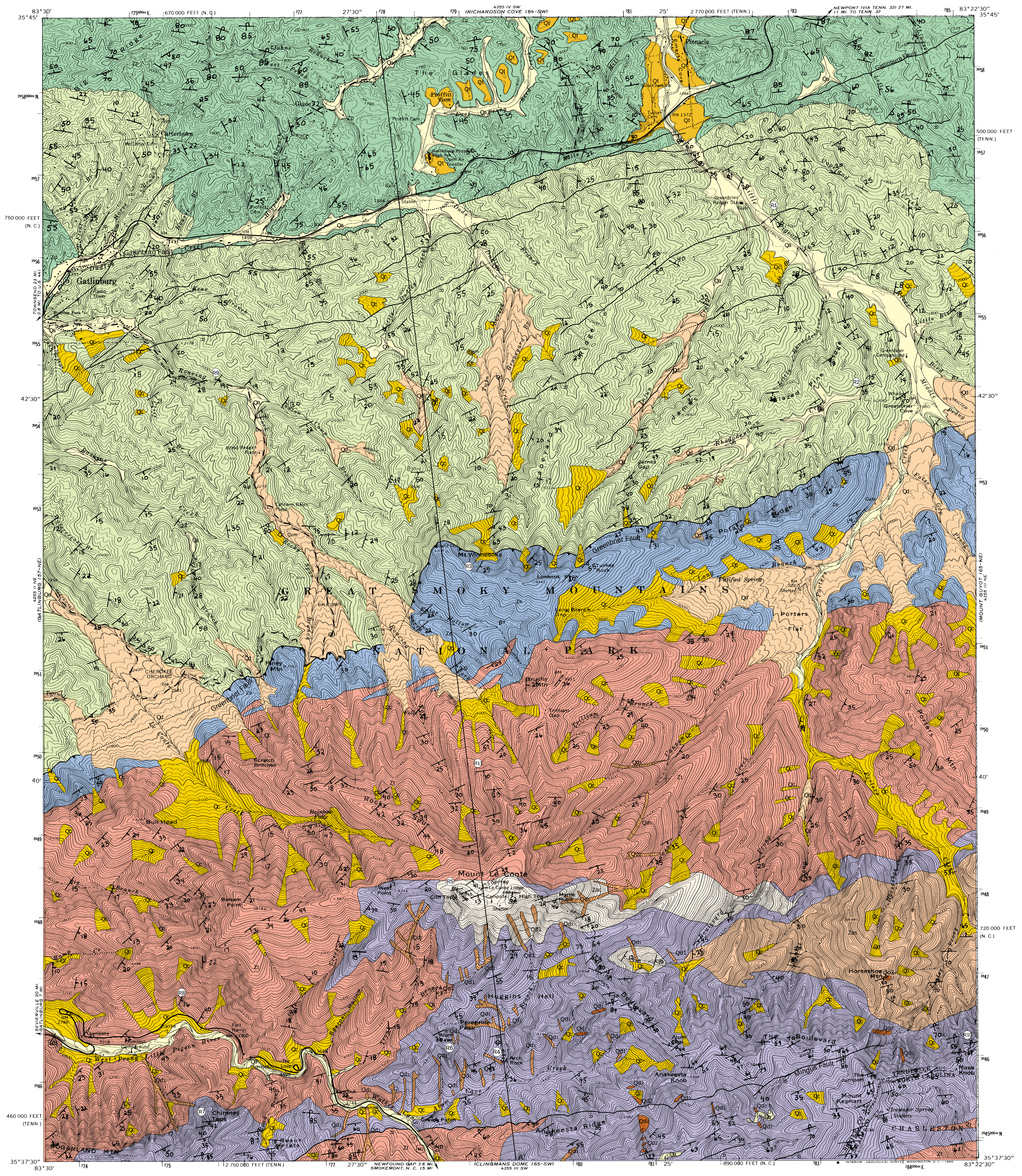
U.S DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

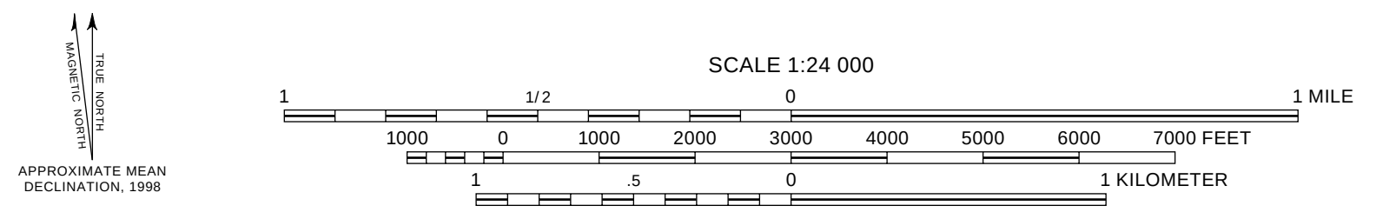
Prepared in cooperation with the
NATIONAL PARK SERVICE

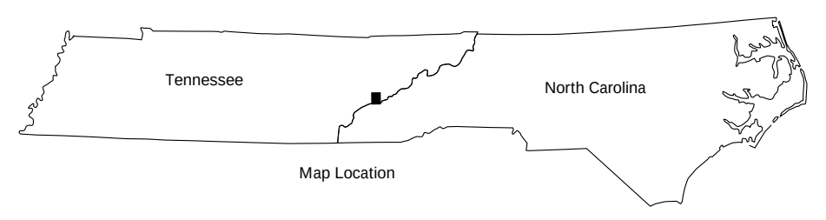
OPEN-FILE REPORT 00-261



Base from U.S. Geological Survey, 1964

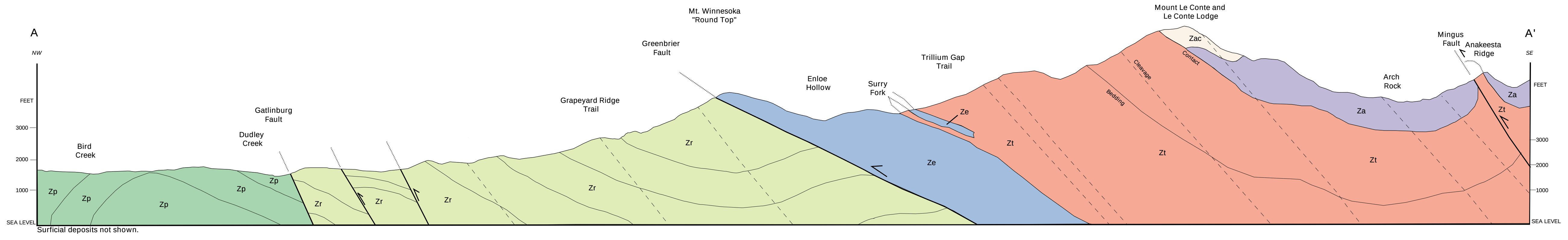
Polyconic projection. 1927 North American datum
10,000-foot grid based on Tennessee and North Carolina coordinate system
1000-meter Universal Transverse Mercator grid ticks, zone 17





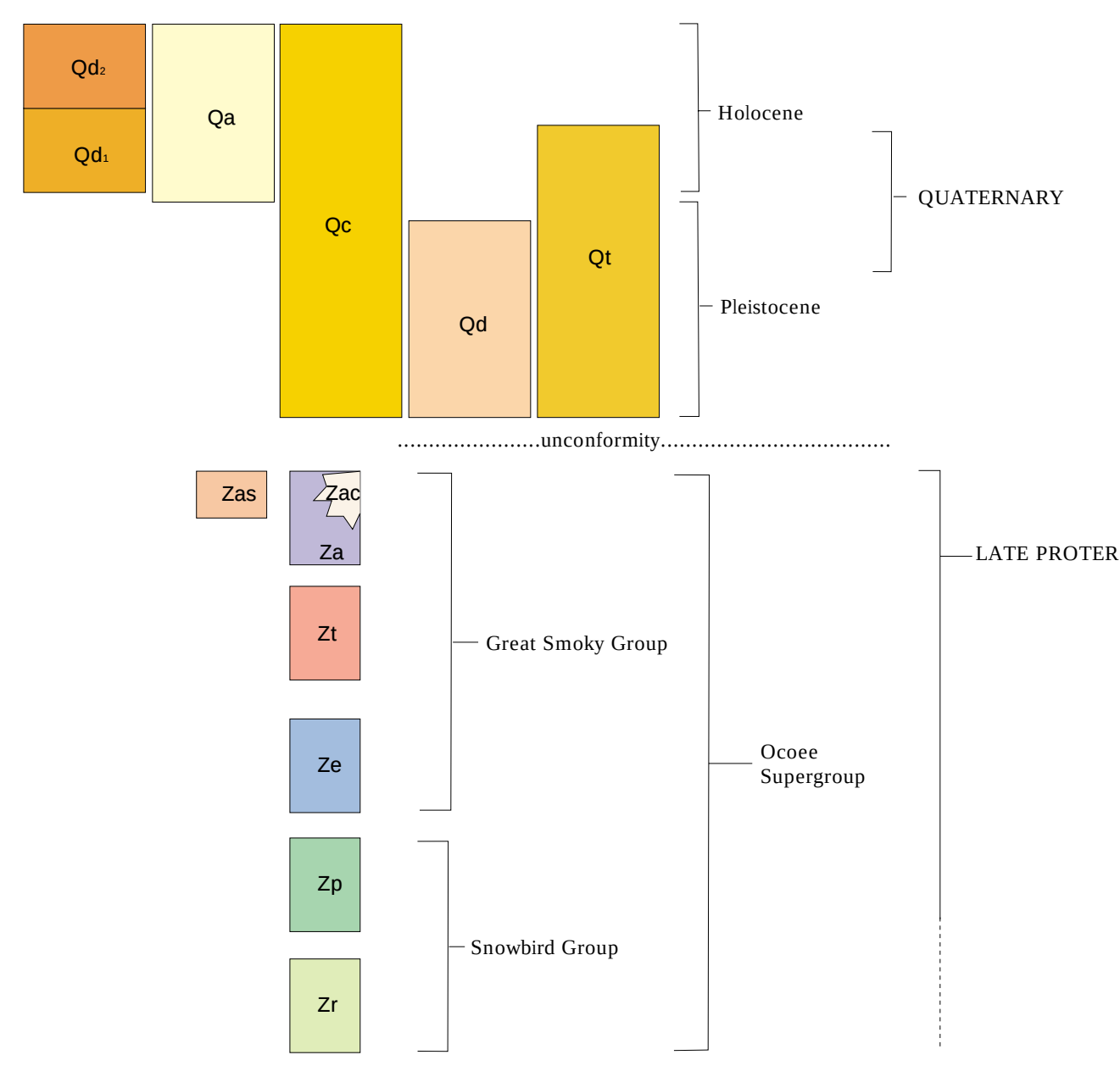
Digital Cartography by Carrie Fingeret (Mary Washington College)

Geology mapped 1993-1997
Compiled in part from Hadley and Goldsmith (1963)



Surficial deposits not shown.

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

Qa	**Alluvium (Holocene)**—Unconsolidated clay, silt, sand, cobbles, and boulders found along flood plains and streams. Much of the alluvium is very coarse and consists of boulders reworked from nearby extensive debris and colluvial deposits. In places, small outcrop of bedrock may be exposed in the river bottoms during times of lower river levels. These outcrops are not shown on the map. However, structural data gathered from these outcrops is included in the mapped alluvium. Thickness from 1 to 30 feet
Qd_2 Qd_1	**Debris flow (Holocene)**—Debris-flow track and deposit. The deposits consist of varying amounts of boulders, cobbles, and pebbles of metamorphosed sandstone, siltstone and shale in a fine matrix of soil, clay, and vegetation including trees, grass, and brush. Both debris flow tracks and deposits of post-1900 to pre-1970 (Qd_1) and post-1970 (Qd_2) debris flows on Mount Le Conte are usually free of vegetation. Thickness from 5 to about 30 feet
Qd	**Debris (Pleistocene)**—Dominantly matrix supported siliciclastic diamicton on lower slopes and valley bottoms consisting of boulders, cobbles, and pebbles of metamorphosed sandstone, siltstone, and shale in a matrix of sand, silt, and clay. Deposits generally are vegetated with some boulders and cobbles scattered across the surface. Fan-like morphology suggests that these deposits are debris-flow fans. Alternatively, some of them may have a periglacial origin. Thickness from 10 to at least 100 feet
Qc	**Colluvium (Holocene and Pleistocene)**—Boulder streams, boulder fields, and talus containing minor alluvium and debris. Boulder streams and boulder fields are chiefly Pleistocene in age, colluvium ranges from Pleistocene or older through Holocene. Deposits are chiefly accumulations of clasts of metamorphosed sandstone and minor amounts of metamorphosed siltstone and shale. Generally found as clast-supported diamicton, rarely matrix supported. Surface of deposits consistently blocky and devoid of finer material. Often nonvegetated and found on the higher steep slopes as talus near bedrock escarpments and as fill in steep-walled mountain gorges and hollows. Deposits may grade down slope into more debris-like deposits, and contacts between colluvial and debris-flow deposits are often transitional. Thickness from 10 to 100(?) feet
Qt	**Terrace deposits (Holocene and Pleistocene?)**—Unconsolidated clay, sand, gravel, cobbles, and boulders. Large clasts are chiefly metamorphosed sandstone with minor amounts of metamorphosed siltstone and shale. Generally located more than 30 ft above the present flood-plain. Some areas of terraced bedrock have very little overlying terrace material. Thickness from 10 to 30(?) ft
Za	**Anakeesta Formation (Late Proterozoic)**—Dark-gray, fine-grained slate and phyllite interbedded with dark-gray metasiltstone and gray fine-grained metasandstone. Includes minor dolomite. Base is placed above highest conglomerate in the Thunderhead Formation; top has been removed by erosion. Thickness from 1,800 to 2,400 ft.
Zas	Upper sandstone member—Light-greenish-gray fine- to medium-grained metasandstone. Upper contact not present. Lower contact placed at first appearance of thick (15 ft) medium-grained sandstone. Thickness from 1,000 to 1,500 ft
Zac	Chloritoid slate member—Light-gray, chloritoid-bearing slate and gray metasiltstone and sandstone. Recognized in the field by first and last appearance of distinctive chloritoid grains visible in hand sample. Thickness from 300 to 500(?) ft
Zt	**Thunderhead Sandstone (Late Proterozoic)**—Light-gray, medium- to coarse-grained feldspathic sandstone or arkose, interbedded with arkosic pebble conglomerate, fine-grained feldspathic sandstone, argillaceous metasandstone, and dark-gray slate. Base is below lowermost conglomerate; top is at highest conglomerate. Thickness approximately 6,000 ft
Ze	**Elkmont Sandstone (Late Proterozoic)**—Medium- to dark-gray, medium- to fine-grained, highly feldspathic sandstone and gray, fine-grained argillaceous sandstone and slate. Base not exposed. Top is just below lowermost conglomerate in Thunderhead Formation. Thickness approximately 3,000 ft
Zp	**Pigeon Siltstone (Late Proterozoic)**—Medium- to dark-greenish-gray and dark-grayish-olive, fine- grained sandstone, metasiltstone, and slate. Top of the formation is not exposed; the base is placed above resistant, 10-ft -thick, feldspathic-rich, coarse-grained sandstone at top of the Roaring Fork Sandstone. Thickness from 3,000 to 6,000 ft
Zr	**Roaring Fork Sandstone (Late Proterozoic)**—Dark-greenish-gray, fine- to medium-grained, feldspathic metamorphosed sandstone, metasiltstone, and minor amounts of slate and muscovite phyllite. Soft-sediment folds are common in some beds. The top of the formation is placed at the highest, thick, resistant coarse-grained sandstones; base is not exposed. Thickness approximately 7,000 ft

Reference Localities, Keyed to Map Locations

R1	Fault zone exposed in bank of Little Pigeon River. Intense fracturing, quartz veining, and folding present in Roaring Fork Sandstone. This fault is one of several mapped along the northwest edge of the park, is associated with the nearby Gatlinburg fault, and is thought to be related to the Alleghanian orogeny.
R2	Cleavage and bedding in sandstone of the Roaring Fork Sandstone is well exposed in creek. Also, massive vein quartz as much as 4 feet thick occurs in sandstone outcrops.
R3	Well exposed outcrops of the Greenbrier Fault zone with folded and cleaved siltstone and fractured quartz veins.
R4	Trail crosses recent debris flow track in bedrock of Anakeesta Formation.
R5	Outcrops of chloritoid-bearing siltstone and sandstone of the Anakeesta Formation.
R6	Outcrops at Alum Cave bluffs of sheared black shale, isoclinally folded sandstone, and fractured dark-gray dolomite of the Anakeesta Formation.
R7	Exposures at Chimney Tops of bedding, cleavage, and joints in Anakeesta Formation slate and siltstone.
R8	Good exposures of massive-bedded, ledge-forming, coarse-grained sandstone and conglomerate of the Thunderhead Formation.
R9	Soft sediment slump folds in thick-bedded, coarse-grained sandstone of the Roaring Fork Sandstone.
R10	Kink folds, cleavage, and overturned beds in slate and sandstone of the Anakeesta Formation.
R11	Exposure on trail of igneous dike intruding sandstone of the Thunderhead Formation.

EXPLANATION OF MAP SYMBOLS

——— - - -	Contact—dashed where concealed
20	Strike and dip of inclined beds
	Strike of vertical beds
20	Strike and dip of Overturned beds
20	Strike and dip of inclined cleavage
20	Strike and dip of axial surface of mesoscopic fold
	Strike of vertical axial surface of mesoscopic fold
▲▲▲▲	Greenbriar Thrust fault—Teeth on upper plate; Dotted where concealed
R	High angle fault—R on hanging wall; Dotted where concealed
R8	Reference locality
———	Contact shown on cross section
———	Bedding shown on cross section
- - - - -	Cleavage shown on cross section

INTRODUCTION

This map was prepared at the request of the Great Smoky Mountains National Park as part of a U.S. Geological Survey-National Park Service cooperative agreement. Geologic map data from this report and from other quadrangles will be used in the preparation of a new 1:100,000 scale bedrock and surficial geologic map of the Great Smoky Mountains National Park.

This geologic map was prepared first by compiling existing geologic data from Hadley and Goldsmith (1963). Contacts and selected structural data were plotted on a modern 1:24,000-scale topographic base. This data was then field checked. About 500 new observations were added to the map using data from outcrops along roads and trails throughout the quadrangle. Additionally, off-trail traverses were made in selected areas to delineate the extent and nature of the surficial deposits. Modern debris flows in the Mount Le Conte area were compiled from Bogucki (1970). Debris flows, post-dating the study of Bogucki (1970) were mapped from aerial photographs taken in 1995. Field checking of many of the modern debris flows was done during the course of mapping .

GEOLOGIC SETTING

The geology of Great Smoky Mountains National Park is summarized in King and others (1968), and the geology of the Mount Le Conte quadrangle is discussed by Hadley and Goldsmith (1963). A good layman's guide to the geology of the Park is by Moore (1988), which also contains technical and non-technical references. A regional tectonic synthesis, which includes the area of Great Smoky Mountains National Park, can be found in Hatcher (1989), and an extensive reference list on the technical aspects of the geology in the park accompanies a recent study by Montes (1997). The summary below is taken from these sources.

Great Smoky Mountains National Park lies within the Appalachian Blue Ridge geologic and physiographic province. The highest mountains in eastern North America occur in the Blue Ridge province, and some of the highest peaks in this province are in the Great Smoky Mountains National Park. The oldest rocks in the Blue Ridge province are at least 1 billion years old and consist of metamorphosed sedimentary and igneous rocks. These Proterozoic rocks form the core of the ancient Appalachian Mountains. Sediments deposited over these older rocks form the majority of rocks in the Great Smoky Mountains National Park.

Most of the rocks in Great Smoky Mountains National Park are metamorphosed sedimentary rocks. These sedimentary rocks were formed from approximately 800 to 450 million years ago from deposits of clay, silt, sand, gravel, and lime or calcium carbonate. The oldest sedimentary rocks consist of vast amounts of clastic material that washed down into lowland basins from adjacent highlands. Rocks of the ancient highlands are similar to the ancient granite, gneiss, and schist found in the eastern parts of the Great Smoky National Park (Hadley and Goldsmith, 1963). Approximately 450 million years ago, the rocks were metamorphosed or "changed" by heat and pressure. For example, sandstone was changed to quartzite and shale to slate.

About 200 to 300 million years ago, the last phase of Appalachian Mountain building, (the Allegheny orogeny) occurred when the North American continent collided with the African and European continents, closing the early Atlantic Ocean. This process, part of a continuous mountain building cycle known as "plate tectonics," ended sedimentation in the Appalachian region and uplifted the entire Appalachian mountain chain from Newfoundland, Canada to Georgia. These mountains may have been much higher than they are today, with elevations perhaps similar to the present-day Rocky Mountains. As the continents collided, the original horizontal layers were bent or folded and broken by fractures and faults. Tremendous forces caused huge masses of older rocks to be pushed westward, up and over younger rocks, along nearly flat-lying faults. Rocks in the Great Smoky Mountains National Park moved westward on the Great Smoky Mountain fault.

Bedrock in the Mount Le Conte quadrangle consists of a thick sequence of Late Proterozoic (800-600(?) million years old) metamorphosed sandstone, siltstone, shale, and conglomerate. A few metamorphosed igneous dikes of uncertain age occur in the Mount Le Conte area (Hadley and Goldsmith, 1963). The metasedimentary rocks in the Mount Le Conte quadrangle have been divided into two groups, chiefly on the basis of age and rock characteristic. The Pigeon Siltstone and the Roaring Fork Sandstone are part of the older Snowbird Group and are overlain across the Greenbrier fault by the younger Elkmont Sandstone, Thunderhead Formation, and Anakeesta Formation of the Great Smoky Group (Hadley and Goldsmith, 1963). These rocks have been metamorphosed by differing degrees of temperature and pressure. On the west, the rocks are of chlorite grade, which indicates a lower temperature and pressure than that experienced by rocks on the southeast part of the quadrangle, which is of garnet grade (Hadley and Goldsmith, 1963). Summaries of available data on the timing of thermal metamorphism of rocks in the park and surrounding areas are found in Drake and others (1989). Most studies indicate that the peak of metamorphism occurred during the Ordovician , around 450 million years ago.

The rocks in the Mount Le Conte quadrangle were deformed by folding, faulting, fracturing, and jointing. Additionally, cleavage, a form of planar "fracture" in the rocks caused by metamorphism and folding, is common in the more shaly rocks (Hadley and Goldsmith, 1963). The largest fault in the quadrangle, the Greenbrier fault, is thought to have formed prior to the regional metamorphism, or prior to about 450 million years ago. Other faults in the quadrangle, such as the Gatlinburg and Mingus faults, occurred during the Alleghanian orogeny, approximately 250 million years ago. Cleavage and folding is thought to have occurred both prior to and during the Alleghanian orogeny (Hadley and Goldsmith, 1963).

The surficial geology in the study area consists of alluvium and terraces along modern low-elevation drainages, and extensive boulder colluvium and boulder debris deposits. Also, modern debris-flow deposits occur in the southern part of the quadrangle.

Terrace deposits and alluvium characteristically contain both coarse and fine material. The very coarse material was derived from reworking of older boulder fans as streams eroded and cut into the older deposits. Finer grained material was derived directly from scour of bedrock, or erosion of soil and weathered rock (saprolite). At lower elevations, cobbles and boulders are well rounded and are in a fine-grained sandy matrix. Alluvium along steep gradient streams at high elevations consists only of poorly rounded coarse boulders and cobbles.

Colluvium consists dominantly of boulders and cobbles derived from weathering of bedrock This rocky material has been transported downslope chiefly by gravity. However, some areas mapped as colluvium also contain boulder streams and boulder fields that may have formed in periglacial environments at the higher elevations during the latter part of the Pleistocene (Delcourt and Delcourt, 1985). In the boulder streams and boulder fields, gravity, solifluction, freeze-thaw ice wedging, and ice rafting may have contributed to downslope movement. In general, colluvium and the periglacial deposits contain little or no matrix or fine-grained material, such as soil, sand, or clay, between the coarse rubble. Additionally, boulder streams, boulder fields, and coarse colluvium often do not have trees and other vegetation growing on them and are usually very well drained. No evidence of present day movement is obvious.

Debris deposits are believed to be the result of ancient, large debris flows and floods that carried large boulders and cobbles down steep-walled valleys and deposited them as fans on the lower slopes. These deposits usually have a finer grained matrix and have soil developed on them. Today, the deposits are tree covered, stable on the slope, and are being incised by the present streams. Both the size of the deposits and the contact between debris deposits and colluvium is usually gradational.

Modern debris flows are common in the Park, particularly on the highest slopes underlain by shales of the Anakeesta Formation. The debris flows were the result of heavy rain and consist of weathered and fresh bedrock, soil, and vegetation, including trees, shrubs, bushes, and grass. The map shows both the debris-flow deposit on the lower slopes and the debris flow scar or source area higher on the mountain. These debris flows pose a hazard to trail hikers and motorists in the park. Whenever several days of heavy rain have occurred, debris flows can be expected in this part of the park.

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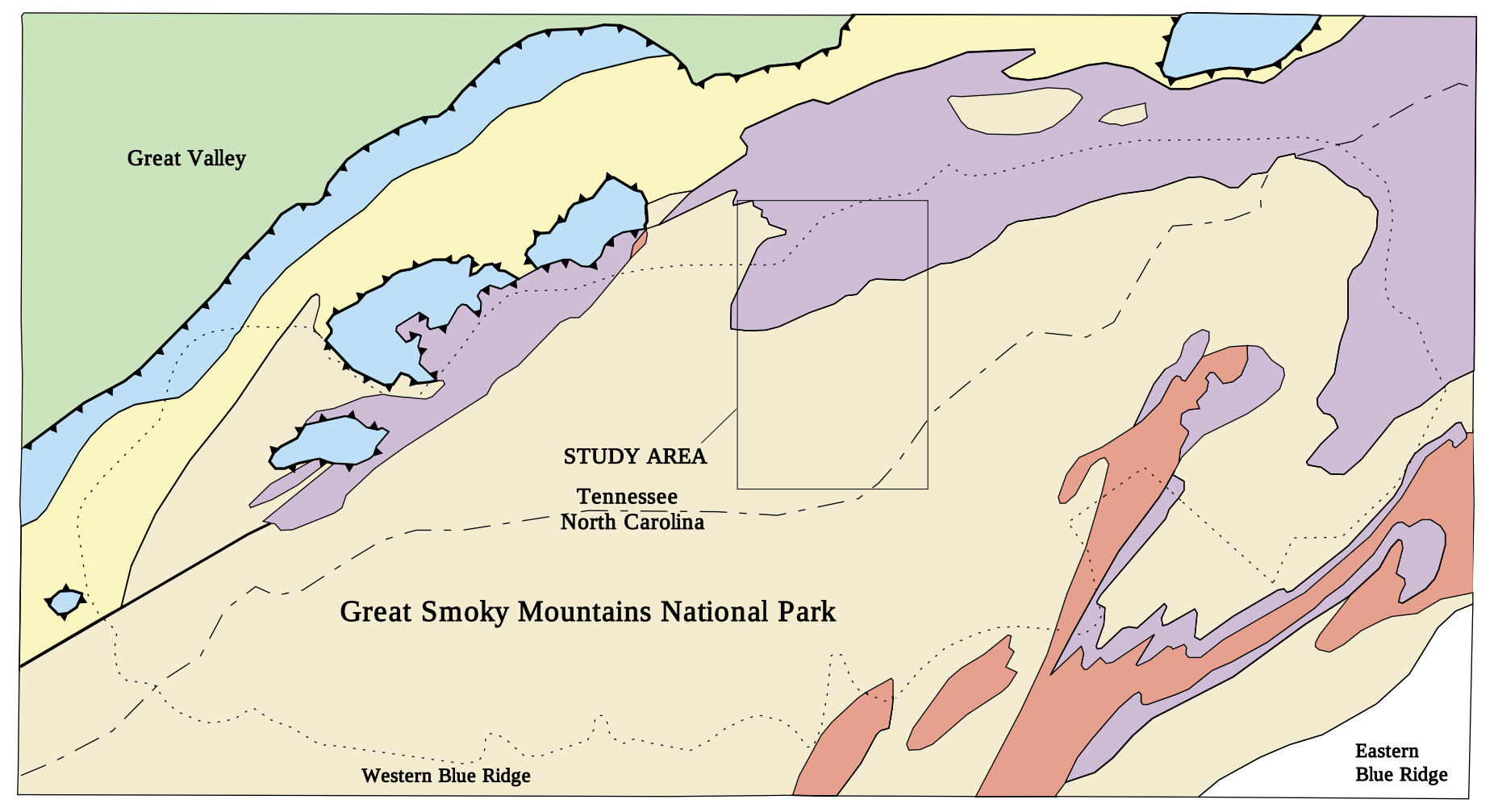
REGIONAL GEOLOGIC MAP



Great Valley

🟩	Paleozoic Sedimentary Rocks

Geologic Contacts

▼▼	Great Smoky Thrust Fault
———	Fault
———	Contact
· · · · · ·	Park boundary

Western Blue Ridge

🟦	Cambrian and Ordovician Sedimentary Rocks

Late Proterozoic Metasedimentary Rocks
Ocoee Supergroup

🟨	Walden Creek Group
▨	Great Smoky Group
🟪	Snowbird Group
🟥	Middle Proterozoic Gneiss

GEOLOGIC MAP OF THE MOUNT LE CONTE 7.5-MINUTE QUADRANGLE, GREAT SMOKY MOUNTAINS NATIONAL PARK, TENNESSEE AND NORTH CAROLINA

By

Art Schultz

2000