

GEOLOGY
OF THE LIMESTONE
COVE WINDOW,
TENNESSEE AND NORTH CAROLINA

A Thesis
Presented to
the Faculty of the Department of Geology
East Carolina University

In Partial Fulfillment
of the Requirements for the Degree
Master of Science in Geology

by
James F. Coble

December 1976

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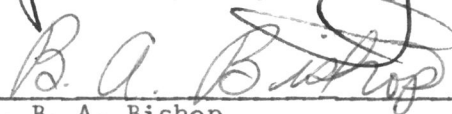
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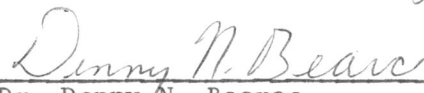
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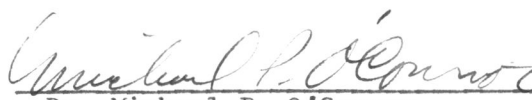

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ABSTRACT

The Limestone Cove Window is located in the Blue Ridge Province of northeast Tennessee and northwestern North Carolina. The rocks in the window range from Precambrian basement complex of Grenville age to the Rome Formation of early Cambrian age. The Snowbird Formation, a unit of the late Precambrian Ocoee Group, is recognized north of the Nolichucky River for the first time. Formations of the early Cambrian Chilhowee Group were mapped. These include the Unicoi, Hampton and Erwin, which consist mostly of metaquartzite and slate, and the Shady Dolomite, the only carbonate unit exposed in the field area.

The window, 17 kilometers long by 5 kilometers wide, was formed when erosion breached an anticlinal fold in a series of imbricate thrust faults. The axis of the major anticline follows the northeast-southwest regional trend; however, transverse warping is also present. The faults in this area are major overthrusts: the structurally highest fault, the Unaka Mountain Fault, forms the southeastern boundary of the Limestone Cove Window; the Limestone Cove Overthrust Fault forms the northwestern boundary; and the structurally lowest Norris Branch Fault outlines three sides of a much smaller window which lies within the southwestern tip of the Limestone Cove Window. Three transverse faults have produced a large salient in the trace of the Unaka Mountain Fault. Both folding and

faulting are probably associated with the late Paleozoic Alleghenian Orogeny on the basis of regional evidence. The only direct evidence in this area indicates that the folding and faulting are post-Cambrian.

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I N T R O D U C T I O N

Limestone Cove Window is a structural window located in the Blue Ridge Province in northeastern Tennessee and northwestern North Carolina. In previous reports the fault contacts of the window were not mapped in detail or in some cases were mapped incorrectly. An attempt is made here to gain a more detailed structural picture of this area of the Appalachians. Field research for this report was conducted over an eight week period during the summer months of 1975. Photographs appearing in this report were taken during the winter and spring of 1975-1976.

P U R P O S E O F S T U D Y

The purpose of this study is threefold 1) to prepare a more detailed geologic map of rocks within the Limestone Cove Window, 2) to trace closely the fault contacts of the Limestone Cove Window in order to determine the degree of folding of the thrust sheet, and 3) to obtain a clearer picture of the nature of the thrusting.

P R E V I O U S R E S E A R C H

The earliest geologic mapping of the Limestone Cove region was done during a general reconnaissance by Safford (1869). Arthur Keith's more detailed work on the Cranberry and Roan Mountain Quadrangles (1903 and 1907) gives a broad overview of the structure and stratigraphy of the area. Bayley (1923, p.240-252) reported the existence of hematitic magnetite deposits that Rodgers (1953, p.160) suggested might be related to faults. A study of manganese deposits by King and others (1944) provided a different interpretation of the structure, while a still more divergent

interpretation of the structure was suggested by Stose and Stose (1944 and 1949). The southwestern tip of the Limestone Cove Window was included in a study of the southwestern end of the Mountain City Window (Lowry, 1951). The Geologic Map of East Tennessee (Rodgers, 1953) provides additional structural and stratigraphic data. King and Ferguson (1960) did a thorough detailed study of northeastern Tennessee.

D E F I N I T I O N O F P R O B L E M

The Limestone Cove Window is referred to by Rodgers (1953, p.140) as structurally the deepest window in northeast Tennessee although the results of this report tend to disprove this. However, no detailed study had been made of the area prior to this study. Reconnaissance mapping by some of the early workers during investigations for mineral deposits resulted in the inexact location of some faults and formational contacts. A difference of opinion existed among the previous workers as to the presence of the Unaka Mountain Fault along the southeastern side of the window. To clear up these conflicting interpretations, detailed field mapping was required.

L O C A T I O N

Limestone Cove Window, which occupies an area of approximately seventy-seven square kilometers, extends from $82^{\circ} 12' 30''$ to $82^{\circ} 25' 00''$ W longitude and from $36^{\circ} 12' 00''$ to $36^{\circ} 3' 30''$ N latitude. About one half of the window is located in Unicoi County, Tennessee, and the other half is located in Mitchell and Yancey Counties, North Carolina (Figure 1).

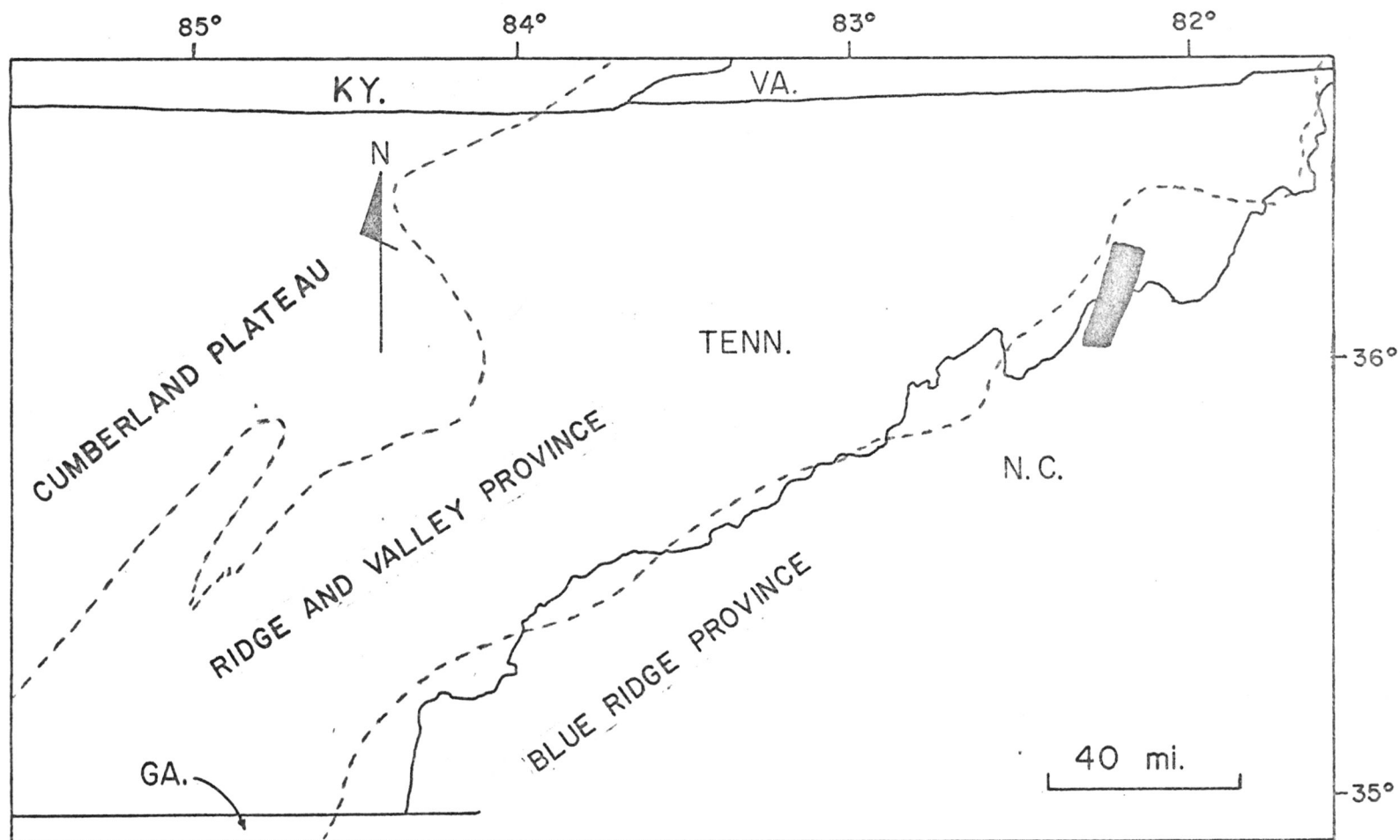


Figure 1. Index map of study area. Area mapped is in black.

T O P O G R A P H Y A N D D R A I N A G E

The topography in the general vicinity of the Limestone Cove Window is varied. In the north the land consists of low-lying floodplain underlain by Shady Dolomite and low rounded hills underlain by Shady Dolomite and by shale and siltstone of the Rome Formation. In the area along the North Carolina-Tennessee border there occurs a range of ridges known as the Unaka Mountains. These northeast trending ridges have a maximum relief of approximately 1070 meters, and a few peaks exceed elevations of 1200 meters above sea level. These ridges are held up by and follow the strike of thick, resistant metaquartzite beds of the Erwin, Hampton and Unicoi Formations. Shaly or more feldspathic beds underlie valleys between the ridges. Where Precambrian crystalline rock is exposed the topography consists of hills of medium elevation or slope areas of the higher ridges.

The topography of the Limestone Cove Window is as varied as that described for the general area (Plate 2). In the northeastern part of the Limestone Cove Window a valley forms a break in the ridges of the Unaka Mountains. This valley, in which the town of Limestone Cove is located, is underlain by easily weathered rocks of the Shady Dolomite and Rome Formation. The valley is rimmed by hills on all sides and has openings only where North Indian Creek flows into Limestone Cove through Iron Mountain Gap at the eastern end of the valley and where it flows out of the valley at the western end. In contrast, in the southwestern part of the window the topography consists of the high ridges and narrow valleys of the Unaka Mountains. The landscape of the southeast-central portion of the window, underlain by Precambrian crystalline rocks, is

somewhat gentler. The ridges of the Unaka Mountains extend southwest throughout the window and are interrupted only by the valley of the Nolichucky River in the southernmost part of the window. Here the Nolichucky River flows through a narrow gorge which cuts across the strike of the ridges.

The entire Limestone Cove area lies within the watershed of the Tennessee River, a tributary of the Ohio River. The master stream of the area is the west-flowing Nolichucky River into which all of the minor streams drain, either directly, or via two main tributaries, North Indian Creek in the northern part and Poplar Creek in the southern portion.

C L I M A T E A N D V E G E T A T I O N

The climate of this part of the Appalachian Mountains is characterized by warm summers and mild winters, although there is substantial snowfall particularly in the higher elevations. The average yearly precipitation is between 100 and 130 centimeters.

Except for the areas under cultivation and for some small areas cleared by logging, the Limestone Cove Window area is thickly forested. Both evergreens and hardwoods are found. Firs and balsam trees grow at higher elevations and the hardwoods grow at lower elevations. Also found at the higher elevations are thickets of blueberry bushes and dense growths of rhododendron. In the logged areas, usually at low or intermediate elevations, small bushes, grasses, and blackberries dominate the vegetation.

A C C E S S I B I L I T Y

The Limestone Cove Window area, except for the northeastern part, is very sparsely populated, and there are few roads into the area (Plate 2). In the northeastern part of Limestone Cove Window there are two paved roads: Tennessee Highway 107 and Simerly Creek Road. In addition, there are several unpaved roads in the area.

In the central portion of the window there are three roads which give access to this area. One is Rock Creek Road which runs southeastward across the window. Another is an unpaved road intersecting Rock Creek Road at Indian Grave Gap which is identified on the topographic map of the area as being a portion of the Appalachian Trail. Poplar Creek Road is intersected by Rock Creek Road on the southeast side of the window in the town of Poplar.

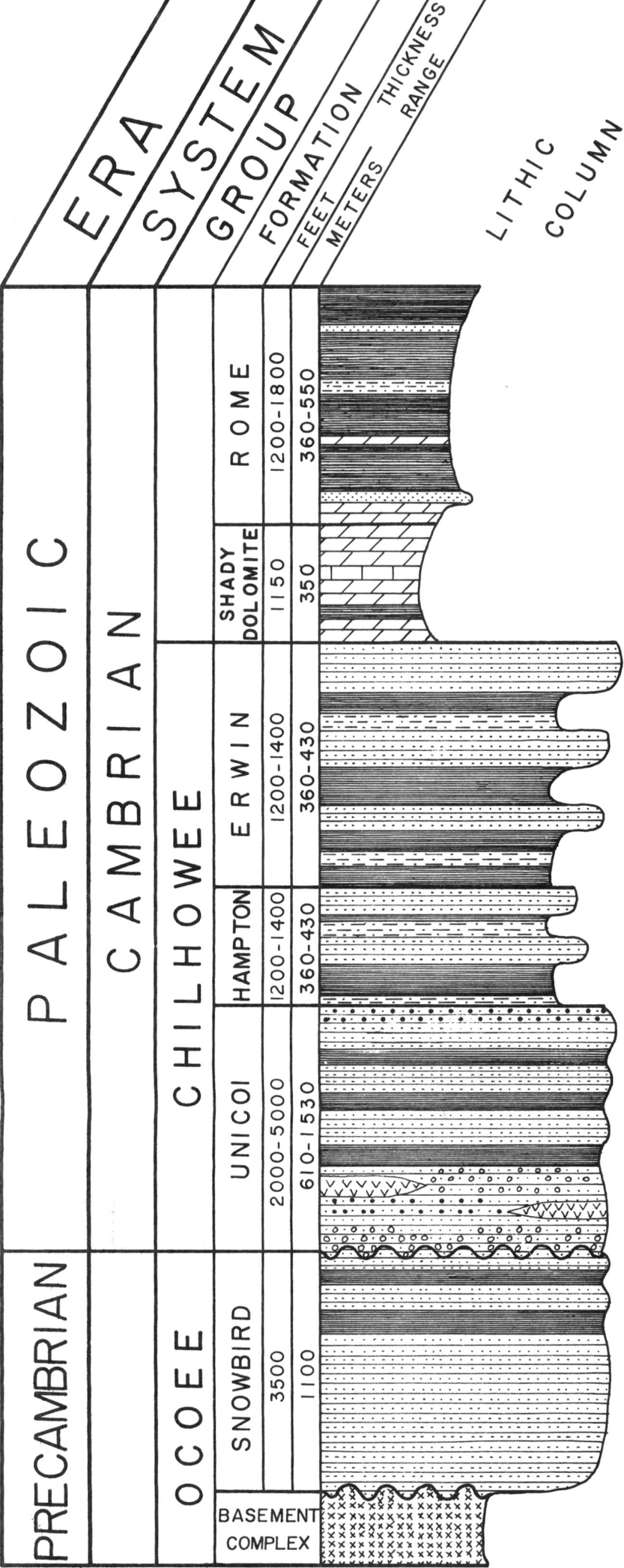
The southern portion of the Limestone Cove Window is accessible only by the Clinchfield Railroad track running along the southern bank of the Nolichucky River. Access to the railroad is by Poplar Creek Road.

S T R A T I G R A P H Y

PRECAMBRIAN BASEMENT COMPLEX

The Precambrian crystalline basement complex in this general region consists of medium-grained granite and granite gneiss of Grenville age; these rocks contain inclusions of schist and have been cut by quartz veins and pegmatites (King and others, 1944, p.41).

The only occurrences of the basement complex within the study area



Red, maroon, and brown shale, silty shale, green, sericitic shale, dolomitic shale, and shaly dolomite interbedded with maroon-red, brown, and greenish brown siltstone and sandstone. Massive beds of blue-gray dolomite occur especially in the lower portions of the formation which is transitional into the underlying Shady Dolomite. Cambrian fossils are found.

Blue-gray to white dolomite with minor amounts of limestone and shale. Usually covered by residual "buckfat" clay.

Interbedded layers of white, vitreous quartzite, ferruginous quartzite, siltstone and shale. Quartzite and shale metamorphosed in study area to metaquartzite and slate. *Scolithus* tubes present.

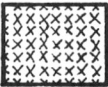
Alternating beds of clay shale, siltstone and sandstone. In study area shale and sandstone metamorphosed to slate and metaquartzite. *Scolithus* tubes present.

Interbedded sandstone conglomerate and shale. In study area sandstone and shale metamorphosed to metaquartzite and slate. Lenticular beds of greenstone present. *Scolithus* tubes present.

Well sorted, crossbedded sandstone with interbedded shale beds near top. Most beds feldspathic. In study area sandstone and shale metamorphosed to metaquartzite and slate. Bounded at the base by a nonconformity and bounded at the top by an angular unconformity.

Medium-grained granite and granite gneiss, inclusions of schist and cut by quartz veins and pegmatites.

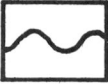
LEGEND



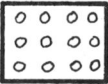
BASEMENT COMPLEX



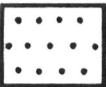
GREENSTONE



UNCONFORMITY



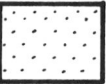
CONGLOMERATE



ARKOSE



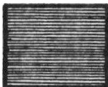
METAQUARTZITE



ORTHOQUARTZITE SANDSTONE



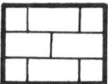
QUARTZ SILTSTONE



SLATE



DOLOMITE



LIMESTONE

Figure 2. Columnar section of formations in study area (After King and others, 1944 and Lowry 1951).



Figure 3. Precambrian basement complex along Rock Creek Road near Poplar, North Carolina. It shows an outcrop of a biotite-rich granite which is the predominant rock type of the basement complex.



Figure 4. Precambrian basement complex looking to the west near Poplar, North Carolina. It shows the typical landscape formed by rocks of the basement complex.

are a large block of biotite-rich granite in the southeast-central portion of the mapped area and a highly sheared granite within the Norris Branch Window near the southern tip of the Limestone Cove Window (Plate 1; Figures 3 and 4).

OCOEE GROUP

Snowbird Formation

The Snowbird Formation was named by Arthur Keith in 1904 for Snowbird Mountain in Cocke County, Tennessee and Haywood County, North Carolina. The type section of the formation, located south of Hot Springs, North Carolina, was described by Keith (1904, p.5) as a fine-to coarse-grained, crossbedded quartzite interbedded with layers of conglomerate, arkose, and gray and black slate which is most abundant in the upper portion of the formation. Some of the quartzites contain feldspar, thought by Keith to have been derived from the Max Patch Granite. The thickness of the formation at the type locality, according to Keith, is 350 feet (107 meters) increasing to 5000 feet (1524 meters) toward the southwest.

There is a problem with the lithologic names which have been applied to the rocks of the Snowbird Formation and the overlying Chilhowee Group. The metamorphism of the rocks in the area of this study is of higher intensity than that affecting the rocks in the type areas of the formations, located on structurally higher thrust sheets. King and Ferguson (1960, p.74) explain the change in metamorphic degree of these rocks as follows:

The rocks of the Chilhowee Group in the Stone Mountains are of a higher metamorphic rank than those elsewhere in the region. . . The argillaceous and silty rocks have been converted to slate and phyllite, in which foliation is well marked at many places. The arkose and quartzite of the Unicoi Formation are likewise split by

coarse cleavage, and the pebbles in the conglomerate are elongated. The quartz grains shattered and drawn out.

Therefore, metamorphic rock names must be applied to the rocks of the Snowbird Formation and the Chilhowee Group in the vicinity of the Limestone Cove Window, but references to the type areas retain the sedimentary rock names appropriate to those regions.

In the adjacent area to the southwest the Snowbird Formation consists of a uniform sequence of well sorted, crossbedded metaquartzite with interbedded slate beds near the top. Some of these metaquartzite beds are quartz rich, but most contain large amounts of feldspar. These beds may easily be mistaken for beds in the upper part of the Unicoi Formation. The thickness of the Snowbird in this region is 3500 feet (1100 meters) (Lowry, 1951, p.62-63). The age of the formation is thought to be late Precambrian.

Within the Limestone Cove Window the Snowbird Formation occurs as a comparatively small block nestled against the southeastern boundary. The formation extends from the southernmost boundary of the Limestone Cove Window south of the Nolichucky River north to the valley of Bowling Green Creek. Approximately 1100 feet (335 meters) of the Snowbird Formation are exposed in the area. The upper stratigraphic boundary is a fault contact (Unaka Mountain Fault); the lower stratigraphic boundary is an angular unconformity that separates the Snowbird from the Unicoi Formation (Plate 1). The Sandsuck "Shale" and an indeterminable amount of Snowbird are missing at the unconformity. The Snowbird Formation consists of clear, medium-grained, well rounded metaquartzite with substantial amounts of ferruginous metaquartzite, of arkose and feldspathic metaquartzite. Granule and pebble metaconglomerate occur in places in the

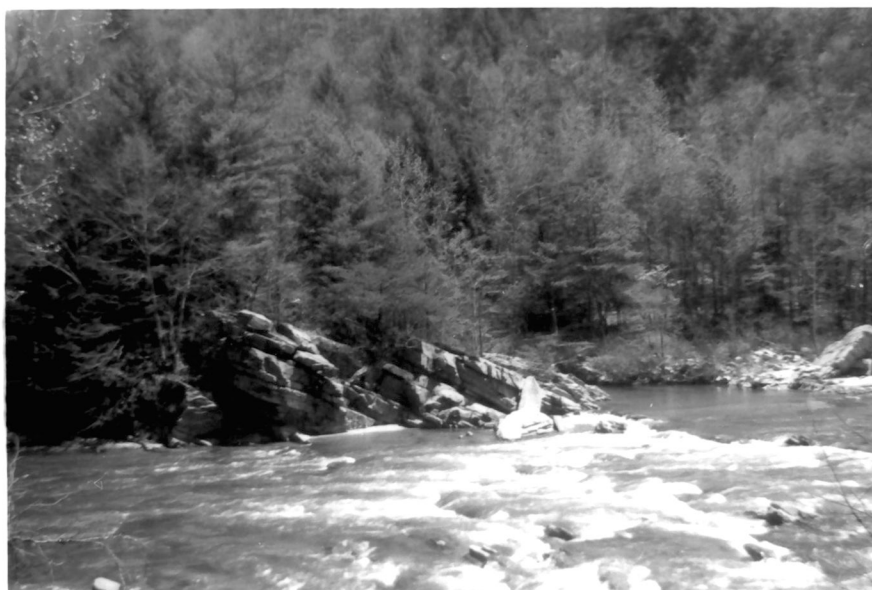


Figure 5. Snowbird Formation Outcrop along the Nolichucky River.
The metaquartzite strata are dipping toward the southeast
(toward the right) at about 21 degrees.



Figure 6. The landscape formed toward the west along the Nolichucky River of the Snowbird Formation. The landscape is characterized by high ridges and cliffs.

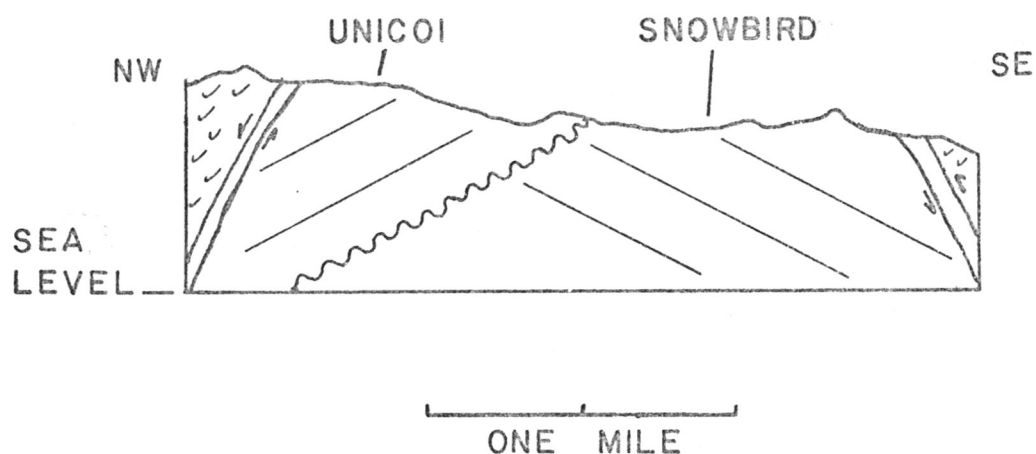


Figure 7. Cross section of Limestone Cove Window north of Poplar showing the relationship of the Snowbird Formation to the surrounding rocks. The long lines within the formations indicate the dip directions. The basement complex is the checked area. The rock along the fault traces is mylonite. The vertical scale is equal to the horizontal scale. The Unicoi and Snowbird formations are separated by an angular unconformity.

stratigraphically lower part of the exposed strata and slate occurs near the bottom of the exposed strata (Figures 5 and 6).

In previous mapping, the Snowbird had not been recognized north of the Nolichucky River. Lowry (1951) mapped Snowbird along the south bank of the Nolichucky River within the Limestone Cove Window. Possibly one reason that the Snowbird had not previously been mapped north of the Nolichucky River is that it is lithologically similar to beds of the Unicoi Formation within the window. King and others (1944), and King and Ferguson (1960) mapped these rocks as Unicoi. A possible reason these rocks were mapped in this manner is that in areas to the north King and others did not find any Ocoee Group rocks and did not expect to find any here. They assumed the somewhat similar Snowbird beds here to be Unicoi. However, a close comparison of these beds with those known to be Unicoi has revealed distinct differences. Unicoi beds are characterized by poor sorting, the presence of pebbles, and interbedded greenstone. Snowbird beds are characterized by a relatively uniform texture and a lack of greenstone beds. The beds in question here are relatively well sorted and lack greenstone units, contrasting with known Unicoi Beds to the west which are conglomeratic and do contain greenstones. Also, structural evidence suggests that the Snowbird occurs in the area. The dip of the beds described as Snowbird is to the southeast while the overlying beds described as Unicoi dip to the northwest. This indicates a break between beds here described as Snowbird and beds described as Unicoi. This break is interpreted as an angular unconformity. This unconformity is the same one that King and Ferguson (1960, p.84) place at the base of the Chilhowee Group, separating the Unicoi Formation from the

underlying Ocoee Group.

The following evidence suggests that this break between Snowbird and Unicoi beds is an angular unconformity and not a fault repeating Unicoi beds. No evidence of shearing was found in this area. Neither mylonite nor breccia were found in outcrop or as float. If reverse faulting had occurred with the hanging wall to the southeast then the Unicoi beds would have been cut off rather than repeated. Reverse faulting with the hanging wall to the northwest or normal faulting would cause Unicoi beds to be repeated but would not account for the differences in the dip directions of the beds (Figure 7). There is still a remote possibility that faulting of previously folded beds could have produced this relationship. However, there is no explanation for the absence of shear zones which are found along known thrust faults in the area.

CHILHOWEE GROUP

Unicoi Formation

The Unicoi Formation, named in 1899 by M.R. Campbell for Unicoi County, Tennessee, is the basal formation in the Chilhowee Group. The type section of this formation is at the base of Holston Mountain in Tennessee and was described by Campbell (1899, p.3) as a coarse feldspathic sandstone. Although Campbell measured a thickness of 1000 feet (305 meters) he noted that the formation is in fault contact with underlying rocks.

The Unicoi Formation in this general region, described by King and others (1944, p.37-38) from sections in the Shady Valley thrust sheet,

consists of interbedded vitreous quartzite, conglomerate and slate. Lenticular beds of amygdaloidal greenstone are present locally. Scolithus tubes are the only fossils that have been reported from this formation. The thickness of the Unicoi Formation ranges from 2000 to 5000 feet (610 to 1524 meters). The upper boundary of the formation is placed at the top of a bed of arkosic metaquartzite which lies between 2500 feet and 3000 feet (762 meters and 914 meters) below the base of the Shady Dolomite. The Unicoi Formation rests unconformably upon either Precambrian igneous or metasedimentary rocks. The age of the Unicoi Formation is early Cambrian. The degree of metamorphism of the Unicoi Formation is higher here than in exposures to the northwest (page 10).

The Unicoi Formation underlies about 60 percent of the area within the Limestone Cove Window, extending from the southwesternmost tip of the Limestone Cove Window south of the Nolichucky River towards the northeast to an area approximately three kilometers from the town of Limestone Cove. A complete section of the Unicoi is not exposed because the Unaka Mountain Fault cuts off the base of the formation (Plate 1). The maximum exposed thickness in the Limestone Cove Window is approximately 4400 feet (1340 meters). The Unicoi Formation in the Limestone Cove Window is composed of pebble metaconglomerate, arkose, slate and quartz rich to ferruginous metaquartzite which grade upward in the formation to a well sorted quartz-rich to feldspathic metaquartzite (Figures 8 and 9). Scolithus tubes were not observed by the writer. Amygdaloidal greenstone was observed to crop out at only two localities in the study area: in a railroad cut along the Nolichucky River, and at an abandoned farm known as Beauty Spot along the Appalachian Trail.



Figure 8. Unicoi Formation on the Appalachian Trail Road. The rocks here are pebble conglomerates and arkoses. The beds dip to the northwest (away from the viewer) at an angle of 10 degrees.



Figure 9. Unicoi Formation looking to the northwest. The top of Unaka Mountain is held up by Unicoi beds. The low relief shown in this photograph is not characteristic of the Unicoi Formation regionally.

Float was seen in several other places.

HAMPTON FORMATION

The Hampton Formation, named in 1899 by M.R. Campbell for the town of Hampton, Tennessee, is the middle formation of the Chilhowee Group. No definite type section of the Hampton Formation was designated, but the section at the base of Holston Mountain in Tennessee was described by Campbell as a sandy shale with a thickness of 600 feet (183 meters).

In this general area the Hampton Formation, as described by King and others (1944, p.35-36) from sections in the Shady Valley thrust sheet and Mountain City Window, consists of alternating beds of clay slate, siltstone, and vitreous quartzite. Scolithus tubes have also been found in this formation. The average thickness of the Hampton Formation is between 1200 and 1400 feet (366 and 427 meters), but in areas to the southeast of Hampton the thickness does not exceed 500 feet (152 meters). The age of the Hampton Formation is early Cambrian.

In the area mapped the Hampton Formation was observed to be lithologically indistinguishable from the overlying Erwin Formation and from the upper part of the underlying Unicoi Formation. As in the other formations of the Chilhowee and Unicoi Groups, here the Hampton has undergone a higher degree of metamorphism than in exposures to the northeast (Page 10). The formation consists of alternating beds of clean, slightly feldspathic metaquartzite and slate (Figures 10 and 11). No Scolithus tubes were seen. The boundaries of the Hampton in this area are estimates at best. They were determined by assuming first that the top of the Unicoi Formation (and thus the base of the Hampton Formation) is located 3000 feet

(915 meters) below the base of the Shady Dolomite (King and others, 1944, p.37), and second that the Hampton Formation is a uniform 500 feet (152 meters) thick (King and others, 1944, p.36). The identification of the Hampton Formation in the Limestone Cove Window was based on these assumptions.

The Hampton Formation in the Limestone Cove Window occurs as a thin strip that extends from the Right Prong of Rock Creek on the central north-western side of the window to the southeastern boundary of the window north of the Appalachian Trail Road (Plate 1).

Erwin Formation

The Erwin Formation, named by Arthur Keith in 1903 for the town of Erwin, Tennessee, is the uppermost formation of the Chilhowee Group. No definite type section was designated. Keith (1903, p.5) described the Erwin Formation as consisting of white sandstone and vitreous quartzite with some partings of shale. Between the Erwin Formation and the Shady Dolomite are beds of sandy shale and thin-bedded sandstone. Keith measured a thickness of 500 to 700 feet (152 to 213 meters).

The Erwin Formation, as described by King and others (1944, p.29-30) from sections in the Shady Valley and Bald Mountain thrust sheets and the Mountain City Window, consists of interbedded layers of white, vitreous quartzite, ferruginous quartzite, siltstone, and slate. Scolithus tubes are abundant in the metaquartzite units. The metaquartzite beds are quite resistant to weathering and erosion and thus form the most prominent outcrops of the formation. However, these beds constitute only a portion of the Erwin Formation, with siltstone and slate being the predominant rock types. The Erwin Formation extends from the base of the Shady Dolomite downward to a consistently traceable bed of white metaquartzite which contains numerous



Figure 10. Hampton Formation near Rock Creek Campground . The rock is a metaquartzite. The strata dip to the northwest (toward the right) at approximately 20 degrees.



Figure 11. Hampton Formation looking to the northeast on Rock Creek Road. This view shows the typical landscape formed by the Hampton Formation.

Scolithus tubes. The thickness of the Erwin usually is from 1200 to 1400 feet (366 to 427 meters); however, in some places it reaches a thickness of 2400 feet (732 meters). The age of the Erwin Formation is early Cambrian.

In the area mapped the somewhat more metamorphosed Erwin Formation occupies an area that extends from the southern end of the town of Limestone Cove to the central northwestern boundary of the window near the Right Prong of Rock Creek, and from the Limestone Cove Fault on the northwest to the Unaka Mountain Fault on the southeast (Plate 1). The Maximum thickness of the Erwin Formation in this area is approximately 1700 feet (518 meters), somewhat greater than the average thickness of the formation. This larger thickness might be due to the inherent inaccuracies in identifying the boundaries of the Hampton and Erwin Formations. In the study area the Erwin Formation consists of alternating beds of quartz rich to slightly feldspathic metaquartzite with interbedded layers of slate (Figures 12 and 13). This is the only formation in the area mapped in which significant numbers of Scolithus tubes were seen, and these were seen mainly in float.

SHADY DOLOMITE

The Shady Dolomite was named by Arthur Keith in 1903 for the Shady Valley area of Tennessee. The type sections of the Shady Dolomite are found on Iron and Doe Mountains in Tennessee. Keith (1903, p.5) described the "Shady Limestone" as a bluish or gray limestone with some layers mottled gray, blue and white. The formation is characteristically cut by veinlets of calcite, and beds of white limestone and marble are found



Figure 12. Erwin Formation along Tennessee Highway 107. Shown here is an outcrop of Erwin consisting of a quartz-rich metaquartzite. The strata dip to the northeast (towards the right) at 14 degrees.



Figure 13. Erwin Formation looking southeast on Tennessee Highway 107. The landscape shown is typical for areas underlain by the Erwin Formation.

also. In many areas thin seams of blue and gray shale occur, and red shale beds occur in the transitional zone below the base of the Rome Formation. Sand and chert nodules are common in the Shady Dolomite. According to Keith the thickness of the Shady Dolomite is between 750 and 800 feet (229 and 244 meters).

The Shady Dolomite in this general area, as described by King and others (1944, p.16-18) from sections in the Shady Valley thrust sheet, consists dominantly of blue-gray to white dolomite, with minor amounts of limestone and shale. The Shady Dolomite, which is the oldest carbonate deposit in the Appalachians (early Cambrian age), weathers and erodes rapidly to form valleys, referred to as coves in local usage. Outcrops are uncommon and most of the Shady Dolomite is covered by a thick residual "buckfat" clay or alluvial gravel. The Shady Dolomite is about 1150 feet (350 meters) thick, and is overlain by the Rome Formation and underlain by the Erwin Formation.

In the study area the Shady Dolomite occurs in the Limestone Cove Valley. This area is found at the northeastern tip of the Limestone Cove Window (Plate 1).

Due to very poorly exposed outcrops of the Shady an accurate thickness could not be determined in this area (Figures 14 and 15). Outcrops of the formation were observed at only two locations: the eastern end of the Limestone Cove area along a road, and at the western end of Limestone Cove along the stream bed of North Indian Creek. The Shady observed in the Limestone Cove Window consists of dark gray, fine to medium crystalline dolomite that weathers tan or light brown.



Figure 14. Shady Dolomite in a road cut in the town of Limestone Cove. The conical projection of dolomite in the foreground is due to solutinal weathering. The weathered zone here is several feet thick. Strike and dip could not be ascertained at this outcrop.



Figure 15. Landscape looking southeast in the town of Limestone Cove. It shows the typical landscape formed by the Shady Dolomite. Both the floodplain in the foreground and the low hills in the left background consist of Shady Dolomite. The hills in the right background are underlain by Erwin.

ROME FORMATION

The Rome Formation was named by C.W. Hayes in 1891 for the town of Rome, Georgia (Hayes, 1891, p.141-154). The name "Watauga Shale" was used by Arthur Keith in 1903 to refer to the same formation along the Watauga River, but the name Rome Formation has priority and is the name currently used. The type section of the Rome Formation occurs south of the town of Rome, Georgia. Hayes (1902, p.2) described the Rome as consisting of thin-bedded, fine-grained sandstones and sandy shales. These rocks are varicolored and include red, purple, green, yellow, and white units. Abrupt color changes cause a banded appearance. The base of the formation was defined as being the bottom of a thin-bedded red sandstone and the top of the Formation was defined as being a thick bed of white sandstone. The thickness of the formation at the type section is between 700 and 1000 feet (213 and 305 meters).

The Rome Formation in this general area, as defined by King and others (1944, p.14-16) from sections in the Shady Valley thrust sheet and Appalachian Valley, consists mainly of red, maroon, and brown shale, silty shale, green, sericitic shale, dolomitic shale, and Shaly dolomite. Interbedded with these sediments are maroon-red, brown, and greenish brown siltstone and sandstone. Massive beds (4.5 to 30 meters thick) of blue-gray dolomite occur within the formation and are especially common in the lower portion of the formation which is transitional through an interval of 23 to 30 meters into the underlying Shady Dolomite. Fossils of early Cambrian age have been found. The formation, which weathers to a red or maroon soil containing clay and rock chips, forms steep knobby hills. The thickness of the unit ranges from 1200 to 1800 feet (366 to

549 meters), but exact thicknesses are difficult to determine because deformation has resulted in many folds and contortions in the unit.

In the area mapped the Rome Formation occurs only as a small block at the northernmost part of the town of Limestone Cove (Plate 2). The only outcrops of the formation in the Limestone Cove Window occur along Simerly Creek Road and along an unpaved road to the west. Elsewhere the Rome Formation is seen only as maroon rock chips in soil on low knobby hills (Figure 16 and 17). As determined by outcrops and rock chips, the Rome Formation consists of maroon to red, sandy siltstone and silty shale.

STRUCTURE

GENERAL STATEMENT

Structurally the Limestone Cove Window is located in the folded and faulted belt of the southern Appalachians and is included within the Mountain City Window. This area is characterized by intense folding and thrust faulting produced by regional deformation in the late Paleozoic. The Limestone Cove Window is bounded by two thrust faults: The Unaka Mountain Overthrust Fault on the southeast and the Limestone Cove Overthrust Fault on the northwest. Oriel (1950, p.64), defines any window which is bounded by more than one shear surface as an eyelid window.

REGIONAL STRUCTURES

Faults and Thrust Sheets

Holston Mountain Fault - The northwesternmost regional structure



Figure 16. Poorly exposed sandy siltstone of the Rome Formation near the town of Limestone Cove. Although siltstone is not the dominant rock type in the Rome Formation, it is the rock type that crops out most often in the Limestone Cove Window.



Figure 17. Landscape looking northward in the town of Limestone Cove. The low hill seen here is typical of the landscape formed by the Rome Formation, both regionally and in the Limestone Cove Window.

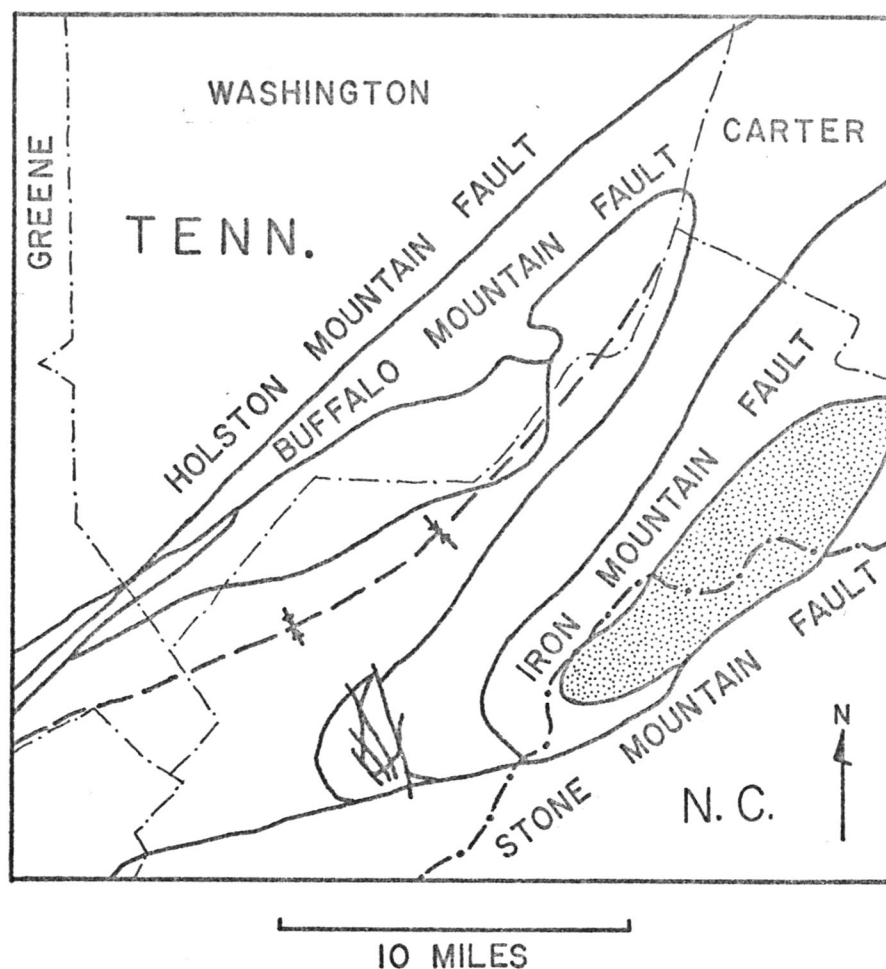


Figure 18. Map of major structural features (after Rodgers, 1953).
Thesis area is outlined by stippled pattern.

in this general area is the Holston Mountain Fault (Figure 18), a thrust fault along the base of Holston Mountain southeast of the Appalachian Valley. Here Chilhowee strata are thrust over Cambrian to mid-Ordovician rocks, although elsewhere the Chilhowee Group, the Shady Dolomite and the Rome Formation have been cut off and the Honaker Formation is the overriding rock. The stratigraphic displacement is almost equal to the entire thickness of strata exposed in this area. The fault plane dips to the southeast. The trace of the fault is remarkably straight, and only a few irregularities and transverse offsets are present (King and Ferguson, 1960, p.63-64).

Shady Valley Thrust Sheet - The Shady Valley thrust sheet lies to the southeast of the Holston Mountain Fault. It extends 57.6 kilometers northeast-southwest and is 13 kilometers wide. The thrust sheet is bordered on the northwest by the Holston Mountain Fault and on the southeast by the Iron Mountain Fault. These two faults probably connect to form a single fault. The rocks in the Shady Valley thrust sheet are downwarped into a northeast-southwest trending syncline called the Stony Creek Syncline. South of the Cross Mountain Fault this syncline plunges to the southwest at an average rate of 71 meters per kilometer. The basal part of the thrust sheet consists mainly of Chilhowee rocks, but locally contains Precambrian basement rocks. The dip of the Chilhowee ranges from 20 to 50 degrees, the steepest dips being on the Iron Mountain side of the Stony Creek Syncline. In the center of the syncline Shady Dolomite is preserved, but successively younger formations such as the Rome, Honaker, Nolichucky and Conococheague crop out toward the southwest in the direction of plunge of the syncline. Still farther to the southwest are

the Jonesboro Limestone and middle Ordovician rocks (King and Ferguson, 1960, p.65).

Although the general structure within the Shady Valley thrust sheet is relatively simple, structural features which complicate the geology of the area are 1) two northwest trending left lateral strike-slip faults in the Watauga River Zone and 2) the Cross Mountain Fault which is a strike-slip fault located 16 kilometers north of the Watauga River Zone. The Cross Mountain Fault runs west from the Mountain City Window into the Appalachian Valley and is younger than the Shady Valley thrust sheet and the Holston Mountain and Iron Mountain Faults because it offsets all of them (King and Ferguson, 1960, p.65-68).

Iron Mountain Fault - The Iron Mountain Fault is a thrust fault trending northeast-southwest. It forms the southeast boundary of the Shady Valley thrust sheet, dips to the northwest, and probably connects with the southeast-dipping Holston Mountain Fault. The Iron Mountain Fault extends to the north into Virginia, forming the northeast end of the Mountain City Window where it is called the Catface Fault. It extends southwest of the Nolichucky River, forming the southwestern end of the Mountain City Window. Thence the trace of the fault follows the southeast base of Iron Mountain. In this area rocks of the lower Unicoi have been thrust over rocks of the Rome Formation and Shady Dolomite (King and Ferguson, 1960, p.68).

Buffalo Mountain Fault and Buffalo Mountain Thrust Sheet - The Buffalo Mountain Thrust Sheet is structurally higher than the Shady Valley thrust sheet and lies within it in the northeast part of the Bald Mountains.

This thrust sheet is defined by the Buffalo Mountain Fault, a downfolded thrust fault which outlines both sides of the Buffalo Mountain thrust sheet along which rocks of the Buffalo Mountain thrust sheet have been moved over rocks of the Shady Valley thrust sheet (Figure 18). The rocks in the southeastern part of the Buffalo Mountain thrust sheet have been downwarped into an asymmetrical syncline, approximately 13 kilometers long called the Rich Mountain Syncline, which plunges to the southwest. All formations of the Ocoee Group and the Chilhowee Group are contained in the Rich Mountain Syncline except for the Erwin Formation (Bearce, 1966, p.93-94).

Mountain City Window - The Mountain City Window extends from Konnarock, Virginia in the northeast to south of the Nolichucky River to the southwest. The window has a length of 99 kilometers and a width of three to eight kilometers except near Mountain City and Butler where it is 16 kilometers wide. This window was formed by the erosion of an anticline created by arching of thrust sheets during the late Paleozoic. The Iron Mountain and Catface Faults define the northeastern, northwestern, and southwestern boundaries of the window, with the Stone Mountain Fault System defining the southeastern boundary. Most of the rocks exposed within the Mountain City Window are Shady Dolomite or Rome Formation; however, to the southeast rocks of the Chilhowee Group and the basement complex crop out consistently. All rocks within the Mountain City Window are strongly faulted and folded (King and Ferguson, 1960, p.71-72).

Stone Mountain Fault System - The Stone Mountain Fault System is a complex system of several thrust faults forming the southeast boundary of the Mountain City Window, running northeast-southwest through most of

northeast Tennessee and northwest North Carolina. The faults curve to the west in the area southwest of the Nolichucky River. The different segments of these faults are of different ages. The structurally lower branches of the fault are probably equivalent to the Holston Mountain and Iron Mountain Faults, while the upper branches are related to the Buffalo Mountain Fault. The Stone Mountain Faults dip to the southeast and rocks of the basement complex are thrust northwest over Chilhowee and Ocoee Group rocks (King and Ferguson, 1960, p.75).

LOCAL STRUCTURES

Structure of the Basement Complex

The basement complex in northeast Tennessee and northwest North Carolina displays evidence of several episodes of deformation. Precambrian structures consist of foliation often folded into isoclinal folds (King and Ferguson, 1960, p.23). The early to middle Paleozoic structures consist of regional shears superimposed on previous structures producing cataclastic foliation. These structures are most abundant in the Mountain City Window (King and Ferguson, 1960, p.24). Late Paleozoic structures consist of faults and associated mylonite or phyllonite. All earlier structures, including faults, were deformed by subsequent folding (King and Ferguson, 1960, p.26). Veins, fractures, small scale folds, and mineral alterations are also found (King and Ferguson, 1960, p.27).

The report area contains relatively small amounts of basement complex, often covered by vegetation or alluvium. However, structures include shear structures in the granite of the Norris Branch Window and major late Paleozoic faults with associated mylonite in the Norris Branch Win-

dow and along the southeastern boundary of the Limestone Cove Window.

Structure of Sedimentary Beds

The sedimentary beds within and outside of the Limestone Cove Window display folding and faulting, although there are differences in the character of deformation between these two areas.

The rocks adjacent to the Limestone Cove Window strike to the northeast and dip to the northwest at very high angles, some beds even being overturned and dipping to the southeast. Several subparallel thrust faults occur adjacent to the Limestone Cove Window, often causing strata to be repeated (King and others, 1944, p.7).

The rocks within the Limestone Cove Window are less intensely deformed than those outside the window. Inside the window the dip angles of the beds are less and there are no major thrust faults other than those that define the window itself.

The Snowbird Formation, Chilhowee Group, Shady Dolomite, and Rome Formation within the Limestone Cove Window generally strike northeast. These beds have been folded into a northeast plunging anticline in the northeast central portion of the window and a northeast plunging syncline in the northeast end of the window (Plate 1). The left limb of the anticline runs from the Limestone Cove Overthrust Fault at the southwestern end of the window to the crest of the anticline near Stamping Ground Ridge in the north-central portion of the window. The right limb of the anticline runs from Stamping Ground Ridge eastward until it reaches the trough of the syncline in the town of Limestone Cove. The right limb of the syncline is found only in the Shady Dolomite and the Rome Formation in Limestone Cove

and is represented by only a small portion of the total amount of sedimentary rocks in the window. It runs from the central part of Limestone Cove northeastward until it is cut off by the Unaka Mountain Fault. The orientation of the axis of the anticline is approximately N17°E. The orientation of the axis of the syncline is approximately N5°E.

The more competent Snowbird Formation and Chilhowee Group apparently suffered little or no disruption due to folding. Numerous joints can be observed in these rocks but whether or not the joints were produced during the initial period of folding or during later deformation is debatable. Due to the sparseness of exposures no determination of deformation of the Shady Dolomite could be made. Very few exposures of Rome Formation were found, but it is apparent that the incompetent Rome has been broken and crumpled by deformation. As a result, the formation lacks a consistent attitude in the area. Strikes and dips taken only a few feet apart differ considerably in orientation.

The Snowbird Formation, although generally striking the same direction as the other formations and being part of the anticlinal-synclinal structure in the Limestone Cove Window, is structurally different from the Chilhowee Group and from the Shady and Rome, all of which dip consistently to the northwest. The Snowbird Formation dips to the southeast (Plate 1). The difference in dip directions was produced by a late Precambrian deformation in which the Snowbird was tilted or folded. An erosional surface was then developed, upon which were deposited the Unicoi Formation and overlying formations. Later both groups of rocks were further deformed. Now both formations are tilted, each in a different direction.

Mylonite

Mylonite is a fine-grained, laminated rock found along fault zones and is produced by grinding during fault movement. Although mylonite is not a stratigraphic formation it is an important rock type in the Limestone Cove Window, where it occurs along the traces of the Limestone Cove Fault, the Unaka Mountain Fault, and the thrust fault which defines the Norris Branch Window (Plate 1). The mylonite is seen both in outcrop and as float, and in several areas reaches thicknesses of several hundred meters. It is an important aid in spotting the traces of the thrust faults and in determining their dip. In outcrop, the mylonite is laminated, ranges from green and pink to cream colored, and contains quartz, weathered feldspar, and mafic minerals (Figure 19). As seen in thin section (Figure 20) the mylonite consists of sheared and stretched quartz, weathered feldspar, biotite, sericite, some opaques, and a dark-green fine-grained mafic mineral which could be either chlorite or microbrecciated micas. The rock has undergone sufficient cataclastic deformation to be classified as a protomylonite or mylonite according to the classification scheme of Justus and Butler (1974, p.370).

Unaka Mountain Fault

The Unaka Mountain Fault is an imbricate thrust fault which shares its root fault with the Limestone Cove Overthrust Fault and the Norris Branch Fault (Figures 22 and 23). The Unaka Mountain Fault was the last and highest of these faults to split off from the root fault.

The Unaka Mountain Fault is a thrust fault that forms the southeast boundary of Limestone Cove Window (Figure 2). It is part of the Stone Mountain Fault System (Figures 18 and 21) and extends from the northeast



Figure 19. Mylonite along the Clinchfield Railroad near Poplar, North Carolina. This mylonite is located along the trace of the Limestone Cove Overthrust Fault. The foliation dips approximately 40 degrees to the southeast (towards the right).

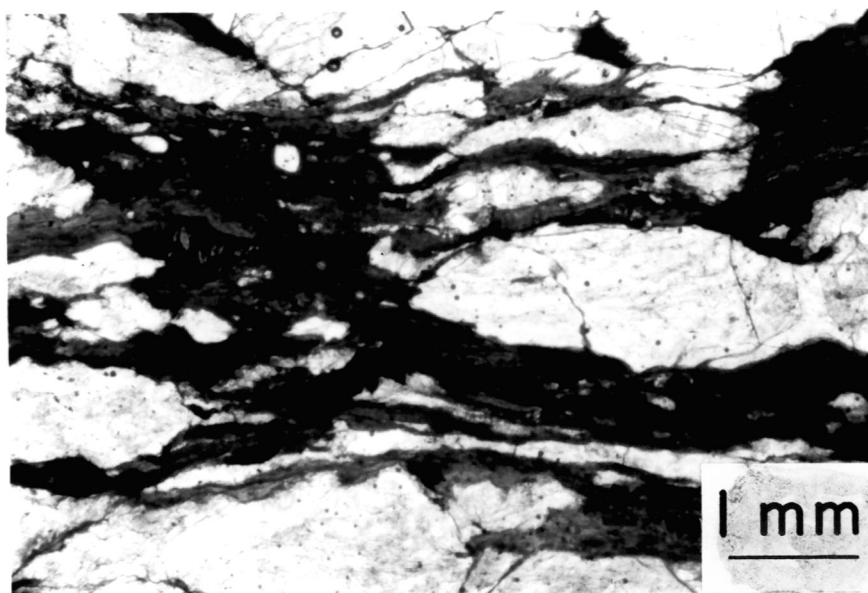


Figure 20. Photomicrograph of mylonite with crossed nicols.
This sample was taken from an outcrop near Beauty Spot Gap. The light mineral is quartz. The dark minerals are biotite, chlorite or microbrecciated micas.

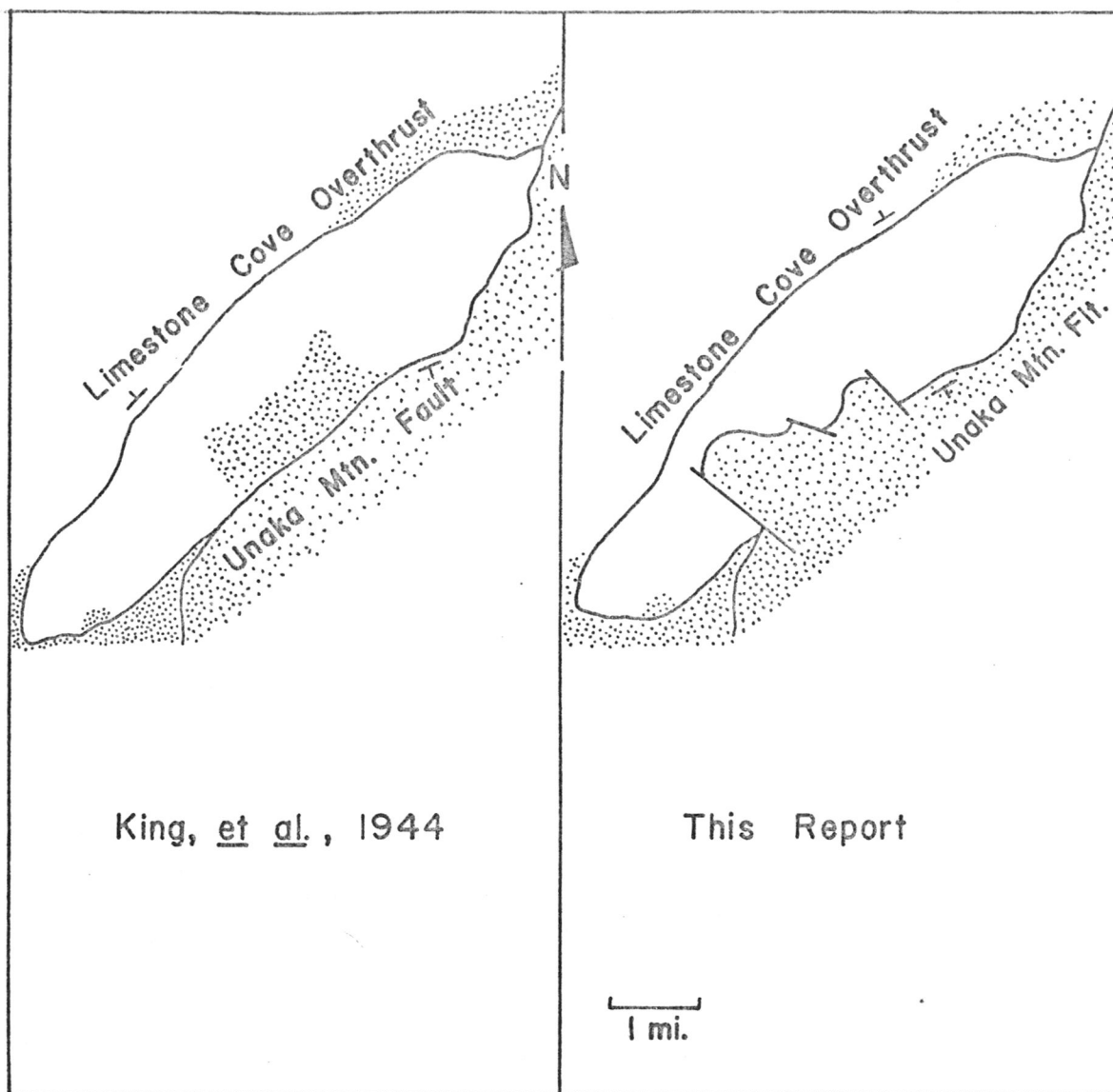


Figure 21. Comparison of the interpretation of the trace of the Unaka Mountain Fault by King and others to the interpretation in this thesis. Stippled pattern indicates rocks of the basement complex.

end of the Limestone Cove Window, southwest, passing west of the town of Poplar before crossing the Nolichucky River and passing out of the study area.

The Unaka Mountain Fault dips to the southeast. Rocks of the basement complex have been thrust northwestward over the sedimentary rocks of the Limestone Cove Window. Mylonite outcrops and float occur along the thrust zone. In an exposure along an unpaved road north of Tennessee Highway 107 east of the town of Limestone Cove, granite of the basement complex on the southeast has been thrust over rocks of the Shady Dolomite on the northwest. Several meters of mylonite are exposed between the Shady Dolomite and the basement rock. The foliation of the mylonite dips 54 degrees to the southeast. In another exposure to the south on Tennessee Highway 107, basement rock to the southeast has been thrust over metaquartzite beds of the Erwin Formation to the northwest. No mylonite was seen but there is a cover of soil. To the southwest in an exposure near Beauty Spot Gap rocks of the basement complex to the southwest are observed to have been thrust over metaquartzite and metaconglomerate beds of the Unicoi Formation to the northwest. Outcrops of mylonite are visible here with the foliation dipping approximately 12 degrees to the southeast.

Assuming the thickness of the Unicoi Formation to be 5000 feet (1524 meters) (King and others, 1944, p.37-38) and that of the Snowbird Formation to be 3500 feet (1100 meters) (Lowry, 1951, p.62-63), it is estimated that stratigraphic separation along the Unaka Mountain Fault is 4100 feet (1250 meters).

A complex part of the Unaka Mountain Fault lies in the area north of the town of Poplar (Plate 2). Here occurrences of granite extend much

farther to the northwest than would be expected in this area. Keith (1907) in his Roan Mountain Folio shows this area as a simple northwesterly salient of the trace of the Unaka Mountain Fault. Stose and Stose (1944, p.372) agreed with Keith. King and others (1944, p.10) showed the Unaka Mountain Fault as being within the granite and interpreted the contact between the granite and the sedimentary rocks as a nonconformity.

This author agrees in part with Keith and with Stose and Stose (Figure 21). The contact between the granite and sedimentary rock is the Unaka Mountain Fault. This interpretation is verified by outcrops of mylonite along the contact between the granite and sedimentary rocks. Figure 20 is a photomicrograph of mylonite taken from an outcrop near Beauty Spot Gap. However, there must be more to the structure than just a simple salient of the Unaka Mountain Fault. What causes this salient? There are several possible explanations. One is that the entire window was folded into a northwest-plunging syncline transverse to the dominant anticlinal-synclinal structure of the region. This would have bent the fault to the northwest. This explanation is unlikely because the amount of folding necessary to make a salient of this magnitude is not reflected in the traces of the adjacent Limestone Cove Overthrust Fault. A second explanation is that the salient is a graben. Since the Unaka Mountain Fault dips to the southeast, this would move the trace of the fault northwest, creating the salient. This explanation is possible, but no supporting evidence was found. A third explanation is that a series of strike-slip faults offset the trace of the Unaka Mountain Fault. Three straight, almost parallel fault zones cut the trace of the Unaka Mountain Fault at almost right angles. However, the trace of the Limestone Cove Overthrust Fault to the northwest is not affected by these faults. These zones contain sparse amounts of my-

lonite and are interpreted here as strike-slip faults offsetting the Unaka Mountain Fault. However, this interpretation does not rule out the strong possibility of a vertical component of movement. It is possible that in addition to any horizontal movement there has also been some vertical movement of the fault blocks. This would cause the fault to have an apparent horizontal offset greater than the actual offset produced by horizontal displacement.

The southernmost of these faults strikes N50°W and runs parallel to Bowling Green Creek from Poplar to Indian Grave Gap. The next fault to the northeast strikes N78°W, straddling the North Carolina-Tennessee state line near Beauty Spot. Between this fault and the southernmost fault the granite has been folded into a small syncline. This is indicated by the trace of the southeast-dipping Unaka Mountain Fault appearing near the top of the southeast slope of the Unaka Range. The folding has locally made the dip of the fault steeper than the 15 degree slope of the mountain. Normally the fault dips about 12 degrees in this area. If the dip of the fault was the normal 12 degrees the fault trace could not exist so far up a slope with a steeper dip and in the same direction as the fault. The northernmost fault strikes N45°W and is located directly northeast of Beauty Spot Gap.

The Unaka Mountain Fault has undergone substantial folding subsequent to its emplacement. The folding was anticlinal in nature with the axis trending northeast-southwest. Along most of its length, the dip of the Unaka Mountain Fault is approximately 12 degrees to the southeast. The large horizontal separation of the fault indicates that the original dip of the fault was only a few degrees, yet the present angle of dip is 12 degrees. Also the Limestone Cove Overthrust Fault trace bends around the

end of the Limestone Cove Window and runs along the opposite side. This interpretation is based in part on the assumption, made by most workers in this area, that the original fault planes were nearly horizontal.

Limestone Cove Overthrust Fault

The Limestone Cove Overthrust Fault forms the northeastern, northwestern, and southwestern boundaries of the Limestone Cove Window (Plate 2). The fault can be traced from a point north of the town of Limestone Cove, where it connects with the Unaka Mountain Fault, west then southwest around the west side of Limestone Cove. It extends from there in a southwest direction to the southeast of Rock Creek Campground. From there the fault extends southeast until it crosses the Nolichucky River at Lost Cove. The fault trace then bends to the east and runs almost due east until it passes west of Poplar, from which point the fault trace swings to the northeast, recrosses the Nolichucky River and once again connects with the Unaka Mountain Fault.

The Limestone Cove Overthrust Fault dips to the northwest on the northwest side of the window and to the southeast on the southeast side of the window. Along it, basement complex and Unicoi Formation have been thrust northwestward over Rome, Shady, and Chilhowee Group rocks of the Limestone Cove Window. Mylonite is found between the overriding rocks and overridden rocks, but not in as large amounts as along the Unaka Mountain Fault. In an exposure on Tennessee Highway 107 near Davis Springs west of the town of Limestone Cove, basement complex on the northwest overlies Shady Dolomite to the southeast. In an exposure to the southwest on Rock Creek Road a thin sliver of basement complex and Unicoi beds to the northwest overlie Unicoi, Hampton, and Erwin beds to the

southeast. The fault contact is covered. In an exposure on the Nolichucky River at Lost Cove rocks of the basement complex to the northwest overlie Unicoi rocks to the southeast. A thickness of approximately 200 feet (61 meters) of mylonite is present, and its foliation dips 43 degrees to the northwest. To the east, also on the Nolichucky River, is an exposure of the Limestone Cove Overthrust Fault. Here rocks of the basement complex and a small sliver of Unicoi to the southeast have been thrust over Snowbird beds to the northwest. At this place a thick zone of southeast-dipping mylonite is exposed in outcrop.

By using an assumed thickness for the Hampton Formation of 500 feet (153 meters) (King and others, 1944, p.37), and an assumed thickness of the Unicoi Formation of 5000 feet (1524 meters) (King and others, 1944, p.37-38), the stratigraphic separation of the Limestone Cove Overthrust Fault has been estimated to be 5500 feet (1676 meters). The thickness of the Snowbird Formation was not used in calculating the separation because the granite on the northwest side of the fault is overlain unconformably by Unicoi beds with no Snowbird present.

The Limestone Cove Overthrust Fault is part of an imbricate thrust system which also includes the Unaka Mountain Fault and the Norris Branch Fault (Figures 22 and 23). The Limestone Cove Overthrust Fault was the second of these three faults to split off of the root fault. The Norris Branch Fault was formed first, then the Limestone Cove Overthrust Fault, then the Unaka Mountain Fault.

The Limestone Cove Overthrust Fault has undergone substantial folding subsequent to its formation. The folding has been anticlinal in nature, with the axis trending northeast-southwest. The forces which created the

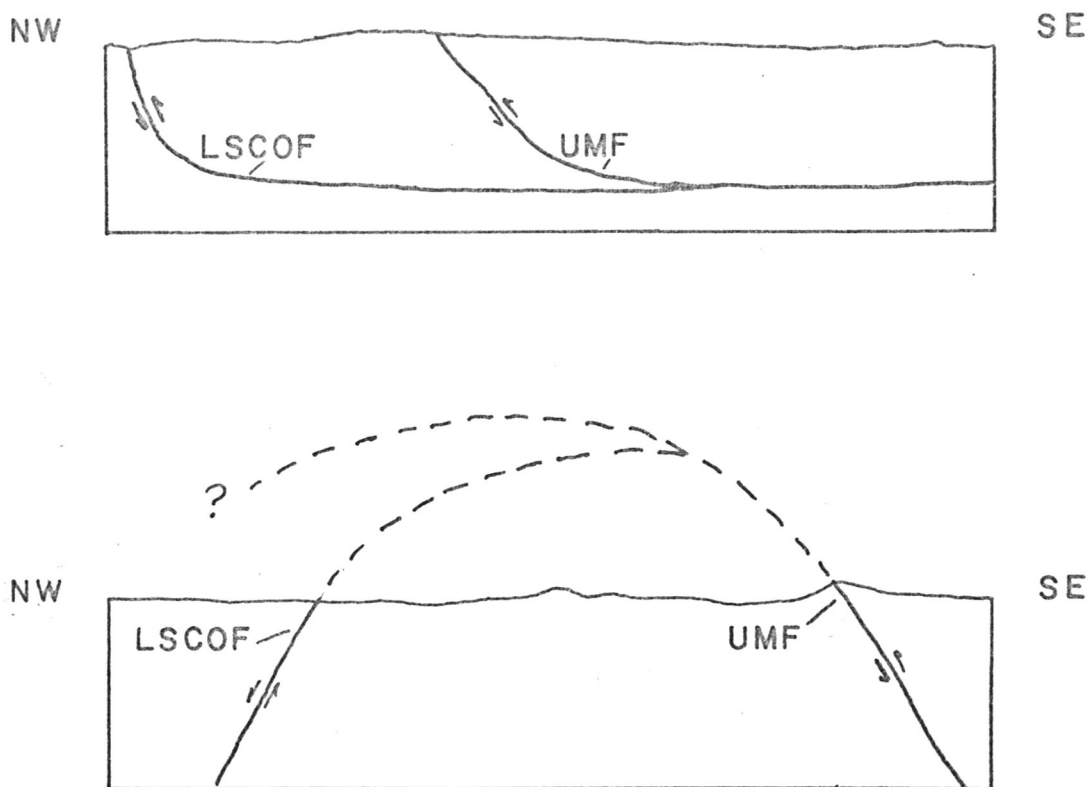


Figure 22. Sketch cross section showing the relationship of the Limestone Cove Overthrust Fault to the Unaka Mountain Fault and the effects of subsequent folding.

folding were directed from the southeast as indicated by rocks being thrust to the northwest. The large amount of horizontal displacement along this fault indicates that the original dip was only a few degrees. As a result of the folding, the Limestone Cove Overthrust Fault now dips approximately 45 degrees to the northwest (Figures 22 and 23).

Norris Branch Fault and Norris Branch Window

The roughly circular Norris Branch Window is located in the southernmost tip of the Limestone Cove Window. Although most of the Norris Branch Window is located south of the Nolichucky River, a small portion of the window is located north of the river.

The Norris Branch Fault is a thrust fault which outlines three sides of the Norris Branch Window (Plate 2). The southern boundary of the Norris Branch Window is the Limestone Cove Overthrust Fault. The Norris Branch and Limestone Cove Overthrust Faults dip radially away from the window.

On the Norris Branch Fault, Unicoi and Snowbird rocks of the Limestone Cove Window have been thrust over the basement complex of the Norris Branch Window. Between the overriding and overridden rocks mylonite is found either in float or outcrop. There are two good exposures of the Norris Branch Fault on the Nolichucky River. One exposure is on the east side of the Norris Branch Window, where Snowbird rocks on the southeast overlie highly sheared rocks of the basement complex to the northwest. Between the two rock types is an outcrop of mylonite approximately 350 feet (107 meters) thick with the foliation dipping 23 degrees to the southeast. On the west side of the Norris Branch Window the other

outcrop exposes Unicoi beds on the northwest which overlies rocks of the basement complex to the southeast. At this locality, the fault trace is indicated also by a layer of mylonite several hundred meters thick. The exact thickness of the mylonite and the dip of the foliation could not be determined.

Normally in a structural window younger rocks are found inside the window, while older rocks are found on the outside. However, in the Norris Branch Window the older basement complex is found on the inside of the window while younger Snowbird and Unicoi beds are found on the outside. Two possible explanations were proposed by Lowry (1951, p.98) and are illustrated in Figure 24. One explanation is that Snowbird and Unicoi beds were deposited on an irregular erosion surface that developed on the basement complex. Thus thrusting could have displaced the sedimentary beds upward onto a topographically higher portion of the older basement complex. The other explanation is that previous folding had upwarped this area so that later thrusting brought sedimentary beds from the adjacent syncline to rest on the older basement complex in the core of the anticline.

The Norris Branch Fault is an imbricate thrust fault which shares its root fault with the Unaka Mountain and Limestone Cove Overthrust Fault. Of these faults the Norris Branch Fault was the first to form (Figure 23) and is the structurally lowest of the three. Due to the limited extent of the Norris Branch Window, the offset of the Norris Branch Fault could not be determined.

The same stresses which folded the Unaka Mountain and Limestone Cove Overthrust Faults have affected the Norris Branch Fault. The fault was

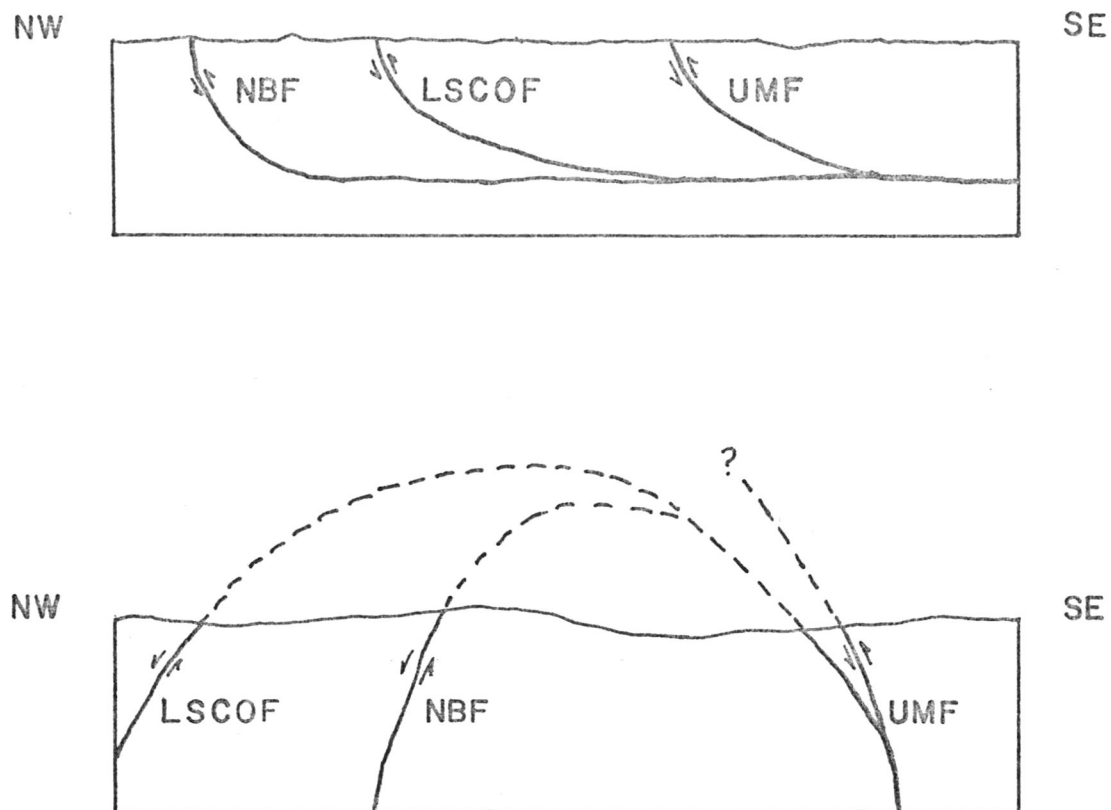


Figure 23. Sketch cross section showing the relationship of the Norris Branch Fault to the Limestone Cove Overthrust and the Unaka Mountain Fault and the effects of subsequent folding.

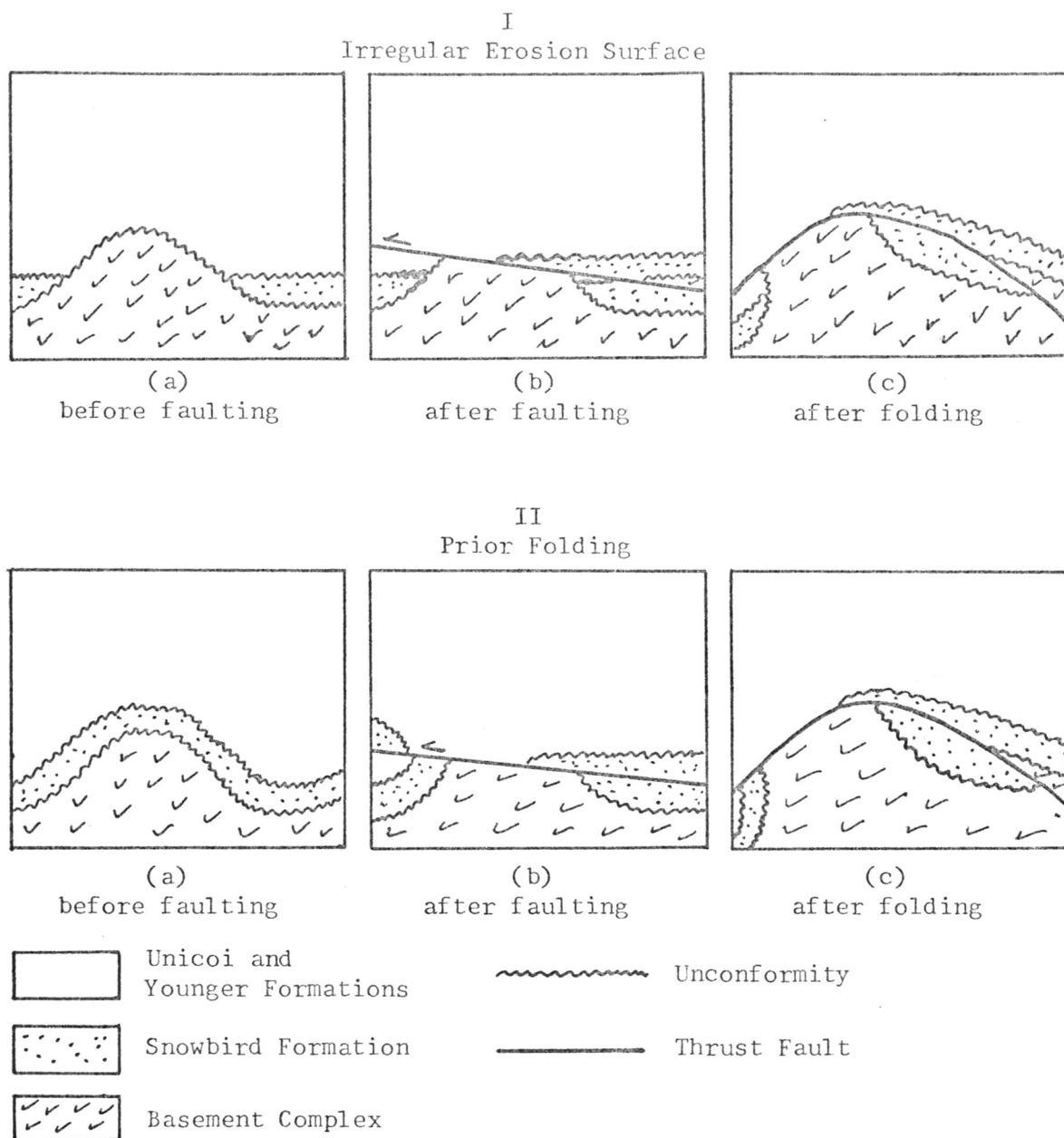


Figure 24. Sketches showing two ways in which the Norris Branch Window could have formed with rocks of the basement complex inside the window (After Lowry, 1951).

originally a low-angle thrust fault dipping to the southeast. Anticlinal folding has warped the fault plane, increased the dip and changed the direction of dip on the northwest side of the fault (Figure 23).

Davis Springs Thrust Fault and Davis Springs Klippe

Within the Limestone Cove Window in the western part of the town of Limestone Cove at Davis Springs there is an isolated round outcrop of the Erwin Formation surrounded by outcrops of Shady Dolomite (Plate 2). This outcrop is 670 meters long and 610 meters wide. The outcrop forms a round knobby hill with a peak 817 meters in elevation. There are four possible explanations for this. First, an old ridge of Erwin sediments may have projected above the sea when the Shady Dolomite was being deposited. Erosion has now exposed part of this ridge. This explanation is rejected because for a barrier bar ridge to make an outcrop of this size by the method described, it would have to have had a height of over 610 meters, which is unlikely. Second, folding may have locally overturned the beds here, so that the Erwin and Shady are in normal contact with each other. This explanation is rejected because there is no field evidence to support it. A third explanation is that a piece of Erwin slid off the northwest slope of Stamping Ground Ridge and onto the Shady Dolomite. This explanation is rejected because the slope of Stamping Ground Ridge is not steep enough to allow such a large piece of rock to break away from the slope and to slide that far. A fourth explanation is that the outcrop of Erwin is an erosional remnant of a slice of Erwin that was thrust over Shady Dolomite. The location of this inferred thrust fault is interpreted to lie to the south of the klippe (Figure 25). This thrust fault is

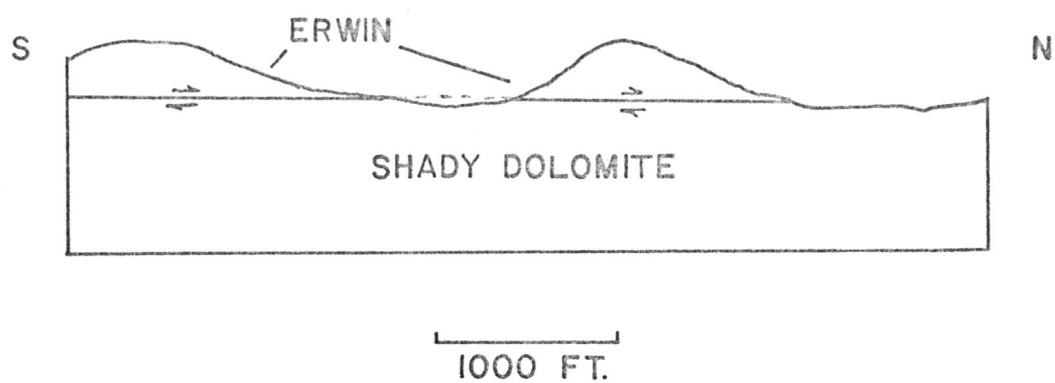


Figure 25. Sketch cross section of the Davis Springs Fault and Klippe.

apparently a small scale feature and represents a minor imbrication of one of the main thrust faults in the Limestone Cove Window. The offset and dip angle of this fault could not be determined. This thrust is here named the Davis Springs Thrust Fault.

Origin of the Deformation

The angular unconformity separating the Unicoi Formation from the underlying Snowbird Formation was produced by an interval of erosion and tilting that preceded the deposition of the basal Cambrian Chilhowee Group. However, the major structures of the Limestone Cove Window were formed later during an orogeny assumed by most workers to be of late Paleozoic age. No direct evidence was found in the Limestone Cove Window bearing on this. In this orogeny, compressive stresses were oriented almost horizontally along a northwest-southeast trend. These stresses are thought to have originated as a result of tectonic forces acting from the southeast. This is indicated by the fact that in the Limestone Cove Window, basement complex was moved to the northwest on the southeast side of the window. These stresses began to fold the rocks. As the stresses exceeded the strength of the rocks, the rocks failed along low angle faults, and later extensive thrust sheets moved over one another, creating the imbricate fault system seen today (King and Ferguson, 1960, p.84).

G E O L O G I C H I S T O R Y

The first major event affecting the rocks in the Limestone Cove Window was an orogenic event occurring in the Precambrian from 600 to 800 million years ago. This event is indicated by an angular unconformity

at the base of the Chilhowee Group (King and Ferguson, 1960, p.84).

The second major event which affected the rocks and structure of the Limestone Cove Window was the Alleghenian Orogeny. This occurred in the Mississippian and Pennsylvanian Periods and included the large scale faulting and folding of this region. Examples are the Great Smoky, Pulaski, and Saltville Faults. Mississippian rocks which show little evidence of previous deformation are overridden along these faults. Thus the major deformation in this area must have been post-Mississippian (King and Ferguson, 1960, p.84). Although this major deformation occurred in the same orogeny, the events did not occur simultaneously, but were prolonged throughout the orogeny (King and Ferguson, 1960, p.84).

A question as to the age of the orogeny in the study area does arise. In the Limestone Cove Window and adjacent areas the youngest rock formation is Cambrian in age. Why could it not have been possible for these major structures, here considered to be Alleghenian in age, to have actually been produced during the Taconic Orogeny (Ordovician), especially since no Ordovician or younger rocks are present? An argument against such an interpretation is the fact that aside from a number of comparatively small cross faults, the major thrust faults of this area are not distorted by other large scale folds or faults which would have been the case had effects of the Alleghenian Orogeny been superimposed on Taconic structures.

The first orogenic structures to form in the Limestone Cove Window were the Norris Branch and Limestone Cove Overthrust Faults. Beginning later and continuing during and after the formation of the Norris Branch

and Limestone Cove thrust sheets was the formation of the Shady Valley thrust sheet (King and Ferguson, 1960, p.85). This thrust sheet is not present in the Limestone Cove Window. The Unaka Mountain Fault, a member of the Stone Mountain Fault System, was formed after the formation of the Norris Branch, Limestone Cove, and Shady Valley thrust sheets (King and Ferguson, 1960, p.85).

The broad arching of the thrust sheets in the region occurred both contemporaneously and subsequent to the development of the Unaka Mountain Fault. Later erosion cut through the thrust sheets, forming the windows as seen today. Several transcurrent faults were formed in this region toward the end of the Alleghenian Orogeny. The largest of these is the Cross Mountain Fault (King and Ferguson, 1960, p.85). It is possible that the small transcurrent faults near Poplar are related to this period of strike-slip faulting.

C O N C L U S I O N S

This report provides greater detail of the Limestone Cove Window than was previously available. As a result of this greater detail four changes or additions to the geologic interpretation of the Limestone Cove Window have been made:

- 1.) The Snowbird Formation has been recognized for the first time north of the Nolichucky River.
- 2.) The Unaka Mountain Fault has been shown to extend along the northwest contact of the Limestone Cove granite instead of cutting the area of basement complex, as shown on earlier maps.
- 3.) Three transverse faults which offset the trace of the Unaka

Mountain Fault have been mapped.

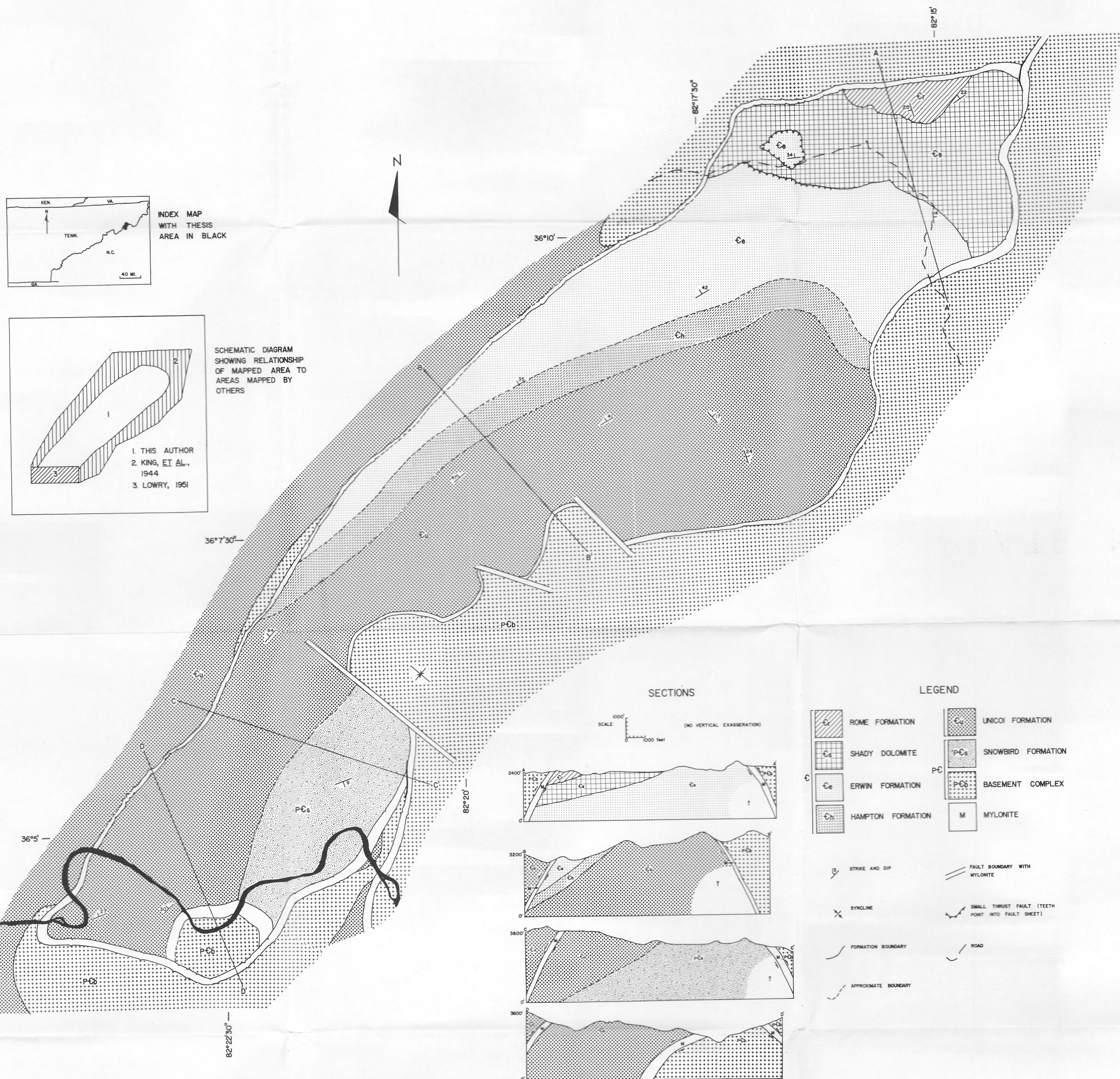
- 4.) A previously undescribed thrust fault and small klippe have been located at Davis Springs in the town of Limestone Cove.

It is confirmed that the degree of folding of the faults of the Limestone Cove Window is substantial.

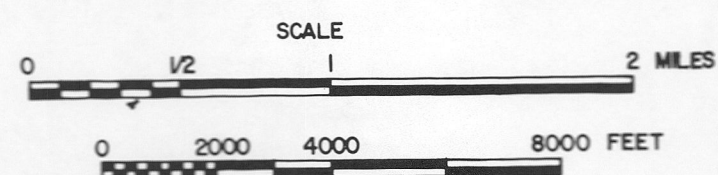
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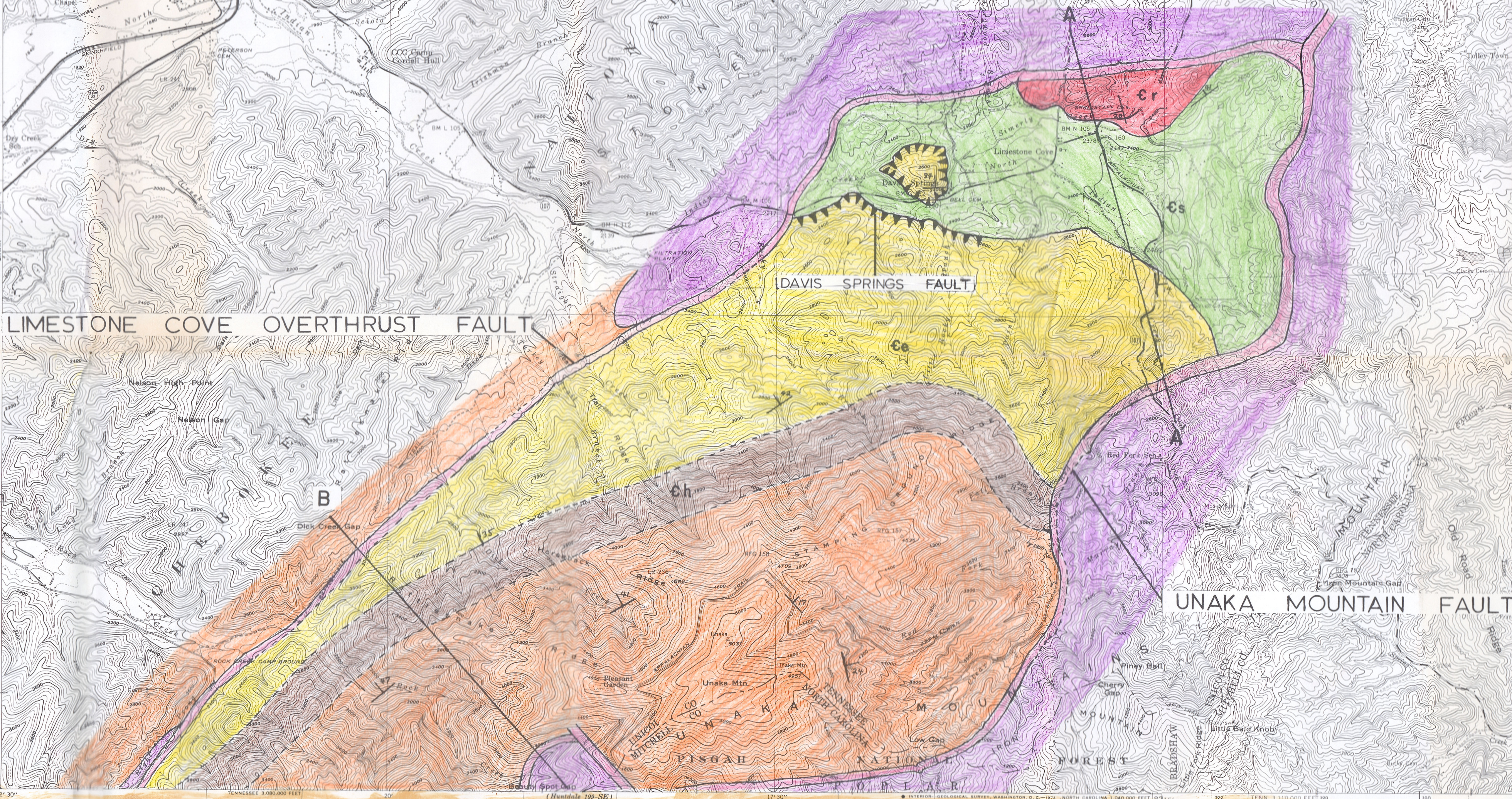
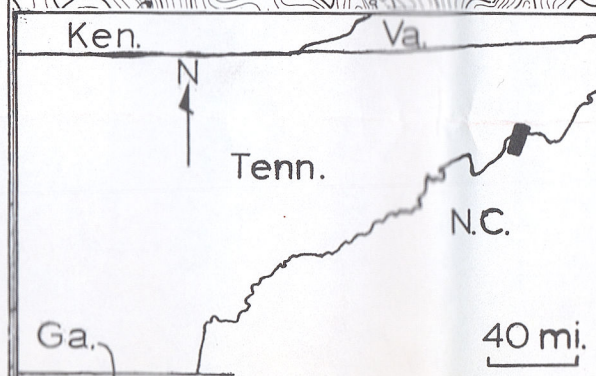
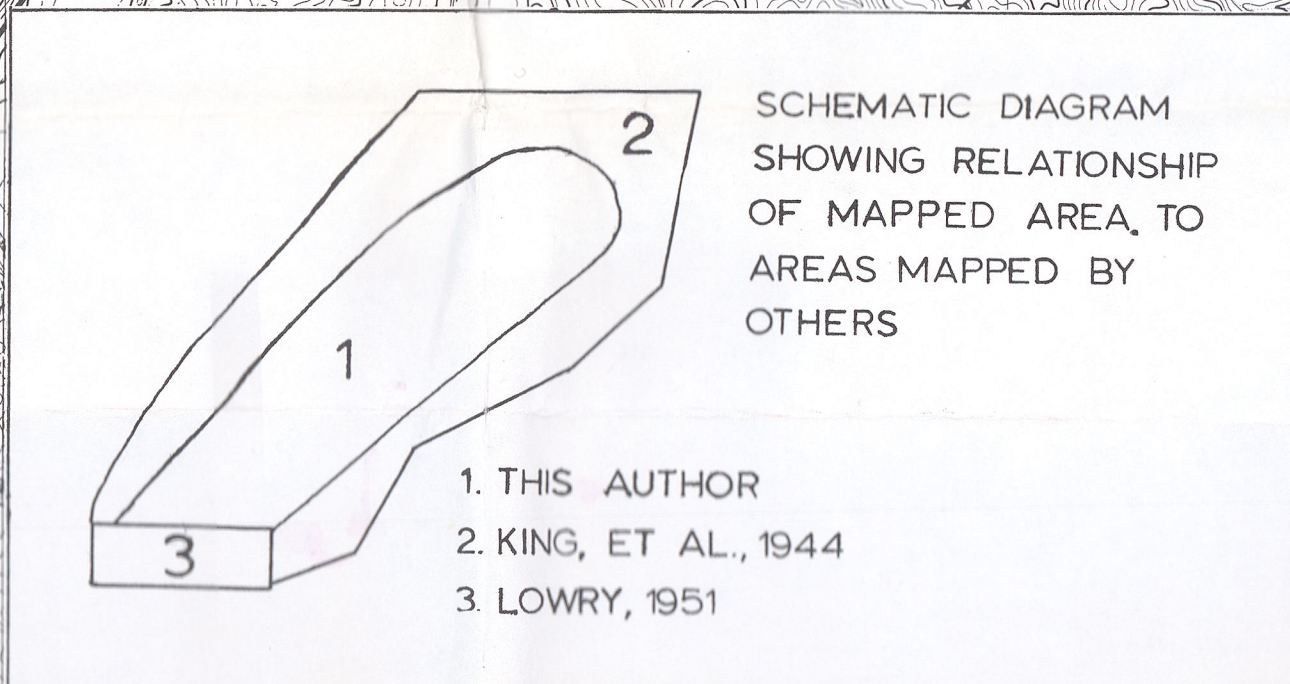
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GEOLOGIC MAP AND STRUCTURE SECTIONS
OF LIMESTONE COVE WINDOW, TENNESSEE AND NORTH CAROLINA





Control by USCGS, USGS, and TVA.
Topography by Fairchild Aerial Surveys, Inc.,
by stereophotogrammetric process.
Field examination by Tennessee Valley Authority-1939.
Office inspection and review by the Geological Survey.

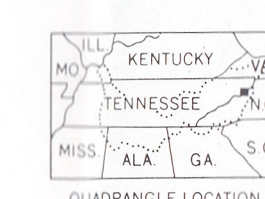
SCALE 1:24,000
Contour interval 40 feet with 80 foot contours shown by broken line
Datum is mean sea level

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AND TENNESSEE DIVISION OF GEOLOGY, NASHVILLE, TENNESSEE 37219.
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST.

Mapped and edited by Tennessee Valley Authority
Published by the Geological Survey
Control by USCGS, USGS, and TVA.
Topography by photogrammetric methods using
aerial photographs taken 1953.
Map field checked by TVA, 1960.
Physiographic projection: 1927 North American datum
10,000 foot grid based on Tennessee and
North Carolina rectangular coordinate systems.
1000 meter Universal Transverse Mercator Grid ticks,
Zone 17, shown in blue.
Fine red dashed lines indicate selected fence and field lines
visible on aerial photographs. This information is unchecked.
Regions shown in purple and reclamation of woodland
areas compiled by the Tennessee Valley Authority from aerial
photographs taken 1968. This information not field checked.

10M GRID AND 1908 MAGNETIC NORTH
DECLINATION AT CENTER OF SHEET

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ROAD CLASSIFICATION
Heavy-duty Poor motor road
Medium-duty Wagon and jeep track
Light-duty Foot trail
U.S. Route
State Route

IRON MOUNTAIN GAP, TENN.-N.C.
1:3607.5-W8207.5/7.5
1960
PHOTOREVISED 1968
AMS 4550 II RE-SERIES 1984

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