Carolina Geological Society

Guide Book Of Excursion In The Great Smoky Mountains

November 1-2, 1952

BY

PHILIP B. KING,

JARVIS B. HADLEY,

AND

ROBERT B. NEUMAN

Geologists,

U. S. Geological Survey

GATLINBURG, TENNESSEE

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Philip B. King, Jarvis B. Hadley, Robert B. Neuman
Geologists, U.S. Geological Survey

Assisted by

Richard Goldsmith, Warren Hamilton, Harold E. Malde

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GUIDEBOOK OF EXCURSION OF CAROLINA GEOLOGICAL SOCIETY, GREAT SMOKY MOUNTAINS AREA, TENNESSEE AND NORTH CAROLINA[1]

NOVEMBER 1-2, 1952

Philip B. King, Jarvis B. Hadley, and Robert B. Neuman

Geologists, U.S. Geological Survey

1.Publication authorized by the Director, U.S. Geological Survey

INTRODUCTION

The staff of the Great Smoky Mountains project of the U.S. Geological Survey takes pleasure in welcoming the Carolina Geological Society to the Great Smoky Mountains. Great Smoky Mountains National Park and the mountains from which it takes its name need little introduction to the visitor. The forested slopes of this mountain wilderness, now in their blaze of autumn color, are exhibiting one of the most attractive of their many-changing aspects. By contrast, the geological features of the Great Smoky Mountains are virtually unknown to the public, or poorly understood at most, and these are the principal objectives of the excursion.

The geology of Great Smoky Mountains National Park and vicinity has been under investigation by a field party of the U.S. Geological Survey since 1946. The project was undertaken primarily to aid the National Park Service in its interpretation of the natural history of the park area; the only comprehensive geologic work in the park that was hitherto available had been done by Arthur Keith more than half a century ago (1895, 1896. 1904, 1907a). The present project is, besides, a piece of fundamental research in Southern Appalachian geology. The drab, difficult rocks of the mountains hold many keys which may unlock secrets of the tectonics of a much wider area.

Up to now, the Geological Survey party, aided from time to time by geologists of the Tennessee Division of Geology, has mapped about half the park area in detail, and has covered large additional areas in reconnaissance. Broader conclusions on tectonics, stratigraphy, metamorphic geology, and geologic history are emerging that before were only dimly perceived. It is therefore appropriate, in mid-passage, to offer to the public an interim presentation of the results of the investigation, and to take opportunity to discuss these results with other geologists.

The excursion of the Carolina Geological Society will traverse a representative cross-section of the Great Smoky Mountains from the lowlands of Paleozoic sedimentary rocks in the Tennessee Valley on the northwest, across Chilhowee Mountain, the foothills, and the main range of the Great Smoky Mountains, to the mountains of gneissic and granitic rock in North Carolina on the southeast. Representative outcrops showing critical features of the rocks will be examined along the traverse.

In the limited time available for the traverse there will be little opportunity for other than sampling of this highly complex area. Many features which bear on broader interpretations lie east or west of the traverse and cannot be visited. If the outcrops visited are to have meaning, they must be placed in proper perspective in the whole fabric of the region. This guidebook therefore contains much discussion of broader features of Great Smoky Mountains geology. These broader relations are further displayed on the map of the Great Smoky Mountains (map B). Relations of the Great Smoky Mountains to the areas surrounding it are shown on the regional map (map A).

OUTLINE OF GEOLOGY OF GREAT SMOKY MOUNTAINS AREA

Method of Presentation

This outline of the geology of the Great Smoky Mountains area will deal wholly with bedrock formations and structures, and will explain relations between different features shown on the accompanying generalized preliminary geologic map (map B). Because of space limitations, no concessions are made to the non-technical reader; for a non-technical account see King and Stupka (1950a, 1950b). Superficial and Pleistocene geology are no mentioned; although these are of great interest they have not been thoroughly studied, and will shortly be investigated in detail.

Description of bedrock units and structures will proceed from the northwest to southeast, or in the direction followed by the excursion. It thus proceeds from relatively will known to relatively less known rocks, and mainly from younger to older rocks. We will descend in the geologic column, rather than ascend in the manner of usual geologic reports.

Four sequences of rocks

The lay of the bedrock formations in the Great Smoky Mountains area is largely controlled by two great low-angle faults, the Great Smoky and the Greenbrier (distinguished by

Table 1. Paleozoic section northwest of Chilhowee Mountain, in southeast part of Tennessee Valley.[1]

(By Robert B. Neuman)

	Approximate thickness in feet
Carboniferous	
Mississippian	
Newman limestone: Argillaceous limestone, passing above into dark gray shale and thin sandstone, and below into red shale	2,000
Grainger formation: Medium-grained feldspathic sandstone, with several coarse sandstone and conglomerate beds; much interbedded shale in lower part.	900
Devonian and Carboniferous	
Chattanooga shale: Black, fissile shale	25
Unconformity; great hiatus but no angular discordance.	
Ordovician	
Middle Ordovician	
Bays formation: (Bays and Clinch sandstones of Keith, 1895, 1896): Red calcareous mudrock with white quartz-rose sandstone lenses.	600
Sevier shale:	
Upper part (upper part of Sevier shale, and Sandstone lentil in Sevier shale of Keith, 1895); Calcareous, silty and sandy shale, with very thick sandstone at base, and thinner sandstone beds above.	3,500
Lower part (lower part of Sevier shale, Tellico sand-stone, and Athens shale of Keith, 1895): Calcareous, silty and sandy shale with two or three beds of calcareous sandstone; a lower unit of black graptolite shale, passing into cobbly argillaceous limestone at base.	3,500
Lenoir limestone (Chicamauga limestone of Keith, 1895): Cobbly argillaceous limestone, and some dove-gray aphanitic limestone.	100
Lower Ordovician	
Knox group: Limestones and dolomites, in part cherty, of Mascot age at top. Underlain northwest of mapped area by Upper Cambrian part of Knox group, by Middle and Upper Cambrian Conasauga group, and by Lower Cambrian Rome formation.	

1.Terminology used here represents that in the latest publication approved by the U.S. Geological Survey (Rodgers, 1952). Further modification in terminology and classification are being proposed by Neuman in manuscripts now in preparation.

different conventions on map B). These divide the country into fault blocks that are broadly expressed by contrasting landscapes, and divide the rocks which compose them into several different sequences, relations between which have not all been fully determined.

The Great Smoky fault emerges along the southeast edge of the Tennessee Valley, but it is brought to the surface again farther south-east, around a number of coves, or windows, within the foothill area. The rocks beneath it, in the Tennessee Valley and the coves, are a sequence of Paleozoic age. The rocks above the Great Smoky fault and beneath the Greenbrier fault form the narrow outlying range of Chilhowee Mountain, and a broad belt of foothill country behind it. They are divided into two sequences by the relatively minor Miller Cove fault—a sequence on Chilhowee Mountain made up largely of earliest Paleozoic (Lower Cambrian) rocks, and a sequence in the foothills made up of rocks of the Ocoee series. The Greenbrier fault emerges along the face of the Great Smoky Mountains which rises behind the foothills. The rocks of the mountain area are also classed as part of the Ocoee series. Southward and southeastward they adjoin other rocks of the Murphy marble belt, and the extensive complex of Carolina and Roan gneisses (map A).

The four sequences — in the Tennessee Valley, Chilhowee Mountain, the foothills, and the mountain area — serve as a basis for the discussion which follows, and are employed as well on the legend of the geologic map (map B).

Rocks of the Tennessee Valley and Cove Areas

The rocks of the Tennessee Valley in the immediate vicinity of the Great Smoky Mountains belong to the Mississippian, Upper Devonian, Middle Ordovician, and Lower Cambrian series; Cambrian rocks extending as low as the Rome formation (Lower Cambrian) emerge not far northwest of the area mapped (Rodgers, 1952, pl. 9). In the coves to the southeast, the Lower Ordovician and part of the Middle Ordovician reappear in windows in the Great Smoky fault. The generalized section in Table 1 is typical of this sequence:

Terminology used here represents that in the latest publication approved by the U.S. Geological Survey (Rodgers, 1952). Further modification in terminology and classification are being proposed by Neuman in manuscripts now in preparation.

These rocks are part of the well-known sequence of Paleozoic fossiliferous sedimentary rocks which extend along the Valley and Ridge province from Pennsylvania to Alabama (Butts, 1926, 1940; Butts and Gildersleeve, 1948; Rodgers, 1952). As they lie on the southeast edge of that province, they exhibit special characters which depart somewhat from those of the better known sections farther northwest.

Lower Ordovician rocks, a part of the Knox group, are not dominantly dolomites as elsewhere in the Valley and Ridge province, but are dominantly limestone. Both the Middle Ordovician and the Mississippian, which are elsewhere dominantly carbonates and fine clastics, are here dominantly clastic, and in part coarsely clastic. The Middle Ordovician, too, thickens from its usual few thousand feet to a total of about 7, 700 feet. Deposition of both Middle Ordovician and Mississippian in this area was no doubt influenced by pulses of orogeny farther southeast in the mobile belt. The Chattanooga shale (Devonian and Carboniferous) lies disconformably on Middle Ordovician rocks; the intervening hiatus, which comprises Late Ordovician, Silurian, and most of Devonian time, is elsewhere well represented by formations.

Great Smoky fault

The rocks and structures of the Tennessee Valley terminate southeastward along a major line of discontinuity, the Great Smoky fault (Keith, 1927; Neuman, 1951). This fault, or faults related to it, extends far northeast and southwest from the Great Smoky Mountains, across Tennessee (Rodgers, 1952) and well into Virginia and Georgia. (Although not shown on map A, it generally follows the contact between unit 1 and units 2 and 3). Along it, old rocks of early Paleozoic and pre-Cambrian age have traveled northwestward--no one knows how far--over younger Paleozoic rocks of the Tennessee Valley. In the vicinity of the Great Smoky Mountains the actual surface on which the Great Smoky fault moved is exposed at numerous localities (Neuman, 1951, pp. 243-746, 750). One of these, at the Townsend entrance of the park on the southeast side of Tuckaleechee Cove (locality B, pp. 35-38; fig. 6, p. 18) will be visited by the excursion.

Along the main trace of the fault on the front of Chilhowee Mountain, it pursues a relatively straight course, and dips between 20 degrees and 60 degrees to the southeast, but in most of the area its attitude is low and undulating. East of the end of Chilhowee Mountain the trace is deflected around the southwest-plunging end of the Fair Garden anti-cline, and southeast of Chilhowee Mountain it emerges around the windows of Wear, Tuckaleechee, Cades, and other coves (map B). A small window east of Cades Cove lies 10 miles southeast of the main trace of the fault on Chilhowee Mountain. Part of the undulations of the fault may have resulted from warping subsequent to its emplacement, thus indicating that the faulting may antedate completion of the folding in the overridden Paleozoic rocks of the Tennessee Valley.

In the Southern Appalachians a common “trademark” of a great fault is the presence of dragged wedges or slices along its sole, made up of rocks intermediate in age between the overriding and overridden rocks. The Great Smoky fault is no exception. Participants in the excursion will see a chain of low knobs along the trace of the fault fringing the base of Chilhowee Mountain at its northeast end, formed by sandstone slices that are part of the same Chilhowee group which caps the mountain. In Wear and Tuckaleechee Coves, the normal cove sequence of Lower Ordovician limestone and Middle Ordovician shale is generally separated from overriding rocks by intermediate slices of Lower Ordovician limestone. One of these slices will be seen on the excursion at the Townsend entrance (locality B and fig. 6)

Although the Great Smoky fault may have been moderately warped subsequent to its emplacement, it is younger than many of the structural features of the region. The overriding rocks exhibit varying degrees of metamorphism, but this metamorphism is unrelated to the thrusting. Farthest northwest, near the main trace of the fault, the overriding argillaceous rocks are merely shales, but they become slates and phyllites farther southeast. Around the coves, chloritic phyllites of the overriding block lie on Ordovician limestones and shales which are mechanically deformed but not otherwise altered. Presumably the metamorphism in the overriding rocks took place before they were thrust over the Paleozoic rocks of the Tennessee Valley sequence.

Presence of Mississippian rocks closely adjacent to the Great Smoky fault is of interest in that it aids in dating this fault and the structure associated with it in the Great Smoky Mountains. The Mississippian forms a narrow synclinal strip along the northwest base of Chilhowee Mountain, and while it at no place is directly in contact with the Great Smoky fault, its structures are so closely related that emplacement of the fault must have taken place in post-Mississippian time.

Rocks of Chilhowee Mountain

The overriding rocks immediately southeast of and above the main trace of the Great Smoky fault make up the narrow Chilhowee Mountain block. Like the rocks they override, these are mainly of Paleozoic age, although belonging to an earlier part of the Paleozoic than those of the Tennessee Valley or the coves. The two Paleozoic sequences are interrupted by the Great Smoky fault, but relations between them can be established through the red shales and sandstones of the Lower Cambrian Rome formation, which form the base of one sequence and the summit of the other. We have already noted that in the Tennessee Valley not far northwest

Table 2. Paleozoic section in Chilhowee Mountain and Miller Cove.
(By H.W.Ferguson, G.D. Swingle, and C.A. Tucker, Jr.)

	Approximate thickness in feet
Cambrian	
Lower Cambrian	
Rome formation (shore deposit of Knox dolomite of Keith, 1895): Red silty shale with some yellow shale and thin-bedded sandstone.	900
Shady Dolomite (Knox dolomite of Keith, 1895): Gray massive dolomite, with white saccharoidal dolomite in lower part, and several persistent calcareous shale beds in upper half.	1000
Chilhowee group:	
Hesse sandstone: Massive white quartzose sandstone and quartzite, in part with *Scolithus*: thin- bedded shaly Helenmode member at top, with *Olenellus* and other fossils (Walcott, 1890; Keith, 1895.	400
Murray shale: Grayish-blue silty shale; fossils reported at locality above Montvale Springs (Keith, 1895)	300
Nebo sandstone: Thin-bedded to massive quartzose sandstone and quartzite, in part with Scoliths.	200
Nichols shale: Greenish-blue silty shale, with detrital mica; rare lenses of feldspathic sandstone.	500
Cochran formation: Feldspathic sandstone, massive and quartzitic at top; lower part contains fine quartz conglomerate and much red arkosic shale.	1000
Unconformity?	
Pre-Cambrian?	
Late pre-Cambrian?	
Ocoee series:	
Sandsuck shale: Shale with lenses of arkosic sandstone and conglomerate; some of latter mapped with Cochran by Keith (1895).	

of the Great Smoky Mountains the section extends down to the Rome; the Rome reappears again as remnants in Miller Cove, the little mountain valley which borders Chilhowee Mountain on the southeast for part of its course (map B). The rocks of Chilhowee Mountain exhibit the sequence shown in Table 2, part of which will be seen on the excursion at locality A (pp. 33-35 and fig. 5, p. 16).

The Chilhowee group has many aspects of an initial deposit of a sedimetary cycle. Its basal deposits, the conglomerate and red shale of the lower part of the Cochran, appears to have been reworked from a regolith. They pass upward into better washed and sorted clastics, and give place at the top to carbonates. It is perhaps the basal unit of the Cambrian and the Paleozoic (King, 1949, p. 638); certainly it is very early Cambrian. Small collections made years ago by Walcott (1890, p. 570) from the topmost beds in Little River gap yielded the Early Cambrian trilobite *Olenellus*; problematical worm tubes, or *Scolithus*, extend down to about the middle of the group. The age of the lowest beds of the group has not been established by fossil evidence.

In regions northeast of the Great Smoky Mountains the basal beds of the Chilhowee group (Cochran equivalent) lie on a profoundly eroded surface of ancient granitic rocks (King, Ferguson, Craig, and Rodgers, 1944, p. 29). At the northeast end of Chilhowee Mountain the basal beds of the Chilhowee group lie instead on earlier sedimentary rocks, the Sandsuck shale (map B), or terminal formation of the Ocoee series.

The shales of the Sandsuck are interbedded with lenticular layers of poorly sorted sandstone and conglomerate. Detailed mapping of the base of the Chilhowee group on Chilhowee Mountain by H.W. Ferguson demonstrates that the Chilhowee rests in places on shale and in others on sandstone and conglomerate. This relation, and the nature of the basal Chilhowee deposits, suggest the existence of an unconformity between Chilhowee and Ocoee, but such an unconformity, if present, did not involve folding and metamorphism, or even much tilting and erosion of the Ocoee. The possible unconformity adds weight to the view that the Ocoee is late pre-Cambrian rather than Cambrian in age (King, 1949, p. 634), although it is not of sufficient magnitude to be decisive.

Miller Cove Fault

The rocks of the Chilhowee Mountain block are separated from those of the foothill area on the southeast by the Miller Cove fault (map B). Some geologists (Wilson, 1935; Stose and Stose, 1949, fig. 4, p. 301) have interpreted this as the main Great Smoky fault--perhaps because of the prominent appearance given it on Keith's Knoxville map (1895), and because it creates a notable displacement of Ocoee series against Rome formation and Shady dolomite in Miller Cove (where it will be crossed by the excursion). Actually, the Miller Cove fault is a subsidiary thrust in the overriding rocks above the Great Smoky fault.

Northeast of Miller Cove the fault splits into several branches which lie mainly within the Ocoee series beneath the Chilhowee group. Northwest of the fault zone Keith assigned most of these rocks to the Sandsuck shale, but southeast of it termed them the Wilhite or Hiwassee slate and the Citico conglomerate. Except for slightly greater metamorphism in the latter, the shales, slates, sandstones, and conglomerates on the two sides of the fault zone are identical. Where the Miller Cove fault lies in these rocks its magnitude is perhaps in no wise diminished, but it no longer is the boundary between contrasting rock formations.

Rocks of Foothill Area

The main body of rocks between the Great Smoky and Greenbrier fault is southeast of the Miller Cove fault and forms a belt of foothills 6 or 8 miles wide. These rocks are part of the Ocoee series, a great mass of clastic sediments whose age and relations have ben debated ever since they were first named by Safford nearly a century ago (Safford, 1856, pp. 152-153; 1869, pp. 183-198; for digest of later interpretations, see King, 1949, p. 623).

Resolution of the problems of the Ocoee series has been one of the principal objectives of the present field party, but like earlier geologists we have found that it is attended by unusual difficulties, which are not amenable to familiar methods of stratigraphic and structural analysis. No fossils are present and there are no widely traceable key beds. Lithologic distinctions are between units many thousands of feet thick, which probably grade into each other laterally and vertically, but which in many places are now brought together by faults. The rocks are much more metamorphosed than those in the Valley and Ridge province, and in parts of the area metamorphic structures of more than one age are superimposed.

Work by the present field party indicates the need of great revision of existing concepts of relations and sequence of named stratigraphic units of the Ocoee series (mostly established by Keith; for summary, see Barrell, 1925). Discovery of the Greenbrier fault indicates that the Ocoee series comprises not one sequence but two--that of the foothills and that of the mountains--which probably were not laid down one above the other, but may have been facies of approximately the same age. In this preliminary account it is undesirable to attempt a new system of nomenclature. We will, however, indicate the trends of our opinion as to the succession in different areas, and the approximate relation of the proposed subdivisions to units named by Keith and others.

The foothill area of the Great Smoky Mountains is part of a belt that extends far northeastward and southwestward along the strike, which contains a characteristic assemblage of rock types throughout (fine-grained part of Ocoee series of Rodgers, 1952). Northeast of the Great Smoky Mountains the rocks of the belt lie between younger rocks of the Chilhowee group on the northwest and older granitic rocks on the southeast (Ferguson and Jewell, 1951; Oriel, 1950); they wedge out northeastward, near or south of the Nolichucky River, probably by overlap or truncation (map A). From the Great Smoky Mountains southwestward, at least as far as the Ocoee River, near the Tennessee-Georgia line, the rocks of the belt are bordered on the southeast by the rocks of the mountain sequence; the Chilhowee group on the northwest is discontinuous.

In the area northeast of the Great Smoky Mountains the foothill sequence has a known stratigraphic position below the Lower Cambrian Chilhowee group and above earlier granitic rocks and constitutes the Snowbird formation and Hiwassee slate of Keith (1904, p. 5). Reconnaissance by H.W. Ferguson (Ferguson and Jewell, 1951, pp. 10-15; summarized in King, 1949, section A, fig. 8, p. 629) near the Pigeon River not far northeast of the Great Smoky Mountains demonstrates that the sequence can be divided lithologically into more units than recognized by Keith, and that its thickness is in the order of 15,000 or 20,000 feet.

In the foothills northwest and north of the Great Smoky Mountains the order of succession is less evident because the rocks are broken into thrust slices and more disturbed by minor folds and faults (fig. 1, p. 7). Nevertheless, units similar to those of Ferguson can be recognized. Detailed work on them, which is still in progress, is indicating at least the broader nature of the sequence. The Table 3 summarizes the section as now known.[1]

Greenbrier fault

The Greenbrier fault, like the Great Smoky, is a major line of discontinuity, and separates the Ocoee series of the foothill area from the Ocoee series of the mountain area. As it is newly discovered and only partly mapped, its full extent is unknown. It has been identified in the Great Smoky Mountains at numerous places for a distance of 45 miles along the strike (map B). Sinuosities in the trace of the fault bring it to the surface for a distance of 11 miles across the strike, and the actual transport of rocks above it was certainly greater.

At many places along the mountain front, rocks of the mountain sequence appear to lie conformably on the foothill sequence. Keith, in his mapping of the Knoxville (1895) and Mount Guyot (unpublished) quadrangles believed that the one stratigraphically succeeded the other, and he therefore concluded that the mountain sequence was equivalent to the Chilhowee group which elsewhere lies in normal order on the foothill sequence (fig. 1, p. 7). Detailed mapping of the contact by the present party demonstrates that at many localities (as on Greenbrier Pinnacle) it strongly truncates the

1.In the descriptions and tables which follow, the terms “metasiltstone”, “metasandstone”, and “metagraywacke” are applied to clastic rocks of the Ocoee series because they have been recrystallized, and exhibit metamorphic fabrics in thin-section. As will be seen at several of the exposures to be visited, bedding structures have survived this recrystallization, as has relative coarseness of grain, but grain outlines are preserved only in the coarser sandstones and conglomerates. (See “Effects of metamorphism”, pp. 24, 28).

Table 3. Sequence in the foothill area, northwest and north of the Great Smoky Mountains.
(By P.B. King and J.B. Hadley)

Pre-Cambrian?

Late pre-Cambrian?

Ocoee series

Shale and slate, with sandstone and conglomerate lenses and some limestone (Sandsuck shale, Wilhite and Hiwassee slates, and Citico conglomerate of Keith, 1895, 1904): Crops out in northwest part of foothill belt, north of Tuckaleechee and Wear Coves, and of Dunn Creek fault (map B). Thickness unknown because of complex structure, but at least several thousand feet. Well be crossed by excursion between Miller and Tuckaleechee Coves. Includes following rock types:

Shale, mostly greenish, argillaceous, thinly laminated, strongly cleaved; some silty shale, and some shale thinly banded by iron-bearing carbonate.

Conglomerate in units a few feet to more than 500 feet thick, apparently lenticular and lying at different horizons. Units show considerable variety, some being made up wholly of rounded quartz pebbles, others being a rubble of slate, limestone, sandstone, and quartz fragments.

Sandstone, in part interbedded with conglomerate, in part non-conglomeratic. Mostly arkose or graywacke but including some units (possibly high in sequence) of clean white quartzite.

Limestone in rare, discontinuous beds up to 100 feet thick, partly compact, dark gray, and thin-bedded, partly sandy: some intraformational limestone conglomerate.

Metasiltstone (Pigeon slate and upper part of Snowbird formation of Keith, 1895, 1904; Pigeon siltstone of King, 1949): Crops out mainly in central part of foothill belt, as between Dunn Creek and Gatlinburg faults north of Gatlinburg. Thickness near Gatlinburg, more than 5, 000 feet. Exhibits following phases:

The main body, from Gatlinburg eastward, a well-indurated blue-green metasiltstone in very massive outcrops but with thin regular laminations; generally without any other rocks interbedded, but in place containing thin sandstone and slate layers. Contains chlorite as a metamorphic mineral and in most places shows moderate cleavage. A characteristic outcrop will be seen at locality F (pp. 40-41).

Siltstone, containing dark-pigmented laminae, alternating with light-gray, iron-carbonate bearing laminae. At east end of Great Smoky Mountains lies stratigraphically above main body of siltstones described above, and may have similar position elsewhere.

West of Gatlinburg, a much more phyllitic and foliated rock, showing greater physical effects of metamorphism than farther east, although of no higher rank mineralogically. Difference in metamorphism results at least in part from increase in argillaceous content and decrease in silt content westward. A characteristic outcrop will be seen at locality C (p. 38 and fig. 7, p. 19).

Metasandstone, with interbedded phyllite and metasiltstone (lower part of Snowbird formation of Keith, 1904): Crops out in southeast part of foothill belt, as between Gatlinburg and Greenbrier faults near Gatlinburg. Thickness, about 7,000 feet. Exhibits contrasting phases from place to place, not certainly of same age, but in about same stratigraphic position:

Near Gatlinburg, fine-grained metasandstone, without coarse beds, containing a high proportion of plagioclase (lime-soda) feldspar, interbedded with metasiltstone and phyllite. Base not exposed. A characteristic outcrop of metasandstone will be seen at locality G (page 42).

In Cataloochee anticlinorium to east, similar rocks contain many interbedded layers of massive, coarse, arkosic metasandstone, with grains and pebbles of quartz and potash feldspar. Apparently have a source different from rest of unit, perhaps from east. Lies unconformably on early pre-Cambrian granite. Same as arkose of Brushy Mountain of Ferguson (Ferguson and Jewell, 1951, p. 16).

Near Cades Cove, the medial phyllitic metasiltstones are underlain by coarse sandstone, conglomerate, and graywacke, with interbedded black argillite. Base not exposed.

Unconformity

Pre-Cambrian

Early pre-Cambrian

Granite (Max Patch and Cranberry granites of Keith, 1904): Come to surface in two narrow fault slices in Cataloochee anticlinorium at east end of Great Smoky Mountains, but expand in area northeastward. Granites have been transformed to unakit (with pink potash feldspar, green saussuritized plagioclase feldspar, blue or gray quartz, and much epidote), and subsequently cataclastically metamorphosed to mylonite, especially near thrust faults.

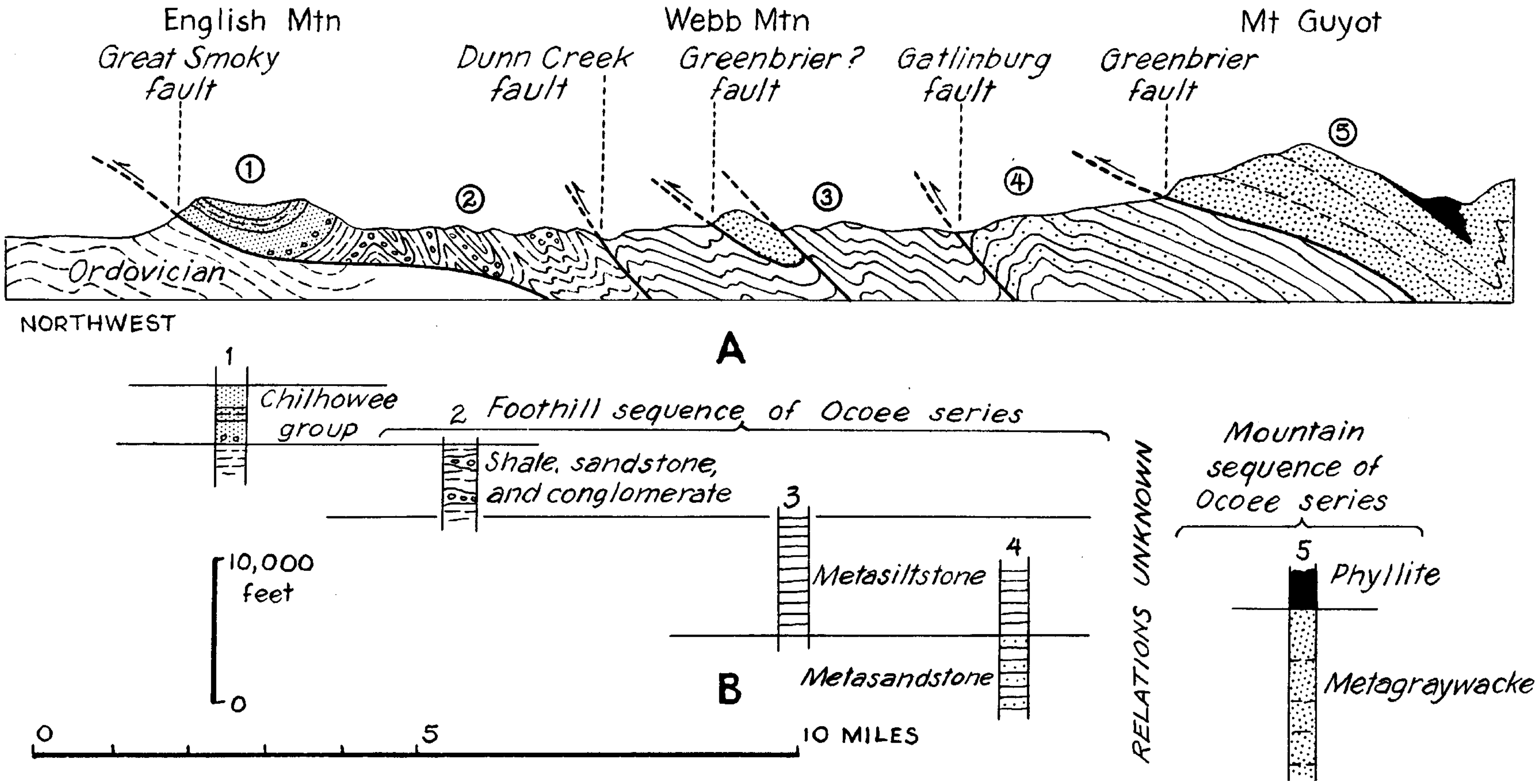

Figure 1. Sections of foothill area in northeast part of Great Smoky Mountains, showing how successively older units of foothill sequence of Ocoee series are brought up in thrust blocks to southeast, and structural relations of foothill sequence to Chilhowee group and to mountain sequence. A- Structure section. B- Stratigraphic sections. Sections based mostly on reconnaissance work, but representation accords with better known structural and stratigraphic features farther west.

structures of the overlying mountain rocks, and over wider areas cuts off great thicknesses of both mountain and foothill sequences. The contact is tectonic and not stratigraphic.

Unlike the Great Smoky fault the actual surface on which the Greenbrier fault has moved has not been seen, perhaps because the Greenbrier is a much older feature and has suffered many more vicissitudes than the Great Smoky. It is older than at least the greater part of the regional metamorphism, for where it is offset southward around the Cataloochee anticlinorium the metamorphic isograds trend northeastward across it without displacement, the faulted rocks on the north being in the biotite zone, and those on the south in the garnet and higher zones. As indicated below, it is deformed by all older structural features with which it is associated. The Greenbrier fault is, in fact, probably the oldest major structural feature in the Great Smoky Mountains. Its emplacement was separated by many deformational events from development of the post-Mississippian Great Smoky fault and related features, but it has not been determined whether all these events were part of a single orogeny, or whether some of them, including emplacement of the Greenbrier fault, took place during an earlier orogeny of Paleozoic time.

Gatlinburg fault system

Among the structures associated with the Greenbrier fault is a great system of high-angle faults which extends along the north edge of the Great Smoky Mountains for their entire length (map B). Component faults characteristically pursue nearly straight courses, and are expressed topographically by trench-like valleys, and aligned notches on successive ridges. One of the principal faults of the system, the Gatlinburg, is well exposed at several places in the town of Gatlinburg, and is a thrust that dips steeply southeast, with a crush zone 100 feet or more wide (fig. 2, p. 9). The fault zone is most complex not far west of Gatlinburg, where the rocks are split into a mosaic of blocks, and various faults branch southward and northward. One of the branches, the Oconaluftee fault, extends east-southeast nearly across the mountains and has a strike-slip displacement of a mile or more.

This fault system dismembers the Greenbrier fault and the sheet of overriding rocks above it. At Fighting Creek Gap west of Gatlinburg (locality E, p. xx, and fig. 9, p. 22), the Greenbrier fault is cut off by the Gatlinburg fault, and its trace is off set 5 mils northwestward, from the face of Mount Le Conte to the face of Cove Mountain. Farther west, near Cades Cove, the Greenbrier fault apparently reappears south of the Gatlinburg fault system.[1]

On the east side of Wear Cove another less extensive fault system branches upward from the Great Smoky fault at the edge of the window, and breaks the forward edge of the overriding rocks above the Greenbrier fault into a series of slices (map B). The evident genetic relation between this less extensive fault system and the Great Smoky fault suggests that the larger Gatlinburg fault system farther south had the same origin, and was formed during emplacement of the Great Smoky fault.

Cataloochee Anticlinorium

Another structure associated with the Greenbrier fault is the Cataloochee anticlinorium, which extends into the eastern part of the Great Smoky Mountains, and brings rocks of the foothill sequence to the surface much farther southeast than in the main part of the mountains (map B). The anticlinorium consists of a number of southwest-plunging folds which raise granitic basement rocks along their crests, and which are broken on their northwest flanks by thrust faults. Near the faults the granitic rocks have been converted to mylonite by cataclastic metamorphism--a form of metamorphism not seen elsewhere in the Great Smoky Mountains and perhaps induced by the relatively greater rigidity of the basement than of the sedimentary rocks which occur elsewhere. Similar mylonitized granite has been described by Oriel (1950, pp. 33-35) in the Hot Springs district not far to the northeast, probably along the same lines of faulting.

The Greenbrier fault is older than the Cataloochee anticlinorium and was folded by it--the fault trace pursues a sigmoid curve around the southwest-plunging end of the anticlinorium; the fault dips steeply to the to the northwest on the northwest flank of the anticlinorium; and the fault is broken by some of the same later faults which bring up basement rocks farther northeast.

The Cataloochee anticlinorium is a feature of regional significance, and is the southwest end of the Blue Ridge anticlinorium--or of its principal branch. The Blue Ridge anticlinorium extends far northeastward, and through much of its course in North Carolina and Virginia, exposes basement rocks along its crest. (On map A, its approximate course is indicated by the band of unit 7 which extends northeast fro the Great Smoky Mountains). Southwestward as far as the edge of the Coastal Plain in Alabama basement rocks reappear no more, at least in this strike belt, but are covered by great masses of partly altered sediments, comprising the Ocoee and related series.

Rocks of Mountain Area

The main area of the Great Smoky Mountains is formed by that part of the Ocoee series which overlies the Greenbrier fault, and comprises the units shown in Table 4.

1.The fault pattern west of the 83° 37′ 30″ meridian has been given three different interpretations by as many members of the field party. Pending final field review it has been necessary to adopt one of these interpretations in compiling the accompanying geologic map (map B).

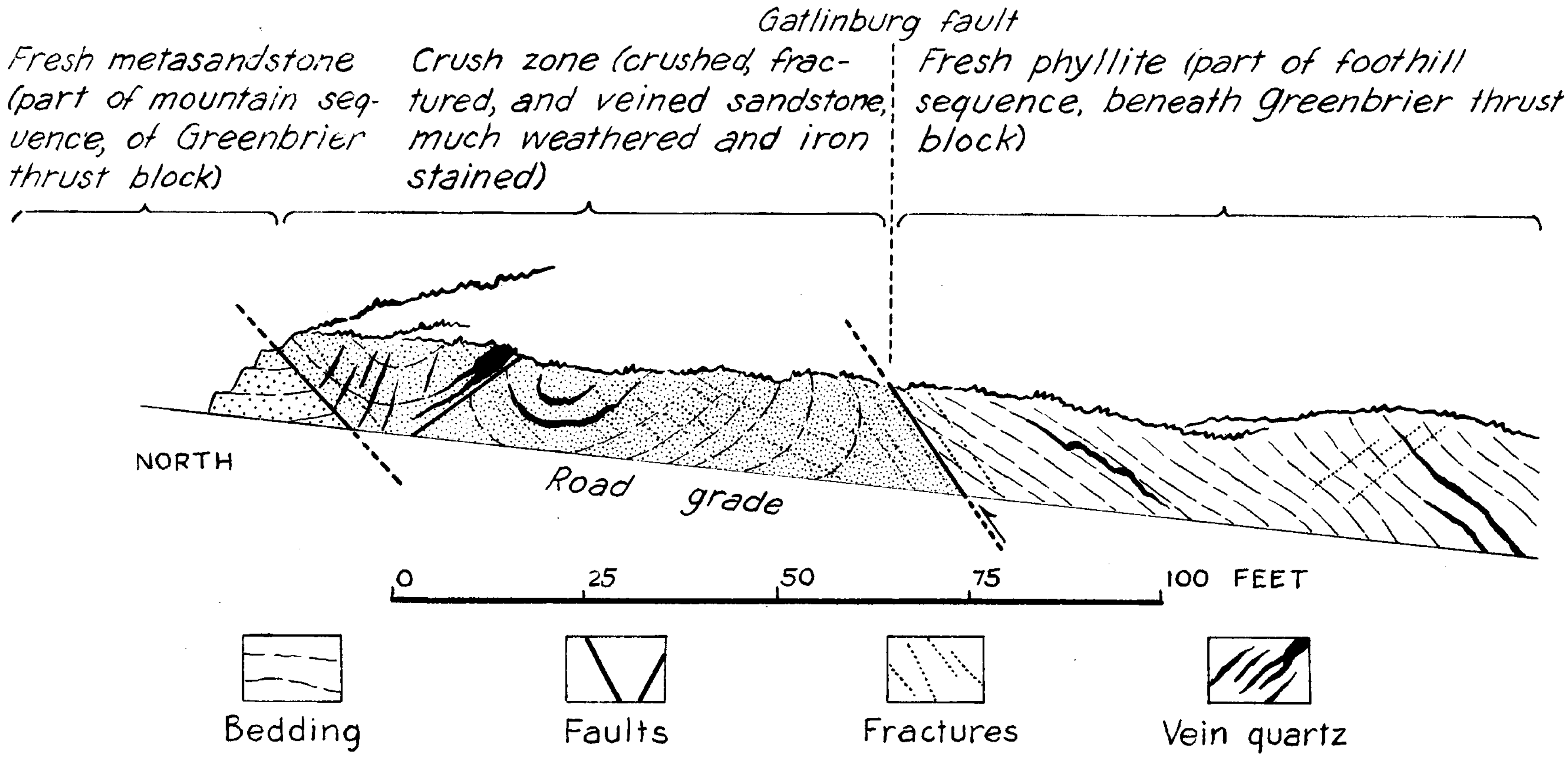

Figure 2. Outcrop of Gatlinburg fault in town of Gatlinburg. Cut on Roaring Fork Road, half a block north of Mountain View Hotel. Note wide crush zone between fresh phyllite and metasandstone of hanging and foot walls. By P. B. King.

Table 4. Sequence in the mountain area, or Great Smoky Mountains proper.
(By J.B. Hadley)

Pre-Cambrian?

Ocoee series

Carbonaceous phyllite, metasiltstone, and metagraywacke
(Hazel and Nantahala slates of Keith, 1895, 1907a): Crops out in a broad synclinorium near crest of range from Mount Guyot to Newfound Gap, forming jagged ridges and very steep slopes, as at The Chimneys (fig. 10A, p. 23) and Aluma Cave. No overlying beds present; maximum thickness about 2,000 feet, but figure uncertain because of intense folding and faulting. Typical outcrops will be seen at localities I and J (p. 46). Includes the following rock types:

Dominant rock is dark carbonaceous and pyritic metasiltstone and phyllite; silty beds well laminated.

Abundant interbedded layers of varied thickness, of fine to coarse metagraywacke like underlying unit. Apparently wedge in and thicken to north and east, so that at northeast end of mountains lower part of unit is indistinguishable from unit beneath.

Thin beds of dark gray siliceous dolomite, which are interbedded in phyllite of parts of area. One will be seen at locality I (p. 46).

Thick-bedded metagraywacke, in part conglomeratic, with slate or schist partings and interbeds (Thunderhead, Clingman, and Great Smoky conglomerates of Keith, 1895, 1904, 1907a): Thickest and most extensive unit of mountain area; forms most of north face of Great Smoky Mountains and wide areas farther southeast. Thickness near Mount Le Conte about 6,000 feet (fig. 9 B, p. 22), but greater elsewhere by intergradation with overlying and underlying units; in northeast part of mountains is 8,000 or 10,000 feet thick. Comprises following rock types (for terminology see King, 1949, pp. 641-643; for petrography compare Moneymaker, 1938).

Characteristic rock is coarse metagraywacke in massive beds a few feet to 50 feet or more thick, showing graded bedding (fig. 10 B, p. 23). Lower part of many beds is conglomerate, made up of white and blue quartz and white potash feldspar (orthoclase or microcline) pebbles less than half an inch in diameter. Main part of typical bed is coarse feldspathic metasandstone grading upward to finer metasandstone and terminating in dark gray slate. Many beds contain slate fragments of intraformational origin. Typical outcrops will be seen at locality H (p. 44 and fig. 10 B, p. 23).

Gray slate, phyllite, or schist, interbedded with relatively fine-grained feldspathic metasandstone in units a few tens of feet to several hundred feet thick, increasing in number and thickness to south and west.

In extreme east part of Great Smoky Mountains, as near Big Creek, upper part contains beds up to 50 feet thick composed of well-rounded pebbles and cobbles of granite and quartzite as much as 3 feet in diameter.

Fine metagraywacke with interbedded slate and phyllite (Not recognized as such by Keith; his Cades conglomerate of 1895, supposedly in this stratigraphic position, is not a valid unit. Lowest part of Ocoee series of Rodgers, 1952): In many places coarse metagraywacke lies directly on Greenbrier fault, but in some areas older beds intervene, as on north face of mountains between Greenbrier Pinnacle and Mount Le Conte, on Cove Mountain, and near Elkmont. Maximum thickness exposed, 3, 000 or 4,000 feet. Consists of fine-grained metagraywacke, largely without coarse beds, and interbedded dark sandy slate. Grades into and interfingers with suceeding unit.

Sequence broken; Greenbrier fault at base.

Relations between units of the Ocoee series in the mountains and the foothills are uncertain. There is little basis for assigning the sequence in the mountain area to any part of the geologic column; neither its base nor its top has been established, the base being cut off by the Greenbrier fault and the top forming the highest rocks of the mountains. Farther south, the Ocoee series of the mountain area adjoins other rocks in the Murphy marble belt (map B), but their relations to the Ocoee have been diversely interpreted, as set for the below (pp. xx-xx). One possibility is that the rocks of the Murphy marble belt overlie the Ocoee series, the Murphy marble itself being an approximate equivalent of the Lower Cambrian Shady dolomite farther northwest.

If such a relation could be proved, it would place the Ocoee series of the mountain area in stratigraphic sequence beneath Lower Cambrian rocks in the same manner as the series in the foothills. The two sequences would then be of about the same age, and the contrasts between them would have resulted from deposition in unlike realms of sedimentation, either in separate basins or on opposite sides of the same basin, that were originally far apart geographically.

Structurally the rocks of the mountain area show increasing complexity southeastward. One the north face of the mountains, immediately above the Greenbrier fault, they dip southeastward at moderate angles (fig. 1 A, p. 7, fig. 9 B, p. 22), toward a broad synclinorium whose trough lies near the crest of the mountains between Newfound Gap and Mount Guyot. On the southeast slope of the mountains, beyond the synclinorium, a broad belt of isoclinally folded, steeply dipping metagraywackes, mica schists, and conglomerates extends to the granitic gneiss along Raven Fork.

Rocks Intrusive Into Ocoee Series of Mountain Area

In the northwest part of the Great Smoky Mountains, no intrusive rocks are present, but in the mountain area to the southeast several kinds of rocks invade the metasedimentary rocks of the Ocoee series.

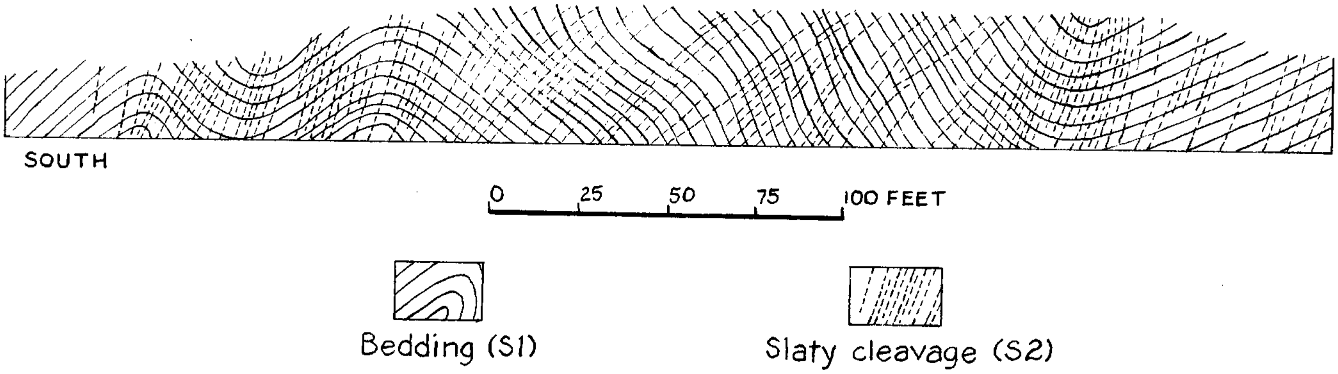

Figure 3. Section showing slaty cleavage, developed parallel to axial planes of folds in laminated metasiltstone of foothill sequence. Part of outcrop at Cove Creek Cascades, on Sevierville – Wear Cove road, 7 miles northwest of Gatlinburg. Metamorphic structure is characteristic of middle part of foothill belt. ByP. B. King.

Among the earliest of the intrusives are metadiorite and metadiabase, forming sills of small individual extent, which occur throughout the length of the mountains. One prominent group extends northeast from Fontanta Reservoir to the neighborhood of Clingmans Dome (map B). One sill north of the dome is 400 feet thick, but the rest are mostly thinner Near Fontana Reservoir they are associated with copper deposits (chalcopyrite-pyrrhotite) which have been worked at the Hazel Creek and Fontana mines (Espenshade, 1944). Another group of intrusives, whose individual bodies are too small to be shown on the geologic map, extends from Mount Le Conte eastward to the end of the mountains, and lies near the Greenbrier fault, invading rocks both above and below it. The metadiorite and metadiabase sills follow southeast-dipping foliation and bedding, but the smaller bodies are themselves considerably altered and foliated. They were intruded during some intermediate stage in the tectonic development of the region, after the emplacement of the Greenbrier fault and before the last period of deformation.

Younger granitic gneisses form much larger bodies. As shown on the geologic map (map B), two bodies occur in the southeast part of the Great Smoky Mountains, one near Raven Fork and Cherokee (locality L, p. 47), and another near Dellwood; a third occurs at Bryson City (Cameron, pp. 10-12). The Raven Fork and Dellwood bodies converge southwestward and join south of the area mapped, forming a great Y-shaped mass that wraps around the southwest-plunging end of the Cataloochee anticlinorium (map A). The bodies are more concordant than discordant with the structures of the metasedimentary rocks in which they lie.

Internally, the bodies are extremely heterogeneous in structure and composition, and contain many xenoliths or enclaves of country rock. The gneisses appear to be products of metamorphic rather than igneous processes; they are tectrusive (Hadley, 1951) in that they achieved their present shapes, positions, and internal structures largely in a solid state under the influence of tectonic forces during a period of major orogeny. The structure of the bodies is closely related to the younger metamorphic structures of the country rock, and they were probably emplaced during one of the later, rather than the earlier orogenies of Paleozoic time.

Associated with the granitic gneisses are pegmatites, the most prominent of which lie on the periphery of the Bryson City body (Cameron, 1951, pp. 22-43). A few small, isolated bodies of meta-peridotite have been found in the rocks of the mountain sequence, and as inclusions in the granitic gneiss. They are probably the oldest rocks intruded into the Ocoee series.

Effects of Metamorphism

Most of the rocks of the Great Smoky Mountains show the effects of regional metamorphism, which increases in intensity southeastward. The Paleozoic rocks of the TennesseeValley are much deformed, but show little slaty cleavage or effects of elevated temperature; bedding fissility is widely preserved. Similar conditions exist in the northwesternmost part of the foothill belt, but here a kind of coarse cleavage commonly transects bedding fissility of shales, siltstones, and argillaceous sandstones (fig. 3, p. 11). Slaty cleavage gradually replaces the coarse cleavage in the finer-grained rocks farther southeast in the foothill belt, where mineral assemblages characteristic of the muscovite-chlorite facies are widespread.

Beginning approximately at the north boundary of the Park, in the vicinity of Gatlinburg, biotite makes its first appearance, but in a zone about two miles wide to the south it occurs only sporadically in the dominantly chloritic metasandstone and metasiltstone of the foothill sequence. Not far north of the Greenbrier fault chloritic rocks give place to rocks in which muscovite and biotite are the characteristic micas. At some places this change is rather abrupt, because of juxtaposition along the fault of dominantly sodic rocks of the foothill belt against more potassic rocks of the mountain belt. Chloritoid occurs in places in muscovitic

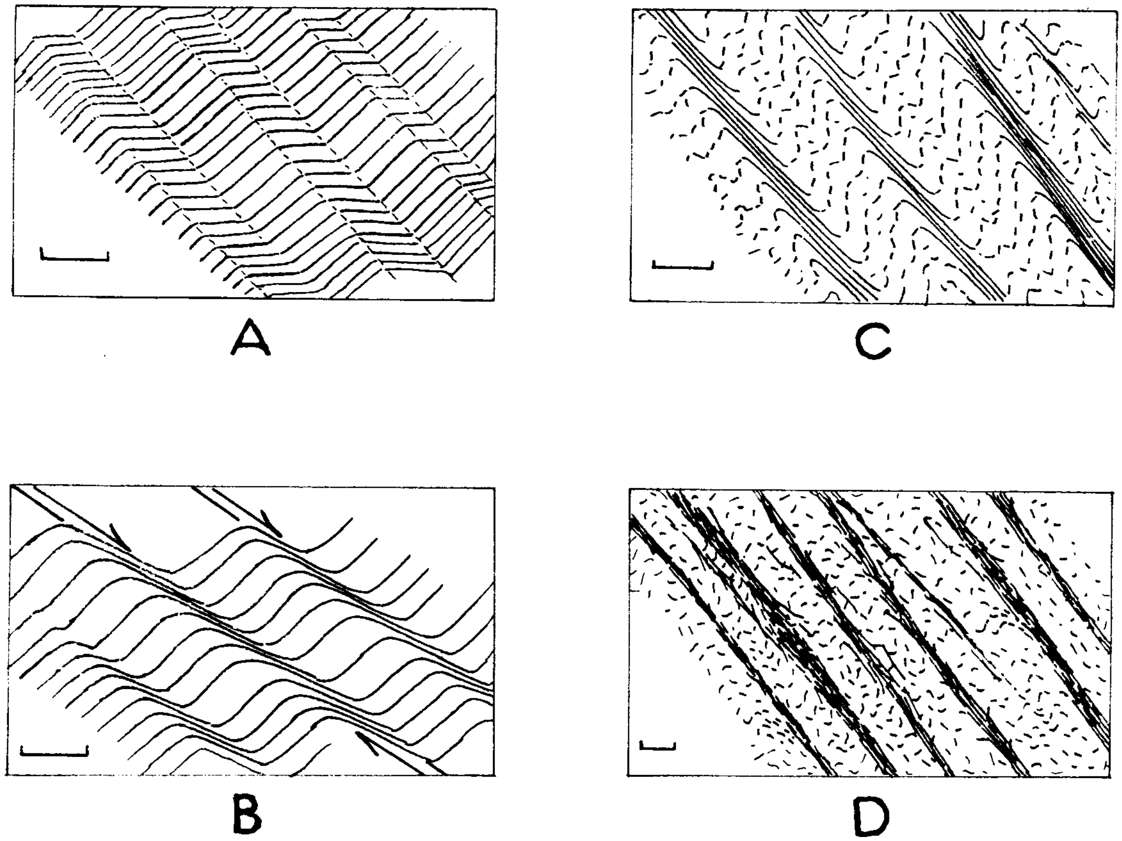

Figure 4. Sketches, based on thin sections, showing development of fracture cleavage, slip cleavage, and schistosity from slates and phyllites during a second deformation. Br represents one millimeter. A – *Slaty cleavage*, somewhat crenulated. *Fracture cleavage* planes, caused by discontinuity of mica fabric, have formed at crests and troughs of minute folds. Spacing of slaty cleavage planes diagrammatic. B – Slaty cleavage more sharply folded. Mica is concentrated in one set of limbs and nonmicaceous material has moved into other set. New continuity of mica in micaceous limbs results in *slip cleavage*. C – Under continued shearing, micas in quartzofeldspathic laminae are rolled, broken, and reduced in size and abundance, although remnants of the older mica fabric persist. D – *Schistosity* of medium to coarse-grained schist. Note prominent segregation laminae, almost complete disappearance of older mica fabric, and coarsening of grain in both micaceous and quartzofeldspathic laminae. By J. B. Hadley.

phyllite along the southern margin of the foothill belt, and again in a prominent zone of chloritoid-bearing metasiltstone in the upper part of the mountain sequence extending eastward from Mount Le Conte.

Almandine garnet, associated with porphyroblasts of biotite and very minor amounts of kyanite, appears in the dark phyllite and metasiltstone of the upper part of the mountain sequence just north of the crest of the range, thus establishing conditions of middle-grade metamorphic intensity. About 3 miles southeast of the crest, both kyanite and staurolite become noticeable in garnet-mica schists of the finer grained parts of the mountain sequence (locality K, p. 46). Interbedded with these schists, or within beds of metagraywacke, local layers and lenses of calcareous sandstone have been transformed into *pseudodiorite*, containing conspicuous garnet and hornblende porphyroblasts, like the rocks described by Keith (1913) and Emmons and Laney (1926, pp. 19-21).

Metamorphic isograds delimiting the biotite, almandine garnet, and kyanite-staurolite zones trend northeast, in general parallel to the main structural trend of the Great Smoky Mountains. In the vicinity of the Cataloochee anticlinoriu the isograds cross the reentrant curve of the Greenbrier fault, so that rocks of the foothill sequence, which occur elsewhere only in areas of low-grade metamorphism, here contain biotite and garnet, denoting middle-grade conditions. No close relation has been observed between the isograds and the large bodies of granitic gneiss, which are wholly within the kyanite-staurolite zone. Sillimanite, commonly found near large intrusive bodies elsewhere in the Appalachians, does not appear in the Great Smoky Mountains.

Accompanying these changes in mineral composition are textural and structural changes implying increasing intensity of deformation and recrystallization toward the southeast; Slates pass into phyllites, and these into fine-grained schists with conspicuous porphyroblasts. Metasandstone and conglomerate along the mountain front show effects of strong shearing stress only locally; a mile or two south of the mountain crest, however, quartz grains and pebbles are rather generally flattened, and somewhat farther southeast even the coarsest rocks possess a conspicuous and widespread foliation (locality K, p. 46).

From the mountain crest southeastward, increasing structural complexity of the rocks of the mountain sequence results from a later deformation superimposed on an earlier one. Evidence for this is twofold; (1) Cleavage of slates and phyllites produced during the earlier deformation and metamorphism is generally crinkled, folded, and transected by a new set of slip cleavage planes (fig. 4 B, p. 12); in many places the original attitude of earlier slaty cleavage has been greatly changed (fig. 4 C), in others it has been almost obliterated by new structures (fig. 4 D).

(2) The later slip cleavage, and minor folds associated with it, trend north-northeast across the dominant east-northeast trend of the older folds; at a few places folds of both generations can be seen in the same outcrop, but in most places the younger structures have greatly obscured the pattern of the older.

The younger structures of the Ocoee series of the Great Smoky Mountains are probably contemporaneous with the emplacement of neighboring bodies of granitic gneiss; they were formed *after* the production of slaty cleavage, but *before* the final development of porphyroblasts in the metasedimentary rocks. The younger structures are clearly products of the last major epoch of deformation and metamorphism of the rocks in which they lie. The older structures may represent merely an earlier stage of the same orogenic epoch, or they may have formed during a significantly earlier period of Paleozoic orogeny. This period cannot be as old as pre-Cambrian, as there is no evidence of major disturbance between later pre-Cambrian and Cambrian rocks of the nearby foothill belt.

A younger metamorphic structure somewhat similar to those just described is seen much farther northwest in phyllitic rocks of the foothill sequence. Well-preserved slaty cleavage in these rocks commonly has been deformed by sharp chevron folds and widely space fracture cleavage, an example of which will be seen at locality C (p. 38, fig. 7, p. 19, stage A or fig. 4, p. 12). Such folds and cleavage represent a second generation deformation, possibly produced under less confining pressure than the closely spaced slip cleavage farther southeast. The two features may, however, be of about the same age.

Relation of Ocoee Series to Rocks of Murphy Marble Belt

South of the Great Smoky Mountains the Ocoee series of the mountain area is in contact with rocks of the Murphy marble belt, which crop out in a narrow strip that extends more than 100 miles southwestward through North Carolina into Georgia (map A). The Murphy marble itself crops out through most of the belt, and is bordered on either side by other distinctive units made up of metamorphosed clastic rocks. The present field party has done no detailed field work in the Murphy marble belt. This discussion, and representation of the belt on the geologic map (map B), is based on work by other geologists.

Keith (1907a, p. 6) interpreted the Murphy marble belt as a complex syncline, steeply folded into, and locally faulted against the Ocoee series, with the Murphy marble near the top of the sequence. He suggested that the Murphy was the approximate equivalent of the Lower Cambrian Shady dolomite farther northwest.

Subsequent work has confused rather than clarified this interpretation. Other geologists have believed that the belt is an anticline (Jonas, 1932, p. 240) a window (Stose and Stose, 1944, p. 377) (a window a mile wide and a hundred miles long), a shear zone (Furcron and Teague, 1945, pp. 44-47), a homocline (Van Horn, 1948, pp. 18-20), and a syncline (Stose and Stose, 1949, pp. 286-291). The Murphy marble has been placed at the base of the sequence, near the middle, at the top, and in tectonic discontinuity with the enclosing rocks.

Van Horn, who has done the most detailed recent mapping of the northern part of the Murphy marble belt, bases his homocline interpretation on the attitude of cleavage and plunge of fold axes. While not doubting the reality of these features, we are inclined to question their application to interpretation of larger features in a region whose deformational history has been as complex as this one. Our observations in the southeast part of the Great Smoky Mountains show that younger cleavage and folds have been superimposed on earlier and greater regional structures, and are unreliable for interpretation of earlier structures. Cameron (1951, pp. 13-16) finds that both earlier structures and superimposed later structures are present in the Bryson City area, not far from the Murphy marble belt. Unpublished reconnaissance mapping of the Fontana reservoir area by Fox (1947) indicates that northeast of the area mapped by Van Horn the Murphy marble belt becomes an open syncline, plunging southwest, with low undulating dips toward the axis from either flank.

Although conclusions are hazardous in view of the complexity of the area and the diverse opinions that have been expressed, we believe that Keith's original interpretation of the Murphy marble belt still has much to recommend it.

Relation of Ocoee Series to Gneiss Complex

Southeast of the Great Smoky Mountains the Ocoee series of the mountain area is in contact with a metamorphic and plutonic complex that occupies a wide expanse in western North Carolina (Keith, 1904, 1907a, 1907b). The dominant component is quartz--feldspar--mica gneiss, the Carolina gneiss, which is interbedded with thinner layers and stringers of hornblende gneiss, the Roan gneiss (for summary of a recent study, see Heinrich, 1951). Embedded in the gneisses are concordant granitic plutons of all sizes, small bodies of ultramafic rocks (Pratt and Lewis, 1905; Hunter, 1941, pp. 20-38; Murdock and Hunter, 1946, pp. 7-8), and innumerable pegmatites (Olson and others, 1946). Keith interpreted the whole complex as of early pre-Cambrian ("Archean") age, and as part of the basement on which the Ocoee and younger series were deposited.

Other geologists have been unable to recognize the marked differentiation between the gneiss complex and the Ocoee series that is implied by this classification. La Forge and Phalen (1913, pp. 4-5), while retaining Keith's classification, pointed out that over wide areas in northern Georgia there is little or no difference in character between the Ocoee series, and that the contact between them may be place only on theoretical grounds. The same conclusion has been reached by later geologists.

The present field party has not yet studied critically the boundary between the Ocoee series and the gneisses to the southeast, but reconnaissance traverses across it suggest that there is no sharp contact and no unconformity between the two series. It is true that in some areas southeast of the boundary, especially where granite and pegmatite are abundant, the gneisses are thoroughly metamorphosed, partly granitized, and with original characters largely obliterated. In intervening areas, however, probably farther from centers of hydrothermal and metasomatic activity, the so-called gneisses are merely altered clastic sedimentary rocks such as metagraywackes and schists, essentially similar to those in the mountain sequence of the Ocoee series in the Great Smoky Mountains. Their layering represents original interbedding of diverse sedimentary rocks, and is not a true gneissic structure.

We therefore believe that a large part of the rocks of the gneiss complex in the immediate vicinity of the Great Smoky Mountains is the heavily and variably metamporphosed equivalent of the Ocoee series. If the Ocoee series is pre-Cambrian, the gneisses are likewise pre-Cambrian. The are not, however, of early pre-Cambrian age, but of late pre-Cambrian age; they are no basement, but a part of the sam geosynclinal body as the Ocoee series and Paleozoic rocks farther northwest; like them, they were probably not severely deformed or metamorphosed until the orogenies of Paleozoic time. Their deformation, metamorphism, and metasomatism are thus not attributes of a fundamental complex, but are another manifestation of the same dynamic forces which produced the folding, faulting, and moderate metamorphism in the rocks of the Great Smoky Mountains and Tennessee Valley.

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DESCRIPTION OF LOCALITIES

Locality A (Section of Chilhowee group in Little River gap

The gap cut through Chilhowee Mountain by Little River affords the most accessible outcrops of the Chilhowee group in its type area. A nearly continuous section is exposed along the old route of State Highway 73 on the northeast side of the river (fig. 5, p. 16). The new route on the southwest side (now under construction) shows good outcrops of the uppermost quartzites of the Chilhowee group, and of the Ordovician northwest of the Great Smoky fault, but the remainder of the section is covered by quartzite talus.

The section on the northeast side extends from the Cochran formation below on the northwest, to the Helenmode member of the Hesse sandstone above on the southeast. Component formations are summarized in table 2, pp. 10-11. The following special features deserve notice:

(1) The Nichols shale has been opened in a large quarry face near the middle of the section, and is worked by Blount County for subgrade on county roads. Note lack of cleavage in the shales (in contrast to shales of the Ocoee series to be seen later) and large flakes of detrital (non-metamorphic) mica on bedding surfaces.

(2) The shales and shaly sandstones of the Helenmode member at the southeast end of the section afforded the principal collection of Lower Cambrian fossils made by C.D. Walcot and Cooper Curtice in the Chilhowee Mountain area. Shale 20 feet above the uppermost quartzite yielded *Hyolithus* of. *H. americanus*, *Isoxys chilhoweana*, and *Olenellus* sp. (Walcott, 1890, p. 570). Diligent search by later collectors has failed to bring to light more specimens. The only indications of life which the visitor will see in the rocks of the section are Scolithus tubes in the quartzites beneath the Helenmode member.

(3) The section is, unfortunately, shortened by faulting, and the Murray shale is cut out, although well developed nearby on Chilhowee Mountain. The ridge southwest of the river is offset westward relative to the ridge northeast of the river, as a result of strike-slip movement on a high angle transverse fault which extends through the gap (fig. 5, p. 16). Detailed mapping for the present project by G.D. Swingle indicates that the fault crosses the section on the old route of the highway in the upper quartzites, bringing the Nebo and Hesse in contact. The upper quartzites are cut by numerous east-west trending vertical fractures whose surfaces are marked by nearly horizontal slickensides. The fault has caused confusion in interpretation of the section by geologists who have studied it, as indicated by table 5, page 36.

Locality B (Outcrop of Great Smoky fault at Townsend entrance of Great Smoky Mountains National Park)

Immediately northwest of the entrance to Great Smoky Mountains National Park on State Highway 73, a cut 900 feet long exposes the Great Smoky fault and structures in the overridden rocks, which are part of the Tuckaleechee Cove window (fig. 6, p. 18). The main fault (A of figure 6) is obscurely exposed at the southeast end and rises northwestward into the slope above the cut. The following features deserve notice.

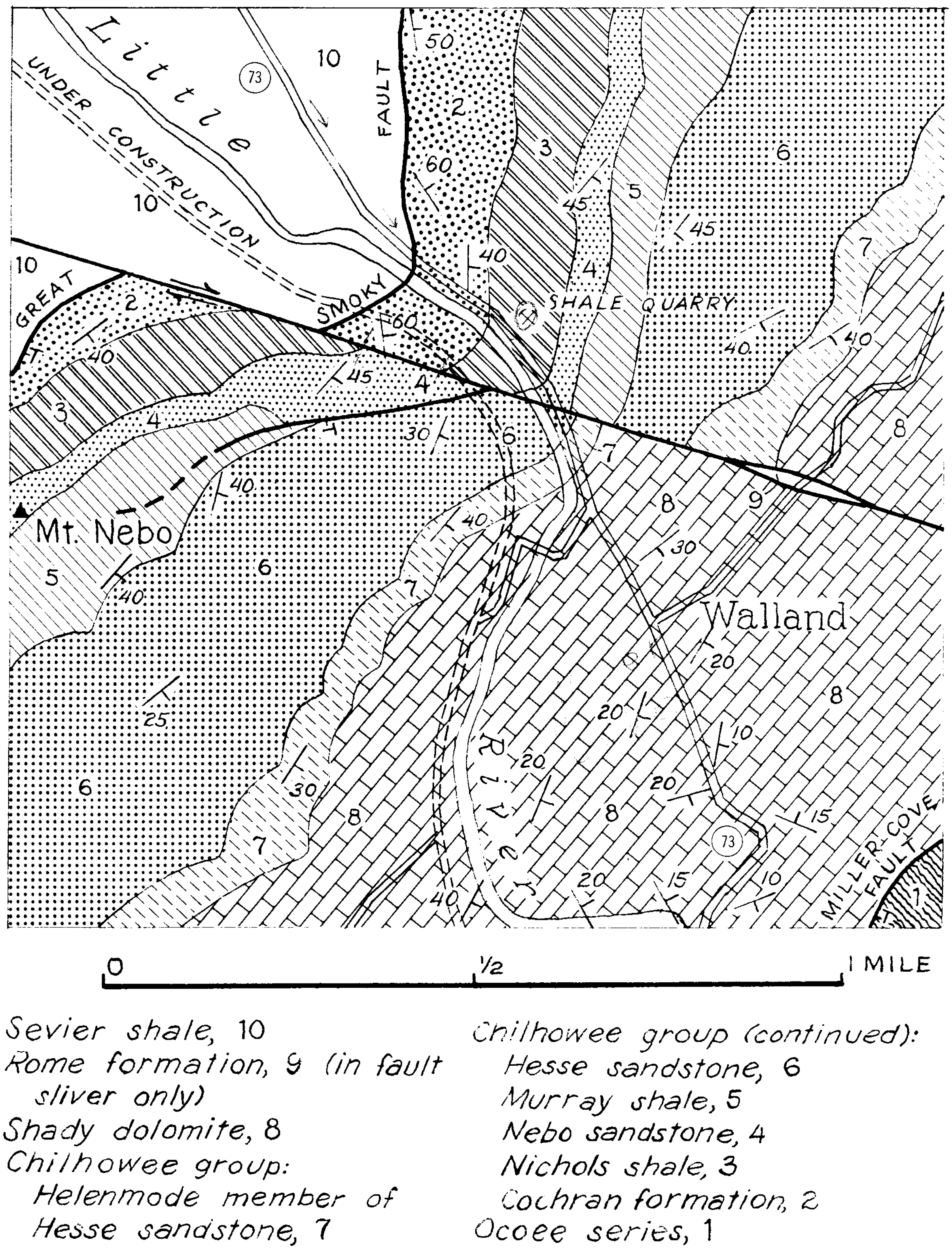


Figure 5. Map of Little River Gap in Chilhowee Mountain (locality A), showing outcrops of Chilhowee group and associated formations. By G.D. Swingle and C.A. Tucker, Jr.

Table 5. Interpretions of geologic section in Little River Ga

Rocks units present:	Interpretation by Keith (1895):	Interpretation by Stose and Stose (1949)	Interpretation by Swingle (1949)
(5) Dolomite to southeast	Knox dolomite	Shady dolomite	Shady dolomite
		Unconformity	
(4) Shale	Murray shale, with fossils	"Transition beds"	Helenmode member of Hesse sandstone
(3) Quartzite, with *Scolithus*, much cut by transverse joints	Nebo sandstone	Hesse quartzite	Main body of Hesse sandstone Fault Nebo sandstone
(2) Shale	Nichols shale	Murray shale	Nichols shale
(3) Feldspathic and conglomeratic quartzite	Cochran conglomerate	Nebo quartzite and Cochran quartzite, with intervening Nichols shale missing	Cochran formation
Fault to northwest	Fault to northwest	"Chilhowee over-thrust" to northwest	Great Smoky fault to northwest

(1) Rocks of the Ocoee series above the Great Smoky fault are chloritic and sericitic sandy phyllite (part of meta-siltstone unit of table 3, pp. 16), whereas the Sevier shale beneath is calcareous shale that has been slickensided and crumpled, but contains no metamorphic minerals. There is thus a "metamorphic unconformity" between the Ocoee and Sevier, indicating that the metamorphism of the Ocoee series took place before its emplacement on the Great Smoky thrust block.

(2) Between the overriding Ocoee phyllite and the Sevier shale is a bed 5 to 25 feet thick of massive blue-gray limestone, much crushed and reconstituted, which is an intermediate slice of the Know group that has been dragged along the sole of the fault. Limestone of the Knox group also occurs in normal stratigraphic order beneath the Sevier shale and Lenoir limestone at the northwest end of the cut.

(3) Exposures high in the cut near its northwest end indicate that bedding in the Sevier shale is disharmonious with that of the Lenoir limestone, although the one lies in normal stratigraphic order on the other. This indicates that the two formations are separated by a surface of movement (line C of fig. 6) which developed during emplacement of the main thrust above.

(4) The overridden Ordovician rocks are cut by a series of normal faults which dip steeply southeast; these also seem to break the Great Smoky fault above, although exposures are too poor to be decisive. One of these faults, which drops Sevier shale against Lenoir limestone, is prominently displayed near the middle of the cut, and has sometimes been mistaken by visitors for the main Great Smoky fault (Wilson, 1935).

Locality C (Outcrops on Laurel Creek showing metamorphic structures in rocks of foothill sequence

Along laurel Creek, on the spur road to Cades Cove, are many fine outcrops of phyllite, belonging to the middle unit of the foothill sequence of the Ocoee series (table 3, p. 16). One outcrop, 1.5 miles from the Y at highway 73, presents an exceptionally good display of superimposed metamorphic structures:

(1) Bedding (S1) is indicated in places by faint, closely spaced, light and dark laminae, but is mostly obliterated by younger structures. It has evidently been much contorted.

(2) Foliation or slatey cleavage (S2) has been produced by parallel orientation of micaceous metamorphic minerals (mostly chlorite and sericite), and has rendered the whole outcrop thinly fissile. Foliation dips about 45 degrees southeast, the bedding in places lying nearly parallel with it, and in others diverging at wide angles.

(3) Lineation appears in places on foliation surfaces, and is expressed by long streaks of dark minerals which extend down the dip.

(4) Chevron folds and fracture cleavage (S3) deform the foliation (fig. 7, p. 19). They are more sporadic than the foliation, being abundant and closely spaced in places, and absent in others. These represent approximately stage A of figure 4 (p. 27), although there may in places be incipient

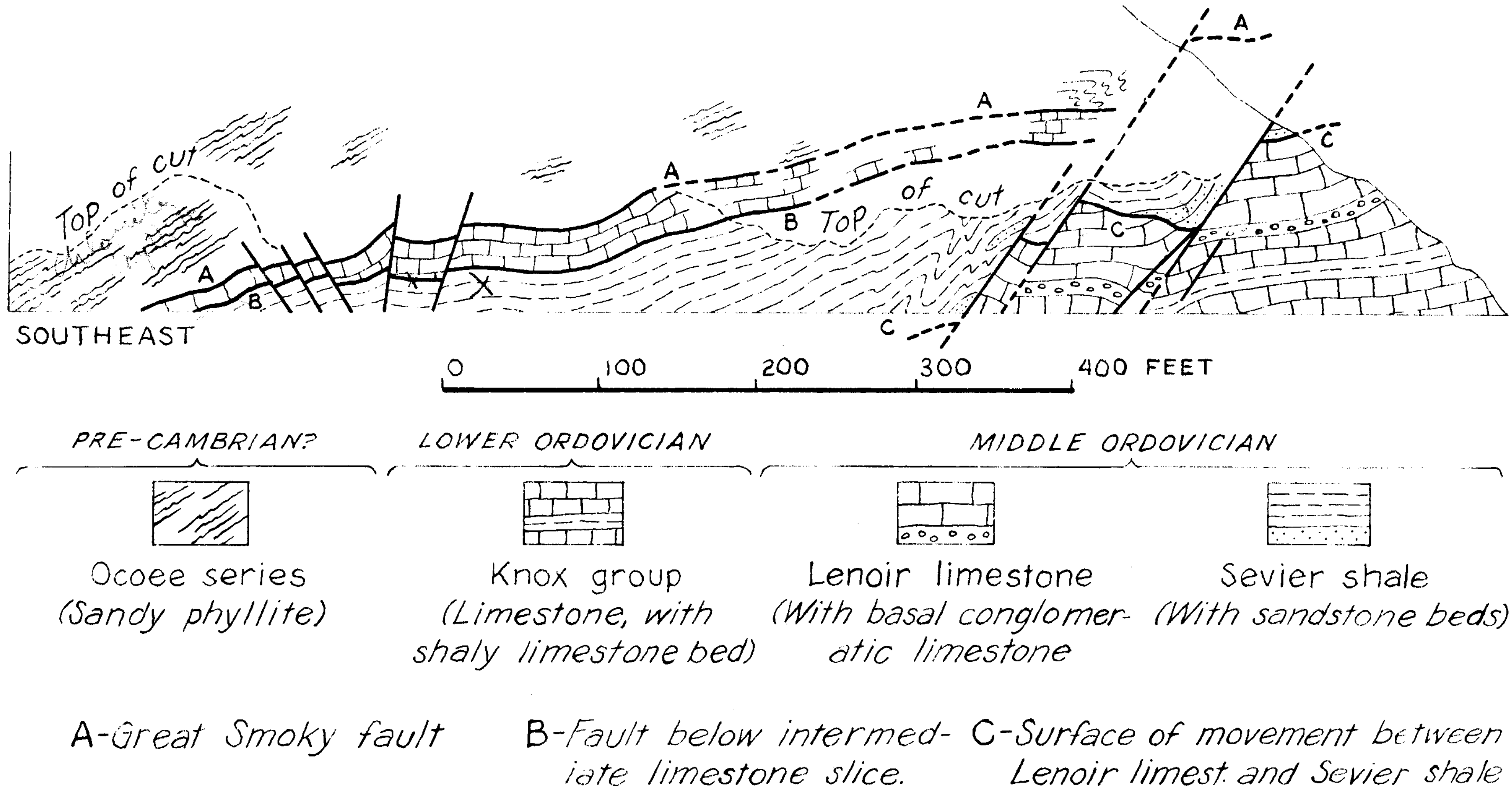


Figure 6. Great Smoky fault and related structures in cut on State Highway 73 at Townsend entrance of Great Smoky Mountains National Park (locality B). By P. B. King, H. W. Ferguson, and R. B. Neuman.

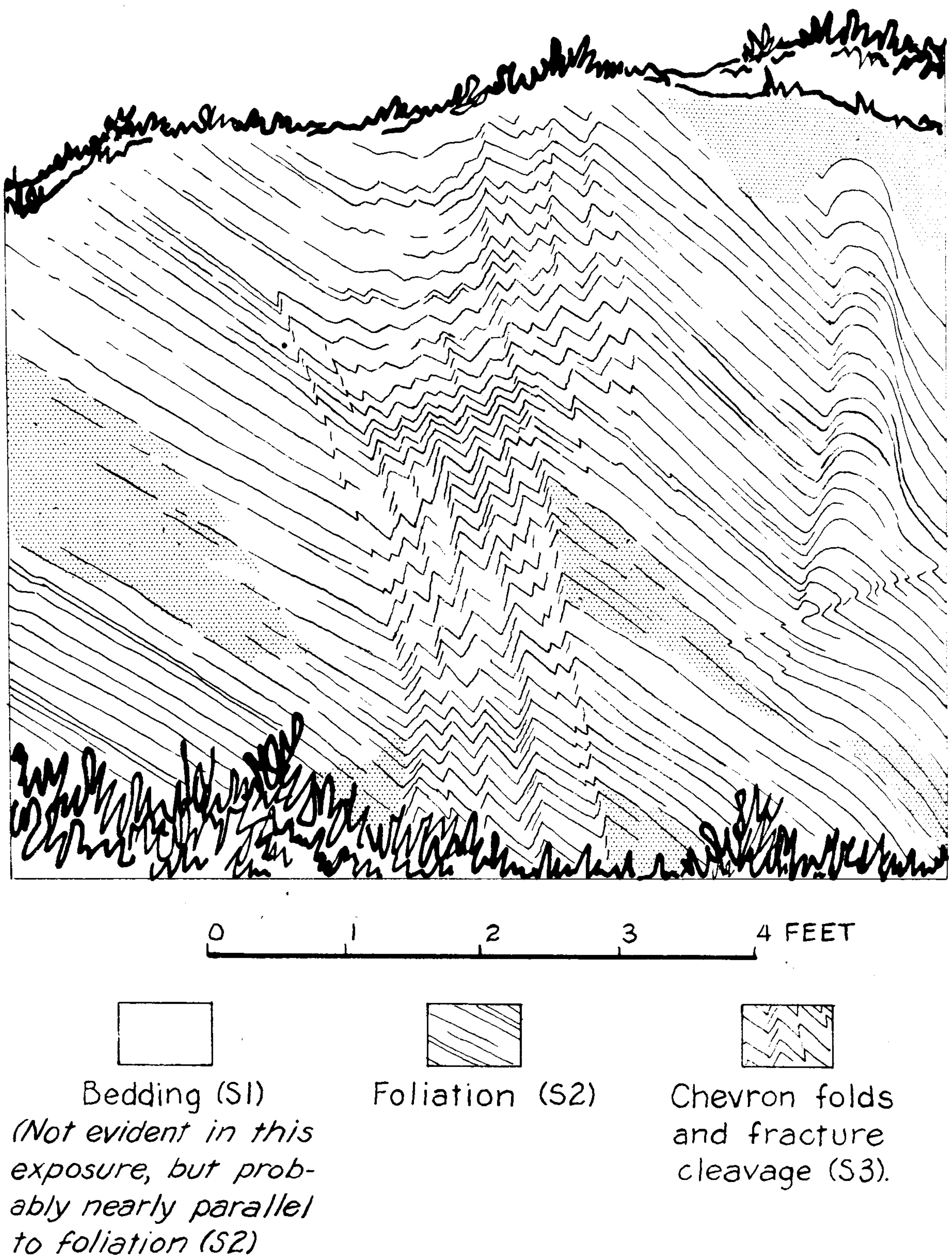


Figure 7. Sketch of part of outcrop on Laurel Creek road, 1 ½ miles from State Highway 73 (locality C), showing chevron folds and fracture cleavage (S3), superimposed on earlier foliation (S2). By P. B. King.

slip cleavage of stage B. Most of these structures dip steeply, but in places the main set is crossed by a minor set which dips at a low angle to the west (one is shown at the extreme right of fig. 7).

The chevron folds and fracture cleavage were formed after the foliation, but how much later is unknown; both sets of structures are believed to be older than the Great Smoky fault, which lies underground at this locality, perhaps no more than a few hundred feet beneath the outcrop.

Locality D (The Sinks)

The Sinks, on State Highway 73 at the Blount-Sevier County line, are so-called because of the rapid drop of Little River at this point, through a series of cascades and whirlpools cut in a rock gorge. They are not a feature of limestone solution, as the name might suggest. The abrupt increase in gradient of the river results from cutting through an old meander neck; an earlier course of the river may be traced around the rocky know immediately southeast of the bridge (fig. 8 A, p. 21).

The rock at The Sinks *is thick-bedded metagraywacke* of the middle part of the mountain sequence of the Ocoee series (table 4, pg. 21-22), which is part of a klippe of the Greenbrier thrust sheet. Bedding dips southeast, but is overturned, as a result of downfolding of rocks of the klippe into overridden rocks of the foothill sequence (fig. 8 A). Overturning is indicated by inverted coarse-fine gradations in the metagraywacke beds, and by poorly developed cleavage in the slate interbeds, which dips southeast at a lower angle than bedding (fig. 8 B).

Locality E (Fighting Creek Gap and Fighting Creek overlook)

This locality affords one of the finest panoramas in the Great Smoky Mountains. Mount Le Conte, which towers above the observer to the east, has an altitude of 6, 593 feet, and is more than a mile higher than the town of Gatlinburg, at 1,292 feet, hidden in the hills to the north (fig. 9 A, p. 22).

The foothill ridges which sweep out northward from the base of the mountains show a striking accordance of levels at an altitude of 2,000 to 2,500 feet, although valleys are cut hundreds of feet below them. They may indicate the former presence of a “valley-floor” erosion surface.

The topographic forms also express bedrock structure. The steep face of Mount Le Conte is formed by rocks of the mountain sequence of the Ocoee series, and the trace of the Greenbrier fault on which they lie is near the base of the slope (fig. 9 B). The lower ridges to the north are carved from less massive rocks of the foothill sequence.

The trace of the Greenbrier fault extends toward Fighting Creek Gap, but is cut off at a point below the overlook by the Gatlinburg fault. Erosion of crushed and fractured rocks along the trench-like course of Fighting Creek to the east. Cove Mountain, north of Fighting Creek, is formed of rocks of the mountain sequence in a part of the Greenbrier thrust block which lies on the downthrown side of the Gatlinburg fault.

Locality F (State Highway 73, one mile east o Gatlinburg)

Beds of the medial *metasiltstone* part of the foothill sequence (table 3, p. 16) are exposed in a long road cut recently excavated on State Highway 73. The eastern part of the cut is mad up of green metasiltstone, which is in part slaty and with thin straight bedding laminae, and in part slightly coarser and cross-bedded on a small scale. To the west, and lower stratigraphically, the rock becomes gradually coarser, and at the western end (beyond a small ravine) are several beds of fine-grained metasandstone. Both metasandstone and metasiltstone are composed principally of quartz, albite, chlorite, and muscovite, with important amounts of epidote and sphene. Beds dip about 20 degrees south-southeast, and are part of the south limb of an anticline two miles broad which plunges at a low angle to the east (map B). The south flank of the anticline, near locality F, is broken by a high-angle thrust fault of the Gatlinburg fault system. Several minor fault surfaces in the cut, trending east-west and dipping steeply south, are probably minor shears related to the main fault; the latter lies in the bottom of the valley of Dudley Creek, just south of the locality.

Slaty cleavage in the finer-grained rocks dips 40 degrees to 50 degrees southeast. Closely related are a system of closely spaced, more steeply dipping strike joints in the sandstone beds. Some of these joints, as well as more irregular fractures in the slaty beds, now contain characteristic segregation veins of quartz, calcite, and chlorite.

Locality G (Sugarland Branch quarry

An aggregate quarry opened by the National Park Service lies on Sugarland Branch a quarter of a mile off U.S. Highway 441 and a mile south of Park Headquarters. It exposes a massive metasandstone bed 120 feet thick, which is part of the lower *metasandstone* unit of the foothill sequence of the Ocoee series (table 3, pp. 16-17).

The metasandstone is typical of this type of rock in the vicinity of Gatlinburg. Although compact and hard, it is not a quartzite in the strict sense, but is more closely related to the graywacke suite. Component grains are very fine (maximum diameter 0.3 mm), and consist of about 60 percent quartz and 40 percent sodic (plagioclase) feldspar. On the quarry face the rock is hard and massive, but because of the high feldspar content it decomposes rapidly on weathering, and affords only discontinuous natural ledges and cliffs. Bedding is indicated by dark laminae, which dip at a low angle to the southeast; some of the layers are cross-bedded. Although the rock shows few mechanical effects of metamorphism, micro-

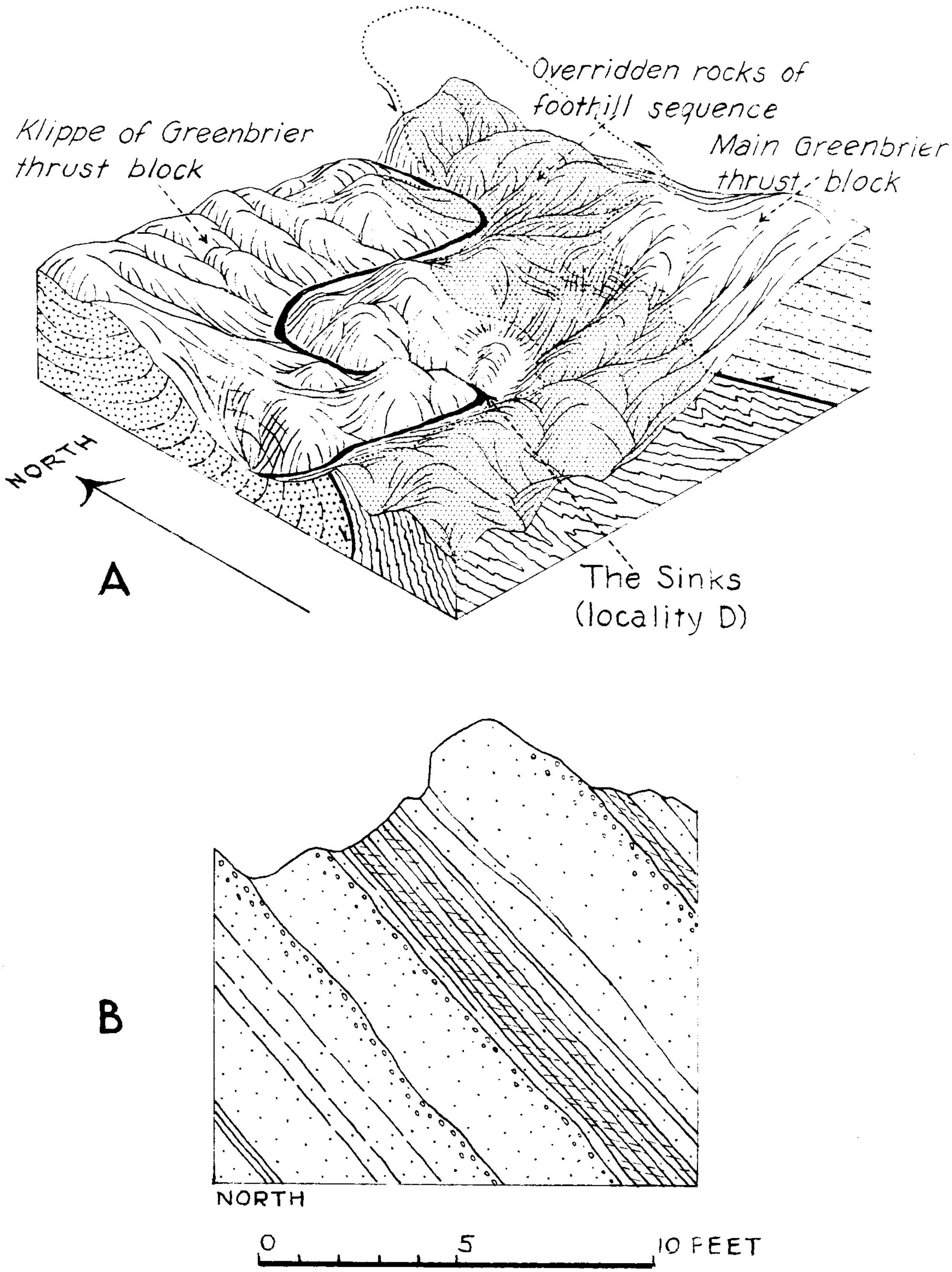


Figure 8. Sketches showing geologic features at The Sinks, on Highway 73 at Blount – Sevier county line (locality D). A – Block diagram, showing distribution of rock formations, and cut off meander neck of Little River.B – Sketch of metagraywacke outcrops at bridge, showing overturned beds, as indicated by graded bedding, and cleavage in slate interbeds. Sketches by P. B.King; geology by H. W. Ferguson.

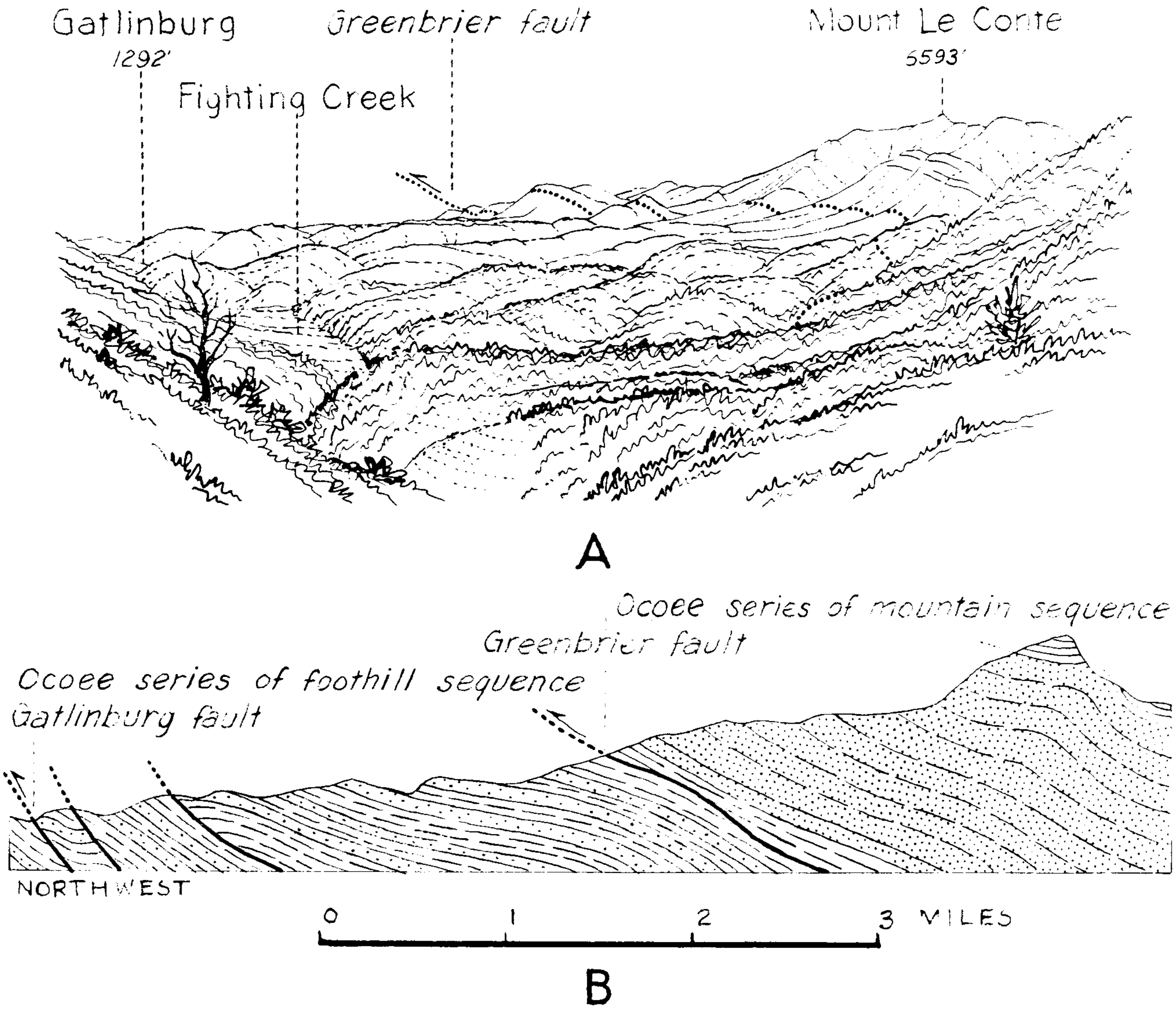


Figure 9. Geologic features visible from Fighting Creek Overlook, on Highway 73, 5 miles west of Gatlinburg (locality E): A – Panorama from Gatlinburg (left) to Mount Le Conte (right), with valley of Fighting Creek in lower left. Note accordance of foothill ridges, suggesting former existence of a "valley-floor" surface. By P. B. King. B – Geologic section from Gatlinburg to Mount Le Conte, approximately along skyline of panorama. By J. B. Hadley.

scopic examination shows that it contains biotite and chlorite as metamorphic minerals.

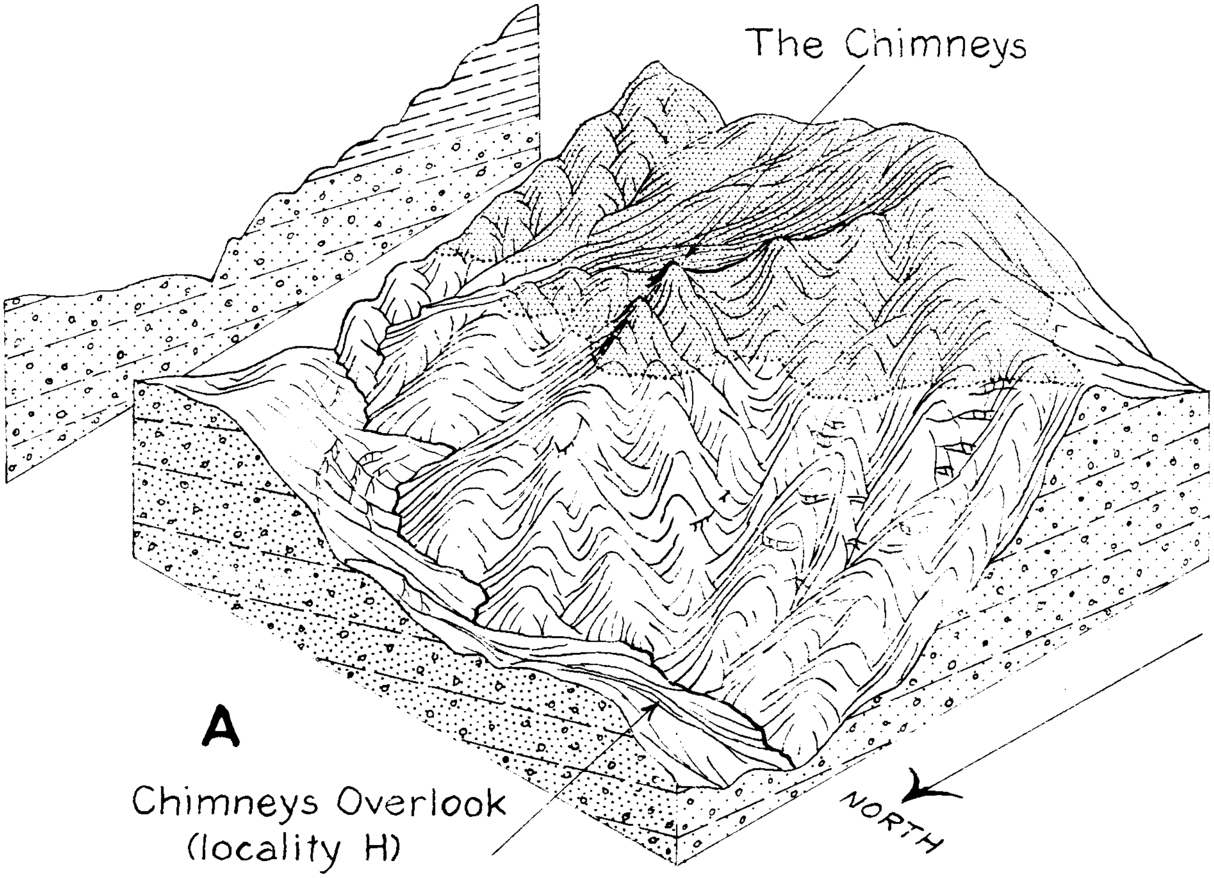
The rock is cut by two sets of nearly vertical joints: An older set parallel to the strike is followed by quartz-calcite veins that contain shreds of biotite absorbed from the country rock. A younger set parallel to the dip is not mineralized.

Phyllite underlying the metasandstone is exposed on the road below the quarry, and shows both bedding laminae and cleavage, which diverge at a low angle.

Locality H (Chimneys overlook, on U.S. Highway 441)

A long succession of road cuts expose metasandstone, conglomerate, and slate typical of the middle part of the mountain sequence of the Ocoee series (*thick-bedded metagraywacke* of table 4, pp. 21-22). The metasandstones of this outcrop, and elsewhere in the middle unit belong to the graywacke suite, but are much coarser graywackes than those of the foothill sequence, as seen in the preceding locality (G). They also differ in that the characteristic feldspar is potassic rather than sodic.

The rocks at this locality show many original sedimentary features (fig. 10 B, p. 23), Bedding units, ranging fro one to 15 feet thick, show graded bedding, local cross-bedding, erosion of underlying beds prior to deposition of the next higher ones, and intraformational conglomerate. The latter is noteworthy in that the rather large fragments of slate



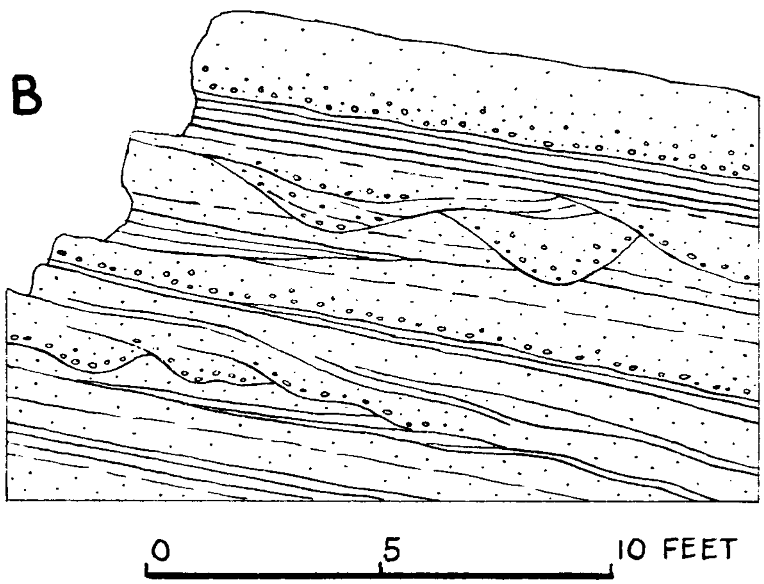


Figure 10. Sketches showing, geologic features at Chimneys Overlook, on U.S. Highway 441, 5 miles south of Gatlinburg (locality H). A – Block diagram of The Chimneys, showing coarse metagraywacke (middle unit of Ocoee series of mountain area), overlain by dark phyllite (shaded). B – Sketch of part of road cut at overlook, showing graded bedding and channeling in coarse metagraywacke. By P. B. King and J. B. Hadley.

are contained in the upper rather than the basal parts of the host beds. In several beds, though in by no means all, complete graded bedding units can be seen, beginning with quartz-feldspar conglomerate at the base, passing upward through gritty metasandstone, medium to fine-grained metasandstone, schistose metasiltstone, and finally to dark gray slate. Many beds apparently represent incomplete cycles, in which the basal conglomerate and concluding slate are absent. Most beds more than 8 feet thick show less systematic grain gradation.

In this and adjacent cuts, extending for about half a mile along the highway, 800 feet of similar beds are exposed. Detailed measurement of this section shows the various sedimentary types are present in the following proportions: fine quartz-feldspar conglomerate, 6 percent; gritty metasandstone, 24 percent; medium to fine-grained metasandstone, 50 percent; schistose metasiltstone, 9 percent; and slate, 1 percent. The coarser beds are composed largely of quartz and microcline, with minor amounts of sodic plagioclase, muscovite, biotite, iron ores, and carbonate. The slate consists largely of muscovite and quartz, with iron ores and possible a little carbon pigment.

The beds at this locality are on the broad, homoclinal, north-western limb of a synclinorium whose axis lies near the crest of the range several miles southeast. Slaty cleavage, well developed in the slate beds, dips southeast at an angle somewhat steeper than the bedding.

Across the valley of the West Fork of the Little Pigeon River are the two sharp peaks known as The Chimneys (fig. 10 A, p. 23), whose upper parts are composed of black carbonaceous phyllite of the upper part of the mountain sequence, conformably succeeding the upper-most metasandstone beds of the middle unit.

Locality I (Walker Camp Prong, on U.S. Highway 441)

In the stream bed, and in road cuts on the opposite side of the highway, are interbedded coarse metagraywacke, dark pyritic phyllite, siliceous dolomite, and intraformational conglomerate belonging to the upper unit of the mountain sequence of the Ocoee series (carbonaceous phyllite etc. of table 4, p. 21). These exposures are near the center of the main synclinorium, and show several minor folds of the first deformation, with a steep easterly plunge. Southeast-dipping slaty cleavage in the phyllite beds has been locally crenulated by the northwestern fringe-effects of the second deformation. The rocks are within the almandine garnet zone, although they are not noticeably garnetiferous.

Locality J (Newfound Gap, and Tennessee-Nort Carolina state line)

From this point one may look across the Oconaluftee fault valley to the southern ridges of the Great Smoky Mountains, with the Plott Balsam range (S 40 degrees E to S 65 degrees E), Bryson City (due S), and Clingmans Dome (S 52 degrees W) in the distance. The rocks exposed in nearby road cuts are interbedded metagraywacke and phyllite of the upper unit of the mountain sequence of the Ocoee series, overturned to the northwest on the southeast limb of the major synclinorium.

Locality K (On Bradley Fork, three mile north of Oconaluftee River at Smokemont)

This locality is reached by the truck road which leads north from Smokemont camp ground. Along the edge of the stream is a series of exposures of metagraywacke, garnetiferous quartz-mica schist, pseudodiorite, and quartz-feldspar conglomerate, which is a part of the more metamorphosed phase of the mountain sequence of the Ocoee series.

The northern, or upstream end of the outcrops includes metagraywacke beds in which are several layers and vaguely defined lenses of hornblende pseudodiorite. Very similar rock collected at a point two miles to the west is composed of quartz, hornblende, calcic plagioclase, and clinozoisite, with minor amounts of garnet and sphene. Immediately upstream and downstream from this point the exposures include beds of thin bedded garnetiferous schist, a rock type widely present in the southeastern part of the mountain sequence. At the south end of the outcrops a thick bed of quartz-feldspar conglomerate contains characteristically flattened quartz pebbles and nearly undeformed pebbles of microcline. This locality marks the northwesternmost appearance of staurolite, which is present in nearby outcrops of schist.

The strata at the locality are nearly vertical, but graded bedding a quarter of a mile upstream indicates that tops are to the southeast, so that the locality is on the southeast limb of an anticline—one of the folds which lies southeast of the major synclinorium. Slaty cleavage in the schist is sensibly parallel to bedding. It is cut in places by an indistinct slip cleavage, but the two are commonly so nearly parallel here that it is difficult to distinguish between them.

Locality L (At Ravensford, on east side of Ocon aluftee River, two miles north of Cherokee)

On a side road at the south edge of Ravensford (an abandoned lumber town, now razed), is an exposure of the eastern boundary of granitic gneiss, of the western arm of the Y-shaped body previously described (p. 23). The body is here 0.65 mile wide, although it broadens to 2 miles not far to the northeast. The eastern boundary of the arm, here exposed, is remarkably straight, and essentially vertical. Characteristic biotite augen gneiss is separated from quartzose metasandstone of the mountain sequence of the Ocoee series by a few feet of finer-grained, dark biotite schist, showing much microscopic granulation and shearing. This rock may have served as a kind of lubrication zone between the tectrusive gneiss and its walls. Foliation of the gneiss and wall rock are about vertical. Neither lineation nor inclusions of wall rock appear to be present in the gneiss.

The western boundary of the same arm of the gneiss (not seen on the excursion) dips northwestward at various angles, reflecting a number of southwest-plunging folds in its contact with the country rock. The latter contain several lenticular concordant off shoots of the gneiss; large and small enclaves of metasedimentary rocks are abundant in the western part of the gneiss. Prominent lineation in the gneiss plunges southwest, parallel to similar lineations in the country rocks, and shows that both rocks were strongly affected by the younger deformation.

Locality M (Road cut on U.S. Highway 19, at Cherokee)

At the east edge of the village of Cherokee, on U.S. Highway 19 just east of its junction with Highway 441, a road cut exposes granitic gneiss which lies in the eastern arm of the Y-shaped gneiss body, a mile or so northeast of its junction with the western arm. The rock at this locality is rather typical of the whole, and is biotite augen gneiss, composed largely of quartz, potash feldspar, plagioclase (albit to andesine), and biotite, with subordinate amounts of muscovite, epidote, and sphene. Its texture is granoblastic-cataclastic throughout. A rather prominent foliation dips 45 degrees to 60 degrees northeast, and parallel to this are a few thin lenses of epidote or feldspar-rich gneiss. A prominent set of cross-joints dipping steeply north-northeast are smoothed and coated with chlorite, and show some evidence of relatively late fault movement.

Locality N (Noland Divide, on spur highway to Clingmans Dome)

Along the spur highway southwest from Newfound Gap are superb views both north and south from the crest of the range. Extensive road cuts are all in rocks of the mountain sequence, mostly dipping at moderate angles to the south-southeast and not overturned, although several small folds appear southwest of the Oconaluftee fault, which is crossed at Indian Gap. Most of the rock exposed is metagraywacke, but layers of thinner-bedded metasiltstone and phyllite are interbedded in the vicinity of locality N.

At Noland Divide is a deep cut in thick-bedded metagraywacke, which dips 33 degrees south-southeast. Notable features of the exposure are ellipsoidal “concretionary” structures (similar structures from another locality are shown on fig. 11 B, p. 26). Ellipsoidal or subspherical bodies are common in metagraywacke beds of the mountain sequence, and are set off from the enclosing rock by the presence of slightly greater amounts of carbonate; some “concretions” contain more or less centrally located angular fragments of dark slate. At this locality the “concretions” are strongly ellipsoidal, with axial ratios averaging 2.3:1:0.7. The plane of the long and intermediate axes is generally vertical and the long axes plunge steeply southwest. Petrofabric analysis shows prominent quartz and muscovite girdles around a “B” petrofabric axis, about parallel to the long axis of the ellipsoids. Oddly enough, this petrofabric axis, is strongly at variance with nearby fold axes, which are nearly horizontal, and trend east-northeast.

The “concretions” have been stated to represent the less metamorphosed equivalents of pseudodiorite nodules commonly seen in metagraywacke farther southeast (Stose and Stose, 1949, p. 282). This conclusion is open to question on two grounds: (1) Pseudodiorite characteristically forms nodules, lenses, or even beds, which lie parallel with the bedding planes; the “concretions” typically do not. (2) Thin layers of pseudodiorite are interbedded with garnetiferous phyllite on Clingmans Dome and at other places in the mountains, where “concretions” in nearby metagraywacke show no sign of conversion to pseudodiorite. An alternative interpretation is that the “concretions” may have formed during a wave of hydrothermal activity which also resulted in widespread distribution of quartz-siderite veins in the surrounding rocks.

Locality O (Forney Ridge parking area, near Clingmans Dome)

Forney Ridge parking area, at the terminus of the Clingmans spur road, affords extensive views over the southwestern part of the Great Smoky Mountains and the valley of the Little Tennessee River. Glimpses of Fontana Reservoir may be seen, but Fontana Dam (S 68 degrees W) is hidden behind intervening ridges.

A good notion may be obtained at this locality of the high-altitude flora of the Great Smoky Mountains. Clingmans Dome and adjacent ridges are covered by a dark, somber conifer forest, a spruce-fir assemblage closely related to that of Maine and southern Canada. This is the southern limit of its range; it ends abruptly a mile or so to the southwest, and is seen no more beyond in the Southern Appalachians. Some of the curious “balds”, or patches on the mountain crest that are grass and shrub-grown, and without trees (King and Stupka, 1950a, pp. 41-42), are visible to the west, especially Silers Bald, 4 miles distant. Some of the nearer slopes to the west also bear little timber, but this has a different cause; they were denuded by a great fire in 1925. The denuded slopes are being reforested naturally by fire cherry, yellow birch, mountain ash, and blackberry.

The rocks exposed at the parking area are massive beds of typical metagraywacke of the mountain sequence (probably the middle unit of table 4, pp. 21-22), with some interbedded finer grained rocks. Beds dip at a low angle to the south-southeast, and graded bedding at the east end of the parking area indicates that the layers are not inverted. The

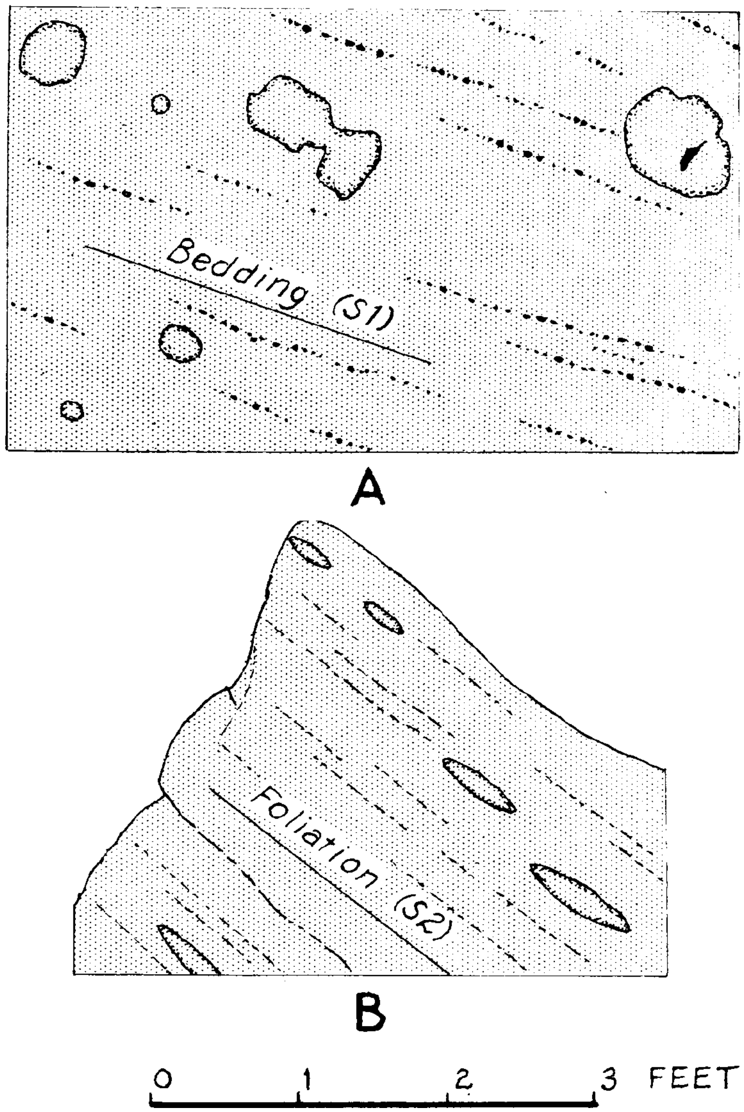


Figure 11. Concretions in metagraywacke in vicinity of Clingmans Dome and locality O.
A – Undeformed concretions; Andrews Bald Trail, below Forney Ridge Parking Area. Note that concretion on right has a nucleus, a slate chip.
B – Deformed concretions, elongated parallel to metamorphic fabric of rock; Fishcamp Prong Trail, 3 miles northwest of Clingmans Dome.
Based on photographs. By P. B. King and R. B. Neuman.

metagraywacke contains numerous subspherical "concretions", which are more irregular and seemingly less altered than those at locality N (fig. 11 A, p. 26). There are also joints of an early generation which are filled with quartz, or quartz and siderite.

ROAD LOG

General Suggestions

1. Participants should provide themselves with a *noonday lunch* each morning before assembling. Lunch stops are to be in the park, where there are no nearby refreshment stands.
2. Cars should be filled with *gasoline* and in *good repair* each morning before starting. There are no facilities for gasoline or repairs on roads traversed on last half of first day, or all of the second.
3. Cars and participants should reach assembly point each morning in ample time to permit *a start at 8:00 A.M.* An early start will be adhered to, as there is a crowded schedule each day. Participants who arrive after party has left can catch up with caravan by following road log.
4. In order to facilitate movement and parking of caravan

on highways, it is requested that cars used be fully loaded. Extra cars should be left in Gatlinburg, especially on first day.

5. Please keep same position in line throughout each day. At road intersections, do not turn off until car behind is in sight.
6. Motor travel on excursion is planned at an *average speed of 30 miles per hou* . There should be no difficulty in keeping up with caravan. If car has to drop out temporarily, it can rejoin party by attention to road log.
7. An average of *30 minutes* is allowed at excursion stops and over an hour at lunch stops. Ample time will be provided for individual examination and discussion *after* talks by excursion leaders. On arrival, please assemble promptly with excursion leader, but be patient, as he cannot begin his talk until those at end of line catch up.
8. At excursion stops, participants *must not stand on pavement*. Other traffic besides our excursion is using the highways.
9. Rest room facilities are indicated in the road log.

SATURDAY, NOVEMBER 1

Assembly poin

Drive north through Gatlinburg on U.S. Highway 441, in the direction of Knoxville and Sevierville, passing beyond shops and houses to point where four-lane pavement is blocked by detour sign (Shell station on left). First car park on right side of highway, south of detour sign and opposite Shell station; other cars line up behind, facing north.

Plan of First Day of Excursion

On the first day of the excursion a cross-section will be examined of the foothills of the Great Smoky Mountains along Tennessee State Highway 73, from Little River Gap east of Maryville, to Gatlinburg. In order to reach starting point, caravan will drive 36 miles, going north from Gatlinburg into Tennessee Valley, then back into mountains. No stops are scheduled in first 36 miles, but notes on geology are given in road log.

0.0 Leave assembly point, following highway markers to left, off four-lane pavement onto two-lane pavement.

1.7 *Banner Bridge* over West Fork of Little Pigeon River. Caution! Sharp turn to left over one-way bridge.

For next two miles, good outcrops along road and in river of metasiltstone of middle unit of foothill sequence of Ocoee series (table 3, p. 16) Beds are vertical with tops to north, indicating a homoclinal succession of great thickness. No stops will be made as same unit will be examined at locality F, at end of day.

4.2 *Rock Fold*. Picnic tables and old quarry on left. Strong folding in metasiltstone with carbonate-bearing laminae, probably in upper part of middle unit of foothill sequence.

4.4 Caution! One-way culvert.

5.0 Road forks; bear left. Highway leaves gorge of West Fork of Little Pigeon River and enters open country; topographic change probably marks the trace of *Dunn Creek fault*, which thrusts hill-making rocks of middle unit of foothill sequence on south up against valley-making shales of upper unit on north.

6.4 Village of *PigeonForge*. Large cut behind buildings to left shows shales of upper unit of foothill sequence.

8.4 Bridge over West Fork of Little Pigeon River. This marks approximately the trace of the *Great Smoky fault*, which here has no topographic expression, as shales of Ocoee series are thrust over shales of Middle Ordovician age (Sevier formation). North end of Chilhowee Mountain in distance to left; note bench topography and regular dips slopes formed on quartzites of Chilhowee group.

11.3 Limestones of Knox group brought to surface in small anticlinal uplift; overlain by residual clay.

12.6 Entering town of *Sevierville*; junction with U.S. Highway 411.

12.9 Turn left on U.S. Highway 441-411.

13.3 Leaving Sevierville; crossing over Smoky Mountain Railroad.

13.3 Highway traverses the “Slate Knobs”, a hilly area formed by limy shales, shaly limestones, and sandstones of Sevier formation, highly disturbed, folded, and faulted. Numerous road cuts show steeply dipping beds.

15.4 Valley of Guess Creek; escarpment on left follows *Guess Creek fault*, which here lies wholly within Sevier formation.

20.9 Behind the shale knobs on left rises *Chilhowee Mountain*, capped by quartzites of Cochran and Nebo formations, of Chilhowee group (table 2, page 11). At foot of mountain are lower ridges and peaks formed of wedges of quartzite of Chilhowee group that have been dragged along Great Smoky fault.

22.8 *Cusick* road forks. Leave U.S. highway 441-411, taking left fork (straight ahead) on blacktop county road. Dangerous intersection! Watch for traffic coming in from right! (County road is not shown on geologic map, map B, but parallels U.S. Highway 411 a few miles to southeast).

24.7 *Knob Creek* community. Low rolling hills on black graptolite bearing shale of lowest unit of Sevier formation.

26.0 Road turns sharp left, then right; end of blacktop; narrow gravel road. From here to intersection with State Highway 73 (at 33.7 miles) road is in open country, on limestones of Knox group, which are very poorly exposed. Excellent views of scarps of Chilhowee Mountain toward left.

29.9 Beginning of blacktop; road bears to left.

31.8 *Ellijoy Creek*; bear sharp left over bridge, then right.

33.7 *Junction with State Highway 73*; turn left. Little River on right. Bed rock near highway is largely covered by river alluvium, but nearby outcrops indicate sequence is homoclinal from here to foot of Chilhowee Mountain, starting near top of Knox group at road junction, and ending high in Sevier formation. That part of Chilhowee Mountain southwest of river is based by foothill ridges, as it is to the northeast. However, these have a different structure; they are formed of resistant rocks at the top of the homoclinal sequence – sandstones of Middle Ordovician and Mississippian (Grainger) age (see table 1, pp. 7-8).

36.8 Entering Little River Gap; approximate trace of *Great Smoky fault*, here obscured by quartzite talus.

37.1 *Locality A (Section of Chilhowee group in Little River Gap)*. For description see pages xx-yy and figure 5, page 16. First half of caravan park in quarry opening on left, last half on road shoulder on right.

37.5 Village of *Walland*.

37.5 *Miller Cove* Many roadside outcrops of Shady dolomite (Lower Cambrian).

38.7 Road bears sharp right, then left, at top of hill. *Miller Cove Fault* crosses highway at this point. Roadside outcrops immediately beyond are slates of upper unit of foothill sequence of Ocoee series (table 3, pages 14-15).

38.7 Winding road in gorge of Little River, cut in upper unit of foothill sequence (slates, siltstones, sandstones, conglomerates). Unfortunately, highway is too narrow to permit parking of caravan, so no stops are possible.

41.3 Conglomerate and conglomeratic sandstone of upper unit (Citico phase), prominently exposed on left.

42.0 Entering village of *Kinzel Springs*; conglomerate outcrops on left.

42.6 Turn sharp right over one-way bridge over Little River.

42.7 *Locality AA (Entrance to Tuckaleechee Cove window)*. Refreshments and rest rooms at Pat's and Anna's Dinette and The Wilson's. Those interested may walk just beyond to a small hill bisected by new highway, which exposes dark laminated slate of Ocoee series, dipping northwest from lying on blue limestone, highly fractured and veined, a part of the Knox group. Contact between i *Great Smoky fault*.

44.4 *Locality AAA (Roadcut outcrops of Knox group)*. Deep road cut exposes gently dipping limestone with pinnacled weathered surface, covered by deep residuum. Probably belongs to Mascot formation, or top unit of Knox; shales of Sevier formation exposed nearby. In contrast to more familiar facies of Knox, rock is largely limestone, rather than dolomite. Contains many sandy seams.

45.1 Village of *Townsend*; outcrops of Knox group across river to left.

47.3 *Cedar Bluff*, across river to left, formed of highly folded Knox group. Top of ridge (in trees) capped by phyllites of Ocoee series.

47.9 *Locality B (Outcrop of Great Smoky fault at Townsend entrance of Great Smoky Mountains National Park)*. For description, see pages 35-38 and figure 6, page 37. Park cars on left shoulder to permit clear view of outcrops on right.

48.1 *Entrance to Great Smoky Mountains National Park*. Beyond are outcrops of phyllite and metasiltstone of middle unit of foothill sequence (table 3, page 16).

48.9 *Tremont* road forks. Cross stone bridge and take road to right, toward Cades Cove.

50.1 Tunnel in phyllite.

51.7 Drive past locality C to wide shoulder on left; turn around and return to locality C, with cars facing toward Tremont forks.

52.1 *Locality C (Outcrop on Laurel Creek showing metamorphic structures in rocks of foothill sequence)*. For description see page xx and figure 7, page yy. Park on right. Lunch stop.

54.4 Return to Tremont road forks; take right fork, or State Highway 73, toward Gatlinburg.

57.5 *Indian Head Rock*; a block of phyllite which overhangs highway.

58.6 Bridge over Little River. Immediately beyond, the phyllites of the foothill sequence give place to coarse metagraywacke of the mountain sequence (table 4, pages xx-yy), the latter forming part of the klippe of the Greenbrier thrust block described under locality D.

60.4 *Locality D (The Sinks)*. For description see pages 38-40 and figure 8, page 41. Park first half of caravan on left shoulder beyond bridge, last half in small parking area on right.

62.6 *Metcalf Bottoms*; carved in phyllite of foothill sequence.

63.4 Trace of *Greenbrier fault* passes through gully. From here to Fighting Creek Gap (locality E) rocks are coarse metagraywacke of mountain sequence, forming part of main Greenbrier thrust block (rather than a klippe, as at The Sinks).

64.9 Bridge over Little River.

67.5 *Elkmont* road forks; keep left on State Highway 73.

68.7 *Fighting Creek Gap.*

69.1 *Locality E (Fighting Creek overlook)*. For description see page 40 and figure 9, page 43. Park cars in turnout to left.

72.4 Intersection of State Highway 73 with U.S. Highway 441 and State Highway 71; *Park Service Headquarters* on left (assembly point of second day). Take left fork, to Gatlinburg.

73.9 *Gatlinburg* city limits; leave Great Smoky Mountains National Park. Continue through Gatlinburg on main street, following highways 441, 73, and 71. Participants who wish to stop for rest room or other facilities can rejoin part at last stop by following road log.

75.9 Turn right off main street on State Highway 73, leaving highways 441, and 71; large sign of Mountain View Hotel. Bear left up hill on *Roaring Fork Road.*

76.0 Curve to right; outcrop of Gatlinburg fault in road cut on right, illustrated in figure 2, page xx.

76.5 Sharp turn to left over one-way bridge over Roaring Fork; leaving Gatlinburg.

77.1 Valley of Dudley Creek; wide pavement and gently curving highway begins. High fresh road cuts in metasiltstone of foothill sequence.

78.1 *Locality F (State Highway 73, one mile east of Gatlinburg).* For description, see pages xx-yy. Sign of Greenbrier Swimming Pool on right. Park cars on right shoulder

End of day's excursion; return to Gatlinburg.

SUNDAY, NOVEMBER 2

Assembly poin

Drive south from Gatlinburg on U.S Highway 441 into Great Smoky Mountains National Park, to National Park Service headquarters building, a mile and a half inside park boundary line. Line up cars in driveway of Park Headquarters, facing toward highway

Plan of Second Day of Excursion

On Second day of excursion a cross-section will be examined across the main range of the Great Smoky Mountains in the vicinity of the trans-mountain highway (U.S. 441), ending at Cherokee, North Carolina. A rather full day is planned, but participants can leave caravan for return home at any point desired. Those returning to Tennessee and not wishing to complete the trip to Cherokee can take shorter alternative trip from Newfound Gap to Clingmans Dome.

0.0 Road forks at intersection of U.S. Highway 441 and State Highway 73; follow U.S. highway 441 (left fork) toward Cherokee, N.C.

0.8 *Locality G (Sugarland Branch quarry)*. For description see page 42. Park cars on right shoulder and walk up side road to right to quarry.

1.2 View to left across valley of West Fork of Little Pigeon River toward *Mount LeConte*, and its nearest projecting spur, The Bullhead. Ledges faintly visible on mountainside are part of middle unit of mountain sequence (table 4, pp. xx-yy).

2.1 *Sugarlands overlook*. This lies approximately on trace of *Greenbrier fault* (see pages xx-yy). Across valley to left the trace is near base of mountain front. Intervening valley floor covered by bouldery alluvium, probably of Pleistocene age.

3.6 View of The Chimneys and Sugarland Mountain straight ahead.

4.8 *Chimneys Camp Ground*. Bear left over bridge across West Fork of Little Pigeon River.

5.6 *Locality H (Chimneys overlook)*. For description, see page 44 and figure 10, page 45. Park cars in turnout at right of road; road cuts on left; view across valley on right. Watch for traffic on highway!

7.0 *Lower tunnel*. In adjacent slopes and road cuts on left, note "block fields" of huge angular metagraywacke fragments. These are talus and creep mantle, probably of Pleistocene age.

9.0 *Alum Cave Bluffs parking area.* Partly repaired washouts on highway just below resulted from flash flood of September 1, 1951, which centered in Alum Cave Branch, to left. This point is near base of upper unit of mountain sequence (table 4, page 22), which forms sharp, laurel-covered peaks to left. Occasional exposures of unit along road for next 1.7 miles are metagraywacke and metasiltstone of this upper unit.

10.7 *Locality I (Walker Camp Prong on U.S. Highway 441).* For description, see page 46. Park cars in graveled area to left of road. Watch for traffic!

11.5 First of a series of long road cuts in upper unit of mountain sequence, which continue at intervals to

Newfound Gap. Rock is dark metagraywacke and metasiltstone, weathering rust as a result of contained pyrite. Beds are steeply dipping and commonly overturned to northwest. Smooth green patches on ridges are "laurel slicks" or "heath balds", formed by laurel, rhododendron, blueberry, sand myrtle, and other members of heath family, which grow densely on rocky slopes, practically without soil. Adjacent forest is largely spruce, balsam, yellow birch, and beech.

12.6 *Upper tunnel*. Just beyond is view to right down valley just ascend. Note The Chimneys on left side of valley, whose tops are now at about same level as observer.

13.5 *Locality J (Newfoundland Gap and Tennessee-North Carolina state line).* For description, see page 46. Drive to far (west) end of parking area, make U-turn to left, then park. Rest rooms at east end of parking area.

At this point, those wishing to make alternate trip to Clingmans Dome will leave the party; for road log of alternate trip see page 60.

13.8 West end of Newfound Gap parking area; on leaving parking area make U-turn into highway at east end.

14.4 Highway swings to left around head of Oconaluftee River valley; at this point crosse *Oconaluftee fault* (see under Gatlinburg fault system, page 18), which is responsible for straight course of valley to southeast. For next six miles the road descends the valley; rocks exposed in road cuts are largely metagraywacke of middle unit of mountain sequence, just southwest of fault. Beds generally dip steeply, due to large-scale folding, but in many places show aberrant attitudes, due to local deformation near fault.

20.1 *Cliff Branch* enters on right. Staurolite first appears in mica schist exposed in adjacent road cuts. Just beyond, both highway and river leave the Oconaluftee fault trend, and turn south.

23.5 *Smokemont Campground* turnoff. Turn left from highway on side road across Oconaluftee River; at far end of bridge, turn left.

23.7 Keep right through campground (built on site of abandoned lumber town of Smokemont).

24.1 Keep straight ahead on gravel road.

24.3 Turn right through gate on truck trail up valley of Bradley Fork. Road ahead is rougher and narrower than others used on excursion, and it is recommended that passengers "double up" in automobiles, and leave extra cars at gate. Bring lunches.

24.9-25.5 Road crosses an arm of the western body of granitic gneiss.

25.5 Road forks; keep left.

27.1 *Locality K (On Bradley Fork, three miles north of Oconaluftee River at Smokemont).* For description, see page 46. Leave cars on road. Lunch stop.

28.1 Continue up road and turn around, returning to Smokemont.

32.5 Gate at Smokemont. Keep right around campground.

33.4 Cross Oconaluftee River; turn left on U.S. Highway 441.

36.1 *Mingus Creek bridge.* Highway enters western body of granitic gneiss.

36.4 *Raven Fork road.* Turn left from highway on side road, crossing Oconaluftee River.

36.8 Take right fork; cross Raven Fork and turn sharp right. Abandoned lumber town of Ravensford, now razed.

37.6 Leave *Great Smoky Mountains National Park* and enter *Cherokee Indian Reservation.*

38.5 *Locality L (At Ravensford, on east side of Oconaluftee River, two miles north of Cherokee).* For description, see page xx, Park cars along right side of road.

38.5-40.5 Continue on gravel road to village of Cherokee.

40.5 Village of *Cherokee*; Indian Agency Headquarters. Turn left on U.S. Highway 441-19 through village. Road cuts on left are meta-sediments, immediately east of western body of granitic gneiss.

40.8 Road forks; intersection of U.S. Highways 19 and 441; keep left on highway 19.

41.2 *Locality M (Road cut on U.S. Highway 19, at Cherokee).* For description, see page 47. Go through deep road cut and park cars on left on far side, in front of cabins; walk back to cut. Watch out for traffic! Stay off pavement!

End of excursion

Alternative trip from Newfound Gap to Clingmans Dome

13.8 Leave Newfound Gap.

15.3 *Indian Gap.* Road crosses Oconaluftee fault (see under Gatlinburg fault system, page 18).

17.8 Metadiorite (see page 23) exposed for about 100 feet in road ditch on right; nearly all weathered to red saprolite. This is part of very thick sill-like body which intrudes the meta-sedimentary rocks north of Clingmans Dome (see map B).

18.9 Collins Gap. View northwest across headwaters of Little River and Great Smoky Mountains foothills in

Tennessee.

19.7 Locality N (Noland Divide). For description, see pages 47-48. Park cars on right beyond road cut.

20.0 6000-foot elevation marker.

21.1 Locality O (Forney Ridge Parking Area, near Clingmans Dome). For description, see pages 48-50 and figure 11, page 49.

End of excursion.