tr><td>Chota formation</td><td>Chota formation</td><td>Holston formation</td><td></td></tr>
<tr><td rowspan="2">Athens shale</td><td>Tellico formation</td><td rowspan="3">Athens shale</td><td rowspan="3">Athens shale</td></tr>
<tr><td>Blockhouse shale</td></tr>
<tr><td rowspan="2">Newala limestone</td><td>Lenoir limestone</td></tr>
<tr><td rowspan="3"></td><td rowspan="2">Knox dolomite or group, undivided</td><td>? ? Newala limestone</td></tr>
<tr><td>Knox dolomite</td><td>Knox dolomite</td></tr>
<tr><td>Conasauga shale</td><td>Conasauga shale or group, undivded</td><td>Conasauga shale and limestone</td></tr>
</table>

*Units as mapped adjacent to the Cohutta Moutain quadrangle.

Table 1. Classification of the Paleozoic rocks west of the Great Smoky fault.

and the order of consideration will be from known rocks of certain correlation to unknown rocks of uncertain correlation, rather than from oldest to youngest.

Rocks West of the Great Smoky Fault

Conasauga shale. The term Conasauga shale is here applied to a distinctive group of limestone and shale that comprises all of the Middle and a small part of the Upper Cambrian section.

The original description of the Conasauga by Hayes (1891, p. 144) stated that it consists of alternating beds of limestone and calcareous shale. It was named for exposures along the Conasauga River in the adjacent Dalton quadrangle. This area was recently restudied by Munyan (1951), and the reader is referred to his report for a thorough description of the type section. Very little of the Conasauga is present in in the northwest quarter of the Cohutta Mountain quadrangle. It crops out only in two road cuts in the extreme southwest corner of the area (map coordinates S. 48, E. 4.5). Thus, a complete description of Conasauga lithology from within the area is not obtainable. Where exposed, the shale appears slightly metamorphosed. On a weathered surface it varies in color from grayish red purple (5 RP 4/2) to dark gray (N 3) and light brown (5 YR 5/6), is slightly contorted, and locally interbedded with thin (2 cm.) beds of light brown (5 YR 6/4) siltstone. Although contacts are nowhere visible, it appears bounded on the east by the Great Smoky fault, and on the west by the basal beds of the Knox group. Identification of the Conasauga was made possible by its lithology and position in the section exposed within the area, and by extrapolation from Munyan's map (1951).

Knox dolomite. The name Knox is here used for a unit that is composed primarily of chert-bearing dolostone, and is underlain by the Conasauga shale and overlain by the Newala limestone. The Knox comprises most of the Upper Cambrian and Lower Ordovician section.

Safford (1869, p. 204) first named the Knox group for rocks exposed along Second Creek at Knoxville, Tennessee. Included within this group were the Knox sandstone (now the Rome formation), the Knox shale (now the Conasauga group), and the Knox dolomite (now the Knox group). Hayes (1891,

Salisbury, 1959	Rodgers & Kent, 1948
Newala limestone	Mascot dolomite
	Kingsport limestone
Knox dolomite	Longview dolomite
	Chepultepec dolomite
	Copper Ridge dolomite

Table 2. Subdivision of the Knox group.

p. 143) renamed the standstone and shale, and restricted the use of the name Knox to the dolostone unit.

Subdivisions within the Knox as defined by Hayes were first proposed by Ulrich (1911, pl. 27). He introduced the name Copper Ridge for certain beds in the vicinity of the type locality of the Knox. Originally, the Copper Ridge dolomite constituted the central part of the Knox section, but this term has since been used for the lower part of the Knox group where the rocks are chiefly dolostone.

The name Chepultepec was also proposed by Ulrich (1911) for a division of the Knox overlying the Copper Ridge. The type locality for this formation is in Blount County, Alabama, near the town of Algood (formerly Chepultepec).

Ulrich (1924, p. 16) also proposed the name Longview for beds overlying the Chepultepec which he found exposed near the town of Longview in Shelby County, Alabama. The formation was first described, however, by Butts (1926, p. 92-95). Butts (1926) also defined the Chepultepec dolomite as resting conformably upon the Copper Ridge, and being overlain unconformably by the Longview.

Immediately overlying the Longview is the Newala formation, named by Butts (1926, p. 95) for the Newala Post Office, Shelby County, Alabama. Butts and Gildersleeve (1948, p

19) included the Newala as the basal member of the Chickamauga limestone, but Oder (1934, p. 488-489) has assigned equivalent beds in Tennessee to the Knox group on the basis of good fossil evidence. The Newala probably represents the upper portion of the Knox sequence in Georgia. Oder and Miller (1945) proposed the names Kingsport limestone and Mascot dolomite for the two formations in Tennessee equivalent to the Newala limestone in Alabama and Georgia.

In this report, following Munyan (1951), the Newala limestone is mapped and discussed separately from the rest of the Knox, and the Copper Ridge, Chepultepec and Longview are mapped collectively as the Knox dolomite (see tbl. 2).

The Knox dolomite rarely crops out in the northwest quarter of the Cohutta Mountain quadrangle. It is present in a narrow belt in the southern portion of the Valley, obliquely intersecting the Great Smoky fault. It is terminated on the west by the Fairy fault, and on the east, except for a small amount of Conasauga intervening below Cohutta Springs, by the Great Smoky fault.

On their map, Butts and Gildersleeve (1948) show this entire Knox belt as Conasauga. There can be little doubt, however, that these rocks correlate with the Knox. The characteristic chert residuum everywhere overlies the weathered rocks, and comparison of fresh rock exposures with those in the adjacent Dalton quadrangle mapped as Knox by Munyan, showed them to be the same. The chert residuum is commonly blocky and varies in color from grayish yellow (5 Y 8/4) to yellowish gray (5 Y 8/1). The yellow chert is typically compact, whereas the gray chert is typically porous and oolitic. Fresh dolomite is generally medium light gray (N 6) in color, and weathers to a light olive gray (5 Y 6/1). It is commonly very fine-grained, almost lithographic, and may break with a conchoidal fracture.

The estimated maximum thickness of the Knox dolomite in the area is approximately 2300 feet. Butts and Gildersleeve (1948, p. 17) believed 3500 feet to be a conservative estimate of the thickness of the Knox in Georgia. Although the Knox-Conasauga contact is not exposed, there is no reason to assume faulting or unconformity between the two formations. Thus it appears that the basal 2300 feet of the Knox group, corresponding to all the Copper Ridge and the base of the Chepultepec (Butts and Gildersleeve, 1948, p. 17), is present within the area. Other evidence supports this view. On a visit to the area in 1957, John Rodgers suggested that a sandstone outcrop midway between Fairy and Cisco on the east side of the Fairy fault (map coordinates S. 28.8, E. 4.2) might represent the basal sandstone of the Chepultepec described by Rodgers and Kent (1948, p. 19). The light tan, coarse-grained sandstone crops out as massive blocks approximately three feet thick. It is quite coherent despite a porous appearance, but no extension of the outcrop to the south could be found.

The best exposure of the Knox dolomite within the area is on the north side of a small hill 1000 feet south of the bridge over Sumac Creek on U. S. Highway 411 (map coordinates S. 44.3, E. 0.3). Other exposures can be found beneath the bridge itself and in the bed of Sumac Creek, as indicated on the map.

Newala limestone. The term Newala limestone is here applied to a limestone sequence immediately overlying the Knox dolomite and underlying the Athens shale. It comprises the uppermost Lower Ordovician section. Although these beds probably represent the upper portion of the Knox sequence (see pp. 11-12 for full discussion), they are mapped separately in this report.

Also included in the Newala as defined in this report are all post-Knox, basal Middle Ordovician limestones which may or may not be present in the area. Various authors have given these limestones such names as Blackford (Butts, 1941), Douglas Lake (Bridge, 1955), Mosheim (Ulrich, 1911). Lenoir (Safford and Killebrew, 1876), Chickamauga (Hayes 1891), and Whitesburg (Ulrich, 1929). The Blackford and Douglas Lake seem to be identical, and all except the Whitesburg are included in the Lenoir limestone as defined by Neuman (1955). The Whitesburg limestone is the basal member of his overlying Blockhouse shale (see tbl. 1).

There is only a single exposure of the contact of the Newala and the Athens in the northwest quarter of the Cohutta Mountain quadrangle. This rather poor exposure lies 290 feet east of the western boundary of the quadrangle on the Cisco crossroad (map coordinates S. 17.7, E. 0.3). The 30-foot section of limestone immediately below the shale at this point has been tentatively identified by John Rodgers, Robert Lawrence, P. B. King, and others (Munyan, 1951, p. 60; and John Rodgers, personal communication) as representing both Mosheim and Lenoir. [The term Lenoir is here used as defined by Safford and Killebrew (1876), rather than as defined by Neuman (1955).] The correlation was solely lithologic, as no fossils were found at this location. No other exposure of the upper 30 feet of limestone was observed within the area, and lateral tracing of the contact between the two limestones proved to be so uncertain that their separation did not seem justified. On the other hand, the contact of the limestone and shale is easily traceable, even without exposures, because of differences in soil formation and topographic expression of the two rock types. The shale produces a yellowish gray (5 Y 7/2) soil, generally containing many residual shale chips and porous sandstone fragments. It has a positive topographic expression, which increases with increasing sandstone content of the shale. The limestone produces a darker soil than the shale, which is commonly reddish brown in color. There are no residual fragments, and the topographic expression is typically negative, forming gentle valleys. The easy traceability of the limestone and shale contact made it the most reasonable point at which to draw the Newala-Athens boundary, despite the probable presence of a great unconformity near the top of the limestone section marking the base of the Middle Ordovician.

As originally described by Butts (1926, p. 95), "The Newala is composed of much limestone and proportionately little dolomite. Most of the limestone is thick-bedded, compact or non-crystalline or textureless, dark gray, pearl-gray, and bluish gray. The pearl-gray color perhaps predominates and is most characteristic."

The fossils present in the type area in Alabama are: *Hormotoma artemesia, Hormotoma gracilens, Coelocaulus linearis, Turitoma cf. T. acrea, Maclurea affinis, ana Ceratopea keithi.* The last is one of the most characteristic fossils of this formation.

Butts (1926, p. 97) estimated the thickness of the Newala to be 1000 feet in the Alabama type area. In Georgia, however, Butts and Gildersleeve (1948, p. 21) judged the thickness to be about 250 feet.

In the northwest quarter of the Cohutta Mountain quadrangle the Newala is present in a belt running diagonally across the northwest corner of the area.

Two major types of lithology were observed along this belt. The first, and most common, type is a finely crystalline and occasionally fossiliferous limestone. Its color on a fresh surface is medium dark gray (N 4) and it weathers to a medium gray (N 5) with a slight bluish cast. Partial recrystallization has often occurred, producing small seams and pockets of calcite crystals.

Fossils preserved in the rock are fragmented and partially recrystallized, making identification extremely doubtful. Sectioning and microscopic examination of specimens by B. S. Norford has revealed, however, a few fairly well preserved nautiloids which seem worthy of description. According to Mr. Norford, "The best preserved nautiloid fragment measures about two cms by one cm, and contains nine chambers. A large, eccentric, tubular siphuncle occupies more than a third of the diameter of the shell, and traces of invaginated endocones may be present. The septal necks appear to bound the siphuncle throughout the lengths of the chambers, and episeptal deposits are present. The preservation of the specimen precludes a conclusive identification but it is probably referable to the Endoceratidae which is found in Chazyian and younger Ordovician rocks. Flower and Kummel (1950)." The most fossiliferous outcrop observed in the area lies beneath a bridge on U. S. Highway 411 one mile north of Tennga (map coordinates S. 0.6, E. 4.3).

The second major type of lithology observed in the area is an extremely finely crystalline, almost lithographic limestone. Its color on a fresh surface is light gray (N 7), but weathered surfaces often appear whitish due to a thin patina of chalky material. No recrystallization of the limestone appears to have occurred, and it breaks with a characteristic conchoidal fracture. Thin seams of rhodochrosite are occasionally seen within the rock.

This type of limestone is best exposed west of Cisco near the contact with the Athens shale (map coordinates S. 17.7, E. 0.3) .

As indicated above, there is little evidence within the area, other than its stratigraphic position, lithology, and a doubtful fossil identification, for identification of this formation as Newala. Six miles to the southwest, however, Munyan (1951, p. 52) found numerous specimens of *Ceratopea* sp. cf. *keithi* Ulrich, and *Maclurites* sp. cf. *affinis* Billings within this same belt of limestones. Butts and Gildersleeve (1948, p. 21-22) also have identified the formation as Newala on the basis of fossil evidence.

The Knox-Newala contact is not exposed within the area, and thus no estimate of the local thickness of the Newala is possible.

Athens shale. The term Athens shale is here applied to a sequence of calcareous silty shales, siltstones, and sandstones comprising the lower part of the Middle Ordovician section. As discussed above (p. 20), the basal limestones usually included within the Athens Shale or its equivalents instead have been included in the Newala limestone.

The type area for the Athens shale is near Athens, Tennessee, in the adjacent Cleveland quadrangle, first mapped by Hayes in 1895. In his description of the Athens, Hayes (1895, p. 3) stated that the shale was ". . . in some places sandy, but generally calcareous, dark-blue when fresh, but weathering yellow." He noted that in its eastern exposures (including exposures within the northwest quarter of the Cohutta Mountain quadrangle) it changed character and included a calcareous sandstone lentil from 250 to 700 feet thick, located about 500 feet from the base of the formation. The thickness of the entire formation varied from 850 to 3000 feet, being thickest to the southeast.

In the northwest quarter of the Cohutta Mountain quadrangle, the Athens shale is present in a belt running diagonally across the northwestern corner of the area. It is underlain by the Newala limestone and overlain by the Chota formation.

The Athens, as defined in this report, is composed largely of calcareous silty shale and calcareous siltstone, with minor amounts of interbedded calcareous feldspathic sandstone. The sandstone is concentrated largely in the lower half of the formation, and the calcareous siltstone is concentrated largely in the upper fourth of the formation.

Hayes (1895), Butts and Gildersleeve (1948), Munyan (1951), and Rodgers (1953) have all mapped this sequence of rocks as Athens. Fossil evidence for this identification is, unfortunately, rare. Munyan (1951, p. 67) reports that a zone of Graptolites (*Diplograptus* ?) was discovered near the base of the Athens on Sumac Ridge by members of a field trip sponsored by the Southeastern Geological Society in April, 1951. No fossils were observed by the writer.

The Athens of this report corresponds to the Blockhouse shale and Tellico formation of Neuman (1955). The term Athens was used instead of Neuman's subdivision of the section for two reasons. First, no unit corresponding to his Blockhouse shale was observed in the northwest quarter of the Cohutta Mountain quadrangle. The entire Athens section corresponds lithologically to Neuman's Tellico. Second, the choice of the much abused term Tellico for these rocks is, in the writer's opinion, unfortunate.

The Athens shale is best exposed in the northwest quarter of the Cohutta Mountain quadrangle in road cuts east of Tennga and west of Cisco (map coordinates from S. 3.8, E. 4 to S. 2.7, E. 11 and from S. 17.7, E. 0.3 to S. 19, E. 3.2).

No fresh exposures of the Athens were observed in the area, but the freshest obtainable calcareous silty shale is generally dark yellowish orange (10 YR 6/6) in color, weathering to a pale yellowish orange (10 YR 8/6) or moderate reddish orange (10 R 6/6).

Bedding is fairly regular, ranging from 2 mm to 8 mm in thickness, but averaging approximately 3 mm.

The freshest obtainable calcareous siltstone is generally dark yellowish brown (10 YR 4/2), weathering to a light olive gray (5 Y 6/1) or grayish orange (10 YR 7/4). Bedding is irregular and as thick as 2 cm, but again averages close to 3 mm.

The calcareous feldspathic sandstone varies in color from grayish orange (10 YR 7/4) to moderate reddish orange (10 R 6/6). Both the quartz and feldspar sand grains usually average about .5 mm in diameter. Thus, the feldspar grains are plainly visible in a hand specimen. Beds of sandstone range in thickness from 1 to 18 cm, generally thickening and assuming greater topographic expression to the southwest. Although the standstone typically appears very porous due to the loss of calcite cement, it remains quite coherent.

Hayes (1895, p. 3) estimates the thickness of the Athens shale in the northwest quarter of the Cohutta Mountain quadrangle as 3000 feet, and Butts and Gildersleeve (1948, p. 29) estimate the thickness as 3500 feet. Both estimates are too low. Although Hayes does not state the evidence for his estimate, it is clear that Butts and Gildersleeve erred in underestimating the average dip of the beds. On the basis of the section exposed east of Tennga (map coordinates from S. 3.8, E. 4 to S. 2.7, E 11), a conservative estimate of the thickness of the Athens is 4000 feet.

Chota formation. The term Chota formation is here applied to a portion of the Middle Ordovician section composed predominantly of quartzose calcarenite, conformably underlying the Athens shale. Near its top, the formation is overriden by the Great Smoky fault.

The type area of the Chota formation is the Vonore quadrangle, Monroe County, Tennessee, and the name is taken from the Chota School. Neuman (1955, p. 157) proposed the term to apply to the "sandstone lentil of the Sevier formation" of Keith (1895), and the Holston formation as mapped in that area by Rodgers (1953).

Neuman (1955, p. 157-160) describes the Chota as a quartzose calcarenite, gray, dark gray, and reddish gray in color. Small well-rounded quartz grains are generally disseminated throughout the rock, which is composed largely of coarse encrinal debris embedded in coarse crystalline calcite. The rock is characteristically cross-bedded, with wavy bedding-plane partings.

Identifiable fossils are rare in the type area. Bryozoans are locally abundant, and debris from these and from crinoids and cystoids locally forms a large proportion of the rock. Numerous trilobites and brachiopods were observed by Neuman, but few of these were sufficiently well preserved to permit specific identification. The generic assignments do not permit definite correlation. Both Rodgers (1953) and Neuman, however, believe the Chota to be the quartzose equivalent of the Holston formation.

In his description of the Chota and Tellico (Athens of this report) formations, Neuman (1955, p. 154-160) differentiated in detail between the sandstones found within each formation.

As there seems to have been much confusion in the past concerning these two sandstone units, a summary of their distinguishing characteristics seems warranted. 1) The calcarenite of the Chota formation is more than 50% calcite, whereas the proportion of noncalcareous material, including detrital grains and clay, is much higher in the sandstone of the Tellico formation. 2) The Chota contains no feldspar grains, whereas the Tellico has a notable feldspar content. 3) The Chota is characterized by cross-bedding and wavy bedding-plane partings, whereas all current features are very rare in the Tellico. 4) Little quartzose calcarenite of the Chota contains sufficient insoluble material to retain its cohesiveness after the calcium carbonate has been dissolved; weathered rock, therefore, rarely has a thick porous rind. The sandstone of the Tellico, on the other hand, retains its cohesiveness after weathering, even though it becomes quite porous. 5) The Chota formation produces a deep red soil composed of a mixture of sand and clay, whereas the Tellico produces a soil containing small porous blocks of weathered sandstone and many thin shale chips.

In the northwest quarter of the Cohutta Mountain quadrangle, the Chota formation is present in a belt extending along the front of the Mountains from the northern edge of the area to the Fairy fault. Hayes (1895) and Butts and Gildersleeve (1948) mapped this belt as Tellico. As redefined by Neuman, however, the term Tellico is restricted to rocks further down in the section, including rocks specified as Tellico by Keith (1895) in the type locality on the Tellico River in the Knoxville quadrangle (see also above, p. 17). Neuman's distinctions are so precise, and those of previous authors so vague by comparison, that his term Chota is used for the unit of quartzose calcarenite overlying the Athens in the northwest quarter of the Cohutta Mountain quadrangle.

The Chota formation of this report may be subdivided into two main rock types. The lower 125 feet and the upper 375 feet of the formation are composed largely of cross-bedded calcareous sandstone. The following description is of weathered outcrop as no fresh exposures were observed in the area.

Medium- to coarse-grained light brown (5 YR 6/4) sandstone is the most abundant constituent of this rock type. The sandstone is invariably cross-bedded. The thickness of the beds is seven to nine cm, and that of the cross-beds is two to six mm. The porous and friable texture of the rock indicates its calcareous nature prior to weathering. Unlike the calcareous sandstone of the Athens, this rock contains no visible feldspar and does not produce large amounts of coherent float.

The beds of light brown cross-bedded sandstone described above are separated by beds one cm thick of medium- to coarse-grained brownish black (5 YR 2/1) sandstone, and beds seven to ten cm thick of medium- to coarse-grained yellowish gray (5 Y 8/1) sandstone. Both of these latter sandstones are also porous and friable, but lack cross-bedding. Beds one to three mm thick of pale red shale also appear in the section.

The appearance of the sandstone units as a whole may be described as variegated, due to the juxtaposition of red, yellow, brown, and black beds. Exposures of the lower sandstone are best seen along an old logging road east of Tennga (map coordinates S. 2.8, E. 11.2). The upper sandstone unit is best exposed both on the logging road east of Tennga and on a wagon road southeast of Cisco (map coordinates S. 3.3, E. 13 and S. 22.7, E. 7).

The middle portion of the Chota formation, 1075 feet thick, is composed largely of cross-bedded quartzose calcarenite (see fig. 6). On a fresh surface it is generally medium gray (N 5) in color, usually with a reddish cast. The rock weathers medium dark gray (N 4) to moderate red (5 R 5/4), depending upon the amount of hematite present. The typical cross-bedded quartzose calcarenite is composed of 61% calcite and 36% quartz. As shown in fig. 6 lenses of quartz-free calcarenite occur interbedded with the quartzose calcarenite. The subrounded quartz grains average .15 mm in diameter and are rarely touching. Although Neuman (1955) observed no feldspar in the rocks of the Chota formation as mapped in Tennessee, rocks of the Chota as mapped in the northwest quarter of the Cohutta Mountain quadrangle show a few small grains of feldspar when examined in thin section.

As noted by Neuman (1955), little quartzose calcarenite of the Chota contains sufficient insoluble material to retain its cohesiveness after calcium carbonate has been dissolved. Weathered rock, therefore, rarely has a thick porous rind.

On occasion, when an outcrop did retain its cohesiveness after calcium carbonate was dissolved it was mapped as cross-bedded sandstone rather than calcarenite (see map).

Also present in the middle portion of the Chota are lenses of bryozoan debris (see fig. 2). The bryozoans are fragmentary and waterworn, obviously having been redeposited. Wearing away of apertural ends of zooecia prevents definite generic identification, but the bryozoans are probably of the genus *Amplexopora.*

Coarse limestone conglomerates are present at various stratigraphic positions within the middle portion of the Chota formation. One such conglomerate exposed east of Cisco (map coordinates S. 20.3, E. 6.9) was studied by Kellberg and Grant (1956, p. 713-714) and compared with other Middle Ordovician conglomerates in the southern Appalachian Valley. As reported by Kellberg and Grant, the conglomerates at Cisco are not basal as was assumed by Butts and Gildersleeve (1948, p. 29). All other limestone conglomerates in the area, however, appear to be at the base of the middle portion of the Chota formation (map coordinates S. O, E. 11.5, S. 27, E. 3.2, and S. 29.2, E. 2.9).

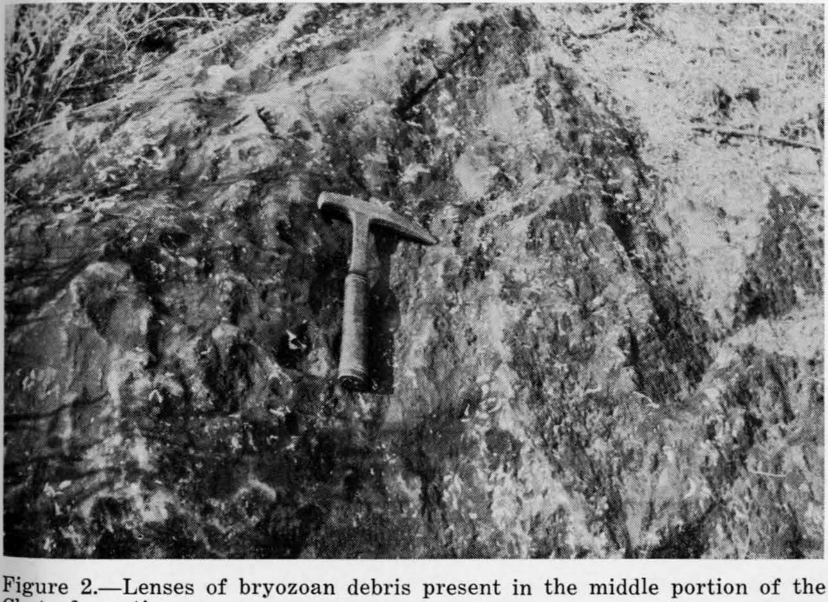


Figure 2.—Lenses of bryozoan debris present in the middle portion of the Chota formation.

The middle calcarenite portion of the Chota, like the upper and lower sandstone portions, is best exposed on an old logging road east of Tennga (map coordinates from S. 2.8, E. 11.2 to S. 3.2, E. 12.9). It is also well exposed in a bend of the Conasauga River on the extreme northern edge of the area (map coordinates S. O, E. 12.5). Fair exposures are found on the shoulders of small ridges east and northeast of Cisco (map coordinates S. 20.3, E. 6 and S. 16.5, E. 7).

The Chota formation produces a characteristic deep red soil composed of a mixture of sand and clay. Its topographic expression is positive, generally as steep conical knobs separated by deep gaps.

Rocks East of the Great Smoky Fault and North of the Alaculsy Valley Fault

Description. Rocks composing the fault block north of the Alaculsy Valley fault present two quite different aspects to the observer. In the southwest portion of the fault block (e.g., map coordinates S. 15, E. 13.5) beds of quartzite are ridge-makers, generally cropping out as high cliffs. Their color on a fresh surface ranges from grayish pink (5 R 8/2) to very light gray (N 8), giving a "clean" appearance to the rocks, and an extremely coherent blocky float is produced upon weathering. These beds of quartzite bear a very close resemblance to quartzites of the Chilhowee group exposed on Bean Mountain ten miles to the north. Stose and Stose (1949, p. 295) believe that these rocks are Chilhowee, and the writer also believed this to be true at the outset of mapping. Subsequent work, however, proved that the beds of quartzite are not part of the Chilhowee group, but rather are a part of the Ocoee "series."[1]

In the northeast portion of the fault block, beds of metasubgraywacke crop out (e.g., map coordinates S. 3.5, E. 22). The metasubgraywacke, unlike the quartzite, generally is not a ridge-maker and does not form cliffs. It has the "dirty" appearance of typical Ocoee rocks, its color on a fresh surface ranging from light olive gray (5 Y 6/1) to greenish gray (5 GY 6/1). Such large amounts of sericite and chlorite are present that, despite the relatively large size of the quartz and feldspar grains, the metasubgraywacke typically has a

[1]The time-stratigraphic term "series" is used here with regret because it has been used in the past. It actually has no time significance.

schistose texture. Upon weathering, the rock becomes very friable, and little float is produced.

By analogy with the structure and stratigraphy of Bean Mountain, an outlier of the Chilhowee group would seem to be present in the northwest quarter of the Cohutta Mountain quadrangle, overlying at least a portion of the Sandsuck shale of Rodgers (1953). As part of the detailed mapping of the area, however, each quartzite bed was walked out along the entire length of its outcrop, and the two different lithologies were found to be two facies of the same rock unit. Thus, not only did the supposed Chilhowee rocks prove to be Ocoee, but they also proved to be stratigraphically equivalent to rocks of quite different appearance cropping out in the northeast portion of the fault block. The facies change is illustrated on the accompanying geologic map and on pl. II. The quartzite facies is represented on the map by a red color, and the metasubgraywacke facies by the same red color with an overlay of horizontal cross-hatching. Where the metasubgraywacke facies also contains feldspar the red color is overlain by both horizontal and vertical cross-hatching. Table 3 lists average modal analyses from locations at regular intervals along the strike of a typical unit of quartzite undergoing the

Location	Map Coordinates	Quartz	Feldspar	Matrix
1	S 14.1, E 13.6	90.3%	0%	9.7%
2	S 13.3, E 14.0	81.6	0	18.4
3	S 12.6, E 14.5	64.4	0	35.6
4	S 11.6, E 15.3	73.0	0	27.0
5	S 10.2, E 16.6	66.1	0	33.9
6	S 8.3, E 18.5	59.6	0	40.4
7	S 6.5, E 20.1	53.2	0.8	46.0
8	S 5.3, E 20.5	38.3	0.4	61.3
9	S 4.1, E 22.5	54.1	0.9	45.0

Table 3. Average modal analyses from locations at regular intervals along the strike of a typical quartzite-metasubgraywacke unit.

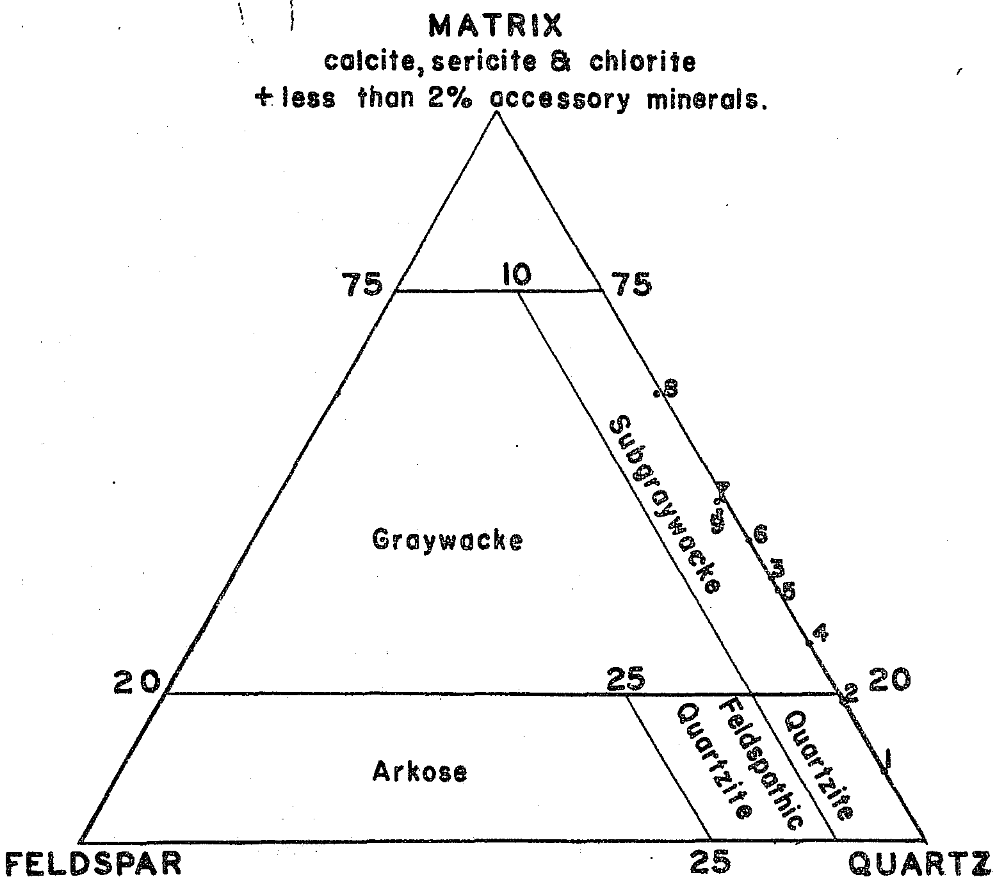
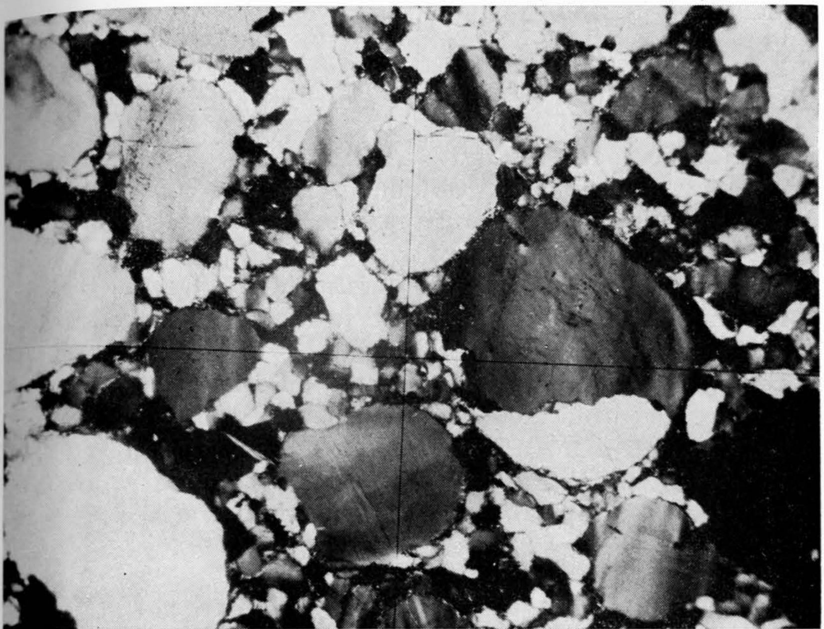


Figure 3. Range in mineral composition along strike of a typical quartzite-metasubgraywacke unit. (Classificatory scheme from Pettijohn, 1949, p. 227).

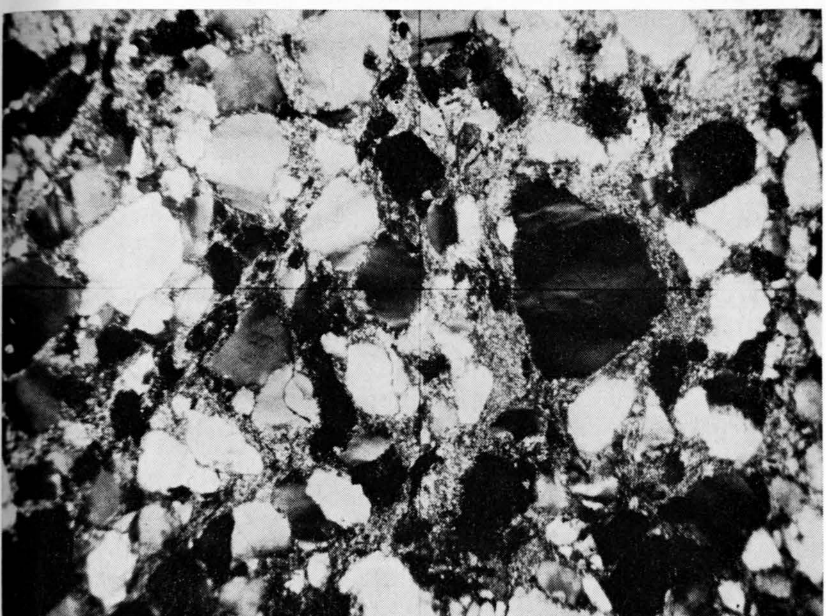
change to metasubgraywacke. Figure 3 illustrates this facies change diagrammatically. Below are megascopic and microscopic descriptions of the rocks at each location.

Location 1. Megascopically, the rocks at location 1 appear to be quite pure and well indurated quartzite. The unit is approximately 50 feet thick and includes three or more beds of quartzite sporadically separated by thin phyllite lenses. The color varies from pinkish gray (5 YR 8/1) to very light gray (N 8) on a fresh surface. Weathering may result in a brownish stain where hematite is present in the rock, but exposure and lichen growth generally produce a medium dark gray (N 4) patina. Jointing is extensively developed and quartz veins are common. Topographic expression is not great, probably owing to the jointing and veining, as well as to the relatively small thickness of the unit. Sorting is good and bedding is difficult to determine.

PLATE II



Location 1. 35X



Location 9. 35X

Much massive, blocky float is produced by weathering. The float is not friable and generally does not have a porous appearance.

Microscopically, the rocks at location 1 do not appear as pure as in hand specimen, but they are still classed as moderately pure quartzite (see fig. 2). Rounded quartz grains 0.6 to 1.0 mm in diameter form the major portion of the typical specimen. The interstices between the grains are filled with subrounded to rounded quartz grains, averaging 0.1 mm in diameter. Many quartz grains of both sizes show unusually clear strain lamallae, and all are slightly corroded at their margins. No recrystallization was observed, and none would be expected considering the preservation of strain lamallae in the quartz grains. The calcite-sericite matrix is nothing more than a thin coating on most of the grains. A few rounded grains of zircon, composing less than 0.1% of the rock, are present as accessory minerals.

Location 2. Megascopically, the quartzite at location 2 still appears pure and well indurated on a fresh surface. Weathering normally produces the same brown or gray patina as at the previous location, but in a few specimens may also bring out dark flecks of limonite and leave the rock slightly porous. Though the quartzite unit is only 50 feet thick, its topographic expression is good (other quartzite units to the west and south average about 100 feet thick). The sorting is also good and the grain size is small (maximum 1 mm). Much massive, blocky float is produced by weathering.

Under the miscroscope, the quartzite from location 2 again does not appear as pure as in hand specimen but is still classed as a quartzite. Subrounded to rounded quartz grains, 0.4 to 1.0 mm in diameter, make up the major portion of the typical specimen. The interstices between the grains are filled with subangular to subrounded quartz grains averaging 0.1 mm in diameter. All quartz grains are corroded at their margins by the matrix, which is composed of very finely divided calcite and sericite with scattered fragments of quartz. Although strain lamallae are still present in many quartz grains, recrystallization of the finest quarz fragments does appear to have taken place. A larger variety of accessory minerals was observed, including hematite, zircon, and what appear to be a few flakes of allogenic muscovite and biotite.

Location 3. Megascopically, the rock at location 3 appears to be fairly pure quartzite when fresh. Weathering, however, quickly indicates the relatively large amount of matrix. The weathered rock is more porous and friable than a quartzite should be and has a "chalky" appearance in addition to the patinas described above. The odor of clay minerals can be detected on all weathered specimens. This odor and the chalky appearance of the specimens suggest the presence of a small amount of feldspar, but microscopic examination proved otherwise (see below). Near location 3 the topographic expression becomes less pronounced, evidently because of the change in composition. Sorting is still good and grain size remains the same, only a few specimens containing grains as large as 1.5 mm. The blocks of float produced on weathering seem to be slightly smaller and definitely more friable and porous than those at the previous two locations.

Microscopically, the rock appears to have a subgraywacke composition. Subangular to subrounded quartz grains, 0.4 to 1 mm in diameter, make up the major portion of the typical specimen. As before, there are slightly smaller grains accompanying the larger ones. Strain lamallae are still present in many quartz grains, and there is no evidence of recrystallization. The matrix slightly corrodes the margins of all quartz grains. Accessory minerals observed were the same as at location 2.

Location 4. Megascopically, the rock at location 4 still appears to be fairly pure quartzite when fresh. As before, weathered rock is porous, slightly friable, and chalky in appearance. Topographic expression remains poor, though still definite. For the first time, sporadic lenses of conglomerate appear in the unit, with grain sizes up to 4 mm. For the most part, however, sorting is good and grain size is small. Float is porous and slightly friable.

Under the microscope the typical specimen from this location again reveals a subgraywacke composition. The quartz grains are slightly more angular than previously, but, except for the pebbles in the conglomerates, remain about the same size. Grain margins are corroded and appear slightly recrystallized, although not sufficiently recrystallized to remove the strain from the quartz. The matrix remains the same.

Location 5. The metasubgraywacke does not crop out near location 5. It has lost all topographic expression, and may be traced solely by means of sporadic concentrations of float. On the basis of the float, little change may be observed from location 4, although a slightly greater friability of the rock was noted. Quartz grains may with difficulty be rubbed off the surface of some float pieces by hand. Further, a large portion (about 15%) of the float is conglomeratic, although 4 mm is still the maximum grain size. As there is so little apparent change in the lithology of the metasubgraywacke from the previous two locations, the loss of topographic expression and lack of outcrops is attributed to attenuation of the unit.

Microscopically, the typical specimen from location 5 is almost identical with the typical specimen from location 4. The sole difference is a slightly larger average matrix content.

Location 6. The metasubgraywacke crops out and reattains pronounced topographic expression near location 6, apparently because of an increase in thickness of the metasubgraywacke unit to between 50 and 70 feet. At this point, two changes in the lithology of the metasubgraywacke are also noted. First, conglomeratic metasubgraywacke, containing pebbles up to 2 cm in diameter, appears in the unit. Second, so great a portion of the rock is matrix that a definite plane of schistosity is present, most notable in the more conglomeratic specimens. Other characteristics appear unchanged from the previous location, especially in the finer grain sizes.

Microscopically, there is again little change in the typical specimen, except for an increase in matrix content.

Location 7. A steady increase in topographic expression near location 7 appears related to a steady increase in the thickness of the unit. The thickness at location 7 is approximately 100 feet, with most of the added beds composed of very fine pebble conglomerate (3 mm average grain size). The maximum grain size observed was 1 cm. Small phyllite fragments are common components of this conglomerate, and all grain sizes show a definite schistosity. A change in the color of the rock was noted for the first time. The typical specimen is light olive gray (5 Y 6/1) in color with a slight greenish cast. The pinkish gray color (5 YR 8/1) common to the rocks of previous locations is no longer observed. Float produced by weathering is more chalky in appearance and more friable than at previous locations.

Microscopically, the greatest change at location 7 is the first appearance of feldspar. The feldspar grains are subangular, badly corroded by the matrix, vary in composition from ($Ab_{58}An_{42}$) to ($Ab_{75}An_{25}$), and appear allogenic. The quartz grains remain the same—subangular with corroded margins and interior strain lamallae. The matrix makes up a greater proportion of the rock than previously and is no longer so finely divided. For the first time chlorite is visible and makes up a significant amount of the matrix (about 10%).

Location 8. Topographic expression is good and the thickness of the unit is still greater (approximately 150 feet) near location 8. Again, most of the additional beds are composed of very fine pebble conglomerate, with maximum observed grain size 1 cm. A plane of schistosity is prominent. The typical specimen remains light olive gray (5 Y 6/1) in color, but the greenish cast is even more unmistakable. Float is chalky and very friable. Most weathered fragments may be kicked to pieces with ease.

Microscopically, there is no change beyond an increase in average matrix content between specimens from location 8 and those from location 7.

Location 9. Topographic expression is excellent near location 9. The metasubgraywacke unit forms the crest of a steep, 200-foot ridge. The thickness of the unit has increased to approximately 400 feet, perhaps 40% of which is conglomeratic. The rocks are commonly greenish gray (5 GY 6/1) in color when fresh, but heavily stained with limonite when weathered. Much of the unit is so friable upon weathering that, considering the thickness of the unit, very little float is produced.

Microscopically, there is no change beyond a decrease in matrix content and an increase in feldspar content between specimens from location 9 and those from location 8.

The facies change described above is typical for all the quartzite-metasubgraywacke units in the area. As is clear from the map, most units cannot be traced throughout the change, although there is generally enough scattered float between endpoints to show that the units are at least discontinuously present.

Two further points concerning quartzite-metasubgraywacke units should, however, be brought out. First, it should be noted that the quartzite beds on the margin of the northern part of the Alaculsy Valley (map coordinates S. 13, E. 24 and S. 5, E. 33) do not undergo a facies change. Second, it should be noted that, in the northeast portion of the fault block, the facies change progresses beyond the endpoint described above for the typical metasubgraywacke facies. Rocks in the vicinity of map coordinates S. 0.2, E. 34 contain a larger proportion of chlorite in their matrix, and hand specimens are a definite greenish gray in color. Quartz content is about the same (50.7%) but feldspar content increases to an average of 8.2%. Potassium feldspar was noted for the first time in the metasubgraywacke at this location, being confined, however, to a few conglomeratic samples. Extensive recrystallization of calcite in the matrix also occurs, authigenic calcite crystals as much as 0.6 mm across being common. In some cases it appears that metasubgraywacke may even grade into phyllite along strike. Rocks exposed at map coordinates S. 4.4, E. 26.8 and S. 5, E. 24.9 present the best example of this phenomenon. On the eastern side of the river bend the rocks are best described as metasubgraywacke showing a pronounced plane of schistosity, and on the western side of the river bend the rocks are best described as phyllite interbedded with metasubgraywacke showing a pronounced plane of schistosity.

Three other rock types are found north of the Alaculsy Valley fault: phyllite, metasiltstone, and metalimestone. The most common is phyllite. Sporadically interlayered with the phyllite are thin layers of metasiltstone, but the two are discussed and mapped together for convenience. Phyllite occurs above, below, and between the quartzite-metasubgraywacke units. It is rarely observed in an unweathered state and, in fact, usually does not crop out at all unless exposed by rapid erosion in stream beds and gulleys or by the works of man, as in the cut banks of logging roads. As might be expected, the phyllite lacks pronounced topographic expression, generally forming the spurs and valleys between high ridges of quartzite. On a fresh surface, both the phyllite and metasiltstone are typically medium gray (N 5) to greenish gray (5 GY 6/1) in color. Weathering produces a variegated appearance, each original layer of silt or clay within the phyllite assuming a slightly different color. For the most part, these colors are shades of yellow or brown, due to limonite staining.

Three outcrops of metalimestone were observed north of the Alaculsy Valley fault. The first, at map coordinates S. 17, E. 11.6, lies just beneath the lower quartzite unit. It is an irregularly laminated metalimestone approximately 150 feet thick. Laminae range in thickness from 1 cm to less than 1 mm, but average about 2 mm. The rock is heavily veined with calcite, most veins averaging about 2 mm in width. On a fresh surface, the metalimestone is medium gray (N 5) in color, weathering to a medium light gray (N 6). Under the microscope the rock reveals very little apparent recrystallization. Except in the calcite veins, identifiable calcite crystals are rare. Some laminae contain concentrations of subangular quartz grains as much as 0.3 mm in diameter but, for the most part, the rock consists of finely divided calcite and argillaceous material.

The second and third outcrops of metalimestone observed north of the Alaculsy Valley fault lie between two beds of metasubgraywacke at map coordinates S. 2.7, E. 29.7 and S. 2.3, E. 30.6. They apparently represent two outcrops of the same bed no more than 50 feet thick. It differs markedly from the other metalimestone in that it displays no stratification. It is, however, heavily veined with calcite, most veins averaging about 1 mm in width. On a fresh surface the metalimestone varies from medium dark gray (N 4) to medium gray (N 5) in color, weathering to a medium light gray (N 6). Under the microscope the rock reveals a greater degree of recrystallization than that of the previous metalimestone, yet no more than 5% of the rock is composed of discernible calcite crystals. Again, most of the rock is composed of finely divided calcite and argillaceous material, with angular to subangular quartz grains up to 1 mm in diameter randomly scattered through it.

Name. It is clear from the detailed investigation discussed above that the pure quartzite beds northwest of the Alaculsy Valley fault cannot be assigned to the Chilhowee group. In the first place, such pronounced facies changes as the one observed in the area are not found in formations of the Chilhowee group. King et al. (1958, p. 964) describe these formations as traceable for hundreds of miles along strike in Tennessee, remaining recognizable Chilhowee throughout. In the second place, the pure quartzite beds have proved to be a facies of rocks mapped by Hayes (1895) and Rodgers (1953) as underlying the Chilhowee group in the adjacent Cleveland quadrangle.

Hayes (1895, p. 2) did not recognize the facies relationships of the quartzite-metasubgraywacke units in the Cleveland quadrangle. He called the quartzite Citico conglomerate, and the metasubgraywacke and phyllite together Pigeon slate. Rodgers (1953, p. 26) assigned to the Sandsuck shale all rocks in the Cleveland quadrangle equivalent to those north of the Alaculsy Valley fault in the northwest quarter of the Cohutta Mountain quadrangle.

Rocks north of the Alaculsy Valley fault are tentatively assigned in this report to the Sandsuck formation. They are undoubtedly the Sandsuck of Rodgers (1953). The Sandsuck shale, however, was named by Keith (1895) for Sandsuck Branch southeast of Chilhowee Mountain near its northeastern end, and lithologic correlation over a distance of some 70

Rock Units	Average Thickness
phyllite	400 +
upper quartzite	100
phyllite	500
lower quartzite	100
phyllite	600 +

Table 4. Typical divisions of the Sandsuck (?) formation.

miles in an area of such great structural complexity calls for caution. It is hoped that these rocks will be positively identified as Sandsuck when the work of King et al. (1958) progresses far enough southward.

It will be noted from Table 4 and the geologic map that the Sandsuck (?) typically contains two quartzite-metasubgraywacke units separated by phyllite. These units are not sufficiently continuous to be called formations, but in most places can be differentiated as upper and lower quartzite members of the Sandsuck (?).

Age. The age of the Ocoee "series," of which the Sandsuck formation is a part, has been the subject of dispute since its first description by Safford (1856, p. 151-152). Ages assigned to the Ocoee have ranged from Precambrian to well up in the Paleozoic (King, 1949, tbl. 2, p. 622-623). The most recent exhaustive reports on the age of the Ocoee are those by King (1949) and Rodgers (1956). King (1949, p. 638) concluded that the Ocoee was of late Precambrian age. Rodgers (1956, p. 410) designated the Ocoee as "Cambrian or Precambrian." King et al. (1958, p. 965), also speaking for the U. S. Geological Survey, now classify the Ocoee as "later Precambrian."

The writer agrees with the classification of King et al. (1958) and, insofar as the rocks under discussion can be assigned to the Sandsuck formation (or at least to the Ocoee "series"), they are also assigned to the later Precambrian.

Rocks East of the Great Smoky Fault and South of the Alaculsy Valley Fault

Description. Two different rock types are found north of the Alaculsy Valley fault: 1) a metagraywacke and 2) a phyllite-metasiltstone combination similar to that found north of the fault. Unlike the quartzite exposed north of the Alaculsy Valley fault, neither rock type crops out strongly or has pronounced topographic expression, necessitating a change in mapping method. Instead of tracing individual beds along strike, as in the case of the quartzite-metasubgraywacke units, traverses across strike were made along streams and old logging roads where exposures were relatively plentiful. Wherever a bed of metagraywacke cropped out strongly, however, it was traced along strike as far as possible.

The metagraywacke differs from the metasubgraywacke exposed north of the Alaculsy Valley fault in the following ways: 1) it generally lacks the relatively large amount of chlorite common to the metasubgraywacke; 2) it has a larger average grain size; 3) it contains a larger amount of feldspar; 4) it commonly contains quartz which is blue in color, unlike the milky or clear quartz of the metasubgraywacke; 5) it commonly has graded bedding, which is rare in the metasubgraywacke; and 6) it contains a large amount of disseminated pyrite, which is also rare in the metasubgraywacke.

Table 5 lists modal analyses of five typical metagraywacke specimens from locations spaced across the entire width of metagraywacke outcrop within the area. Figure 4 diagrammatically illustrates the range in composition of these specimens.

The metagraywacke exhibits the typical "dirty" appearance of Ocoee rocks. The color on a fresh surface ranges from pale yellowish brown (10 YR 6/2) to light olive gray (5 Y 6/1), weathering to medium light gray (N 6). Outcrops are generally stained moderate brown (5 YR 4/4) with limonite.

Location	Map Coordinates	Quartz	Feldspar	Matrix
800	S 31.7, E 21.2	62.0 %	31.3 %	6.7 %
800 A	S 31.7, E 21.2	56.1	19.6	24.3
564	S 16.5, E 39.1	61.4	18.3	20.3
564 A	S 16.5, E 39.1	60.6	15.2	24.2
510	S 34.2, E 30.7	53.8	12.0	34.2
510 A	S 34.2, E 30.7	53.8	5.8	41.0
TG-1	S 50.5, E 37.8	47.5	22.6	29.9
701	S 34.8, E 7.6	60.2	8.8	31.0
526	S 38.5, E 41.3	42.8	23.6	33.6
526 A	S 38.5, E 41.3	41.8	18.2	40.0

Table 5. Modal analyses of ten typical metagraywacke specimens.

Bedding ranges from thin to very thick, and the metagraywacke is commonly interbedded with laminated phyllite and metasiltstone. Graded bedding is found in both the metagraywacke and metasiltstone, whereas cross-bedding and scour channels are generally found only in the metasiltstone. As in the case of the rocks north of the Alaculsy Valley fault, the grade of metamorphism is equivalent to that of the chlorite zone of Fyfe, Turner and Verhoogen (1958, p. 218), and the low grade of metamorphism makes possible ready determination of bedding features. A relatively small amount of float is produced owing to the friability of the weathered rock.

Microscopically, the rock appears to be composed principally of subrounded quartz grains averaging 1.5 mm in diameter (see pl. III). The quartz is commonly a bluish color in hand specimen, but is colorless under the microscope. Strain shadows are much in evidence, but no strain lamellae were noted.

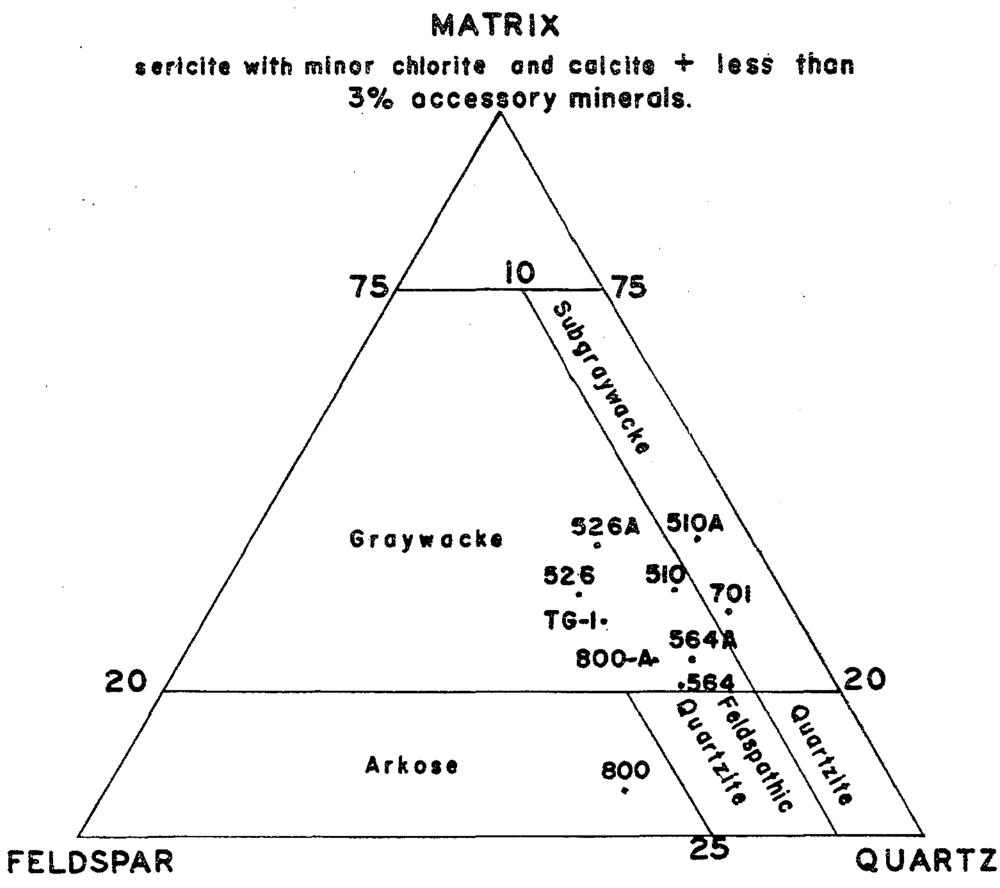
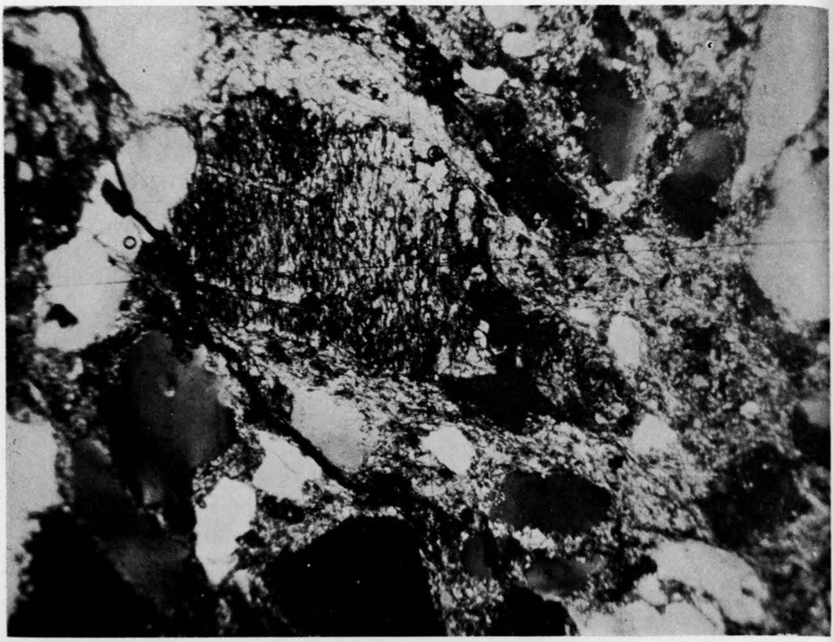


Figure 4. Range in mineral composition of ten typical metagraywacke specimens. (Classificatory scheme from Pettijohn, 1949, 227).

PLATE III



Location 564. 35X

Location 526A. 35X

A relatively large amount of plagioclase feldspar is present in the rock, ranging in composition from ($Ab_{50}An_{50}$) to ($Ab_{82}An_{18}$). Some potash feldspar was observed in specimens from locations near the southern edge of the area—e.g., number 526. Both quartz and feldspar grains are corroded by the matrix, and the feldspar is penetrated and replaced in places by sericite and chlorite.

Phyllitic fragments are common, and are generally aligned parallel to the bedding. They range in length from less than 1 mm to more than a foot. The matrix of the metagraywacke is composed largely of sericite, with minor amounts of chlorite and accessory minerals. The accessory minerals include pyrite, hematite, magnetite, zircon, and apatite. Some of the smaller grains of quartz, as well as some of the sericite and chlorite, appear to be porphyroblastic, but recrystallization is only incipient.

The second rock type mapped south of the Alaculsy Valley fault is phyllite. Metasiltstone also occurs in the section, but the collective term phyllite has been used here for both lithologies because the beds of metasiltstone do not form mappable units. Nevertheless two distinct and arresting lithologic combinations of phyllite and metasiltstone occur within the phyllite section which merit separate discussion here.

The first combination is a metasiltstone rhythmite, composed of alternating layers of metasiltstone medium dark gray (N 4) and medium light gray (N 6) in color. The width of the layers commonly ranges from 1 mm to 14 cm, but averages about 1 cm. The darker layers are rarely phyllitic, although they may exhibit strong slaty cleavage. (Slaty cleavage, as used in this report, refers to that variety of foliation typical of slates and generally the result of parallel arrangement of platy minerals.) They are calcareous, but require powdering before they will actively effervesce with a 10% solution of hydrochloric acid.

The lighter layers are never phyllitic, although they too may exhibit strong slaty cleavage. They are more calcareous than the darker layers, contain siderite, and will commonly effervesce without powdering. Both layers contain fine crystals of disseminated pyrite.

Upon weathering, the lighter gray (N 6) sideritic layers quickly assume a light brown color (5 YR 5/6), while the darker gray (N 4) layers remain relatively constant in color. The result is an eye-catching alternation of light brown and gray layers which has been noted in similar Ocoee rocks along much of the western edge of the Southern Appalachians. For example, Hadley et al. (1955, p. 70) speak of an "argillite" rock type near Tuckaleechee Cove, Tennessee, which "includes silty shale thinly banded by iron-bearing carbonates," and similar rocks have been seen by the writer cropping out in the gorges of the Ocoee and Hiwassee rivers. Graded bedding is a common feature of such rocks, and was used in the northwest quarter of the Cohutta Mountain quadrangle in determining the top and bottom of beds (e.g., map coordinates S. 15, E. 40). The metasiltstone rhythmite is best exposed on the Conasauga River between map coordinates S. 17.7, E. 28.2 and S. 21.9, E. 32.2. It is also well exposed on Jacks River between map coordinates S. 4.6, E. 38.1 and S. 6.9, E. 41.7.

The second unusual lithologic combination included under the term "phyllite" is composed almost entirely of true phyllite. This phyllitic rhythmite is also commonly composed of alternating layers which are gray in color, although a shade darker (N 3 and N 5) than similar layers of the metasiltstone rhythmite. The darker gray layers are more phyllitic than the lighter layers, and show a stronger slaty cleavage. Thickness of the layers again ranges from 1 mm to 14 cm, and averages about 1 cm.

The lighter gray (N 5) layers commonly have an unusually high (15%) pyrite content. Although pyrite is disseminated throughout the rock, it is concentrated in the lighter layers in crystals up to 5 mm in diameter. In addition to having a higher pyrite content, the lighter layers differ from the darker ones in that they are slightly coarser grained. Most cross-bedding, scour channels, and other indications of current action are found in these coarser-grained layers. Very little of the phyllitic rhythmite appeared to be calcareous in hand specimen, although small amounts of calcite and siderite were observed under the microscope. Good exposures of fresh rhythmite are found on the Conasauga River at map coordinates S. 22, E. 32.3.

Unfortunately, the metasiltstone and phyllitic rhythmites under discussion cannot be mapped separately over the whole area of phyllite outcrop. Although they are outstandingly different and completely separate locally, the metasiltstone rhythmite unit progressively loses its separate identity with distance along strike to the southwest of the Conasauga River. It was also noted that higher in the section (southeast along the Conasauga River) thick sections composed solely of dark gray (N 2 to N 3) nonrhythmic phyllite are exposed. These facts, complicated by the increasing mutual resemblance of all phyllite units with progressive weathering, led to the mapping of all phyllite and metasiltstone south of the Alaculsy Valley fault as a single lithology (i.e., "phyllite"). Further, the lack of good exposures of fresh phyllite and metasiltstone north of the Alaculsy Valley fault for comparative purposes prevented any definite differentiation on the map between that phyllite and phyllite south of the Alaculsy Valley fault.

Even though insufficient evidence exists to make possible a differentiation on the map between the phyllite units north and south of the Alaculsy Valley fault it should be noted that there is lithologic and structural evidence to show that they are differentiated. In terms of lithology, neither siderite-bearing metasiltstone rhythmite nor pyritiferous phyllite rhythmite was seen at any location north of the Alaculsy Valley, but both lithologic combinations are common south of the fault. In terms of structure, there is also a change in the attitude of the slaty cleavage at the Alaculsy Valley fault. North of the fault the cleavage commonly parallels the bedding and reflects the local structure, but south of the fault it was never observed parallel to the bedding and rarely bears any relation to the local structure.

Name. Rocks south of the Alaculsy Valley fault cannot be correlated with any degree of certainty with any modern section of Ocoee rocks. In the outdated section used by Hayes (1895) for the Cleveland quadrangle, the phyllite and metagraywacke units of the northwest quarter of the Cohutta Mountain quadrangle would correspond, at least in part, to the Wilhite slate, Citico conglomerate, and Thunderhead slate and conglomerate. King et al. (1958, p. 961-962) point out that the term Citico conglomerate has little meaning and should be abandoned, and they redefine the Wilhite on the basis of a section exposed on Wilhite Creek near the western tip of English Mountain. As redefined, the formation has very different stratigraphic relations, which certainly could not be extended to cover the rocks south of the Alaculsy Valley fault (see below). It seems necessary, therefore, to propose local names for this section. Rodgers (1953), in his map of the adjacent Cleveland quadrangle, faced a similar difficulty with an Ocoee sequence, which included the section exposed in the northwest quarter of the Cohutta Mountain quadrangle. He overcame this difficulty by dividing his section into two very broadly defined formations: the "fine-grained part of the Ocoee series" and the "Great Smoky conglomerate." Not wishing to complicate the literature any further than necessary, the writer will follow the lead of Rodgers (1953) by using the terms "fine-grained part of the Ocoee series" and "coarse-grained part of the Ocoee series" to apply to the two broad divisions of the Ocoee section exposed in the northwest quarter of the Cohutta Mountain quadrangle.

The dividing line between the two formations, however, is not the same as that used by Rodgers (1953) in his map of the adjacent Cleveland quadrangle. The dividing line of Rodgers, drawn at the base of his Great Smoky conglomerate, corresponds to the base of the Thunderhead conglomerate of Hayes (1895). The dividing line between the two formations in this report is drawn lower in the section at the first appearance of metagraywacke, corresponding to the base of the Citico conglomerate of Hayes (1895).

It must also be made clear that the sequence and stratigraphic relations of these two formations are far different from the sequence and stratigraphic relations of similar rocks mapped in Tennessee by Rodgers (1953) and King et al. (1958). These workers have discarded or redefined the Ocoee stratigraphy used in the Cleveland quadrangle by Hayes (1895) on the basis of exposures in the Knoxville quadrangle 70 miles to the north. In the Knoxville quadrangle, the stratigraphic sequence of the Ocoee section as used by Hayes (1895) is largely reversed. It is most important to note, however, that, on the basis of exposures in the northwest quarter of the Cohutta Mountain quadrangle, the stratigraphic sequence of the Ocoee section used by Hayes (1895) is not reversed (see tbl. 6). This conclusion was reached only after carefully checking the evidence (preserved sedimentary structures) in numerous exposures south of the Alaculsy Valley fault (a fuller discussion of the evidence involved is contained in the section concerning preserved sedimentary structures).

Columnar Section	Thickness (feet)	Rock Type	Formation Names Salisbury, 1959	Hayes, 1895	Rodgers, 1953 (inverted)
	600-1000	metagraywacke	coarse-grained part of the Ocoee series	Thunderhead conglomerate	Great Smoky conglomerate
	?	phyllite		Thunderhead slate	
	300-400	metagraywacke		Thunderhead conglomerate	
	?	phyllite		Pidgeon slate	fine-grained part of the Ocoee series
	200-300	metagraywacke		Citico congl.	
	?	phyllite	fine-grained part of the Ocoee series	Wilhite slate	

Table 6. Generalized columnar section of the rocks south of the Alaculsy Valley fault, and approximate correlation with sections used by Hayes (1895) and Rodgers (1953).

Special attention was paid to the key contact between the fine-grained and coarse-grained parts of the Ocoee "series." There can be little doubt that the coarser-grained section containing metagraywacke overlies the finer-grained section containing only phyllite and metasiltstone, and that both sections are right side up.

The apparent conflict concerning the stratigraphic sequence of rocks in the area mapped by King et al. (1958) and in the area of the present report, indicates the great caution which must be exercised in correlation over the intervening 70 miles. Special care must be taken with the Dixon member of the Wilhite formation and the Shields formation, as these two units most closely resemble the Ocoee section exposed south of the Alaculsy Valley fault, both in lithology and thickness.

Age. The rocks south of the Alaculsy Valley fault may almost certainly be assigned to the Ocoee "series." They do not appear to be part of, or younger than, the Cambrian and Precambrian (?) Chilhowee group, as they contain no fossils and do not bear the slightest resemblance to the unfossiliferous parts of the Chilhowee. They also bear no resemblance to the earlier Precambrian granitic and gneissic rocks. All rocks between these two limits, which must include the rocks south of the Alaculsy Valley fault, are assigned to the Ocoee "series" and classed as later Precambrian in age (see p. 33).

PRESERVED SEDIMENTARY STRUCTURES

Vernon J. Hurst (1955, p. 67-71) has recently demonstrated in full detail the preservation of original sedimentary structures in highly metamorphosed rocks in the Mineral Bluff quadrangle, Georgia. The relatively low grade of metamorphism (chlorite zone of the greenschist facies) in the northwest quarter of the Cohutta Mountain quadrangle makes possible even more perfect preservation of sedimentary structures, and the writer was fortunate to have been instructed in the field by Dr. Hurst in the recognition and interpretation of such structures.

Preserved sedimentary structures in the area were used in two ways: 1) as bedding indicators, and 2) as top-bottom indicators. Bedding indicators, discussed more fully below, made possible the determination of the attitude of even the more massive and metamorphosed rocks. Top-bottom indicators made possible not only an interpretation of the structure of the rocks, but also an interpretation of their stratigraphic relations. It is important to note that the top-bottom criteria used in the field were both internally consistent and mutually corroborative.

Bedding

The determination of bedding poses a problem only in the more massive metamorphic rocks in the area (i.e., quartzite and metagraywacke). In both cases, thin intercalated lenses or beds of phyllite are common enough to permit bedding determination, and often more subtle grain size changes are recognizable. In the case of phyllite and metasiltstone, changes in composition, color, fabric, and grain size generally take place from bed to bed, and, despite the sometimes confusing effect of slaty cleavage, produce recognizable bedding. In the typical example, grain size variations from bed to bed are slight, measurable merely in terms of more or less silt and clay. Such a grain size variation by itself could only be recognized with difficulty. The silty layers, however, may commonly contain relatively large concentrations of calcite, siderite, hematite, or pyrite to add a compositional variation; the argillaceous layers are generally darker gray in color and more strongly cleaved than the silty layers, adding color and fabric variations. Weathering accentuates all such variations

Figure 5.—Weathering has accentuated bedding in the phyllite here (map coordinates S 24, E 30.7) to such an extent that the finest laminae are clearly visible. Note truncated laminae indicating top of beds upward.

between beds, both by throwing into relief the less friable or soluble layers, and by translating compositional changes into striking color variations (see fig. 5).

In the Paleozoic rocks of the Valley, only massive dolostone and limestone posed a problem in bedding determination, generally because of their limited area of outcrop. The dolostone of the Knox, however, contains thin stringers and zones of chert, which are good bedding indicators, and also exhibits less obvious variations in color and solubility from bed to bed. The Newala limestone commonly contains zones of fossil debris as its best bedding indicators, and also exhibits slight color, solubility, and textural variations from bed to bed. As with the metamorphic Precambrian rocks, weathering tends to accentuate the bedding.

Graded Bedding

Graded bedding was observed only in the metamorphosed Precambrian rocks of the area. It is most common in the phyllite, but more easily recognizable in the metagraywacke.

Recognition and interpretation of graded bedding in the phyllite on both sides of the Alaculsy Valley fault may be accomplished in two major ways. Where both thickness of the graded bed and grain-size variation are relatively large, direct observation will reveal top and bottom. Such conditions are rare, but can be particularly well displayed, as near map coordinates S. 14.5, E. 38.5. Here graded bedding in the meta-siltstone rhythmite is quite prominent. In thick but fine-grained beds, on the other hand, where grain-size variation is indetectable to the naked eye, grading may be made conspicuous by the slaty cleavage. Cleavage is more prominent in the least competent, more argillaceous tops of the beds, than in the more competent silty bottoms. Thus, the cleavage may fade out on one side, which is toward the bottom of the bed, and be cut off abruptly on the other side, where there was once a sharp break between the fine-grained top of the bed and the coarser basal portion of the overlying bed. This method of top and bottom distinction was most useful in the southwest portion of the fault block north of the Alaculsy Valley fault, where fine-grained phyllite layers are inter-bedded with quartzite. The method requires a small amount of judgment, and thus was not relied upon unless the cleavage gradation was both prominent and consistent.

Graded bedding in the metagraywacke is more easily recognizable than that in the phyllite. Almost every metagraywacke unit contains zones of conglomerate which grade upward into fine metagraywacke or phyllite, producing textbook examples of graded bedding. Grading in the metagraywacke is, however, less common and on a much larger scale than that in the phyllite, requiring a larger area of outcrop for recognition and accurate interpretation. As the outcrop area at any one place for both metagraywacke and phyllite is generally limited, graded bedding in the phyllite was more useful as a top-bottom indicator.

Cross-Bedding

Cross-bedding is most prominent in the quartzose calcarenite of the Chota formation, as almost all the formation is cross-bedded (see fig. 6).

Such extreme current features are rare, however, in the Precambrian metamorphic rocks. Cross-bedding was never observed in the quartzite, metasubgraywacke, or metagraywacke, but is present in the coarser zones of the inter-bedded

Figure 6—Cross-bedded quartzose calcarenite in the Chota formation at map coordinates S 2.8, E 12.1. Top of beds upward.

phyllite. Generally, however, cross-bedding in the phyllite is suggestive rather than definite as a top-bottom indicator. Because of the small range in grain size of the original sediment, individual cross-bed laminations normally are not traceable with complete certainty. Where, however, prominent cross-bed laminations stand out in relief as a result of weathering, or where some of the cross-bed laminations consist of thin seams of darker argillaceous material to provide color contrast, cross-bedding can be used as a definite top-bottom indicator.

Scour Channels

Large scour channels subject to ready and unequivocal interpretation as top-bottom indicators were not observed in any of the rocks of the area. Small scour channels one to four feet in width and three to twelve inches in depth were, however, rarely observed in the metagraywacke (see fig. 7). For the most part, such features were doubtful indicators and too few in number to supply checks on the consistency of the top-bottom indications.

In the phyllite, less extreme results of bottom scour were more useful as top-bottom indicators. On both sides of the

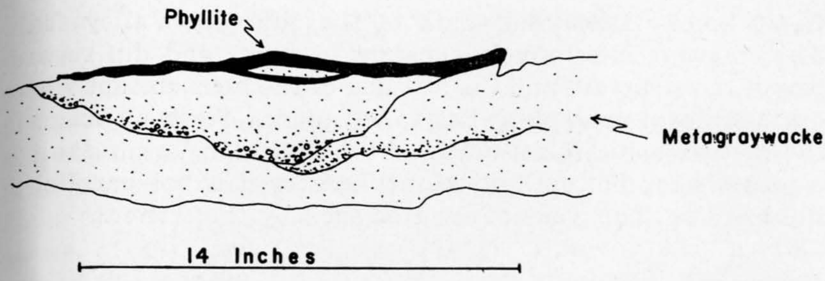


Figure 7. Scour channels in metagraywacke at map coordinates S 34, E 38.7.

Alaculsy Valley fault the phyllite contains truncated laminae (see figs. 5 and 8). When laminae are consistently cut off by layers above them, the beds are right side up. To eliminate chance, more than five such determinations were required at any one outcrop before top-bottom decisions were made. Characteristically, however, where one set of diagnostic truncated laminae existed, a great many others were generally to be found.

Other Top-Bottom Criteria

Although slaty cleavage is by no means a preserved sedimentary structure, it seems pertinent to note here that it cannot be used as a top-bottom criterion in the rocks east of the

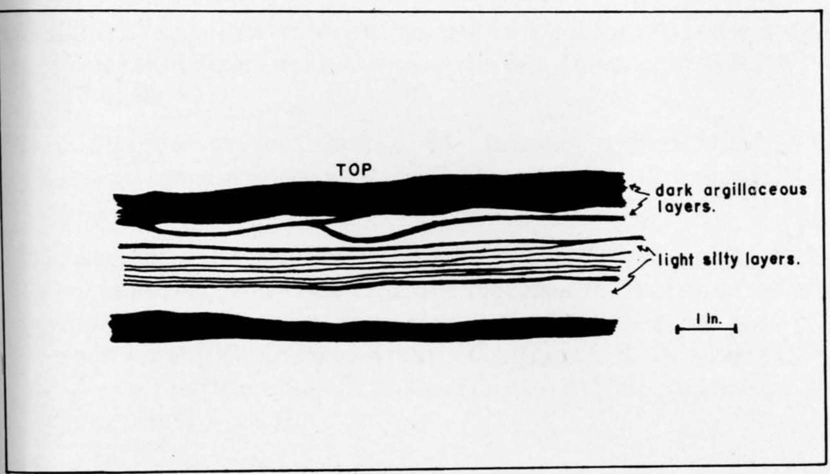


Figure 8. Truncated laminae in phyllite at map coordinates S 26.5, E 29.

Great Smoky fault and south of the Alaculsy Valley fault. The cleavage is relatively constant in strike and dip regardless of the structure and the attitude of the beds, except where extreme local crumpling has taken place. Slaty cleavage in the metamorphic rocks north of the Alaculsy Valley fault is a possible top-bottom indicator wherever it is not parallel to the bedding, but was not used as such by the writer.

SECONDARY STRUCTURES

Faults

Great Smoky fault. All small-scale maps of the southern Appalachians show a major thrust fault separating the Mountains from the Valley—e.g., Jonas (1932), Crickmay (1936), Stose (1946), Stose and Stose (1944, 1949), Butts and Gildersleeve (1948), and Crickmay (1952). Hayes (1891, p. 147) named this boundary fault the Cartersville thrust. At a much later date, Keith (1927, p. 154) called a portion of the fault in Tennessee the Great Smoky overthrust. Further work in Tennessee has firmly established the existence of the Great Smoky thrust in that state—e.g., Hayes (1895), Keith (1895), Rodgers (1953), Hadley et al. (1955), King (1955), King et al. (1958). In his report on the Cartersville district in Georgia, however, Kesler (1950, p. 31-33) denied the existence of a major thrust fault near Cartersville. The lack of sufficiently detailed mapping in Georgia permitted Kesler to throw doubt on the existence of a major thrust fault at any point along the eastern margin of the Valley in Georgia.

Detailed mapping in the area of the present report, however, indicates the presence of a major thrust fault along the Valley margin, and makes possible the extension of the Great Smoky fault (thrust, overthrust) at least eight miles from Tennessee into Georgia.

Evidence for the Great Smoky fault is as follows:

(1) The Conasauga shale is cut off as it obliquely meets the Mountain front near Cohutta Spring (map coordinates S. 45.5, E. 5).

(2) Lithologic discontinuities are present across the fault trace, limestone as well as shale cropping out under the phyllite (map coordinates S. 44.5, E. 4.8).

(3) Although the Valley Paleozoic rocks are slightly metamorphosed, there is an abrupt increase in degree of metamorphism across the fault trace. Such an increase may be seen on the Cisco road (map coordinates S. 21.5, E. 8.1), where phyllite overlies shale and the actual fault contact is exposed (see fig. 9).

(4) A structural discontinuity also exists on either side of the fault trace. The complex folding of the Sandsuck (?)

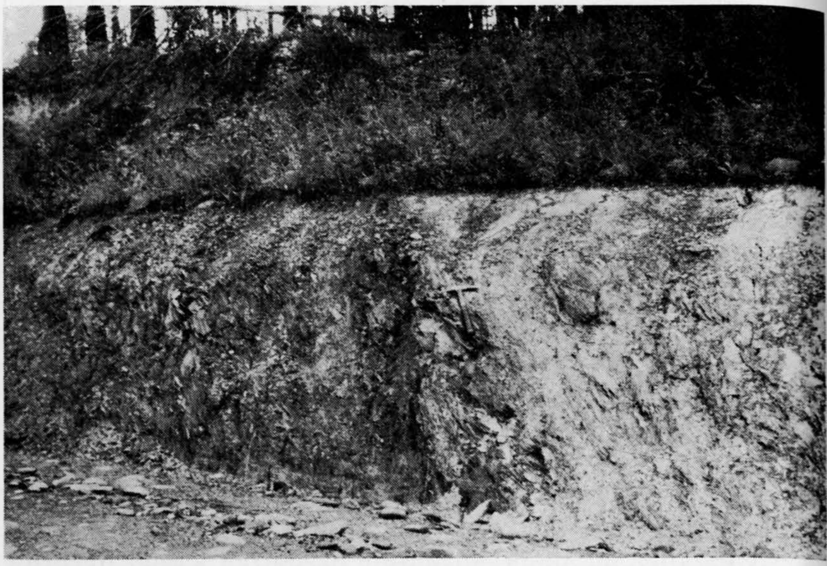


Figure 9.—Fault contact betwen the phyllite (light) and shale (dark) east of Cisco. Looking north.

formation is in strong contrast to the essentially unfolded Chota formation and Athens shale.

(5) Fault slices of anamolous rock occur at no less than two places along the trace of the fault. An isolated slice of quartzite crops out at map coordinates S. 19.9, E. 8.7, and a chert conglomerate (chert now recrystallized) crops out at map coordinates S. 16.6, E. 9.8.

Fairy fault. A minor fault is present in the Valley Paleozoic rocks of the northwest quarter of the Cohutta Mountain quadrangle. The fault, which brings Knox dolomite over the Chota formation, is here named the Fairy fault after Fairy station on the Louisville and Nashville railroad.

Butts and Gildersleeve (1948) mapped the same fault as bringing the Conasauga over the Chota (Tellico of their report) but detailed mapping indicates at least a portion of the Knox section intervening between the Conasauga and the fault contact with the Chota.

Alaculsy Valley fault. The origin of the Alaculsy Valley, and the lineament of which it is a part, has long been the subject of disagreement. In his mapping of the adjacent

Cleveland quadrangle, Hayes (1895) did not recognize the existence of a fault along the extension of the Alaculsy Valley lineament in Tennessee. He mapped the extension (the valley of Sylco Creek) as the center of a breached anticline. Thus, according to Hayes, the quartzite-metasubgraywacke beds north of the Alaculsy Valley and the lowest metagraywacke beds south of the Alaculsy Valley would be the north and south limbs of an overturned anticline. On the basis of evidence obtained in the northwest quarter of the Cohutta Mountain quadrangle, however, such an interpretation of the structure is not possible. In the first place, the quartzite-metasubgraywacke differs from the metagraywacke in six important respects (see p. 34), and is almost certainly not part of the same unit. Further, the finer-grained rock types on either side of the Alaculsy Valley also appear to differ in a few important respects. Phyllite north of the Alaculsy Valley contains lenses of true limestone, but does not contain siderite-bearing metasiltstone rhythmite, phyllitic rhythmite, or disseminated pyrite. Phyllite south of the Alaculsy Valley does not contain lenses of true limestone, but is notable for its siderite-bearing metasiltstone rhythmite, phyllitic rhythmite, and disseminated pyrite. In the second place, where beds of quartzite parallel the Alacaulsy Valley (in the extreme northeast corner of the area and in the adjacent Cleveland quadrangle), both the quartzite and the metagraywacke beds dip to the southeast and are right side up, thus making a fold relationship impossible.

On their small-scale generalized maps of the southern Appalachians, Stose and Stose (1944, 1949) show the Alaculsy Valley not as an anticlinal axis but as a window. According to them (1949, p. 295), "Blue limestone and overlying shale and sandstone of the lower part of the Tellico formation crop out in Alaculsy Valley, Ga. (Pl. 1), and are overlain on their northwest side by quartzites of the Chilhowee group in thrust relation." Actually, not limestone, shale and sandstone, but metasiltstone and calcareous phyllite crop out in the Alaculsy Valley. None of these rocks is fossiliferous, and no differences were observed between the phyllite and metasiltstone in the Alaculsy Valley and the phyllite and metasiltstone in the mountains immediately to the south. Further, the quartzites northwest of the Alaculsy Valley, which were referred to the Chilhowee group by the Stoses, have been shown in this report (see p. 23) to be a facies of the Sandsuck (?) formation. Thus, there seems to be no evidence for the presence of a window in the Alaculsy Valley.

Rodgers (1953) mapped the Alaculsy Valley lineament in the Cleveland quadrangle as a fault (the Sylco Creek fault), and detailed investigation in the northwest quarter of the Cohutta Mountain quadrangle indicates that here also the lineament is the site of a fault. There is, unfortunately, little direct evidence for a major thrust fault, but the conclusion that one exists is almost inescapable. The line of reasoning that leads to such a conclusion is as follows:

(1) Different rock types crop out on either side of the Alaculsy Valley.

(2) Both sections have their tops to the southeast.

(3) Such a relationship can only be produced by a natural stratigraphic succession or by faulting.

(4) A quartzite unit (map coordinates S. 16, E. 18.8 to S. 10, E. 30.3) is cut off as it reaches the Alaculsy Valley, indicating the presence of at least a minor fault.

(5) The presence of a major fault is indicated by a definite increase in the degree of contortion of the phyllite as the Alaculsy Valley is approached from the southeast, and by the marked shattering and hydrothermal alteration of quartzite outcrops along the northern margin of the Alaculsy Valley.

(6) Stratigraphic considerations also favor a major fault, as otherwise formations south of the Alaculsy Valley would be younger than the Sandsuck (?), a circumstance that appears most unlikely.

For these reasons the writer concludes that the Alaculsy Valley marks the site of a major thrust fault.

Folds

Folding west of the Great Smoky fault. Folding was observed at only one place west of the Great Smoky fault (map coordinates S. 4.1, E. 6.9), and is so minor that it cannot be shown on the map. For the most part, rocks west of the fault are remarkably uniform in strike and dip.

Folding east of the Great Smoky fault and north of the Alaculsy Valley fault. Folding in the fault block north of the Alaculsy Valley fault is closely related to rock type. The quartzite-metasubgraywacke units show an overall pattern of large-scale folds overturned to the northwest. In the southwest portion of the fault block, where the units approach pure quartzite, the overturned folds are clearly marked, with no subsidiary folding to mask the total structural picture. In the northeast portion of the fault block, where the units are composed of metasubgraywacke, the rocks appear to lose their ability to sustain large-scale structures. Many subsidiary folds occur (e.g., map coordinates S. 4, E. 24.7) to produce "rumpling" rather than large-scale folding of the metasubgraywacke beds.

The phyllite, though poorly exposed, appears to have been compressed into tight folds by the folding of the quartzite-metasubgraywacke units. The best exposure of phyllite is from map coordinates S. 10, E. 20.2 to S. 6.6, E. 20.1. Here, in the stream bed and adjacent logging roads, the almost isoclinal folding may be followed in detail. Slaty cleavage generally parallels bedding in the phyllite.

Folding east of the Great Smoky fault and south of the Alaculsy Valley fault. The metagraywacke in the fault block south of the Alaculsy Valley fault shows the same weak structural characteristics as the metasubgraywacke north of the fault. The folding is an irregular rumpling which appears highly inconsistent along strike. Most of the folds do not appear to be overturned, as preserved sedimentary structures commonly indicate that the beds are upright both where they are dipping southeast and where they are dipping northwest.

The phyllite seems to be folded after the same fashion as the metagraywacke, except near the Alaculsy Valley fault where tighter folding and more complex crumpling occur. Almost all folding and crumpling on an observable scale show a remarkable agreement in strike and plunge, the strike of the typical axial line averaging N. 45° E. and plunging about 25° NE.

Although slaty cleavage north of the fault is commonly parallel to the bedding, the slaty cleavage south of the fault was never observed parallel to the bedding. Slaty cleavage over the entire fault block south of the Alaculsy Valley fault generally has approximately the same strike and dip (strike N. 10° E.; dip 30° SE.), which shows no relationship to the axial planes of folds in the rocks. The origin of this uniform cleavage is unknown, but it must be due to some regional structure not evident in the relatively limited area mapped.

ECONOMIC GEOLOGY

Iron Oxide

Limited amounts of iron and manganese oxide (often referred to as "mountain iron ore") are present in the northwest quarter of the Cohutta Mountain quadrangle. Haseltine (1924) and Watson (1908) have described the iron and manganese prospects in the area, and the writer discovered only one prospect pit not referred to by these authors (at map coordinates S. 8.3, E. 31.3).

All prospects are marked on the map, but only the so-called Powell prospect at one time gave indications of a minable ore body. It evidently did not prove economic, but is described here as the best example within the area. The Powell prospect is located near map coordinates S. 13.2, E. 21 (lot 237), and consists of numerous pits and shafts on the summit and slopes of a minor quartzite ridge. The ore contains both iron and manganese, but iron predominates. The most common iron oxide mineral is hematite, but some limonite is also present. According to Haseltine (1924, p. 75), a tunnel 150 feet long was driven into the ridge, encountering ·ood ore; and a shaft 50 feet deep was sunk, penetrating ·9 feet of solid iron ore and a foot of manganese. A small ›ss-cut at the head of the shaft exposed ore over a distance 40 feet.

Access to the tunnel and shafts is no longer possible today, but surface float confirms Haseltine's report that the ore contains from 34 to 55% metallic iron. All float is composed of the nodular masses typical of a syngenetic origin. Watson (1908, p. 178) noted flecks of iron oxide finely disseminated through the quartzite, and suggested that acidic ground water leached the iron oxide from the quartzite and redeposited it as limonite at favorable locations. The writer, noting that iron and manganese are disseminated throughout the rocks of the entire Ocoee section, sees no reason, other than proximity, to confine the source to the quartzite. Ground water is, however, undoubtedly the agent of concentration.

Iron Sulfide

Several prospects in the southwest corner of the area appear to explore veins of pyrite rather than pockets of iron oxide. At map coordinates S. 39.7, E. 12.5 on the east side of Sumac Creek, an adit has been driven about 20 feet into the phyllite just above a bed of metagraywacke. Pyritiferous quartz veins (1 to 3 cm wide) in the phyllite are the only evidence of local mineralization, and exposing them seems to have been the purpose of the adit.

At two places near Cohutta Springs (map coordinates S. 44.5, E. 8.2 and S. 41.9, E. 7.5), a zone of brecciated phyllite is exposed in shallow pits. More than one zone may be involved but, as the prospect pits lie along the apparent strike, only one zone is assumed to be present. It is from ten to fifteen feet wide and may be as much as 2200 feet long. The breccia is heavily impregnated with an earthy limonite, and has attracted prospectors as a promising pyrite or chalcopyrite gossan. The limonite is entirely transported limonite, however, indicating a lack of chalcopyrite in the unweathered rock (Bateman, 1955, p. 253). No appropriate voids are present in the gossan, indicating that pyrite also is lacking. The limonite appears to have traveled an indefinite distance from the site of its originating sulfide, probably having been concentrated in the breccia from the widespread disseminated pyrite common to the local phyllite.

Lead-Silver

A section on lead and silver is included here, not beca any was found in the area, but because of the widesprea and rather consistent rumors of its presence. A visitor to the area is told over and over again of the silver mine and/or lead mine which "is right there if only a body could find it." The writer was surprised to discover that many different accounts consistently placed the location of "right there" near an abandoned homestead in the mountains north of the Alaculsy Valley. To spare interested parties the effort of piecing together various stories in order to place the homestead's location, map coordinates and directions are given here.

The homestead is located at map coordinates S. 12, E. 21.2. It is reached by taking the Doogan fire tower road (not shown on map) from map coordinates S. 16.7, E. 25.2 northwest to the saddle atop the first quartzite ridge (map coordinates S. 12.5, E. 22.8). There an old logging road, blocked by windfelled timber, turns off to the northeast. This road may be followed to a water gap in the second quartzite ridge, where a clearing indicates the location of the old homestead.

According to local legend, the man who lived here around 1880 counterfeited silver dollars with silver from the mine, and was sent to prison for doing so, even though his dollars contained more silver than those made by the government. Unfortunately, the only observable traces of nearby mineralization or mining activity were at the site of the Powell iron prospect discussed above.

Limestone

As pointed out by Maynard (1912, p. 265), the Knox dolomite is generally concealed by residual soil and is generally below water level. It thus would be difficult to quarry for lime manufacture. The high percentage of magnesia is objectionable for its use in cement manufacture.

The Newala limestone is also generally concealed by residual soil and is generally below water level in the area. It presents the same quarrying problems as the Knox. Munyan (1951, p. 105) recommends the Newala section exposed at the west base of Sumac Ridge in the Dalton quadrangle as deserving further investigation, however, and the writer agrees with this recommendation. Low ridges of limestone crop out along the base of Sumac Ridge; these ridges are high enough above the local water table to make possible a small quarrying operation.

Metasiltstone

At map coordinates S. 18.2, E. 22.3 on the Alaculsy Valley road approximately 350 cubic yards of metasiltstone have been quarried out of the side of a ridge for use as road aggregate. The metasiltstone evidently was not found satisfactory for this use, as road aggregate is now trucked in from outside the area.

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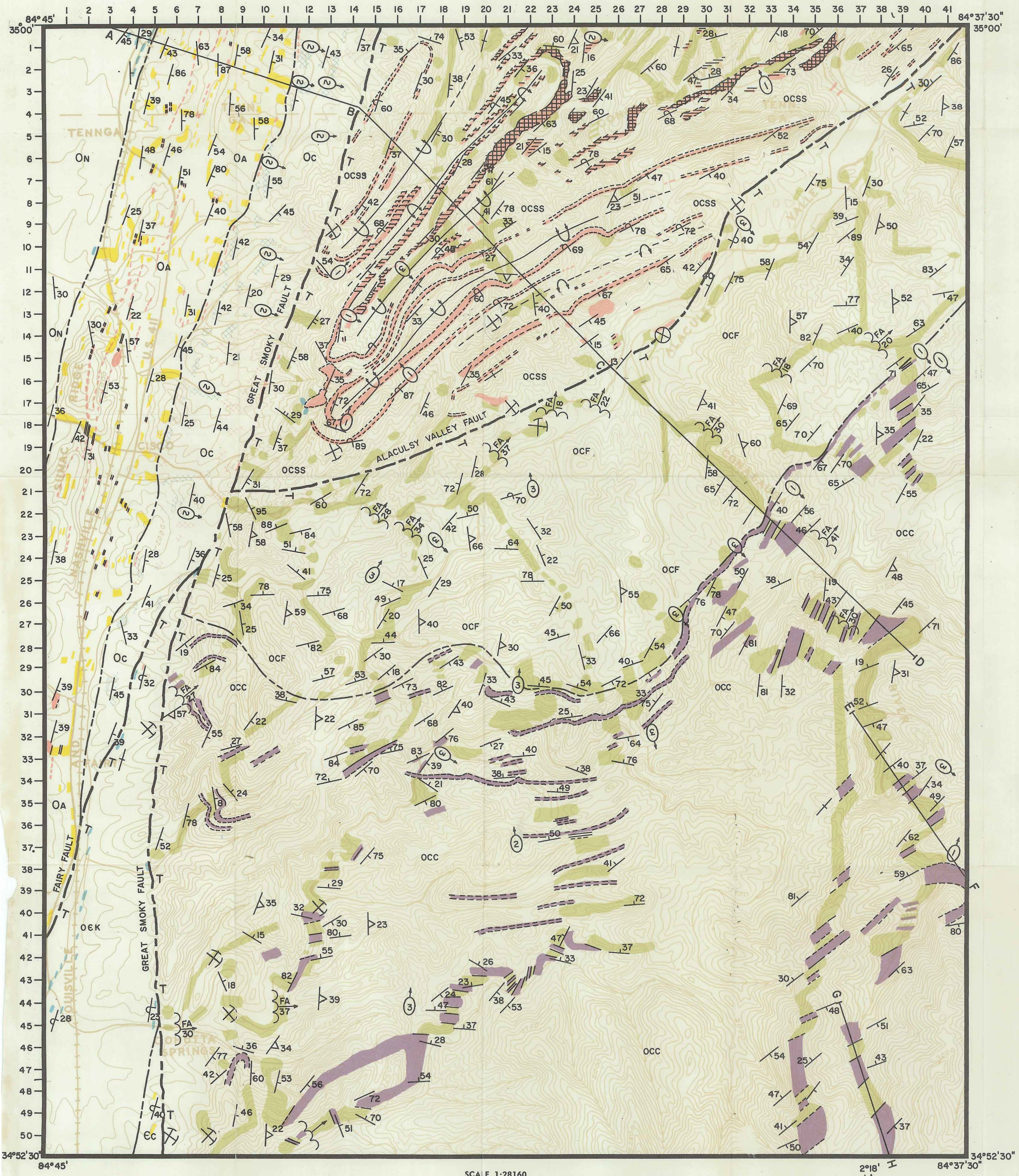
INDEX

GEOLOGIC MAP of the NORTHWEST QUARTER of the COHUTTA MOUNTAIN QUADRANGLE

by

JOHN W. SALISBURY

1959



BASE MAP FROM THE COHUTTA QUADRANGLE, EDITION OF 1913

SCALE 1:28160

0 1/3 2/3 1 2 MILES

CONTOUR INTERVAL 50 FEET
DATUM IS MEAN SEA LEVEL

2°18'

APPROXIMATE MEAN DECLINATION 1959

EXPLANATION

FORMATIONS

ORDOVICIAN

- Oc — CHOTA FORMATION
- OA — ATHENS SHALE
- ON — NEWALA LIMESTONE

- O€K — KNOX DOLOMITE

CAMBIAN

- €c — CONASAUGA SHALE

PRECAMBRIAN

- OCSS — SANDSUCK (?) FORMATION
- OCC — COARSE-GRAINED PART OF THE OCOEE SERIES
- OCF — FINE-GRAINED PART OF THE OCOEE SERIES

LITHOLOGIC SYMBOLS USED INDEPENDENTLY OF FORMA'AL BO

- SANDSTONE OR QUARTZITE
- X-BEDDED SANDSTONE
- LIMESTONE OR DOLOSTONE
- METASUBGRAYWACKE LACKING FELDSPAR
- METASUBGRAYWACKE CONTAINING FELDSPAR
- X-BEDDED CALC
- LIMESTONE CONG
- METAGRAYWA
- DOMINANTLY S WITH SILTST
- DOMINANTLY PH WITH METASILT

- LITHOLOGIC CONTACT, DASHED WHERE APPROXIMATE
- FORMATIONAL CONTACT, DASHED WHERE APPROXIMATE
- FAULT CONTACT, DASHED WHERE APPROXIMATE
- STRIKE & DIP OF BEDDING
- BEDDING VERTICAL
- BEDDING HORIZONTAL
- BEDDING OVERTURNED
- STRIKE & DIP OF SLATY CLEAVAGE
- PROSPECTS
- CLEAVAGE & BEDDIN
- GRADED BEDDING: CO IN DIRECTION OF AR
- X-BEDDING: TOP OF DIRECTION OF ARR
- TRUNCATED LAMINA IN DIRECTION OF AR
- AXIS OF OVERTURN
- AXIS OF OVERTURNE
- STRIKE & PLUNGE FOLD AXES
- SLATY CLEAVAGE BEDDING