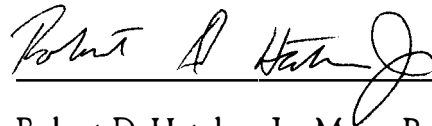


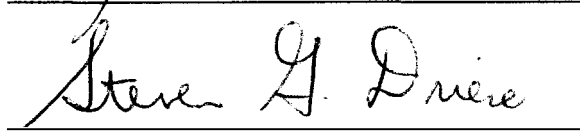
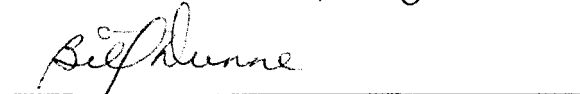
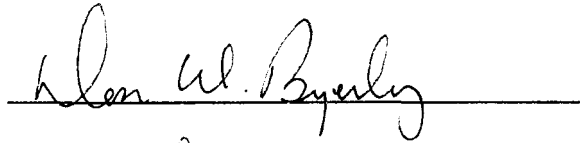
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**STRATIGRAPHY, STRUCTURE, AND ENVIRONMENTAL SITE
ASSESSMENT OF A PORTION OF THE WESTERN BLUE RIDGE,
MONROE COUNTY, TENNESSEE**

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

Donald James Geddes

August, 1995

ACKNOWLEDGMENTS

Numerous people were instrumental, both directly and indirectly, in the creation and production of this thesis. I am particularly grateful to my major advisor, Prof. Robert D. Hatcher, Jr., for his help in every aspect of this research, from helping to formulate the project through the final (under-the-wire) revisions. His insight, instruction, encouragement, and, of course, financial support and field vehicle, were invaluable. The other members of my committee, Dr. William M. Dunne, Dr. Don W. Byerly, and Dr. Steven G. Driese also deserve many thanks for their comments and assistance throughout this project. The Department of Geological Sciences Graduate Teaching Assistantship enabled me to attend The University of Tennessee, the U. T. K. Science Alliance Center of Excellence-Distinguished Scientist Stipend enabled me to remain enrolled after my initial support was depleted, and the George D. Swingle Memorial Fellowship allowed me to conduct field work with a bit more peace of mind.

A great many thanks go to fellow western Blue Ridgers Mark Carter and Steve Martin for helping me onto my feet in the early stages of this project, for field assistance in dangerous situations, and for participating in continually evolving discussions on the geology in this part of the world. Their friendship and support are unparalleled. Special thanks go to Mark Carter for his pioneering efforts in western Blue Ridge geology that made my research substantially easier, for his reassurances during times of duress, and for all his help in computer- and thesis-related matters. Thanks also to present and past trailerites for being so much fun to share a second home with, and to all the students and faculty who have helped make my time here enjoyable. Thanks to Leonard Wiener and Carl Merschat (North Carolina Geological Survey), and Dr. Kauko Laajoki (University of Oulu, Finland) for sharing their work and interpretations in some of the same rocks, and to Don McClanahan for his assistance with computer graphics. Not enough can be said of the departmental office staff who are always willing to help, even with unreasonable last-minute requests.

I am very grateful to the rangers and staff at the Tellico and Cleveland Ranger Districts for loaning me keys and air photos, and giving me Forest Service maps. Larry Fleming, Mike Nicolo, Gary Hubbard, Jeanette Tate, Deborah Turpin, and Jill Franklin were always willing to help a bumbling graduate student. Thanks also to my friends in Rafter, Tennessee for making some really tough field days a little easier to bear.

To my parents Don and Carol Geddes, and the rest of my family and friends in Sloatsburg, New York, thank you for a lifetime of love and support that created the foundation upon which all else has been built. Thanks to Mr. Joe Gonyo, who helped kindle my interest in geology, and to the faculty at S.U.N.Y. Geneseo, who fanned the flames of interest and taught me how to think critically. Lastly, I wish to extend my greatest appreciation to my wife, Mary Ellen, for her patience, her undying love and support, and her continual encouragement even in the face of so many disasters. To her I owe the world.

ABSTRACT

The western Blue Ridge in southeastern Tennessee is underlain principally by metasedimentary rocks of the Walden Creek and Great Smoky Groups (Ocoee Supergroup). These rocks have traditionally been interpreted as turbiditic synrift sediments deposited along the Late Proterozoic to Early Cambrian southeastern Laurentian margin, which were subsequently metamorphosed and deformed during an early Paleozoic (Taconic) orogeny, then brittlely deformed and thrust westward during a late Paleozoic (Alleghanian) orogeny. More recent hypotheses suggest that at least part of the Walden Creek Group was deposited above the regional Middle Ordovician unconformity in post-Taconic successor basins, and deformed and metamorphosed only during a later Paleozoic event. Data gathered for this study in southeastern Tennessee support traditional interpretations of the age, stratigraphic relationships, and structural history of this portion of the Ocoee Supergroup.

First-generation detailed (1:12,000-scale) geologic mapping of a 175 km² (68 mi²) area in the Foothills and Mountains belts between Tellico River and Citico Creek, southeastern Tennessee, indicates that the contact between the Great Smoky Group and the overlying Walden Creek Group is conformable. This contact has previously been interpreted as the southern extension of the Greenbrier fault (a major premetamorphic tectonic boundary in the Great Smoky Mountains northeast of the study area), as a candidate for the Middle Ordovician unconformity, or as conformable. Rocks assigned to the Great Smoky Group are correlated with the Ammons and Dean Formations, and rocks assigned to the Walden Creek Group are correlated with the Wilhite Formation. These units are offset by the Rabbit Creek and Oconaluftee-Greenbrier faults.

Rocks within the study area were metamorphosed once, developed three foliations, displaced twice by thrust faults, and developed four generations of folds. Metamorphism reached chlorite and biotite grades in the Taconic orogeny, during which regionally dominant F₁ folds

with axial-planar slaty cleavage (S_1) were formed. Pressure-solution cleavage (S_{1a}) also formed during this event. The Rabbit Creek and Oconaluftee-Greenbrier faults are Taconic structures that were reactivated in the Alleghanian orogeny, during which the entire predeformed package was thrust westward over unmetamorphosed Paleozoic platform rocks. Crenulation cleavage (S_2) and F_2 folds were probably also formed during this event. In the waning stages of the Alleghanian orogeny, F_3 folds formed as the result of footwall duplexing in the Paleozoic rocks.

The Oconaluftee-Greenbrier thrust sheet is comprised of upper Great Smoky Group units and lower Walden Creek Group units, and contains the southwest-plunging Epperson synclinatorium, which is analogous to the Murphy synclinatorium on the west limb of the Ducktown anticlinorium. This simplified regional structure permits correlation of units within the study area with lithostratigraphically similar units in the Murphy belt to the east.

The Rabbit Creek thrust sheet is comprised of rocks previously assigned to the Cades Sandstone and contains southwest-plunging structure and a stratigraphic assemblage equivalent to that observed in the Oconaluftee-Greenbrier thrust sheet. The Rabbit Creek thrust sheet is here interpreted as containing the entire suite of Great Smoky Group formations. The name "Cades Sandstone," then, should be abandoned as a formation name.

The Alleghanian Foothills duplex produced the antiform that was eroded to breach the Great Smoky fault and form the windows in the Great Smoky Mountains National Park. Seismic evidence suggests this structure exists beneath the present study area. Other evidence includes a fold interference pattern, deflection of the biotite isograd, geomorphic anomalies, and rotation of bedding and cleavage.

An environmental site assessment for a hypothetical road construction project in the study area suggests that northeast- and south-facing slopes are the best candidates for planar or wedge failures, and that finer-grained lithologies crossed by the road have the most potential for producing acidic drainage. Further detailed study of these slopes and encapsulation of pyritic materials would diminish or mitigate environmental damage.

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Chapter I

INTRODUCTION

The western Blue Ridge of eastern Tennessee, western North Carolina, and northern Georgia (Fig. I-1) is underlain principally by rocks of the Ocoee Supergroup and Chilhowee Group (Fig. I-2) (Rodgers, 1953). These rocks have long been interpreted to represent Late Proterozoic to Early Cambrian synrift deposition along the southeastern edge of Laurentia (King and others, 1958; Rankin, 1975; Hatcher, 1972, 1978; Rast and Kohles, 1986). They were subsequently deformed during early Paleozoic (Taconic) and late Paleozoic (Alleghanian) orogenies (Butler, 1972; Rankin, 1975; Hatcher, 1978; Kish, 1989; Connelly and Dallmeyer, 1990; Kish, 1991; Woodward and others, 1991; Connelly and Woodward, 1992). Reported paleontological evidence and related hypotheses dispute these interpretations (Tull and Groszos, 1988, 1990; Unrug and Unrug, 1990; Unrug and others, 1991; Tull and others, 1993). Hypotheses derived from the reported fossils suggest that all or part of the Ocoee Supergroup may be middle Paleozoic (Silurian to Mississippian), deposited above the regional Middle Ordovician unconformity in post-Taconic successor basins, and then deformed and metamorphosed only during the Alleghanian orogeny. This hypothesis contradicts other structural and stratigraphic evidence of earlier metamorphism and penetrative deformation overprinted by younger brittle faults and folds.

The portion of the western Blue Ridge between Tellico River and Citico Creek is critical for determining stratigraphic and structural relationships within the Ocoee Supergroup (Fig. I-2). The geology of this region does not include any of the carbonates from which the reported controversial paleontological evidence was gathered (Unrug and Unrug, 1990; Unrug and others, 1991), but the base of the Walden Creek Group—the lithostratigraphic unit that contains the disputed carbonates—has previously been interpreted as an unconformity in this region (Tull and Groszos, 1988, 1990; Thompson and Tull, 1991; Tull and others, 1993). Great Smoky Group

Figure I-1. Simplified tectonic map of the southern Appalachians showing lithotectonic subdivisions. Approximate location of study area is represented by black box northwest of the Murphy syncline. Modified from Davis (1993).

Geologic abbreviations: BFZ–Brevard fault zone; EBR–eastern Blue Ridge; GMW–Grandfather Mountain window; MS–Murphy syncline; PMW–Pine Mountain window; SMW–Sauratown Mountains window; SRA–Smith River allochthon; TB–Talladega belt; WBR–western Blue Ridge.

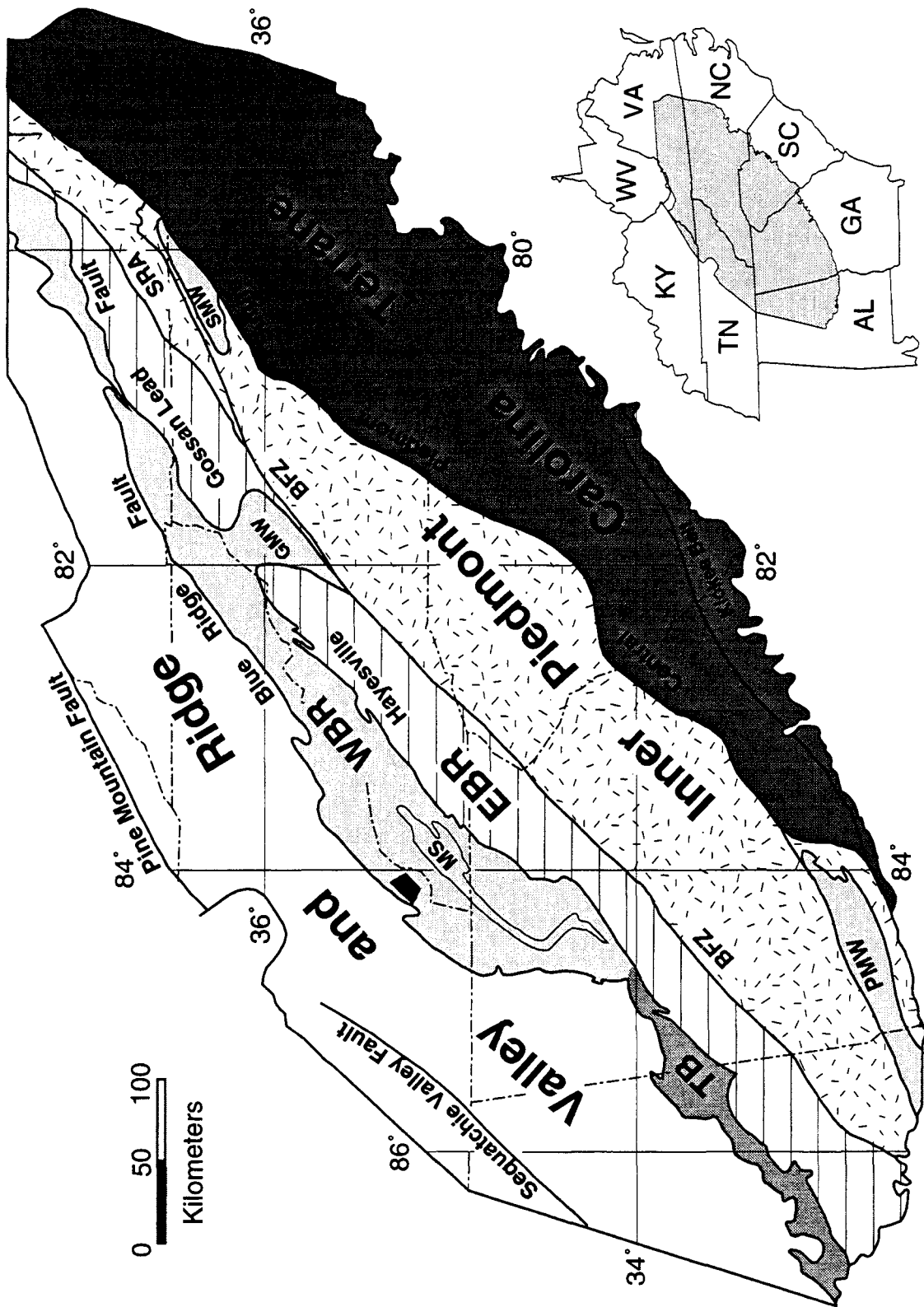
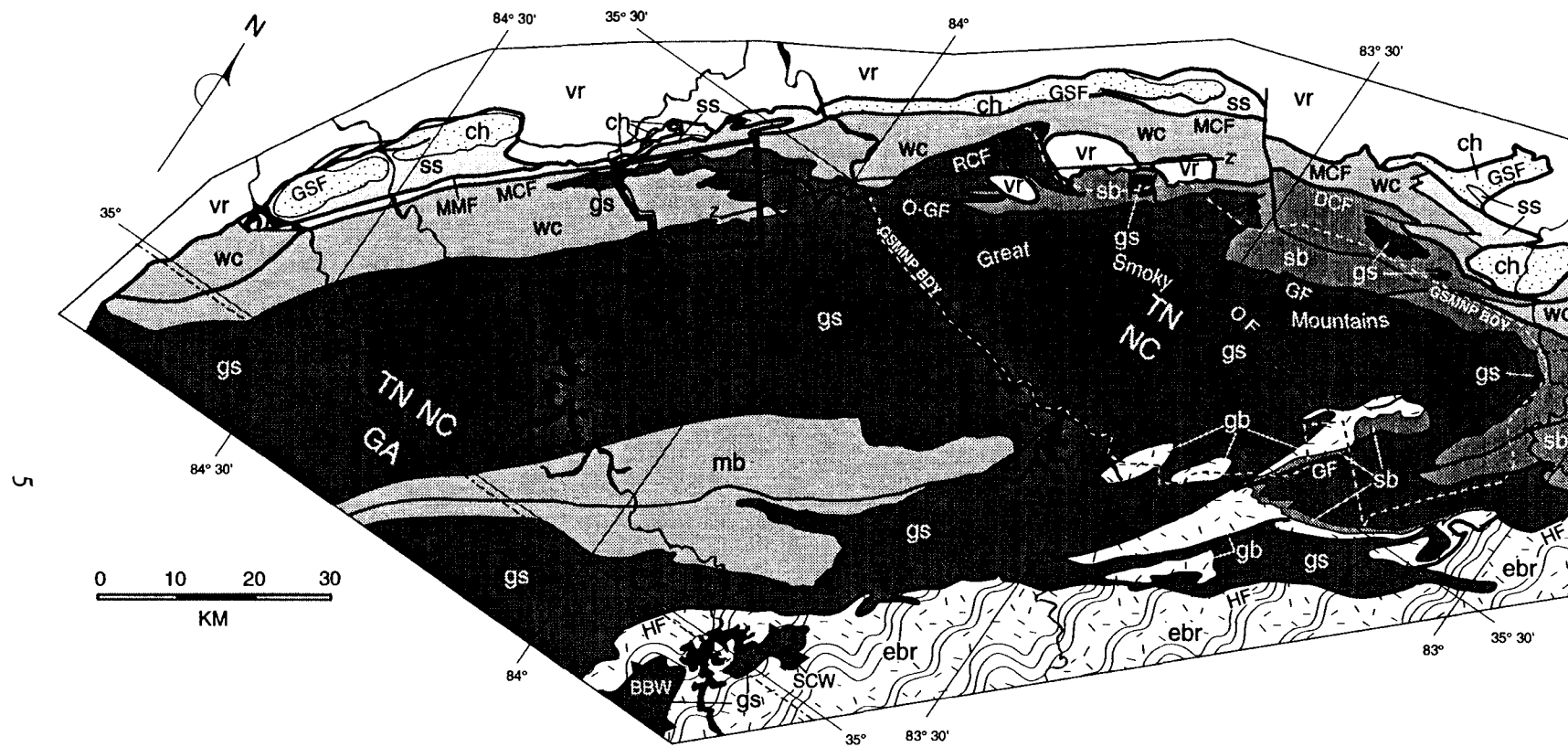


Figure I-2. Geologic sketch map of the western Blue Ridge in southeastern Tennessee, western North Carolina, and northern Georgia. Physiographic subdivisions of Rodgers (1953) are separated by constituent rock units. Field area is represented by polygon outlined by heavy black line. Approximate position of cross section in Figure III-7 represented by line Z-Z'. Modified from compilation by Carter and others (1995a).

Geologic abbreviations: BBW–Brasstown Bald window; DCF–Dunn Creek fault; GF–Greenbrier fault; GSF–Great Smoky fault; HF–Hayesville fault; MCF–Miller Cove fault; MMF–Maggies Mill fault; O-GF–Oconaluftee-Greenbrier fault; OF–Oconaluftee fault; RCF–Rabbit Creek fault; SCW–Shooting Creek window.

Geographic abbreviations: GSMNP BDY–Great Smoky Mountains National Park boundary.



Frontal fault blocks

vr	Valley and Ridge Fms
ch	Chilhowee Group
ss	Sandsuck Formation

Foothills belt

ss	Sandsuck Formation
wc	Walden Creek Group
sb	Snowbird Group

Mountains belt

gs	Great Smoky Group
gb	Grenville basement
mb	Murphy Belt rocks

ebr

 Eastern Blue Ridge rocks

lithologies lie below the Walden Creek Group (Fig. I-2; Plate I). The contact between the Great Smoky and Walden Creek Groups in the present study area has also been previously interpreted as the southern continuation of the Greenbrier fault (Merschhat and Wiener, 1973; Wiener and Merschhat, 1981, 1992), which is a major premetamorphic fault in the Great Smoky Mountains National Park to the northeast of the study area (King and others, 1958) (Figs. I-2, I-3), and as a stratigraphic contact without unconformity (Swingle, in Hardeman, 1966). These conflicting interpretations prevent stratigraphic and structural relationships from being resolved.

Conflicting interpretations also surround the nature and extent of Cades Sandstone lithologies. Neuman and Nelson (1965) mapped the Cades Sandstone in the southwestern Great Smoky Mountains (Figs. I-2, I-3). The stratigraphic relationships between this formation and others in the Park could not be established, and it was left unclassified (King and others, 1958). Neuman and Nelson (1965) and Rast and Kohles (1986) believed the Cades to be correlative with the Snowbird Group (Ocoee Supergroup), but subsequent structural analysis suggests it is correlative with the Great Smoky Group (Lewis, 1988; Walters, 1988; Woodward and others, 1991). Reconnaissance mapping indicated to Neuman and Nelson (1965) that Cades Sandstone was exposed beyond the southwestern boundary of the Great Smoky Mountains, but others indicated the Cades was truncated within the Park (Hardeman, 1966; Hadley and Nelson, 1971). Subsequent detailed mapping reconfirmed that Cades Sandstone lithologies do indeed extend south of the Park (Wiener, unpub.; Merschhat and Wiener, 1973; Wiener and Merschhat, 1981, 1992) and into the present study area (Fig. I-3; Plate I).

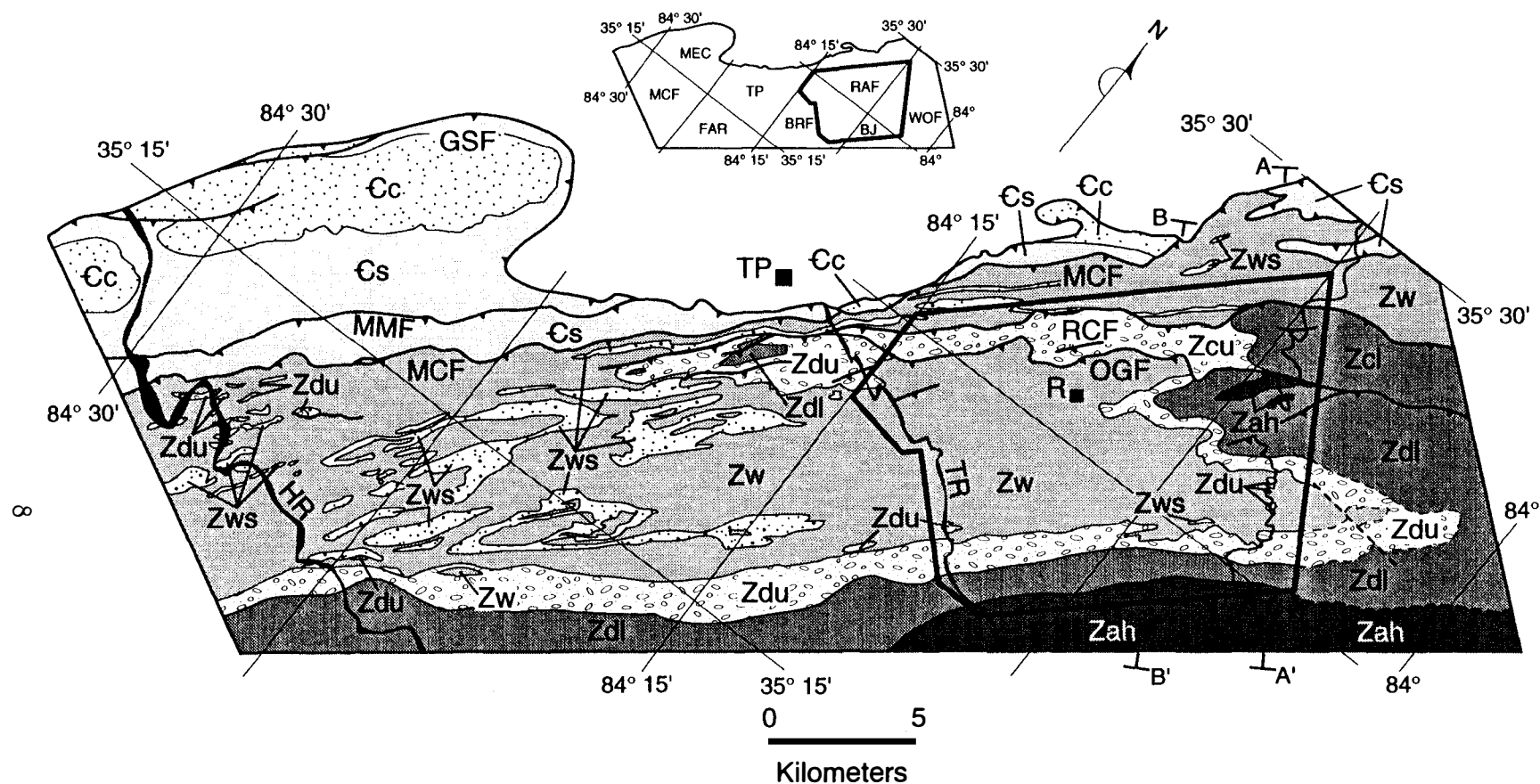
This study deals with the stratigraphy of the upper Great Smoky Group and lower Walden Creek Group, and the depositional and tectonic settings of these Ocoee Supergroup units. Several sets of conflicting reports in the vicinity of the study area indicate the necessity for a study of this type. The interpretation that the Cades Sandstone is truncated within the Great Smoky Mountains National Park (Hardeman, 1966; Hadley and Nelson, 1971) differs from subsequent detailed mapping (Wiener, unpub.; Merschhat and Wiener, 1973; Wiener and

Figure I-3. Regional geologic map showing location of study area (black line) and quadrangle locations. Position of cross sections (Plate III) represented by lines A-A' and B-B'. Modified from Carter and others (1995a).

Geologic abbreviations: GSF–Great Smoky fault; MCF–Miller Cove fault; MMF–Maggies Mill fault; OGF–Oconaluftee-Greenbrier fault; RCF–Rabbit Creek fault.

Geographic abbreviations: HR–Hiwassee River; R–Rafter; TP–Tellico Plains; TR–Tellico River.

Quadrangle abbreviations: BJ–Big Junction; BRF–Bald River Falls; FAR–Farner; MCF–McFarland; MEC–Mecca; RAF–Rafter; TP–Tellico Plains; WOF–Whiteoak Flats.



Cc Chilhowee Group
 Cs Sandsuck Fm
 Zw Wilhite Fm
 Zws Zws-sandstone members

Zdu Dean Fm (upper)
 Zdl Dean Fm (lower)
 Zah Ammons Fm
 Horse Branch (?) Member

Zcu Cades Sandstone (upper)
 Zcl Cades Sandstone (lower)
 ——— known faults
 - - - - - postulated faults (unconfirmed by detailed mapping)

Mersch, 1981, 1992). Paleontological evidence suggesting a mid-Paleozoic age for rocks of the Walden Creek Group (Unrug and Unrug, 1990; Unrug and others, 1991) contrasts with established stratigraphic constraints (King and others, 1958; Hamilton, 1961; King, 1964; Carter, 1994). The interpreted existence of the Greenbrier fault (Mersch and Wiener, 1973; Wiener and Mersch, 1981, 1992) or an unconformity (Tull and Grosz, 1988, 1990; Thompson and Tull, 1991; Tull and others, 1993) along the Walden Creek Group/Great Smoky Group contact challenges the findings of other studies in the region (Hardeman, 1966; Costello and Hatcher, 1986, 1991; Carter, 1994). The purpose of this study is to resolve stratigraphic and structural relationships and chronologies of the upper portion of the Ocoee Supergroup in a geologically unexplored region of southeast Tennessee.

Study Area

The study area is located in the Foothills belt and easternmost Mountains belt (Rodgers, 1953) in the western Blue Ridge of southeastern Tennessee (Fig. I-1). It lies entirely within Cherokee National Forest lands in Monroe County, east of Tellico Plains, Tennessee (Fig. I-3). The area encompasses approximately 175 km² * (~68 mi²) across portions of the Bald River Falls, Rafter, Whiteoak Flats, and Big Junction U.S.G.S. 7.5-minute quadrangles (Fig. I-3). The topography is varied but generally quite rugged, with total relief of 3,100 ft * (945 m) (elevations range from 900 ft to 4,000 ft *; 275 m to 1,220 m). The study area is bounded to the southwest by Tellico River, to the southeast by the western ridges of the Unicoi Mountains, to the northeast by Citico Creek, and to the northwest by a line passing through Hells Hole Branch and Tyler Mountain (Fig. I-3; Plate I).

* Elevations are presented in feet, with metric equivalents in parentheses, to remain consistent with topographic maps available for the region. All other measurements are presented in metric units, with English equivalents in parentheses.

Objectives of this Study

The main purposes of this study were to: 1) determine the lithologies and geometries of constituent formations of the lower Walden Creek Group, upper Great Smoky Group, and Cades Sandstone; 2) determine the stratigraphic and structural relationships between and within these units; 3) interpret the structural history of the area as determined from macro- meso- and microstructural fabric analysis. Achievement of these goals will help: 1) determine the geometry of the southern extent of the Rabbit Creek thrust sheet; 2) determine the nature of the northeastern extent of Walden Creek Group lithologies and the nature of its lower contact; 3) construct a model of tectonic events that led to the present configuration of units; and 4) employ lithologic and structural data to produce a portion of a hypothetical initial environmental and geotechnical site evaluation. The geologic map (Plate I) provides linkage to previously mapped areas (Wiener, unpub.; Slack and others, 1984; Carter, 1994), and to work in progress by S. L. Martin.

Methods Used in this Study

The majority of this research involved detailed 1:12,000-scale geologic mapping of the study area (Plate I). Field work was conducted from May, 1993, through August, 1993, and January, 1994, through August, 1994, and entailed making foot traverses along stream valleys, logging and U. S. Forest Service roads, ridge crests, county and state roads, and foot trails (Plates I, II). Structural data were collected at more than 2,200 stations throughout the study area (Plate II) using a Brunton™ compass. Measurements were taken on bedding, cleavages, folds, faults, lineations, joints, and veins.

Cross-sections A-A' and B-B' (Plate III) were constructed by integrating surface geological data from the geologic map (Plate I), surface information from off the line of section (Neuman and Nelson, 1965; Hardeman, 1966; Wiener, unpub.; Slack and others, 1984; Carter, 1994) and projected down-plunge onto the section, and seismic reflection data (Cook and

others, 1983). Structural styles observed at the surface in the study area were projected into the subsurface, making these admissible sections (Elliott, 1983). Sections were constructed and retrodeformed simultaneously according to standard balancing procedures (Dahlstrom, 1969; De Paor, 1988; Woodward and others, 1989).

Structural analyses were aided using Stereonet® software, developed by R. W. Allmendinger (Cornell University) for Macintosh™ computers. Petrographic and microtextural studies were conducted using a Leitz Orthoplan Pol™ polarizing microscope, and photomicrographs were taken with a Wild™ MPS 51S camera assembly.

Word processing was done in Microsoft Word®, figures were drafted using Adobe Illustrator® and Macromedia FreeHand®, scans were done on an Apple Color OneScanner™ using Ofoto® scanning software, tables were compiled in Microsoft Excel®, and final document layout was done in Aldus PageMaker®, in Goudy 11 point text.

Chapter II

LITHOSTRATIGRAPHY OF THE OCOEE SUPERGROUP

Introduction

The Upper Proterozoic Ocoee Supergroup forms most of the western Blue Ridge province of the southern Appalachians in southeastern Tennessee, southwestern North Carolina, and northeastern Georgia (King and others, 1958) (Figs. I-1, I-2). It has been estimated to be a 15 km (50,000 ft) -thick sequence dominated by terrigenous clastic sedimentary rocks deposited nonconformably on Middle Proterozoic (Grenvillian) crystalline basement in western North Carolina and northwestern Georgia (Hayes, 1900; Keith, 1907; Stose and Stose, 1949; King and others, 1958; Odom and others, 1973; Costello, 1978; McConnell and Costello, 1980; Costello and others, 1982; McConnell and Costello, 1982, 1984; Costello, 1986; Rankin and others, 1989) (Fig. II-1) during the initial continental rifting that formed the Iapetus ocean (Hatcher, 1972, 1978, 1987, 1989; Rast and Kohles, 1986). To the south and east in the central Blue Ridge, the Ocoee is conformably overlain by rocks of the Murphy belt (Keith, 1907; Hurst, 1955; King and others, 1958; Hadley, 1970; Mohr, 1973) (Figs. I-2, II-1), which belong to the Lower Cambrian (?) Hiwassee River Group and Ordovician (?) Mineral Bluff group (Tull and others, 1991, 1993). To the north and west, it is conformably overlain by the Lower Cambrian Chilhowee Group (King and others, 1958; King, 1964; Neuman and Nelson, 1965; Walker and Driese, 1991) (Figs. I-2, II-1). Rodgers (1991) and Carter (1994) presented detailed accounts of the history of previous stratigraphic investigations in this region.

Lithostratigraphy

Ocoee Supergroup lithologies are diverse, even within individual formations. Furthermore, the Ocoee is nowhere found as a complete stratigraphic section because of faulting and probable complexity in the depositional basin geometry. Previous workers have been able to

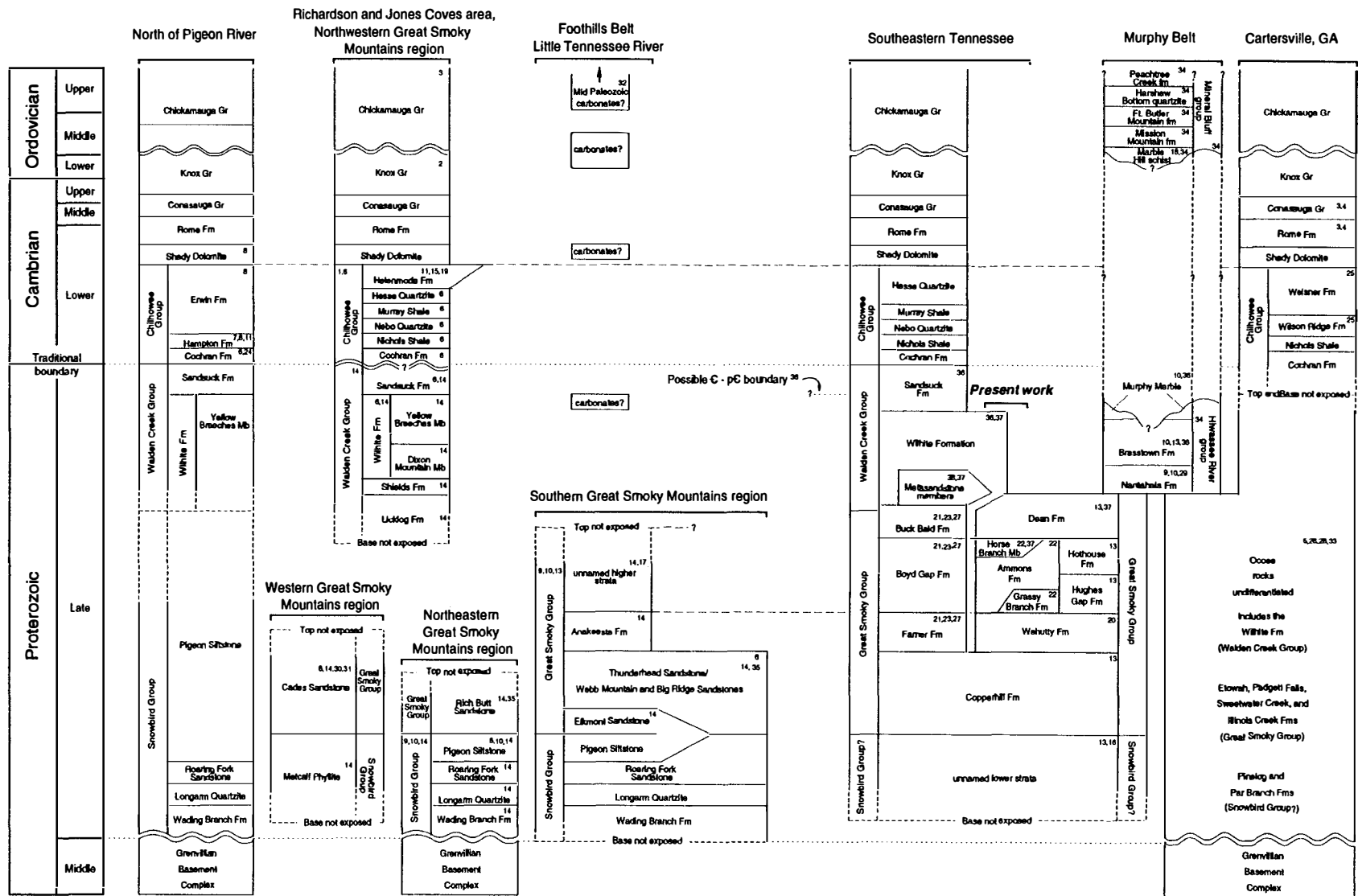
Figure II-1. Stratigraphic relationships of the Ocoee Supergroup and overlying Paleozoic units.

Number key indicates author(s) and contributor(s) who defined the stratigraphic unit.

No thicknesses or time durations are indicated by individual block size.

Modified from Carter (1994).

Number key index: 1-Safford (1856); 2-Safford (1869); 3-Hayes (1891); 4-Walcott (1891);
5-Hayes (1895, 1900); 6-Keith (1895); 7-Campbell (1899); 8-Keith (1903); 9-Keith (1904);
10-Keith (1907); 11-King and others (1944); 12-King (1949); 13-Hurst(1955);
14-King and others (1958); 15-King and Furguson (1960); 16-Hurst and Schlee (1962);
17-King (1964); 18-Fairly (1965); 19-Neuman and Nelson (1965); 20-Hernon (1968);
21-Merschhat and Wiener (1973); 22-Mohr (1973); 23-Wiener and Merschhat (1978);
24-Keller (1980); 25-Mack (1980); 26-McConnell and Costello (1980, 1982, 1984);
27-Wiener and Merschhat (1981); 28-Costello and others (1982); 29-Ausburn (1983);
30-Walters and Woodward (1987); 31-Lewis (1988); 32-Unrug and Unrug (1990);
33-Costello (1991); 34-Tull and others (1991); 35-Woodward and others (1991);
36-Carter (1994); 37-present study.



construct a partially complete stratigraphy by employing correlation across faults, but others (King and others, 1958; Hamilton, 1961; Unrug and Unrug, 1990) have suggested that formations in the hanging walls are not necessarily correlative with similar units in the footwalls. The following section describes units of the Ocoee Supergroup, as defined by various investigators, and includes regional correlations proposed in this report.

Snowbird Group

The basal unit of the Ocoee Supergroup is the Snowbird Group, which lies nonconformably on Middle Proterozoic (Grenvillian) granite and gneiss (Keith, 1907; Stose and Stose, 1949; King and others, 1958) (Figs. I-2, II-1). The Snowbird has a maximum thickness of approximately 4,000 m to 5,500 m (13,000 ft to 17,000 ft), and consists of both clean and feldspathic metasandstone, metasilstone, and phyllite. It both pinches out and is truncated by faults southeast of the Great Smoky Mountains (King and others, 1958; Hadley and Goldsmith, 1963) where it is conformably overlain by the Great Smoky Group (King and others, 1958) (Figs. I-2, II-1). Northeast of the Great Smoky Mountains, Keller (1980) demonstrated that the Snowbird is conformably overlain by the Walden Creek Group, a stratigraphic relationship also observed in a succession of rocks lying above Grenville basement in northwestern Georgia (McConnell and Costello, 1984) (Figs. I-2, II-1). In the southwestern Great Smoky Mountains, Neuman and Nelson (1965) mapped Snowbird lithologies in stratigraphic contact with the Cades Sandstone, one of the unclassified formations of their stratigraphic hierarchy (Fig. II-1). Several workers have correlated the large body of fine-grained rocks underlying most of the present study area (Figs. I-2, I-3; Plate I) with the Snowbird Group (Wiener and Mersch, 1978; Mersch and Hale, 1983; Wiener and Mersch, 1992).

Great Smoky Group

The thickest unit in the Ocoee Supergroup is the Great Smoky Group, estimated to be at least 8,000 m (25,000 ft) thick in the Great Smoky Mountains region (King and others, 1958; Hadley and Goldsmith, 1963; King, 1964). Its outcrop belt comprises most of the western Blue Ridge, extending 240 km (150 mi) from the Pigeon River southwestward into northwestern Georgia, and eastward at least 65 km (40 mi) from the Great Smoky Mountains and Foothills belt into northeastern Georgia and southwestern North Carolina (Fig. I-2). There it is exposed in the Brasstown Bald and Shooting Creek windows beneath the Hayesville thrust sheet (Hopson and others, 1989) (Fig. I-2).

In the Great Smoky Mountains National Park, the Great Smoky Group conformably overlies the Snowbird Group and in places is faulted over Grenville basement (King and others, 1958; King, 1964) (Fig. I-2). Eastward, the Great Smoky Group is conformably overlain by Murphy belt lithologies (Hurst, 1955; Tull and others, 1991), and to the southwest of the Great Smoky Mountains the Great Smoky Group is conformably succeeded by the Walden Creek Group (Hale, 1970, 1974; Costello and Hatcher, 1986, 1991; Carter, 1994; present study) (Figs. I-2, II-1; Plate I).

Great Smoky Group lithologies are diverse and consist primarily of repetitively interbedded, fine- to coarse-grained metagraywacke and metasandstone, granule to pebble metaconglomerate, and dark metasiltstone and slate (Hurst, 1955; King and others, 1958; King, 1964; Hernon, 1968; Mohr, 1973). Formations are distinguished by the relative abundances of lithologies. The metaconglomerate is generally just a coarser facies of the metagraywacke, and graded bedding and poor sorting are ubiquitous in these coarser-grained lithologies.

Copperhill Formation

Hurst (1955) described the Copperhill Formation as the lowest unit in the Great Smoky Group south of the Little Tennessee River (Fig. II-1). It is a coarse-grained unit composed

principally of metagraywacke interbedded with mica schist and minor bodies of metaconglomerate, metaquartzite, and metaarkose. He also described an unnamed unit lying stratigraphically below the Copperhill as a staurolite-mica schist of undetermined thickness and extent. Structural complexity and paucity of distinctive horizons precluded an accurate measurement of the Copperhill, but Hurst (1955) estimated its thickness in the Ducktown, Tennessee vicinity at 600 m to 1,525 m (2,000 ft to 5,000 ft).

Mohr (1973) correlated Hurst's (1955) Copperhill Formation with the Anakeesta Formation of King and others (1958) with his work in the Fontana Lake region of western North Carolina (Fig. II-1). Mohr described this unit as the most lithologically heterogeneous of the Ocoee Supergroup, consisting predominantly of black schist (which defines the unit), with abundant lighter-colored laminated schist, feldspathic metagraywacke, light gray quartz-muscovite schist, and less-abundant matrix-poor metaconglomerate. According to Mohr (1973), the formation has pronounced lateral variation of lithologies, but is divisible into five mappable units. The lower, middle, and upper units are black schist, while feldspathic metagraywacke makes up most of the other two units. Defining the Anakeesta in this manner, the lower unnamed schist unit of Hurst (1955) could be correlative with the middle black schist unit described by Mohr (1973). Hurst's (1955) Copperhill Formation is then correlative with the uppermost metagraywacke unit of Mohr (1973), with Mohr's upper black schist pinching out to the northwest of Hurst's field area. Mohr (1973), however, did not account for the work of Hernon (1968), who mapped in the same vicinity as Hurst (1955). Hernon was able to map a unit of principally silty and argillaceous rocks above the coarser-grained Copperhill Formation (Hernon, 1968) and he named this unit the Wehutty Formation (see next section). The Copperhill Formation is lithologically more like the Thunderhead Sandstone of King and others (1958), while the Anakeesta Formation of King and others (1958) and Mohr (1973) is lithologically similar to the Wehutty. It is therefore more logical to correlate the Copperhill Formation with the Thunderhead Sandstone, and the Wehutty Formation with the Anakeesta

(Fig. II-1). The Thunderhead is 1,800 m to 3,000 m (5,900 ft to 9,800 ft) thick in the Great Smoky Mountains. Mohr (1973) estimated the Anakeesta Formation at 1,200 m (3,900 ft) thick, approximately the same thickness as Hernon's (1968) estimate for the Wehuty.

Wehuty Formation

Hernon (1968) defined the Wehuty Formation in the Ducktown, Tennessee region (Fig. II-1) as a dominantly graphitic and sulfidic schist with alternating amounts of feldspathic metagraywacke, feldspathic quartzite, and metaconglomerate. This unit is equivalent to the upper portion of Hurst's (1955) Copperhill Formation and is generally conformable with it except where local faulting has displaced the contact. The Anakeesta Formation of King and others (1958) and Mohr (1973), and the Farnet Formation of Merschat and Wiener (1973) and Wiener and Merschat (1981, 1992) are northern and western equivalents, respectively. Hernon (1968) estimated a minimum thickness of the Wehuty to be 1,200 m (4,000 ft), but postulated that it may be up to 2,400 m (8,000 ft) thick. The Wehuty may thin to 750 m (2,500 ft) or less toward the northwest (Hernon, 1968; Merschat and Hale, 1983).

Hernon (1968) described the Wehuty Formation as greater than 50 percent light gray to black argillaceous or silty metasedimentary rocks, with metaconglomerate interbedded throughout the unit. The conglomeratic beds in the lower half are compositionally similar to his lower metagraywacke unit, while the upper quartz-pebble metaconglomerate is more abundant in, and more characteristic of, the overlying Hughes Gap Formation (Hernon, 1968).

Grassy Branch Formation

The Grassy Branch Formation (Mohr, 1973) stratigraphically overlies the Wehuty Formation and is equivalent to the Hughes Gap Formation of Hurst (1955) and Hernon (1968), and to the lower part of the Boyd Gap Formation of Merschat and Wiener (1973) and Wiener and Merschat (1978, 1981, 1992) (Fig. II-1). In the Fontana Lake, North Carolina region, Mohr

(1973) described the Grassy Branch Formation as consisting of predominantly feldspathic metagraywacke, quartz-pebble metaconglomerate and laminated schist. The Hughes Gap is generally finer-grained, with schistose units comprising more of the formation than metaconglomerate (Hurst, 1955; Hernon, 1968). Mohr (1973) estimated the thickness of this unit to be 100 m to 300 m (330 ft to 980 ft), while Hurst (1955) and Hernon (1968) estimated at least 1,200 m to 1,800 m (4,000 ft to 6,000 ft) of Hughes Gap, barring any major structural repetition. These workers noted, however, that substantial changes in thickness and lithology are common along strike within this unit. These units were not recognized in the present study area.

Ammons Formation

The Ammons Formation (Mohr, 1973) conformably overlies the Grassy Branch Formation, and is stratigraphically equivalent to the Hothouse Formation of Hurst (1955) and Hernon (1968), and to the upper part of the Boyd Gap Formation of Merschat and Wiener (1973) and Wiener and Merschat (1978, 1981, 1992) (Fig. II-1). Near Fontana Lake, North Carolina, the Ammons Formation consists of fine- to medium-grained feldspathic metagraywacke, dark metasiltstone, quartz-mica schist, and rare metaconglomerate, with a distinctive sulfidic and graphitic unit at the top of the formation named the Horse Branch Member (Mohr, 1973; Ausburn, 1983). Hurst (1955) described the Hothouse Formation as composed principally of interbedded metagraywacke and mica schist, with lesser amounts of metaconglomerate and quartzite. The Ammons is estimated to be 1,200 m to 1,500 m (3,900 ft to 4,900 ft) thick near Fontana Lake (Mohr, 1973), and the Hothouse is estimated to be 2,440 m to 3,350 m (8,000 ft to 11,000 ft) thick near Ducktown (Hurst, 1955).

Horse Branch (?) Member

The lowest stratigraphic unit in the present study area is tentatively correlated with the Horse Branch Member of the Ammons Formation (Figs. II-1, II-2). It is exposed along the southeastern boundary of the study area and in the core of the Rafter anticline (Fig. II-3; Plate I). This unit is equivalent to Units 9 and 10 of Lesure and others (1977) and to Unit V of Slack and others (1984) and is conformably overlain by the lower conglomerate of the Dean Formation (Figs. II-2, II-3; Plate I). In the southern exposure belt, the lithologies include medium gray to black, sulfidic and variably graphitic, medium- to very coarse-grained metagraywacke and interlayered dark gray to black sulfidic and graphitic slate and banded metasiltstone (Fig. II-2). The metagraywacke occurs in 0.1 m- to 1.0 m- (4 in to 3.3 ft) thick beds and contains prominent rutilated blue quartz clasts, as well as disseminated sulfides and up to 18 percent graphite (Fig. II-4; Appendix B). Near Eagle Gap and Hemlock Knob, Big Junction 7.5-minute quadrangle (Plate I), the slates and metasandstones are highly sulfidic, which imparts a green and yellow coating of secondary iron sulfate precipitate to the weathered roadcuts at that location. A minimum of 700 m (2,300 ft) of the Horse Branch is exposed in the southeastern portion of the study area, but the basal contact falls outside the study area boundary (Plate I). Excellent exposures of Horse Branch Member lithologies occur along Tennessee State Highway 165 (Tellico Plains–Robbinsville Highway), between Eagle Gap and Hemlock Knob, Big Junction 7.5-minute quadrangle (Plate I).

In the core of the Rafter anticline, and a smaller anticline on its southeastern flank, the Horse Branch Member is finer-grained and consists of dark gray to black, sulfidic and graphitic slate and banded metasiltstone, with minor beds of gray sulfidic quartzite 0.1 m to 1.0 m (4 in to 3.3 ft) thick. Primary depositional banding occurs in much of the metasiltstone, and consists of 0.5 cm to 1.5 cm bands of off-white to light brown, very fine-grained metagraywacke and feldspathic metasandstone, alternating with dark metasiltstone and silty slate. A sharp conformable contact exists between this slate unit and the overlying quartz-pebble

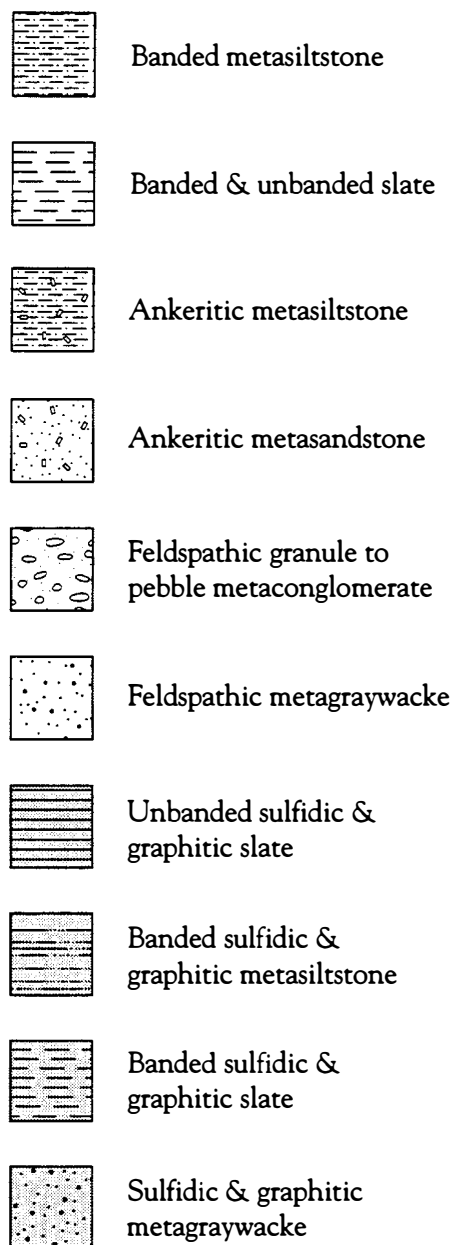
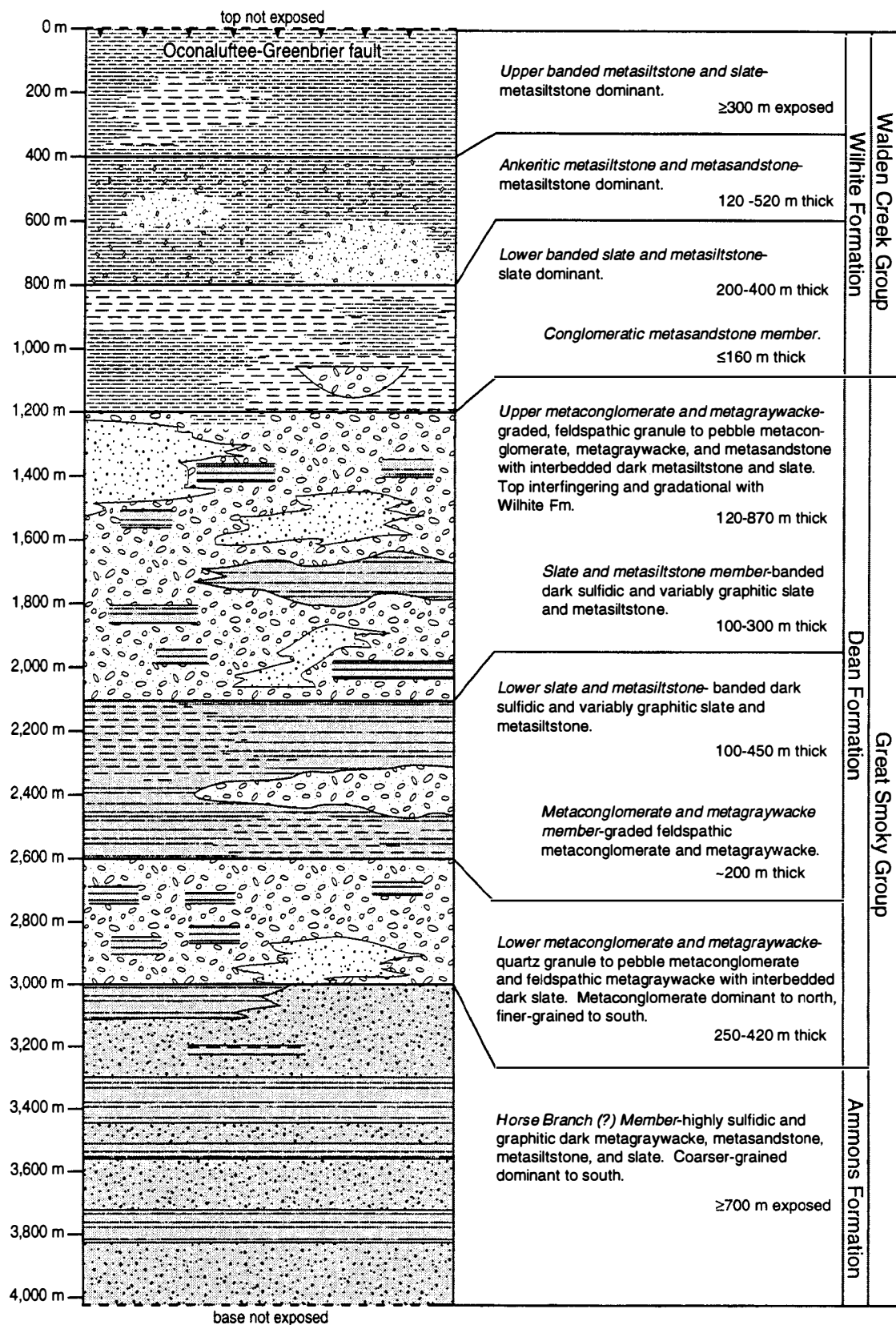


Figure II-2. Schematic tectonostratigraphic column for Great Smoky Group and Walden Creek Group rocks in the Oconaluftee-Greenbrier thrust sheet in the study area.



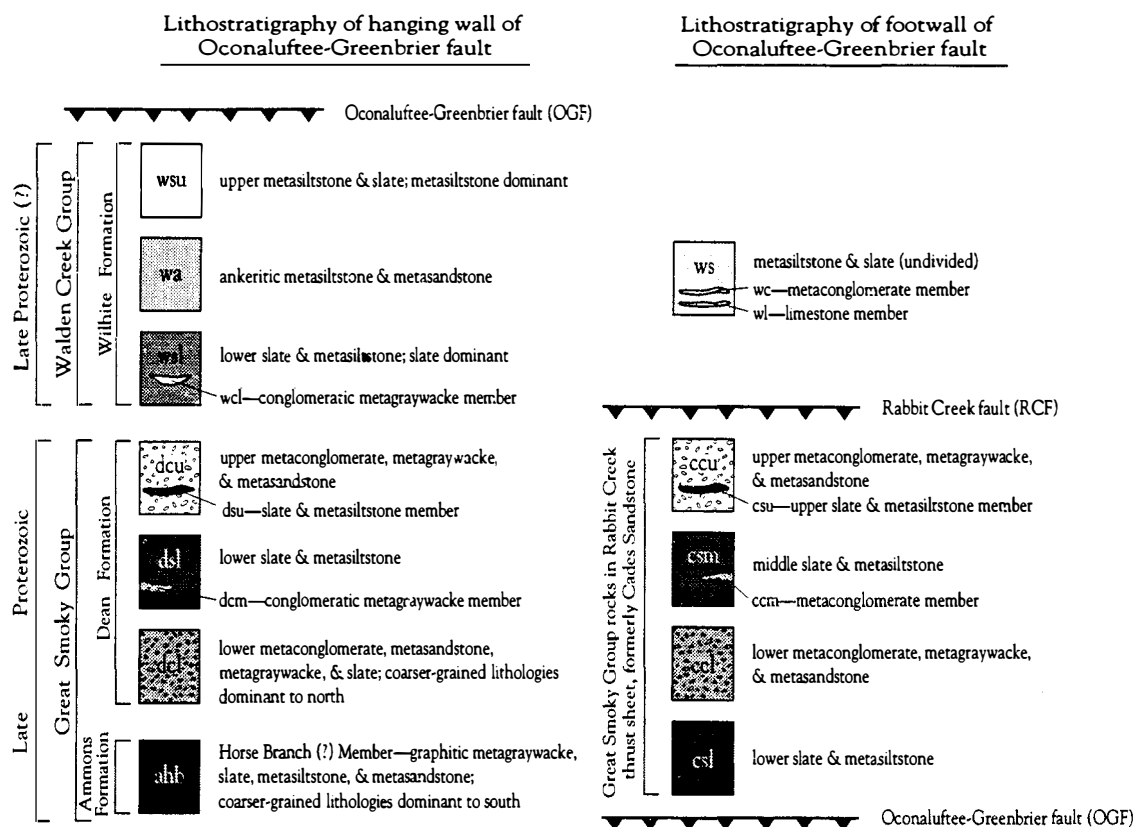


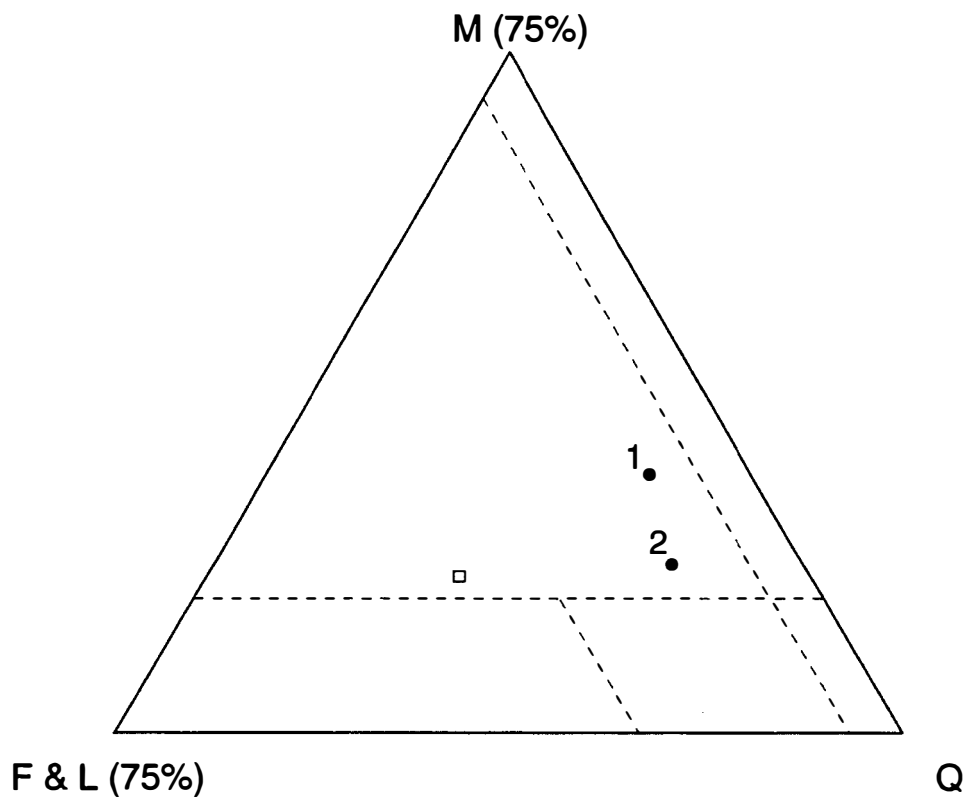
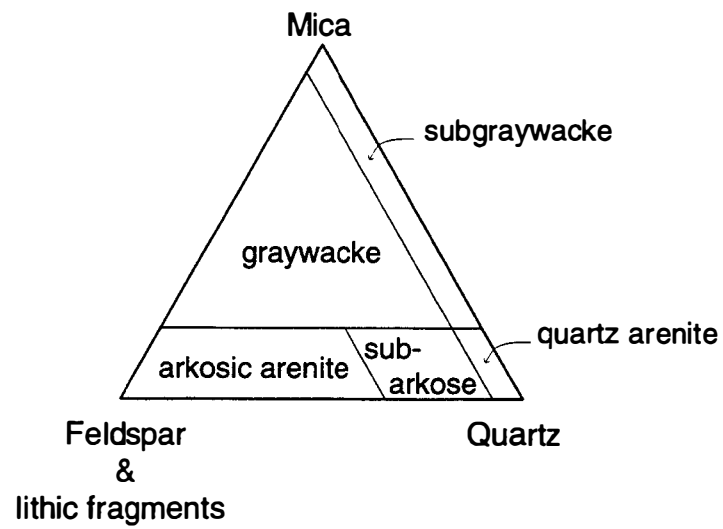
Figure II-3. Simplified geologic map and stratigraphic column of study area. See Plate I for detail. Cross-sections (Plate III) located along lines A-A' and B-B'.

Geologic abbreviations not included in explanation above: BBF—Barkcamp Branch fault; BMA—Blue Mountain anticline; CCMF—Cane Creek Mountain fault; ES—Epperson synclinorium; FCF—Flats Creek fault; HBS—Hampton Branch syncline; OCF—Oosterneck Creek fault; RA—Rafters anticline; WFS—Whiteoak Flats syncline.

Geographic abbreviations: CC—Citico Creek; R—Rafters.

Figure II-4. QMF diagram for coarse-grained rocks of the Horse Branch (?) Member of the Ammons Formation in the present study area (black circles) and in western North Carolina (white square). QMF diagram modified from Pettijohn (1949).

Number key: 1—Sample BRF 811; North River, Bald River Falls 7.5-minute quadrangle.
 2—Sample BJ 013; Hemlock Knob, Big Junction 7.5-minute quadrangle.



Explanation

- Horse Branch sandstones—this study
- Horse Branch sandstone—Ausburn (1983)

metaconglomerate and metagraywacke of the lower Dean Formation. A minimum of 100 m (330 ft) of the Horse Branch is present in the Rafter anticline, but the base of the unit is not exposed. The best exposures of the Horse Branch in the Rafter anticline are along U. S. Forest Service Road 36 (near the head of Tavern Branch) and along Citico Creek Road approximately 0.75 km (0.5 mi) south of the confluence of Tavern Branch and Citico Creek, Whiteoak Flats and Rafter 7.5-minute quadrangles (Plate I).

Dean Formation

The Dean Formation (Hurst, 1955; Hernon, 1968; Mohr, 1973) conformably overlies the Ammons Formation and is equivalent to the Buck Bald Formation of Merschat and Wiener (1973) and Wiener and Merschat (1978, 1981, 1992) (Fig. II-1). The Dean is the uppermost Great Smoky Group unit in southeastern Tennessee and western North Carolina. Hurst (1955) described this unit as dominantly staurolite-mica schist, cross-biotite schist, metaconglomerate, and quartzite. Mohr (1973) described subequal amounts of light gray, cross-biotite, laminated schist, and graded, feldspathic metagraywacke, with a distinctive horizon of quartz pebble metaconglomerate near the top of the unit. Most of the metagraywacke is coarse-grained to conglomeratic (Mohr, 1973). The thickness of the Dean in both regions was estimated to be 750 m to 1,000 m (2,500 ft to 3,500 ft) (Hurst, 1955; Mohr, 1973).

Rocks correlated with the Dean Formation are exposed in a strike belt along the southeastern edge of the map, in the Rafter anticline, and in several erosionally breached anticlines ("whalebacks") along the southwest and northeast edges of the map (Fig. II-3; Plate I). The lithologies are dominantly medium gray to grayish-green granule to pebble metaconglomerate, and medium gray to greenish-gray, medium- to coarse-grained, graded, feldspathic metagraywacke, with light to dark gray banded metasiltstone and dark gray to black slate comprising approximately 30 percent of the formation (Fig. II-2). None of the distinctive granitoid-boulder metaconglomerate mapped by Carter (1994) at the top of this unit was

observed in the present study area. The Dean Formation is divided into three map units in the present study area, and is estimated to be 470 m to 1,700 m (1,500 ft to 5,700 ft) thick.

Lower metaconglomerate and metagraywacke

Rocks of the lower unit of the Dean Formation lie conformably above the Horse Branch Member of the Ammons Formation. They are exposed in the Rafter anticline, and along the southeastern border of the field area (Fig. II-3; Plate I). In the Rafter anticline the lithologies are dominantly medium gray, thin- to thick-bedded, quartz-granule to pebble metaconglomerate and fine- to very coarse-grained metagraywacke (Fig. II-2). Clasts are generally composed of milky quartz, with lesser amounts of pale blue and smoky quartz, plagioclase and potassium feldspar, and dark slate or metasiltstone (Appendix B). Graded beds are very common, and horizons of dark slate or metasiltstone are present locally. In the southern exposure belt, this unit is generally finer-grained, with approximately equal proportions of interbedded, medium- to very coarse-grained metagraywacke and arkosic metasandstone, granule metaconglomerate, and dark metasiltstone or slate (Fig. II-2). Less than 5 percent of the outcrops in the lower unit are calcareous. The contact between the lower metaconglomerate of the Dean and the underlying Horse Branch (?) Member of the Ammons in this region was previously interpreted to be the Nichols Cove fault (Slack and others, 1984). Data gathered during the present study, however, indicates that the contact is gradational and conformable along most segments. The stratigraphic position above the Horse Branch Member enables the lower metaconglomerate to be correlated with Unit 3 of Lesure and others (1977) and Unit I of Slack and others (1984). The lower unit of the Dean Formation in the Rafter anticline is estimated to be approximately 250 m to 400 m (820 ft to 1,300 ft) thick, and the southern exposure is approximately 420 m (1,375 ft) thick (Plate I). Excellent exposures in the Rafter anticline are located along Citico Creek Road (Forest Service Road 35-1), from just north of the confluence of Burnt Station Branch and Citico Creek, southward to approximately 1.0 km (0.6 mi) south of the confluence

of Flats Creek and Citico Creek, Whiteoak Flats 7.5-minute quadrangle (Plate I). Good exposures in the southern portion of the study area can be observed along a stretch of Tellico River Road (Forest Service Road 210), between 1.2 km and 1.8 km (0.7 mi and 1.1 mi) west (downstream) of the confluence of North River and Tellico River, Bald River Falls 7.5-minute quadrangle (Plate I).

Lower slate and metasiltstone

Rocks of the lower slate unit of the Dean Formation are exposed in a belt along the southeastern edge of the study area, approximately 1.3 km (0.85 mi) northwest of the study area boundary, and in the north-central portion of the map area in the Rafter anticline (Fig. II-3; Plate I). In both locations, these rocks lie conformably above the lower metaconglomerate and metagraywacke of the Dean Formation. In the southern exposure belt, this unit consists of light to dark gray, banded sulfidic metasiltstone, and dark gray to black, sulfidic and variably graphitic slate, with one thick (200 m; 660 ft) intervening tongue of quartz granule to pebble metaconglomerate and fine- to coarse-grained, graded feldspathic metagraywacke (Fig. II-2; Plate I). This coarser-grained member is essentially the same as the overlying upper metaconglomerate and metagraywacke, but it pinches out to the northeast (Plate I). Northeastward along the southern exposure belt, and in the Rafter anticline, the upper unit is composed almost exclusively of dark slate and metasiltstone, with only occasional beds of fine- to medium-grained metasandstone. The upper contact of the lower slate and metasiltstone unit is drawn at the uppermost occurrence of continuously mappable dark argillaceous bodies, or, when this does not exist, where higher percentages of the fine-grained lithologies occur. The lower slate and metasiltstone is 100 m to 450 m (330 ft to 1,500 ft) thick within the study area. Good exposures of the tongue of metagraywacke and metaconglomerate occur along Tellico River Road, 0.9 km to 1.5 km (0.6 mi to 0.9 mi) southeast (upstream) of Bald River Falls, Bald River Falls 7.5-minute quadrangle (Plate I). Good exposures of the more typical fine-grained facies of this unit

crop out along this same stretch of Tellico River, and along Citico Creek Road, 0.9 km (0.6 mi) northwest of Doublecamp Campground, Whiteoak Flats 7.5-minute quadrangle (Plate I).

Upper metaconglomerate and metagraywacke

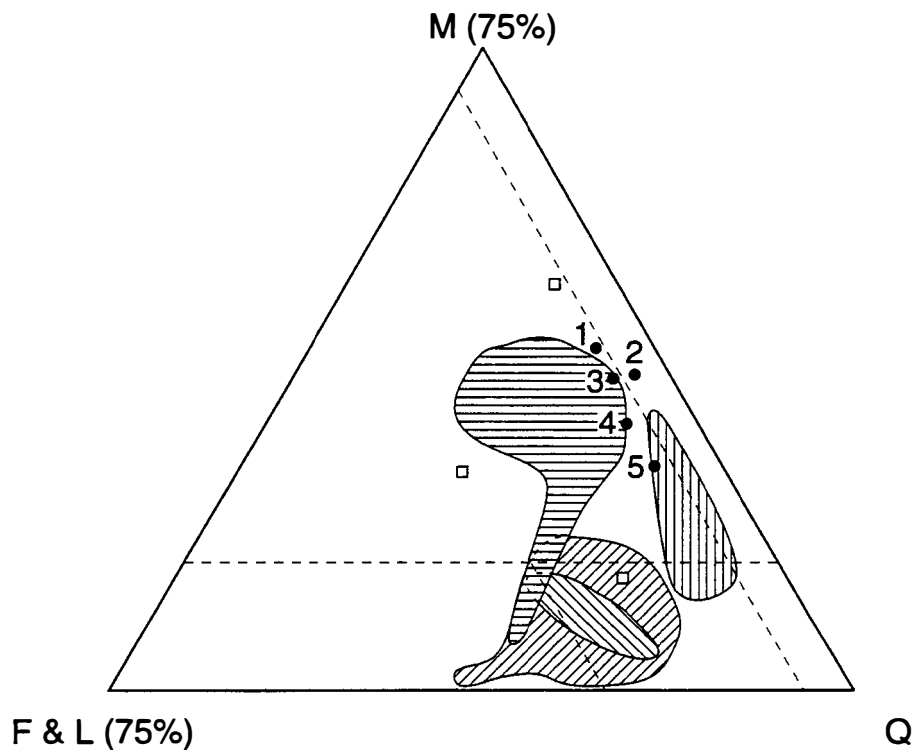
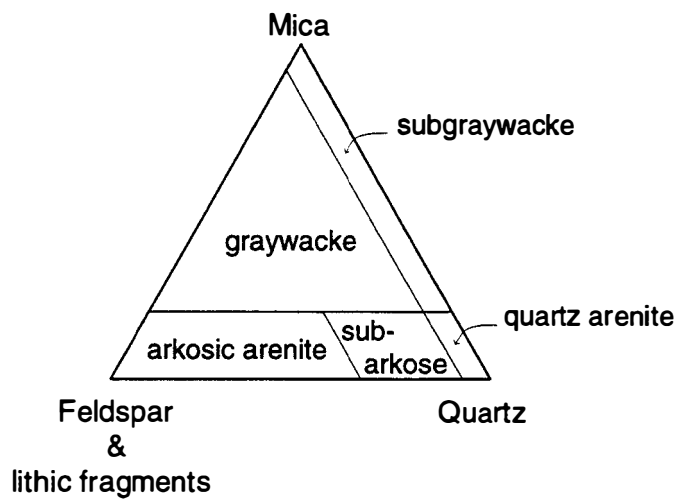
The upper unit of the Dean Formation lies conformably above the lower slate and metasiltstone unit, and is exposed along the southeastern study area boundary, in the Rafter anticline, and in several erosionally breached anticlines (“whalebacks”) along the northeast and southwest study area boundaries (Fig. II-3; Plate I). This unit is composed dominantly of granule to pebble metaconglomerate and feldspathic metagraywacke, but generally fines to the north and west, where fine- to coarse-grained feldspathic metagraywacke dominates and metaconglomerate is only sporadically interbedded. Approximately 10 to 12 percent of the outcrops in this unit are calcareous, but these are concentrated in the northern and western exposures and near the top of the unit. Clasts in the metagraywacke and metaconglomerate consist of subrounded white quartz and rutilated blue quartz grains, black slate chips of various sizes, and lesser amounts of subangular plagioclase and potassium feldspar grains in a chlorite-rich, sandstone matrix (Fig. II-5; Appendix B). Beds near the upper contact of the Dean commonly grade from metaconglomerate or metagraywacke near the base to fine-grained metasandstone or metasiltstone at the top, which is compositionally and texturally similar to the lower unit of the overlying Wilhite Formation. The upper metaconglomerate and metagraywacke has an estimated variable thickness of 120 m to 400 m (400 ft to 2,850 ft), and is vertically gradational into, and in places interfingers with, the overlying Wilhite Formation of the Walden Creek Group (Plate I).

One lens (or possibly a whaleback) of Dean-like lithology was mapped within the Wilhite Formation, on the north facing slope of Flats Mountain (see Wilhite conglomeratic metasandstone member section) (Fig. II-2; Plate I). The bedrock in Gold Branch, a tributary of Indian Boundary Lake that flows north off of Flats Mountain and intervenes between

Figure II-5. QMF diagram for coarse-grained rocks of the upper metaconglomerate unit of the Dean Formation in the present study area (black circles) and western North Carolina (white squares). Compositional fields from stratigraphically equivalent units (uppermost Great Smoky Group and Buck Bald Formation), and older Great Smoky Group units (Thunderhead Sandstone and Elkmont Sandstone) included for comparison. QMF diagram modified from Pettijohn (1949).

Number key:

- 1—Sample BRF 658; TN Hwy. 165 on Turkey Creek Mountain, Bald River Falls 7.5-minute quadrangle.
- 2—Sample BRF 688; confluence of Thrashing Branch and Tellico River, Bald River Falls 7.5-minute quadrangle.
- 3—Sample WOF 025; Flats Creek, Whiteoak Flats 7.5-minute quadrangle.
- 4—Sample RAF 202; unnamed creek west of Bivens Branch, Rafter 7.5-minute quadrangle.
- 5—Sample WOF 087; Citico Creek, Whiteoak Flats 7.5-minute quadrangle.



Explanation

- | | | |
|---|---|---------------------------------|
|  | Uppermost Great Smoky Group—Salisbury (1961) (n=10) | |
|  | Thunderhead Sandstone—King (1964) (n=12) | |
|  | Elkmont Sandstone—King (1964) (n=3) | ● Dean Formation—this study |
|  | Buck Bald Formation—Carter (1994) (n=3) | □ Dean Formation—Ausburn (1983) |

demonstrably Dean Formation beds to the west and the lens of lithologically similar Wilhite metasandstone to the east, is composed of rocks with characteristics of both formations. It is a banded, greenish-gray, coarse-grained metasilstone to medium-grained metasandstone, which is characteristic of the Wilhite Formation, but contains stringers, lenses, and thin beds of fine-grained metaconglomerate to blue quartz pebbly metasandstone that contains 0.5 percent tourmaline (Fig. II-6; Appendix B), which is characteristic of the Great Smoky Group (Hadley and Goldsmith, 1963). This is an important location to test the conformable relationship hypothesis, as it appears to exhibit the change in depositional environments. Excellent exposures of the upper metaconglomerate and metagraywacke of the Dean Formation can be observed at the Bald River Falls parking lot and trailhead, Bald River Falls 7.5-minute quadrangle (Plate I).

Slate and metasilstone member. Two long (> 4 km), thin (100 m to 300 m) bodies of light to dark gray, banded sulfidic metasilstone and dark gray to black, sulfidic and variably graphitic slate occur within the lower 330 m (1,100 ft) of the upper metaconglomerate of the Dean Formation in the southern portion of the map area (Figs. II-2, II-3; Plate I). These lenses are lithologically and texturally identical to the underlying lower slate and metasilstone unit.

Cades Sandstone and rocks in the Rabbit Creek thrust sheet

The Cades Sandstone has been an enigmatic unit since it was first mapped in the Cades Cove region of the southwestern Great Smoky Mountains National Park (King and others, 1958; Neuman and Nelson, 1965) (Fig. I-2). There, the Cades Sandstone comprises the hanging wall of the Rabbit Creek fault and the footwall of the Oconaluftee-Greenbrier fault, which prevented Neuman and Nelson (1965) from correlating it with any of the three groups of the Ocoee Supergroup. They tentatively correlated it with the Snowbird Group, but noted its compositional and textural similarity to Great Smoky Group rocks. More recent investigations

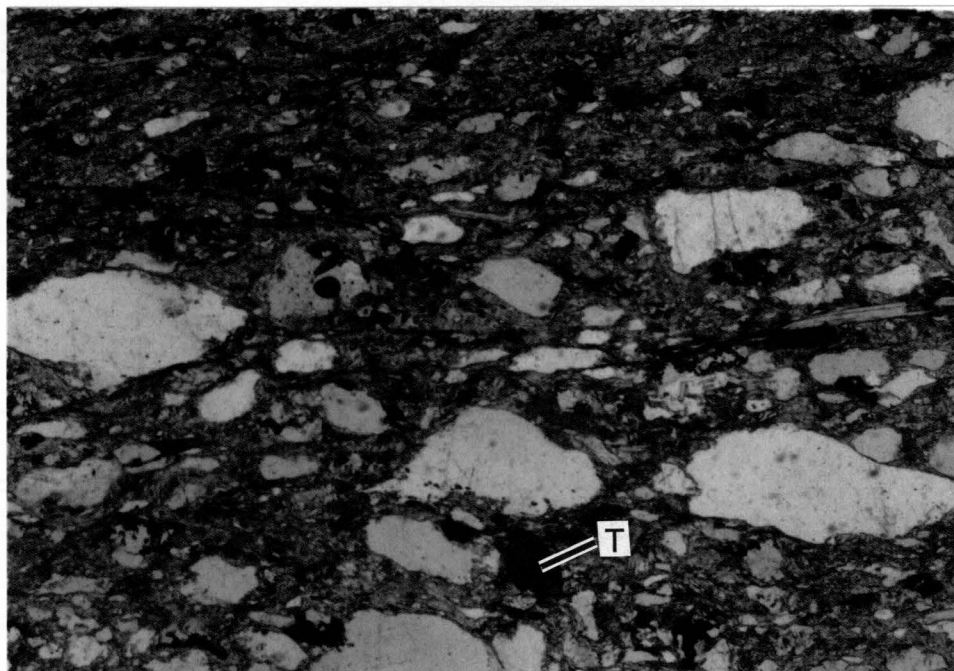


Figure II-6. Photomicrograph (plane light) of rocks near contact showing mixture of lithologies. Pebbly coarse-grained metasandstone (bottom) is typical of Dean Formation and metasiltstone (top) is typical of Wilhite Formation. Sample WOF 303; Gold Branch, Whiteoak Flats 7.5-minute quadrangle. T=tourmaline clast. Field of view is 7.0 mm.

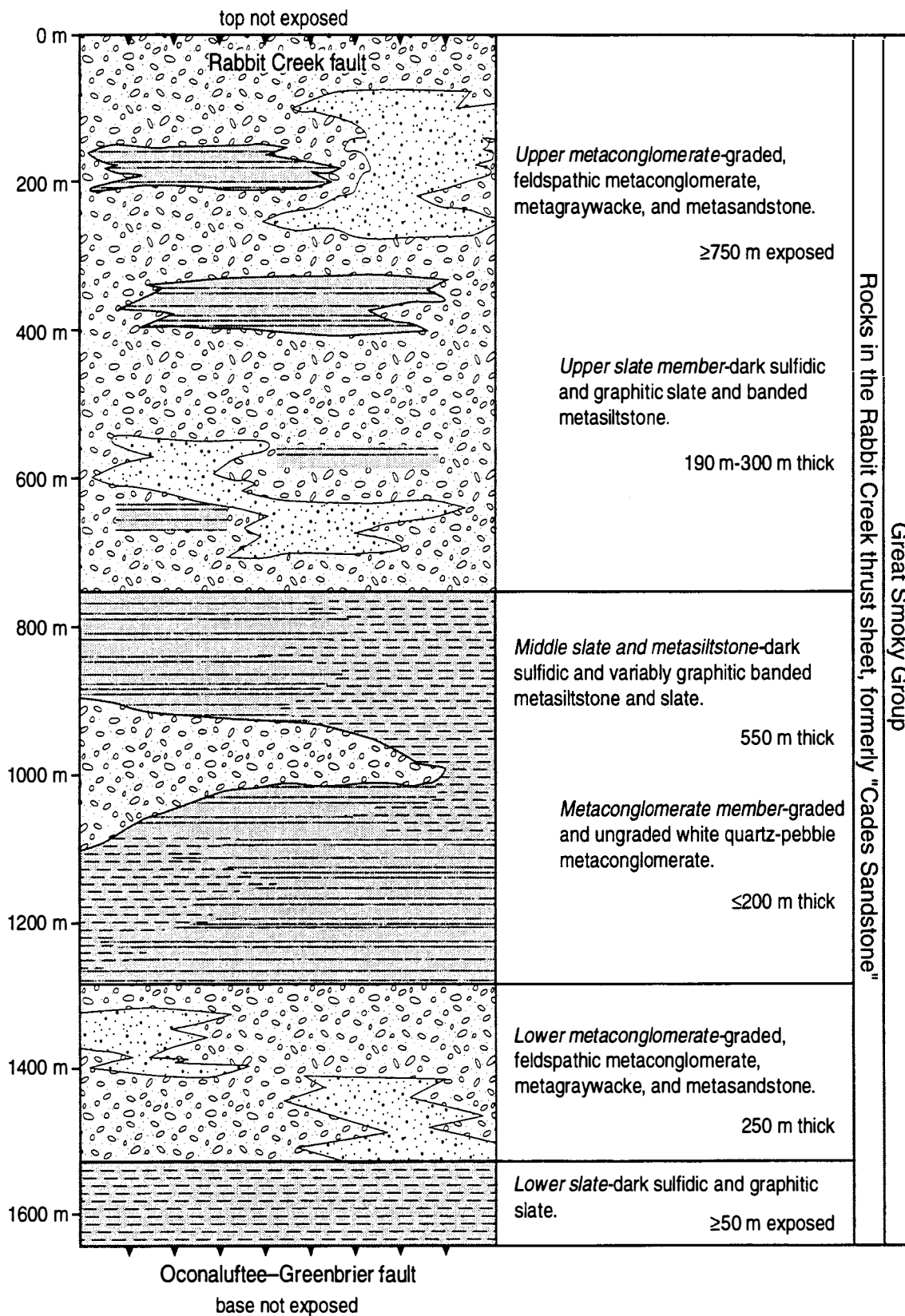
indicate that these rocks in the Rabbit Creek thrust sheet are equivalent to the Great Smoky Group (Lewis, 1988; Walters, 1988; Connelly and Woodward, 1991; Woodward and others, 1991; Connelly, 1993). Neuman and Nelson (1965) described the Cades Sandstone in the Great Smoky Mountains as dominantly dark gray, medium- to thick-bedded, medium- to coarse-grained, graded, feldspathic metagraywacke and granule metaconglomerate. These lithologies lack the distinctly blue quartz clasts observed in Great Smoky Group formations (Neuman and Nelson, 1965). Dark metasiltstone and slate is interbedded with the coarse-grained lithologies, and in some places forms mappable units (Neuman and Nelson, 1965). Neuman and Nelson (1965) did not estimate the total thickness of the Cades Sandstone, but reported up to 1,220 m (4,000 ft) of section in some areas.

On the East Sheet of the Geologic Map of Tennessee and on the Knoxville 2° sheet, G. D. Swingle (in Hardeman, 1966) and Hadley and Nelson (1971), respectively, chose to truncate the southern end of the Rabbit Creek thrust sheet, and therefore the exposure of Cades Sandstone, at the Oconaluftee fault to the north of the Little Tennessee River. Detailed mapping from the Little Tennessee southward (Wiener, unpub.), however, permitted Merschat and Wiener (1973) and Wiener and Merschat (1981, 1992) to trace the Rabbit Creek thrust sheet farther south to at least the Tellico River (Fig. I-2). Based on this work, rocks in the Rabbit Creek thrust sheet are interpreted to be exposed along the northwest edge of the study area and are divisible into three lithofacies: granule to pebble metaconglomerate; feldspathic metagraywacke; and dark gray to black banded metasiltstone and slate (Fig. II-7). The stratigraphic assemblage exposed in the Rabbit Creek thrust sheet in the study area is estimated to be approximately 1,600 m (5,200 ft) thick (Fig. II-7).

Metaconglomerate and metagraywacke

The dominant lithologies in the Rabbit Creek thrust sheet within the study area consist of medium gray, medium- to thickly-bedded, granule to pebble metaconglomerate and medium-

Figure II-7. Schematic tectonostratigraphic column for Great Smoky Group rocks in the Rabbit Creek thrust sheet within the study area. See Figure II-2 for explanation of lithologic symbols.



to very coarse-grained feldspathic metasubgraywacke and metagraywacke, commonly in graded beds. These lithofacies occur at two levels in the succession of rocks within the Rabbit Creek thrust sheet mapped in the study area (Figs. II-3, II-7; Plate I). They are essentially the same in both horizons, except the lower unit is thinner, somewhat finer-grained, shows a narrower range of grain size, and contains less interbedded slate than the upper unit. These lithologies are similar to Dean Formation metasediments, but are more commonly calcareous (approximately 15 percent of the outcrops). Clasts are composed dominantly of subrounded milky and smoky quartz, subangular plagioclase and potassium feldspar, and black slate and metasilstone (Fig. II-8; Appendix B). Rutiled blue quartz was observed at numerous localities, enhancing the affinity of these rocks for the Great Smoky Group. The lower metaconglomerate and metagraywacke is approximately 250 m (820 ft) thick and is exposed in the core of the Blue Mountain anticline, along Citico Creek Road 400 m (1,300 ft) south of the confluence of Barkcamp Branch and Citico Creek, Whiteoak Flats 7.5-minute quadrangle (Fig. II-3; Plate I). The upper metaconglomerate and metagraywacke unit is a minimum of 750 m (2,500 ft) thick, but the top is truncated by the Rabbit Creek fault. Excellent exposures of this unit are present along Ballplay Creek, between 300 m and 600 m (1,000 ft and 2,000 ft) southeast of Williamsburg Cemetery, Rafter 7.5-minute quadrangle (Plate I).

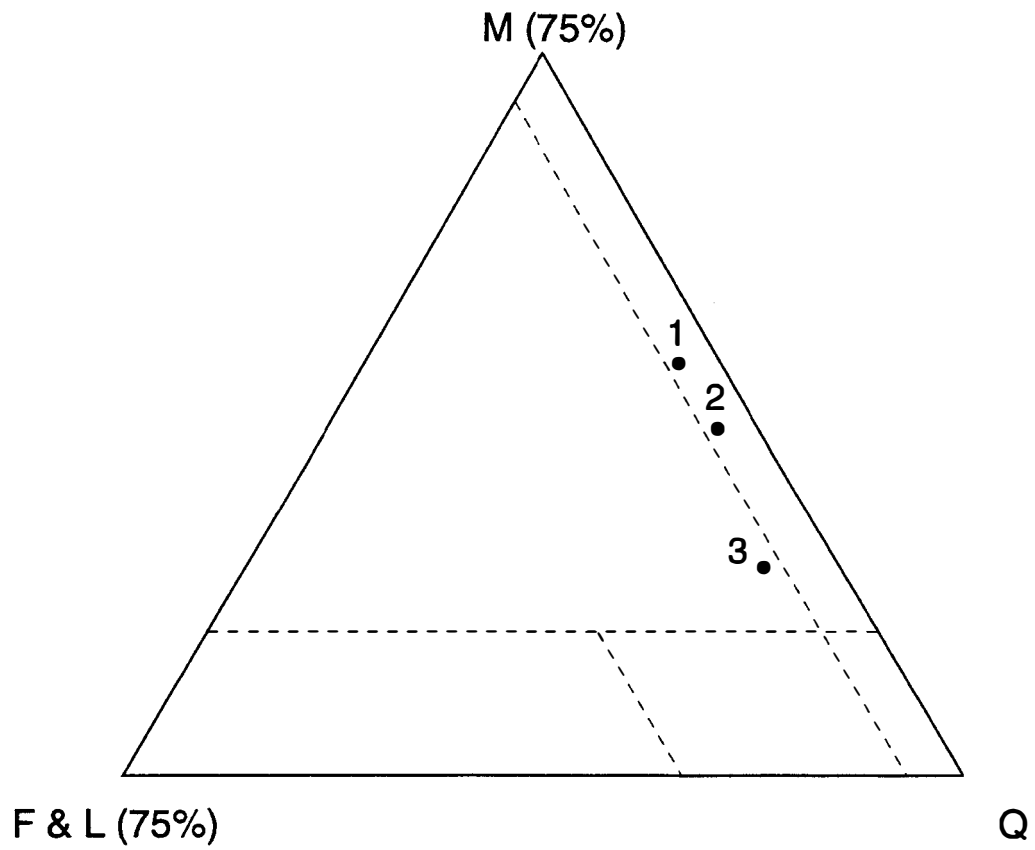
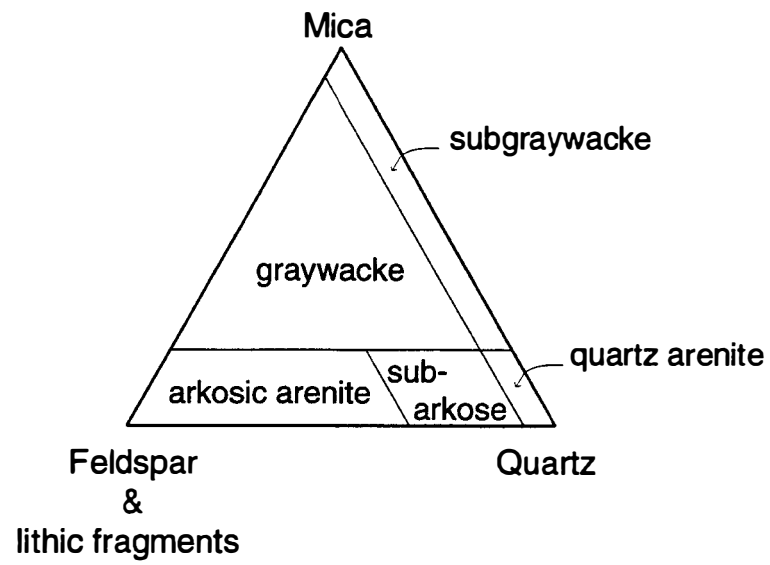
Metasilstone and slate

Dark gray to black, variably sulfidic and graphitic, banded metasilstone and slate makes up approximately 40 percent of the Rabbit Creek thrust sheet in the study area, and occurs at three levels in the succession (Figs. II-3, II-7; Plate I). These units are essentially the same as finer-grained lithologies found throughout the Great Smoky Group, except that primary banding is occasionally composed of alternating horizons of black silty slate and whitish to tan fine-grained sandstone. The slate and metasilstone is more heavily pressure-solved than most Great Smoky slate, a relationship also observed by Walters (1988). The lowest unit within the Rabbit

Figure II-8. QMF diagram for coarse-grained rocks in the Rabbit Creek thrust sheet within the study area. QMF diagram modified from Pettijohn (1949).

Number key:

- 1—Sample RAF 465; Smoky Run, Rafter 7.5-minute quadrangle.
- 2—Sample RAF 595; Lost Cove Branch, Rafter 7.5-minute quadrangle.
- 3—Sample RAF 792; Huckleberry Ridge, Rafter 7.5-minute quadrangle.



Creek thrust sheet mapped in the study area is a black slate in the core of the Blue Mountain anticline. It is well exposed only in the channel of Citico Creek, 650 m (2,100 ft) south of the confluence of Barkcamp Branch and Citico Creek, Whiteoak Flats 7.5-minute quadrangle (Plate I). Only the top 50 m (160 ft) of this unit is exposed. The middle slate unit is approximately 550 m (1,800 ft) thick, and contains more banded metasiltstone than the lower slate unit. Good exposures of this unit can be found along Citico Creek Road (Forest Service Road 35-1), 0.5 km (0.3 mi) north of the confluence of Citico Creek and Barkcamp Branch, Whiteoak Flats 7.5-minute quadrangle (Plate I). The upper slate unit occurs as mappable bodies within and above the upper metaconglomerate unit in the Rabbit Creek thrust sheet (Fig. II-3; Plate I). These units appear to be discontinuous lenses that interfinger with the surrounding metasandstone on their ends. Discrepancies in bedding measurements and highly contorted regions within these units, however, suggest that the geometry and distribution of these slate bodies may be controlled by unrecognized faulting or folding within the Rabbit Creek thrust sheet. The upper slate unit bodies range from approximately 190 m to 300 m (625 ft to 980 ft) thick. Excellent exposures of the upper slate unit can be observed along Rafter Road (Forest Service Road 2342) where it parallels Barum Creek, approximately 2.7 km (1.7 mi) west of Mount Isabel Church, Bald River Falls 7.5-minute quadrangle (Plate I).

Metaconglomerate member. Within the middle slate unit in the Rabbit Creek thrust sheet is one lensoidal horizon of medium gray, massive to medium-bedded pebble metaconglomerate (Figs. II-3, II-7; Plate I). Most of the clasts are composed of white quartz, but smoky quartz, black slate, and plagioclase and potassium feldspar are also present, set in a medium- to very coarse-grained sandy matrix. Blue quartz was not observed in this unit. The metaconglomerate member reaches a maximum thickness of approximately 200 m (660 ft), but the top of the thickest section is truncated by the Oconaluftee-Greenbrier fault. Good exposures can be found on

Citico Creek Road (Forest Service Road 35-1), 300 m (980 ft) north of Jake Best Campground, Whiteoak Flats 7.5-minute quadrangle (Plate I).

Relationships between rocks in the Rabbit Creek thrust sheet and other Great Smoky Group formations

Rock units in the Rabbit Creek thrust sheet are completely fault bounded and so have eluded placement within the stratigraphic hierarchy of the Ocoee Supergroup. King and others (1958) and Neuman and Nelson (1965) elevated the name “Cades” to formation status, and assigned rocks in the Rabbit Creek thrust sheet near Cades Cove in the Great Smoky Mountains National Park to the “Cades Sandstone.” Neuman and Nelson (1965) mapped these rocks in stratigraphic contact with the Metcalf Phyllite and tentatively correlated them with the Snowbird Group, but noted their resemblance to Great Smoky Group lithologies. Rast and Kohles (1986) followed the earlier interpretation and correlated these rocks with the Snowbird Group.

More recent investigations indicate that these rocks are equivalent to the Great Smoky Group (Lewis, 1988; Walters, 1988; Connelly and Woodward, 1991; Woodward and others, 1991; Connelly, 1993). Walters (1988) remapped the exposures of “Cades Sandstone” and Metcalf Phyllite on the west side of Cades Cove, and presented evidence that the contacts between the two are faulted rather than conformable. Cross section and strain analysis led Walters (1988) to interpret the rocks in the Rabbit Creek thrust sheet as correlative with the Elkmont Sandstone, the lowest formation in the Great Smoky Group in the Great Smoky Mountains (Fig. II-1). The Elkmont forms the hanging wall of the Oconaluftee-Greenbrier fault in the Cades Cove region. The Rabbit Creek thrust sheet forms the footwall of the Oconaluftee-Greenbrier fault and contains the overturned northwest limb of an anticline, whose hinge and opposing limb were truncated by faulting (Walters, 1988). Subsequent structural analyses by Connelly and Woodward (1991) and Woodward and others (1991) support those findings.

Walters (1988) noted slight variations in grain size and bedding characteristics between the Elkmont and rocks in the Rabbit Creek thrust sheet, but attributed these to a variation in distances from a common source. Carroll and others (1957) detected no significant differences between the heavy mineral suites of the "Cades Sandstone" and the Elkmont. Lewis (1988) interpreted the Elkmont Sandstone to be equivalent to the Thunderhead Sandstone, which King and others (1958) interpreted to lie stratigraphically above the Elkmont as part of the Great Smoky Group. The Thunderhead also forms part of the hanging wall of the Oconaluftee-Greenbrier fault in the vicinity of Cades Cove. The interpretations of Walters (1988) and Lewis (1988) correlate the rocks in the Rabbit Creek thrust sheet near Cades Cove with the oldest formations in the Great Smoky Group.

In the present study area, rocks in the Rabbit Creek thrust sheet are correlated with the Dean Formation, the youngest formation in the Great Smoky Group. This correlation is based primarily on lithologic and stratigraphic similarities across the Oconaluftee-Greenbrier fault. Rocks of the upper metaconglomerate and metagraywacke unit in the Rabbit Creek thrust sheet are nearly identical in composition, texture, and thickness to the upper metaconglomerate and metagraywacke of the Dean Formation in the Oconaluftee-Greenbrier thrust sheet (compare Figs. II-5 and II-8, and II-2 and II-7). The upper slate unit in the Rabbit Creek thrust sheet is also very similar to the upper slate and metasiltstone member of the Dean Formation. The middle slate unit and lower metaconglomerate unit in the Rabbit Creek thrust sheet are similar in character to the lower slate unit and lower metaconglomerate unit in the Dean Formation (compare Figs. II-2 and II-7), and the lower slate unit in the Rabbit Creek thrust sheet is similar in character to the exposure of the Horse Branch (?) Member in the Rafter anticline (Plate I). These observations suggest that units on opposite sides of the Oconaluftee-Greenbrier fault are equivalent.

Structural relationships across the Oconaluftee-Greenbrier fault support lithostratigraphic evidence. The Blue Mountain anticline is the dominant structure in the

Rabbit Creek thrust sheet in the present study area (Fig. II-3; Plate I). This structure is analogous to the Rafter anticline in the Oconaluftee-Greenbrier thrust sheet, and probably represents the faulted northwest limb of the Epperson synclinorium. Folds in both the Rabbit Creek and Oconaluftee-Greenbrier thrust sheets plunge southwest, which brings down successively younger units between the Great Smoky Mountains National Park and the present study area. The region between the Little Tennessee River and Citico Creek has not yet been mapped in detail, but the rocks in both thrust sheets in this intervening region are probably equivalent to the Ammons and Wehuttu Formations, the middle units in the Great Smoky Group stratigraphic assemblage. If the Blue Mountain anticline remains the dominant structure within the Rabbit Creek thrust sheet northeast of the present study area, the upright southeast limb and the axis would be truncated by the Oconaluftee-Greenbrier fault between Citico Creek and the Little Tennessee River, so that only the overturned northwest limb remains in the Great Smoky Mountains, as observed by Walters (1988). Using these relationships, I interpret the Rabbit Creek thrust sheet as a fault block comprised of all of the Great Smoky Group formations, rather than being comprised of a separate and distinct stratigraphic unit. I propose that the formation name "Cades Sandstone," then, should be abandoned.

Regional correlation of Great Smoky Group formations

Three lines of evidence indicate that Great Smoky Group rocks in the study area are equivalent to the Ammons and Dean Formations in the Murphy synclinorium stratigraphic assemblage. First, Great Smoky Group units in the present study area are, in general, lithostratigraphically similar to that suite of rocks found on the western limb of the Murphy synclinorium. Formation thicknesses, stratigraphic order, and bulk compositions of units in the present study area correlate well with the Ammons and Dean Formations to the east, but the specific compositions and textures of individual map units do not correlate as readily. For example, the Dean Formation is somewhat finer-grained to the east than it is in the present study

area, and is comprised principally of well-oxidized rocks that contain no graphite and few sulfides (Mohr, 1973). The fine-grained units assigned to the Dean in the present study area are commonly graphitic and sulfidic, and could actually represent a transitional lithofacies between the Ammons and Dean Formations. It is well established, however, that rocks of the Great Smoky Group display substantial changes in lithology, both laterally and vertically, even over short distances, which makes these discrepancies regionally insignificant.

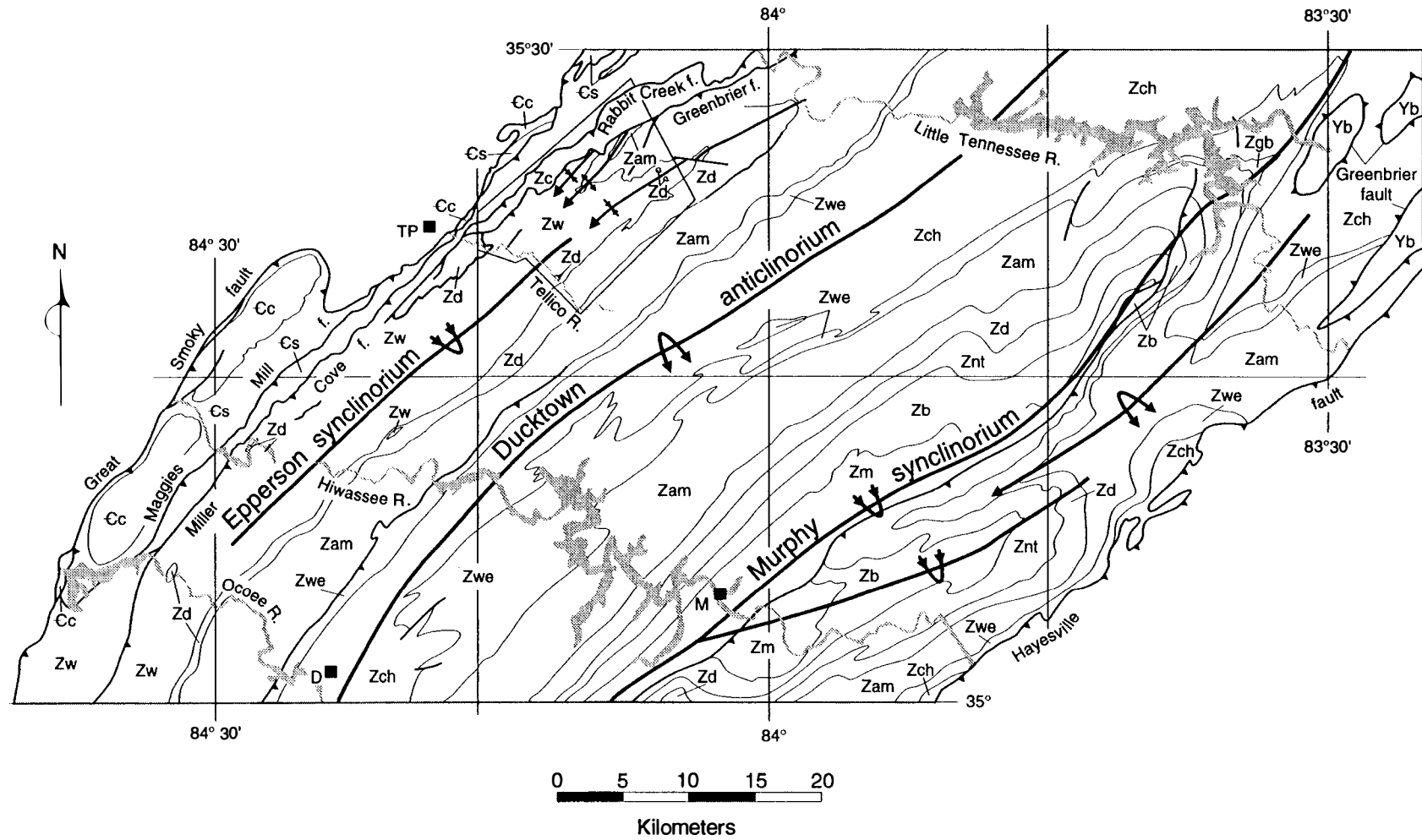
Secondly, Great Smoky Group formations in both regions are overlain by fine-grained rocks that are not part of the Great Smoky Group. The Dean Formation in the Murphy synclinorium is stratigraphically overlain by the Nantahala Formation, and rocks correlated with the Dean in the Epperson synclinorium are overlain by the Wilhite Formation. The Nantahala and Wilhite Formations are compositionally and texturally similar to one another, and are interpreted in this study to be equivalent.

The third line of evidence used to correlate Great Smoky Group units is similar stratigraphic position on opposing limbs of the Ducktown anticlinorium (Fig. II-9). Each formation was first described on the western limb of the Murphy synclinorium (the eastern limb of the Ducktown anticlinorium), and are exposed in the present study area on the eastern limb of the Epperson synclinorium (interpreted in this study to be the western limb of the Ducktown anticlinorium) (Fig. II-9). If no faults with significant displacement occur in the hinge zone of the Ducktown anticlinorium, this regional stratigraphic correlation is reasonable. No major faults have been recognized in the intervening region, but detailed mapping is not yet complete, so at present the Great Smoky Group rocks in the study area are interpreted as western equivalents of the Horse Branch Member of the Ammons Formation and the Dean Formation, correlated across the Ducktown anticlinorium. Detailed mapping of the Great Smoky Group rocks between the present study area and Ducktown, Tennessee should resolve any remaining discrepancies.

Figure II-9. Regional (1st-order) fold pattern of the western Blue Ridge in southeastern Tennessee and southwestern North Carolina, as related to correlation of units. Study area highlighted by gray box. Modified from compilation by Carter and others (1995a).

Geologic abbreviations: Cc—Chilhowee Group; Cs—Sandsuck Formation; Yb—Grenvillian basement; Zam—Ammons Formation; Zb—Brasstown Formation; Zc—rocks in Rabbit Creek thrust sheet, formerly Cades Sandstone; Zch—Copperhill Formation; Zd—Dean Formation; Zgb—Grassy Branch Formation; Zm—Murphy Marble; Znt—Nantahala and Tusquitee Formations; Zw—Wilhite Formation; Zwe—Wehutty Formation.

Geographic abbreviations: D—Ducktown; M—Murphy; T—Tellico Plains.



Contact between the Great Smoky Group and the Walden Creek Group

The contact between the Great Smoky Group (Dean Formation) and the overlying Walden Creek Group (Wilhite Formation) in the vicinity of the present study area has been variously interpreted as the southern extension of the Greenbrier fault (Merschhat and Wiener, 1973; Wiener and Merschhat, 1978, 1981; Merschhat and Hale, 1983; Wiener and Merschhat, 1992), as a conformable contact (Hardeman, 1966; Hale, 1974; Poppelreiter, 1980; Costello and Hatcher, 1986, 1991; Carter, 1994; this study), or as an unconformity (Tull and Groszos, 1988, 1990; Thompson and Tull, 1991; Tull and others, 1993; Carter and others, 1995b). Data gathered for the present study were evaluated for each of these interpretations to determine the nature of this contact. No evidence for a fault, such as truncated map units, gouge, small faults, or slickenlines, was observed along the contact in the study area. The data also do not support the interpretation of an unconformable relationship, since the contact is generally gradational, no units appear to be erosionally truncated, and no clasts of the Dean Formation were observed in the Wilhite Formation. The pronounced lithologic change across the contact and the extremely variable nature of the sediments beneath the Wilhite, however, could indicate that an unconformity is present between the Dean and Wilhite Formations. Hurst (1955) originally suggested that these latter observations could be evidence for an unconformity between the Dean Formation and Nantahala Formation, which lies stratigraphically above the Dean in the Murphy synclinorium and is interpreted in this study as a regional equivalent of the Wilhite Formation. Most of these observations imply that the contact is neither faulted nor unconformable.

I believe the strongest evidence points to a conformable contact between the Great Smoky and Walden Creek Groups. First, the contact is variably gradational, intertonguing, and sharp in the study area. Many of the beds in the uppermost Dean Formation grade from metaconglomerate or metasandstone at the base to banded metasilstone at the top, which is compositionally and texturally similar to the overlying Wilhite Formation, indicating a

gradational relationship. Also, banded metasiltstone correlated with the Wilhite Formation on the northwest slopes of Flats and Turkey Creek Mountains, Big Junction and Whiteoak Flats 7.5-minute quadrangles, is interpreted to be intertongued and interbedded with metaconglomerate and metagraywacke of the uppermost Dean Formation (Fig. II-10A; Plate I). Further, erosionally breached map-scale anticlines (whalebacks) along the Tellico River and Citico Creek northwest of the main contact expose upper Dean Formation lithologies in their cores, below banded metasiltstone and slate correlated with the Wilhite Formation (Plate I). Most of these whalebacks display a sharp contact between Dean and Wilhite lithologies (Fig. II-10B), but gradational relationships are also observed. Hurst and Schlee (1962) and Carter (1994) recognized similar anticlines along the Ocoee River and Hiwassee River, respectively.

Second, rocks assigned to the lowermost Walden Creek Group are similar to fine-grained rocks assigned to the upper Great Smoky Group. For the purposes of this study, the stratigraphic contact between the Great Smoky and Walden Creek Groups was drawn at the boundary between fine- and coarse-grained lithologies, because the greatest change in lithologies occurs across this boundary and there is a continuum of banded fine-grained rocks above this boundary. Rocks assigned to the lowermost Wilhite Formation are darker and more sulfidic than those in the middle and upper portions of the Wilhite. I believe this relationship strengthens the conformable contact interpretation, as it suggests a map-scale gradation from older formations to younger formations. Other workers would interpret darker sulfidic regions of the fine-grained lithologies to belong to the Dean Formation (C. E. Merschat, L. S. Wiener, pers. comm., 1995) because their reduced nature suggests an affinity for Great Smoky Group lithologies. These relationships between the uppermost Great Smoky Group and lowermost Walden Creek Group strongly suggest that the contact between the two units is stratigraphic and conformable.

Figure II-10. Contact relationships between Dean Formation and Wilhite Formation.

(A) Interbedded Dean (massive) and Wilhite (banded) lithologies along overturned portion of contact. Hammer handle (32 cm long) points to top of beds. Station BRF 790; Turkey Creek Mountain, Bald River Falls 7.5-minute quadrangle. (B) Sharp contact and slight channeling between the Dean Formation (thick-bedded) and Wilhite Formation (thin-bedded) on upright southeast limb of whaleback. Station WOF 088, Citico Creek, Whiteoak Flats 7.5-minute quadrangle. Hammer handle (32 cm long) points to top of beds.



(A)



(B)

Walden Creek Group

The Walden Creek Group is the youngest and most heterogeneous unit in the Ocoee Supergroup (King and others, 1958) . In the Great Smoky Mountains National Park, the Walden Creek Group consists of shale, siltstone, sandstone, conglomerate and carbonate (King and others, 1958; Hamilton, 1961; King, 1964) and was estimated to be 2,500 m (8,000 ft) thick. The Walden Creek Group lies conformably above the Snowbird Group in the Great Smoky Mountains (King and others, 1958), and lies conformably above the Great Smoky Group southwest of the park (Hale, 1974; Poppelreiter, 1980; Costello and Hatcher, 1986, 1991; Carter, 1994; this study) (Figs. I-2, II-1). Hamilton (1961) recognized a continuous sequence upward from lower Walden Creek Group strata (Wilhite Formation) through the Sandsuck Formation, thus placing Sandsuck at the top of the Walden Creek Group. Southwest of the Great Smoky Mountains, the Sandsuck lies conformably below the Chilhowee Group, but is separated from the lower Walden Creek Group (Wilhite Formation) by the Miller Cove fault (King, 1964; Neuman and Nelson, 1965; Carter, 1994) (Fig. I-2).

Shields Formation

The Shields Formation was interpreted by previous workers to be the lowest unit in the Walden Creek Group exposed in the study area (Wiener, unpub.). In the Great Smoky Mountains National Park, this unit is dominantly coarse-grained and consists of feldspathic ungraded sandstone, interbedded with seams or lenses of white quartz pebble conglomerate and minor shale, with shale becoming dominant in the upper part of the formation (King and others, 1958). On the Knoxville 2° sheet, Hadley and Nelson (1971) correlated Neuman and Nelson's (1965) coarse-grained part of the Wilhite Formation north of the Little Tennessee River and immediately northwest of the Rabbit Creek fault with the Shields Formation. This correlation was followed by Wiener (unpub.), for slate, metasandstone, and metaconglomerate he mapped between the Little Tennessee River and the Tellico River. As defined by Wiener (unpub.), the

upper portion of the Shields Formation crops out along the northwest edge of the present study area immediately northwest of the Rabbit Creek fault. This unit consists of purplish, tan, and buff-colored banded metasilstone and slate, with discontinuous lenses or channels of quartz pebble to boulder metaconglomerate and coarse-grained metasandstone, and rare mappable beds of black limestone and calcareous metasandstone (Plate I). According to Wiener (unpub.), the Shields Formation is conformably overlain by the Wilhite Formation in the northernmost corner of the study area. Black limestone is rare in the Wilhite, but it has been mapped in the lower member of the Sandsuck Formation (Carter, 1994), the Walden Creek Group unit interpreted to lie above the Wilhite. It was not present in the Shields Formation in the Great Smoky Mountains (Hadley and Goldsmith, 1963). Except for the presence of the limestones and coarser-grained lenses—which are not unknown in the Wilhite Formation—the slate and metasilstone assigned to the Shields Formation by Wiener (unpub.) is compositionally and texturally very similar to the Wilhite Formation, as defined in the present study, and is here mapped as Wilhite. These rocks could also belong to the lower member of the Sandsuck Formation.

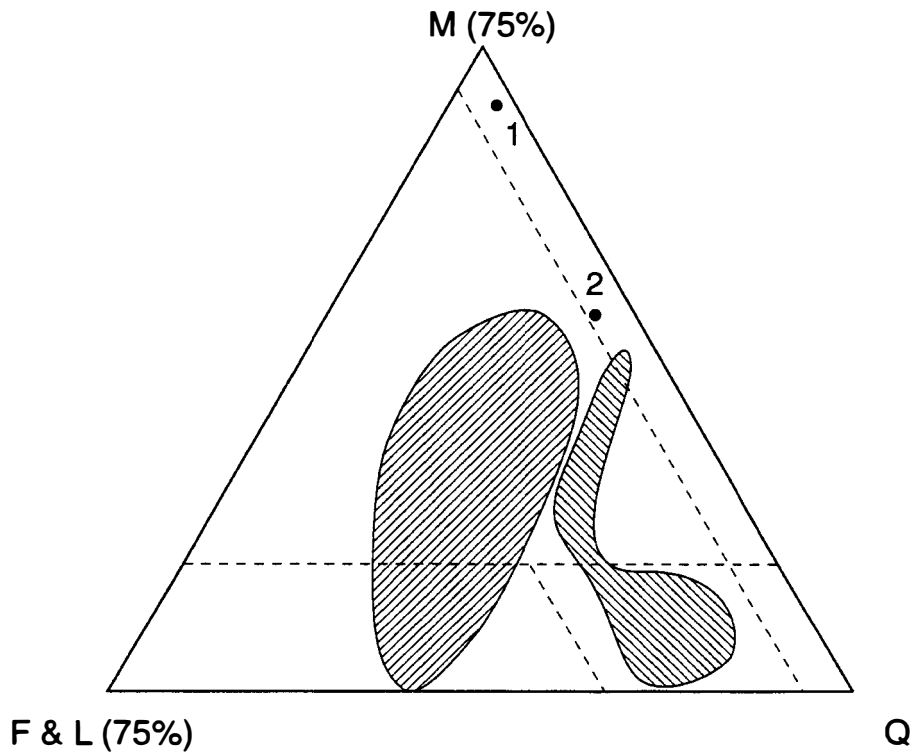
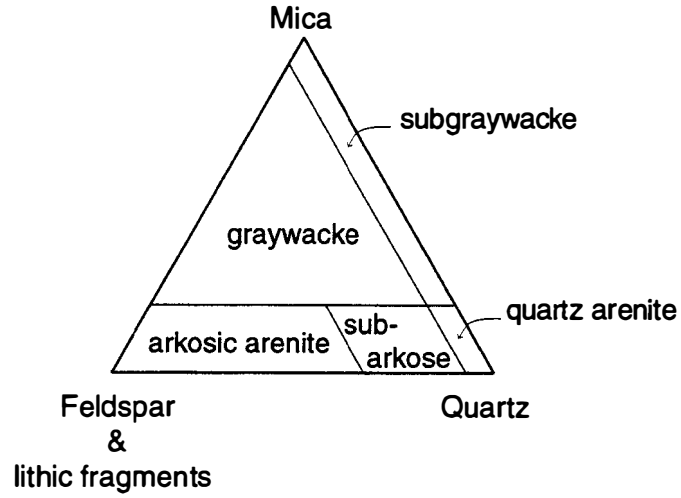
Wilhite Formation

Rocks assigned to the Wilhite Formation comprise most of the bedrock in the study area, and consist predominantly of metasilstone, phyllite, and slate with rare exposures of conglomeratic metasandstone (subgraywacke) (Figs. II-2, II-3, II-11; Plate I). These rocks have previously been interpreted to belong to the Snowbird Group (Mersch and Wiener, 1973; Wiener and Mersch, 1978, 1981; Mersch and Hale, 1983; Wiener and Mersch, 1992). Carter (1994) determined that the coarser-grained lithofacies—which is more prevalent to the south and rare in this study area—is compositionally more quartz-rich, less feldspathic, and less micaceous than coarse-grained rocks assigned to the Snowbird Group by King and others (1958) in the Great Smoky Mountains (Fig. II-11). For that reason, Carter (1994) assigned the rocks in this strike

Figure II-11. QMF diagram for coarse-grained rocks of the Wilhite Formation (Walden Creek Group) within the study area (black circles). Compositional fields from other Wilhite metasandstones (Carter, 1994), and Snowbird Group rocks (Hadley and Goldsmith, 1963; King, 1964) included for comparison. QMF diagram modified from Pettijohn (1949).

Number key: 1–Sample WOF 303*; Gold Branch on Flats Mountain, Whiteoak Flats 7.5-minute quadrangle.
2–Sample WOF 036; Footes Creek, Whiteoak Flats 7.5-minute quadrangle.

*Sample WOF 303 was collected near the Great Smoky/Walden Creek gradational contact. The high mica content may have been influenced by a large number of points counted in slaty metasilstone portion of sample rather than coarse-grained portion.



Explanation

-  Snowbird Group rocks—Hadley and Goldsmith (1963) and King (1964) (n=7)
-  Wilhite metasandstone—Carter (1994) (n=9)
- Wilhite metasandstones—this study

belt to the Wilhite Formation (Walden Creek Group), and that assignment is followed here. Rocks assigned to the Wilhite Formation in this study area are equivalent to the Dixon Mountain Member of the Wilhite Formation as mapped in the Great Smoky Mountains region (King and others, 1958; Hamilton, 1961) and to the Wilhite Formation of northwestern Georgia (McConnell and Costello, 1980, 1982, 1984) (Fig. II-1).

The outcrop belt of Wilhite Formation is finer-grained and lighter in color than Great Smoky Group units, and contains metasilstone, slate, phyllite, and very fine- to medium-grained metasandstone lithologies (Fig. II-2). Metasilstone, along with sandy metasilstone and silty fine-grained metasandstone, is the most common lithology in this formation, but locally phyllite, slate, or metasandstone dominate. Phyllite is more commonly associated with large quartz veins, which are common throughout the metasilstone. Some quartz veins in the metasilstone in this region, especially in the Coker Creek district 12 km (7.5 mi) to the southwest, are gold-bearing (Hale, 1974).

Structural complexity precludes an accurate calculation of the thickness of the Wilhite Formation. Estimates range from 300 m to 400 m (1,000 ft to 1,300 ft) (Laajoki, 1995) to greater than 1,200 m (4,000 ft) (Carter, 1994). Approximately 500 m to 800 m (1,600 ft to 2,600 ft) are preserved in the present study area.

Metasilstone

The Wilhite Formation is dominated by a very fine- to coarse-grained, light to dark gray to greenish- or bluish-gray to grayish-green, banded metasilstone lithofacies (Fig. II-2). This lithology is present throughout the Wilhite outcrop belt, but is dominant in the upper 300 m to 400 m (1,000 ft to 1,300 ft). Much of the metasilstone in the lower portion of the Wilhite is darker gray to black and more sulfidic than the upper portion, which reinforces the theory that the contact between the Dean and Wilhite Formations is gradational and conformable.

Primary depositional banding is very common and ranges from 0.1 cm to 4.0 cm thick. On large outcrops, individual bands can be traced up to tens of meters. Bedding is rhythmic and graded, with metasiltstone or very fine- to medium-grained metasandstone grading upward into finer-grained metasiltstone or clay- and mica-rich layers. The silt- and sand-sized particles are composed mainly of quartz, whereas the finer fraction is composed predominantly of recrystallized chlorite (Appendix B). Coarser-grained horizons are lighter colored than finer ones, giving the rock its banded or striped appearance. Pyrite cubes (or, where weathered, goethite pseudomorphs after pyrite), and rhombs of ankerite (or, where weathered, limonite pseudomorphs after ankerite) are locally abundant, comprising up to 30 percent of the rock. Commonly, horizons may contain higher percentages of carbonate minerals that turn reddish-brown or weather out completely, accentuating the striped appearance. Along ridge crests and on certain older roadcuts where the metasiltstone is more deeply weathered, the rock and soil is often a maroon to brick red color. Excellent exposures of the metasiltstone occur along Tellico River Road (Forest Service Road 210), from the intersection of Tennessee State Highway 165 and Forest Service Road 210, to approximately Bald River Falls, Bald River Falls 7.5-minute quadrangle (Plate I).

Slate

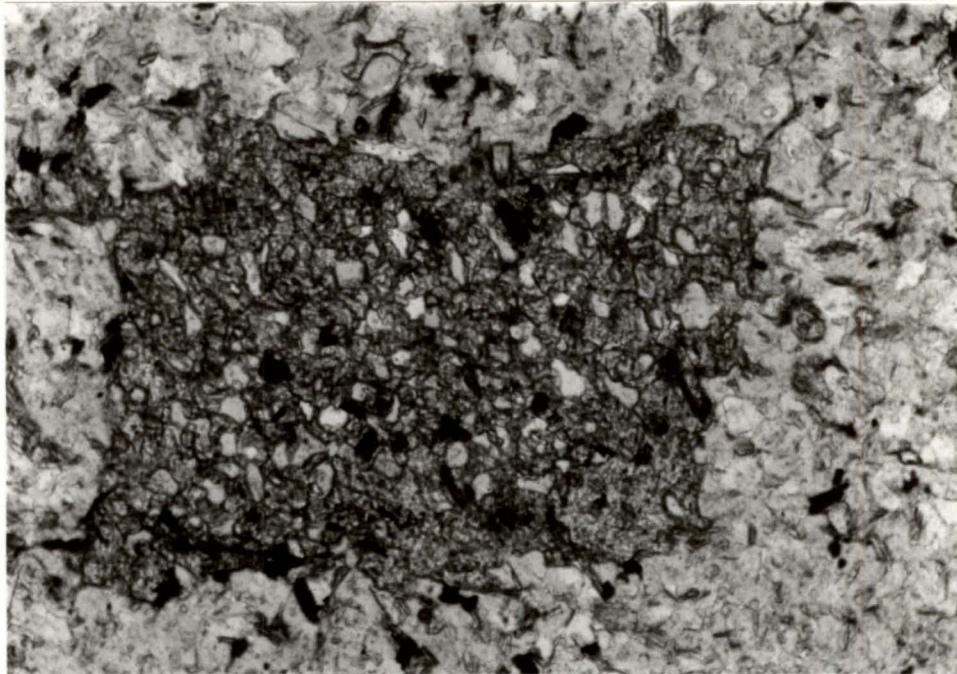
Bodies of medium to dark gray, to light greenish-gray slate and silty slate occur throughout the metasiltstone. This lithology generally lacks the prominent banding found in the metasiltstone. It is especially common in the lower 200 m to 400 m (650 ft to 1,300 ft) of the Wilhite Formation outcrop belt, where it dominates over the metasiltstone (Fig. II-2; Plate I). The slate is composed principally of clay, muscovite, and chlorite, commonly with fine-grained silt-size particles of quartz. Slate found in the lower Wilhite is darker, contains more pyrite (or, where weathered, goethite pseudomorphs after pyrite), and is higher in disseminated sulfides than the upper portions of the Wilhite. The deformation during which slaty cleavage developed

also deformed the pyrite cubes into rhombs whose long axes parallel the slaty cleavage. In the Ocoee River Gorge, Hurst and Schlee (1962) observed a dark gray to black pyritic slate above the Great Smoky Group that they correlated with the Nantahala Formation found in the Murphy belt to the east. Although the slate assigned to the lower Wilhite Formation in the present study area is slightly lighter colored, it is similar in composition, texture, and stratigraphic position to the slate in Ocoee Gorge. This implies that at least the lower portion of the Wilhite Formation may be correlative with the Nantahala Formation. Good exposures of the slate are present along Citico Creek Road (Forest Service Road 35-1) from Indian Boundary Campground to the old Citico Warden Station, Whiteoak Flats 7.5-minute quadrangle (Plate I).

Ankeritic metasiltstone

A mappable zone of metasiltstone that contains accessory ankerite $\{Ca (Mg, Fe^{+2}, Mn) (CO_3)_2$ (Deer and others, 1962)} occupies a stratigraphic position 200 m to 400 m (650 ft to 1,300 ft) above the base of the Wilhite Formation (400 ft to 2,500 ft map distance) (Figs. II-2, II-3; Plate I). Ankerite was observed throughout the study area, but is especially prevalent and recognizable in this map unit (Fig. II-12). This zone is 120 m to 520 m (400 ft to 1,700 ft) thick and often coarsens to a fine- to medium-grained metasandstone. Where fresh, the ankerite occurs as pink to tan irregularly shaped aggregates and anhedral to euhedral rhombs up to 2.5 mm in size (Fig. II-12A), but it is more commonly weathered and found as limonite pseudomorphs (Fig. II-12B) or as weathered-out voids. Like pyrite, the ankerite was deformed during slaty cleavage development, which both accentuated its rhombohedral shape or flattened it into more cubic morphologies depending on its initial orientation relative to regional stress. Hale (1974) noted that in specimens containing ankerite, the carbonate occurred only in rhombs or aggregates and that no carbonate was present in the groundmass. He also noted that the ankerite contains abundant, regularly distributed, well-rounded opaque and nonopaque

Figure II-12. Characteristics of ankerite and ankeritic metasiltstone. (A) Photomicrograph (plane light) of fresh ankerite from ankeritic metasiltstone portion of Wilhite Formation showing inclusions of quartz and opaque grains. Sample BRF 493; Tellico River, Bald River Falls 7.5-minute quadrangle. Field of view is 3.0 mm. (B) Ankeritic metasiltstone sample containing approximately 20 percent limonite pseudomorphs after ankerite (rust-colored specks 1 mm in size). Sample WOF 252; north of Indian Boundary Lake, Whiteoak Flats 7.5-minute quadrangle.



(A)



(B)

mineral inclusions that have the same composition as those in the groundmass (Fig. II-12A), indicative of a diagenetic origin.

In hand sample, ankerite generally makes up 5 percent or less of the total rock mass, but has been observed to constitute up to 25 percent of the rock mass, especially within this unit (Fig. II-12B; Appendix B). Southwest of the study area, the ankerite-bearing zone disappears and reappears along strike, eventually decreasing in proportion to localized, very thin (< 5 m; 16 ft), discontinuous lenses on the Farner 7.5-minute quadrangle (Carter, 1994). Hurst and Schlee (1962), and Hale (1974) and Merschat and Hale (1983) reported similar occurrences of ankerite-bearing rocks along the Ocoee River and on the Farner 7.5-minute quadrangle, respectively. Excellent exposures of ankerite-bearing metasiltstone occur along a 500 m (1,640 ft) stretch of Tellico River Road (U. S. Forest Service Road 210), between 0.8 km and 1.3 km (0.5 mi and 0.8 mi) southeast of the confluence of Turkey Creek and Tellico River, Bald River Falls 7.5-minute quadrangle (Plate I).

Conglomeratic metasandstone member. At several locations in the study area, irregular discontinuous lenses of feldspathic metasandstone (subgraywacke) and metaconglomerate occur in the metasiltstone (Figs. II-2, II-3; Plate I). These bodies occur only in the lower 400 m (1,300 ft) of the Wilhite Formation and are very similar in composition and appearance to the underlying Dean Formation (compare Figs. II-5 and II-11). The unit consists of grayish-green granule to pebble metaconglomerate, medium- to very coarse-grained feldspathic metasandstone, and metagraywacke, generally in graded beds up to 2 m (6 ft) thick. It is composed of moderately to poorly sorted, subrounded to subangular quartz, plagioclase and potassium feldspar clasts set in a chlorite-rich sandstone matrix (Fig. II-11; Appendix B). Because these lenses lithologically resemble the Dean, and because of their stratigraphic occurrence and outcrop pattern, they are interpreted here to represent small pulses or slumps of Great Smoky Group sediments, after Wilhite sedimentation had begun. The metasandstone is equivalent to Unit IVa of Slack and

others (1984). The largest of these lenses is approximately 160 m (525 ft) thick by approximately 1.3 km (0.8 mi) long, and occurs on the northwest-facing slope of Flats Mountain, 1.2 km (0.75 mi) southeast of Indian Boundary Lake, Whiteoak Flats 7.5-minute quadrangle (Plate I).

Chapter III

STRUCTURAL GEOLOGY OF THE WESTERN BLUE RIDGE IN TENNESSEE BETWEEN TELlico RIVER AND CITICO CREEK

Introduction

Ocoee Supergroup rocks of the western Blue Ridge have undergone at least two periods of deformation, interpreted as having occurred during the Taconic orogeny (Ordovician) and the Alleghanian orogeny (Carboniferous–Permian). The earlier event was characterized by folding, faulting, cleavage development, and Barrovian metamorphism, and the later event was characterized by brittle folding and faulting (LaForge and Phalen, 1913; Gordon, 1920; Keith, 1927; Wilson, 1935; Hamilton, 1961; Hadley and Goldsmith, 1963; King, 1964; Neuman and Nelson, 1965; Butler, 1972; Hatcher, 1972; Dallmeyer, 1975; Hatcher, 1978, 1989; Hatcher and others, 1989; Connelly and Dallmeyer, 1991; Kish, 1991; Woodward and others, 1991). Structures attributed to both orogenies were observed in the study area. A detailed chronology of previous structural studies in the southeastern Tennessee Blue Ridge is presented by Rodgers (1991) and Carter (1994).

Structures observed in the study area include thrust faults, folds, foliations, joints, and quartz veins. The thrust faults include meso- and macroscale structures. All are interpreted as postmetamorphic brittle structures, but many are likely reactivated pre- to synmetamorphic structures. Folds in the study area range from centimeter- to kilometer-scale and formed during several periods of deformation. Foliations include continuous (slaty) and spaced cleavage—with associated rough or anastomosing cleavage in the coarser-grained rocks—pressure-solution cleavage, and crenulation cleavage. Joints and associated quartz veins are ubiquitous.

Faults

Two major and several minor thrust faults are exposed in the study area. Major faults are the Rabbit Creek fault and the Oconaluftee-Greenbrier fault (Fig. II-3; Plate I). The trace of the Miller Cove fault crops out northwest of the study area, but the southeastern flank of the Miller Cove thrust sheet is exposed along the northwestern boundary of the study area. The Miller Cove thrust sheet is composed of anchizone and lower chlorite grade Walden Creek Group rocks that are variably cleaved (e.g., Carter, 1994). East of the Miller Cove thrust sheet is the Rabbit Creek fault, which was originally mapped in the Great Smoky Mountains National Park (Neuman and Nelson, 1965) (Fig. I-2), and traced into the present study area by Wiener (unpub.). The regional significance of the Rabbit Creek fault was recognized because it emplaced much coarser-grained and deeper-water turbiditic metasandstone and metaconglomerate over generally finer-grained, shallower-water slate and metasilstone. The Rabbit Creek thrust sheet is composed entirely of Great Smoky Group rocks (Figs. I-3, II-3; Plate I), metamorphosed to chlorite grade, and penetratively cleaved. East of the Rabbit Creek thrust sheet is the Oconaluftee-Greenbrier fault, which was also originally mapped in the Park (King and others, 1958; Neuman and Nelson, 1965) (Fig. I-2). The Greenbrier fault was attributed regional importance because it is one of the large thrusts that is transected by metamorphic isograds, and was interpreted to have emplaced younger over older rocks everywhere along its length. The Oconaluftee is a postmetamorphic dextral strike-slip fault that obliquely cuts the Greenbrier, but then swings into parallelism with it and truncated or occupied the same movement plane as the Greenbrier (Neuman and Nelson, 1965). The Oconaluftee-Greenbrier thrust sheet consists of upper Great Smoky Group and lower Walden Creek Group rocks (Figs. I-3, II-3; Plate I), which are penetratively cleaved and metamorphosed to chlorite and to lower biotite grade.

Adjacent to the present study area, the contact between the lower metaconglomerate of the Dean Formation and the Horse Branch Member of the Ammons Formation (as defined in

the present study) was originally mapped as the Nichols Cove fault in the Joyce Kilmer–Slickrock Wilderness (Lesure and others, 1977) and the Citico Creek Wilderness (Slack and others, 1984). A gradational contact was observed at this stratigraphic level in the present study area and the boundary is interpreted as depositional, despite the compelling evidence in the Wilderness Area studies for a fault.

Rabbit Creek fault

The northernmost fault in the study area is the Rabbit Creek fault, originally mapped in the Great Smoky Mountains National Park (Neuman and Nelson, 1965) (Fig. I-2). This fault extends at least 56 km (35 mi) southward from the vicinity of Cades Cove in the Great Smoky Mountains, across the northwest side of the present study area (Wiener, unpub.; Fig. II-3; Plate I), and appears to be truncated by the Oconaluftee-Greenbrier fault near Tellico Plains immediately west of the study area (S. L. Martin, pers. comm., 1995).

The fault was recognized in the Park mainly by the major lithologic contrast across its trace, as well as fault fabrics at several locations and distinct topographic lineaments. The lithologies in the footwall of the Rabbit Creek fault consist of lighter-colored metasiltstone and slate, and lighter-colored metasandstone and channel metaconglomerate of the Walden Creek Group, while hanging-wall lithologies consist of coarser-grained turbiditic metaconglomerate and metasandstone, and darker-colored slate and metasiltstone of the Great Smoky Group (Plate I). Based on this distinct lithologic change, as well as a pronounced topographic lineament and truncation of mappable units, Wiener (unpub.) traced the Rabbit Creek fault from the Little Tennessee River into the present study area. This interpretation is very different from that of G. D. Swingle (in Hardeman, 1966) and Hadley and Nelson (1971), who depicted the Rabbit Creek fault as truncated by the Oconaluftee-Greenbrier fault north of the Little Tennessee River. I chose to follow the work of Wiener (unpub.), and compilations by Merschat and Wiener (1973) and Wiener and Merschat (1981, 1992) because this mapping has revealed

several features that would be expected for a major fault: truncation of units both northwest and southeast of the fault trace; gross change in lithostratigraphy across the trace; geomorphic expression along the trace; fault rocks and small faults; and a stepwise increase in metamorphic grade across the trace.

Wiener (unpub.) mapped the region north and west of the Rabbit Creek fault, using the fault as the southeastern boundary of his study. He recognized truncated lenses of metaconglomerate and black limestone of the Walden Creek Group on the northwest slope of Tyler Mountain near Chestnut Valley, Rafter 7.5-minute quadrangle (Fig. II-3; Plate I). Mapping for the present study verified these bodies and revealed truncated units southeast of the fault trace: 1.4 km (0.9 mi) northeast and southwest of Chestnut Valley; 1.0 km (0.6 mi) northwest of Bell Mountain; and at Hells Hole Gap, Rafter 7.5-minute quadrangle (Fig. II-3; Plate I). These units are within the upper metaconglomerate, and upper and middle slate units in the Rabbit Creek thrust sheet. The hinge of a smaller anticline on the northern flank of the Blue Mountain anticline is also truncated by this fault, 1.2 km (0.75 mi) northwest of Williamsburg Cemetery, Rafter 7.5-minute quadrangle (Plate I). These truncations and the change from light-colored metasiltstone and slate southeastward to dark metasiltstone and turbiditic metaconglomerate and metagraywacke, provide the most compelling evidence for the Rabbit Creek fault in this area.

At one location along the fault (station RAF 455, Plate II), 450 m (1,500 ft) south of Hells Hole Gap, Rafter 7.5-minute quadrangle, bedding, quartz veins, and cleavage are intensely deformed. Several meter-size blocks of metasandstone were rotated in a finer-grained matrix and wrapped by foliations unique to this locality. Isoclinal folds, slickenlines on bedding and foliation surfaces, and meter-scale thrust faults are also present here.

Within the present study area, the trace of the Rabbit Creek fault follows a relatively clear, albeit less-pronounced topographic lineament. This feature is represented by the unnamed ridge on which Hells Hole Gap is located, as well as Tyler Mountain and numerous unnamed

ridges to the southwest, Rafter and Bald River Falls 7.5-minute quadrangles (Plate I). Along some segments, fine-grained rocks occur in both fault blocks, precluding a geomorphic expression. Neuman and Nelson (1965) observed dips of the Rabbit Creek fault ranging from 30 to 65 degrees southeast. There are no exposures of the fault in the present study area, but its outcrop pattern indicates a dip ranging from 30 degrees southeast to nearly vertical (Plate I).

North of the Little Tennessee River, metamorphic isograds were interpreted to transect the Rabbit Creek fault and ductile fault fabrics were observed at several locations (Neuman and Nelson, 1965), indicating a premetamorphic origin. This relationship led Walters (1988) to correlate the Rabbit Creek fault in the Great Smoky Mountains with the demonstrably premetamorphic Greenbrier fault system. Observations along the fault trace during the present study, however, include brittle fault structures, deformation of slaty cleavage (both of which are discussed above), and an increase in metamorphic grade from anchizone and lower chlorite grade to chlorite grade when crossing the boundary from northwest to southeast. An unpublished mica crystallinity study confirms this stepwise increase in metamorphic grade (L. S. Wiener, pers. comm., 1995). This evidence strongly suggests that at least the last movement on this fault in the present study area was postmetamorphic.

Discrepancies in the relative age of the Rabbit Creek fault may be explained by the geometry of the fault trace as it is exposed 7 km (4.4 mi) northeast of the study area (Wiener, unpub.), in the north-central portion of the Whiteoak Flats 7.5-minute quadrangle. Here, a 1.7 km (1.1 mi) long segment of the fault trace trends north-northwest, suborthogonal to the general trend of the remainder of the trace (Figs. I-2, II-9). This segment follows Bald Hill Lead and appears to offset the Rabbit Creek fault with a dextral strike-slip sense of motion. The relationships in this area are unknown because the hanging wall of the Rabbit Creek fault has not been mapped. In light of the data presently available, these relationships are here interpreted as reactivation of the Taconic (pre- to synmetamorphic) Rabbit Creek fault south of this segment of the fault trace in the Alleghanian (postmetamorphic) orogeny. If a dextral

strike-slip fault exists along this segment, it is analogous to the Oconaluftee fault in the Great Smoky Mountains National Park.

The unknown stratigraphic position of rocks in the Rabbit Creek thrust sheet in the Great Smoky Mountains National Park precluded a precise measurement of the displacement on the Rabbit Creek fault in that region (Neuman and Nelson, 1965). Utilizing stratigraphic correlations interpreted in the present study (see “Relationships between rocks in the Rabbit Creek thrust sheet and other Great Smoky Group formations” section, Chapter II) and the stepwise increase in metamorphic grade across the trace of the fault, maximum vertical offset on the Rabbit Creek fault in the present study area is estimated to be 2.5 km (1.5 mi), and maximum horizontal displacement is estimated to be 5 km (3 mi) (Plate III).

Oconaluftee-Greenbrier fault

The Greenbrier fault is the most significant fault mapped in the Great Smoky Mountains because it divides the Ocoee Supergroup into two major stratigraphic sequences (King and others, 1958; King, 1964) (Fig. I-2). In the hanging wall of this structure in the Park, the Great Smoky Group conformably overlies the Snowbird Group, and in the footwall the Snowbird is conformably (?) overlain by unclassified Ocoee Supergroup formations and by the Walden Creek Group (King and others, 1958). In the Park, the Greenbrier fault thrust Great Smoky Group rocks over Walden Creek Group, Snowbird Group, rocks in the Rabbit Creek thrust sheet, and Grenvillian crystalline basement rocks (King and others, 1958; Hadley and Goldsmith, 1963; King, 1964; Neuman and Nelson, 1965). The Greenbrier fault was determined to be a ductile premetamorphic fault associated with the Taconic orogeny because ductile fault fabrics were observed at many locations, regional metamorphic isograds transect the boundary, and the fault does not deform the regional cleavage (Hadley and Goldsmith, 1963; King, 1964; Milton, 1983; Connelly and Dallmeyer, 1990; Woodward and others, 1991; Connelly and Woodward, 1992). Connelly and Woodward (1992) interpreted Hamilton's (1961) unclassified rocks of Webb

Mountain and Big Ridge as Great Smoky Group equivalents, preserved in klippe of the Greenbrier fault.

The Oconaluftee fault is a high-angle dextral strike-slip fault and low-angle thrust fault in the central and western Great Smoky Mountains (King, 1964; Neuman and Nelson, 1965). At its northern end, this fault is a northwest-trending dextral strike-slip fault that obliquely cuts the earlier Greenbrier (Fig. I-2). South of Wear and Tuckaleechee Coves, however, the trend of the Oconaluftee swings southwest into parallelism with the Greenbrier, and it becomes a low-angle thrust fault that either truncates, overrides, or reactivates the preexisting fault plane of the Greenbrier (Neuman and Nelson, 1965). Along this segment the fault was named the Oconaluftee-Greenbrier fault (Neuman and Nelson, 1965). In the southwesternmost portion of the Park along the Little Tennessee River, Neuman and Nelson (1965) mapped the lowest formation of the Great Smoky Group—the Elkmont Sandstone—in the hanging wall of the Oconaluftee-Greenbrier fault with “Cades Sandstone” and Metcalf Phyllite (Snowbird Group) in the footwall. Although King (1964) and Neuman and Nelson (1965) considered the Oconaluftee fault to be a postmetamorphic (Alleghanian ?) brittle fault, Neuman and Nelson (1965) presented evidence that the biotite isograd transects it, indicating that it is pre- to synmetamorphic.

A fault that trends across the northwestern portion of the present study area emplaces Wilhite Formation and Great Smoky Group units over rocks in the Rabbit Creek thrust sheet and has a pronounced topographic lineament along which topographic contour lines in the footwall tighten within 15 m (50 ft) of the fault trace (Plate I). This structure is tentatively correlated with the Oconaluftee-Greenbrier fault in the Park because both faults juxtapose Great Smoky Group units over rocks in the Rabbit Creek thrust sheet, and both are aligned with a prominent topographic lineament named Salt Spring Mountain located in the region between Citico Creek and the Little Tennessee River, Whiteoak Flats 7.5-minute quadrangle. Lithologies found in the hanging wall of the fault in the present study area are exposed along the

crest of Salt Spring Mountain (R. D. Hatcher, Jr., pers. comm., 1995). If this correlation is correct, the Oconaluftee-Greenbrier fault extends 72 km (45 mi) from near Elkmont, Tennessee in the Great Smoky Mountains, through the present study area and southwest (Figs. I-2, I-3), where it probably truncates the Rabbit Creek fault and then dies out in the northwest limb of the Tellico Mountain anticline or is truncated by the Miller Cove fault (S. L. Martin, pers. comm., 1995).

The fault is not exposed in the study area, but its outcrop pattern suggests a dip at the present erosion surface of approximately 55 to 75 degrees southeast. Exact displacement on the Oconaluftee-Greenbrier fault in the study area is unknown, but utilizing stratigraphic correlations interpreted in the present study (see "Relationships between rocks in the Rabbit Creek thrust sheet and other Great Smoky Group formations" section, Chapter II), maximum vertical offset in the present study area is estimated to be 1 km (3,300 ft), and maximum horizontal displacement is estimated to be 2 km (6,600 ft) (Plate III).

The Oconaluftee-Greenbrier fault truncates rock units in the Rabbit Creek thrust sheet to the north of the fault trace and Great Smoky and Walden Creek formations to the south (Fig. II-3; Plate I). Along Citico Creek, near the confluence of Tavern Branch and Citico Creek, Whiteoak Flats 7.5-minute quadrangle, the metaconglomerate member within the middle slate unit of the Rabbit Creek thrust sheet is truncated and overridden by the similarly truncated Horse Branch (?) Member of the Ammons Formation (Plate I). The middle and upper slate units and upper metaconglomerate unit in the footwall of the Oconaluftee-Greenbrier fault are likewise truncated a short distance along strike to the southwest (Plate I). Each unit in the Great Smoky and Walden Creek Groups above the Horse Branch (?) Member in the hanging wall are in turn cut by this fault between Tavern Branch and Ballplay Creek (Plate I). Of these units, the upper metaconglomerate of the Dean Formation and the lower slate and ankeritic metasiltstone of the Wilhite reappear in the hanging wall in the westernmost portion of the study area (Plate I). The northwest limb of the 1st-order Epperson synclinorium, and the 2nd-

order Rafter anticline and 2nd-order Hampton Branch syncline are also truncated at a low angle by this fault (Fig. II-3; Table III-1; Plate I).

The hanging wall of the Oconaluftee-Greenbrier fault in the Great Smoky Mountains National Park is comprised of Elkmont and Thunderhead Sandstones, the lowest two formations of the Great Smoky Group (Neuman and Nelson, 1965). In the present study area, however, the hanging wall is comprised of Dean and Ammons Formations, the two uppermost Great Smoky Group formations. This change can be explained by regional structures. In the Park, 1st-order anticlines bring up the older Great Smoky Group units, but between the Little Tennessee River and the present study area, the southwest-plunging 1st-order Epperson synclinorium brings down the youngest Great Smoky Group units as well as the overlying Wilhite Formation (Fig. II-7; Table III-1) (Carter and others, 1995b).

Minor map-scale faults

Several minor map-scale faults deform rocks within the Rabbit Creek and Oconaluftee-Greenbrier thrust sheets. These faults have vertical displacements of tens to hundreds of meters (50 ft to 3,000 ft), and do not exceed 3.4 km (2.1 mi) in outcrop length. The largest of these faults have been informally named the Flats Creek fault, Cane Creek Mountain fault, Oosterneck Creek fault, and Barkcamp Branch fault (Fig. II-3; Plate I).

Flats Creek fault

The Flats Creek fault is the most important of the minor faults and offsets rocks of the Dean Formation and possibly the Wilhite Formation (Fig. II-3; Plate I). The Flats Creek fault trends north-northeast and is located on the southeast limb of the Rafter anticline in the northeast-central portion of the study area (Plate I). This fault is approximately 3.0 km (1.9 mi) long from its southwestern terminus near the Whiteoak Flats syncline to the northeastern map boundary, but may continue beyond this boundary (Fig. I-3). Aerial photo interpretation

Table III-1. Size orders of folds in the study area.

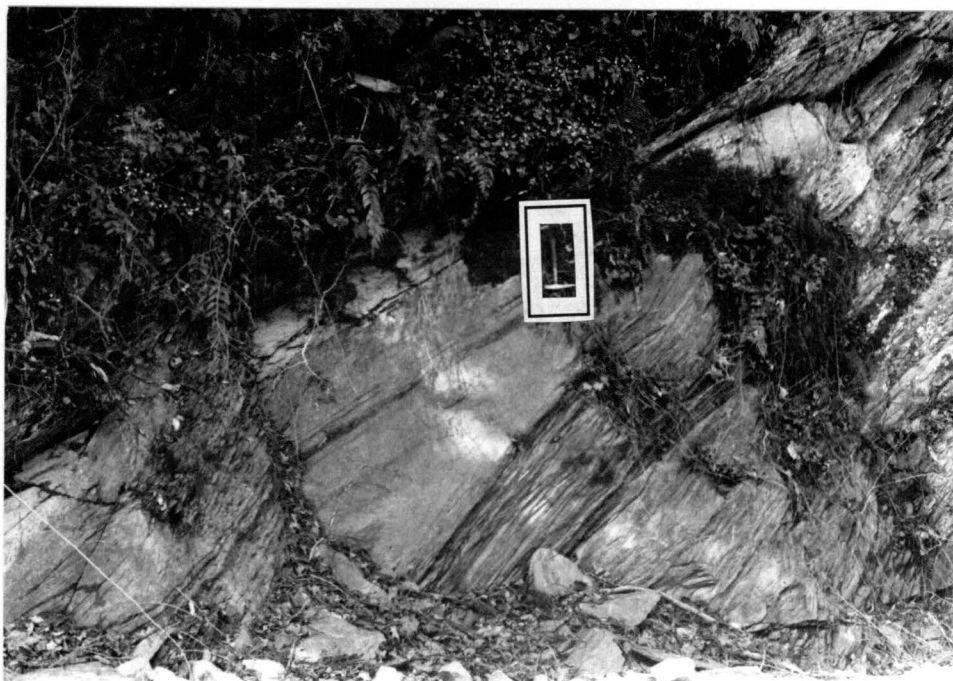
	<i>Order</i>	<i>Amplitude Range</i>	<i>Wavelength Range</i>	<i>Examples</i>
<i>Regional Structures</i>	1st	>500 m	>5 km	Ducktown anticlinorium Murphy synclinorium Epperson synclinorium
<i>Map Scale (Quadrangle) Structures</i>	2nd	500 m - 50 m	5 km - 1.0 km	Hampton Branch syncline Rafter anticline Whiteoak Flats syncline Blue Mountain anticline
	3rd	50 m - 15 m	1.0 km - 50 m	Whalebacks on Tellico River Whalebacks on Citico Creek
<i>Mesoscale Structures</i>	4th	15 m - 1 m	50 m - 1 m	
	5th	1 m - 10 cm	1 m - 10 cm	
	6th	<10 cm	<10 cm	

indicates that this structure may be truncated by the larger Oconaluftee-Greenbrier fault to the north on Salt Spring Mountain. Also, the fault was not traceable into the Wilhite Formation, but this may be because of poor exposure or the difficulty of tracing faults into weak rocks. As shown, the fault terminates in the lower slate and metasiltstone of the Dean Formation (Plate I).

The Flats Creek fault was recognized from repetition of the lower metaconglomerate and lower slate units of the Dean Formation in the Rafter anticline (Fig. II-3; Plate I), outcrop-scale faults with abnormally tight folds (Fig. III-1), truncation of small folds, and a zone of intensely deformed quartz veins. Direct exposures of the Flats Creek fault were not observed, but small faults, abnormally tight folds, and gouge that are associated with it are exposed in the footwall along Citico Creek Road (U. S. Forest Service Road 35-1), 350 m (1,100 ft) south of the confluence of Flats Creek and Citico Creek, Whiteoak Flats 7.5-minute quadrangle (stations WOF 115, 116, Plate II; Fig. III-1; Plate I). Truncated meter-scale folds and deformed quartz veins in the footwall of the fault can be observed on Citico Creek Road, approximately 100 m (330 ft) northwest of the intersection of Citico Creek Road and U. S. Forest Service Road 26 (the road leading to Salt Spring Mountain and Farr Gap), Whiteoak Flats 7.5-minute quadrangle (station WOF 129, Plate II; Plate I).

Lack of exposure of the fault precludes determination of its dip, but the minor faults along its length have dips ranging from 25 to 65 degrees southeast. The Flats Creek fault is interpreted as an Alleghanian structure, perhaps as a small splay off of the Oconaluftee-Greenbrier fault, or as a small splay off of the Great Smoky fault (Plate III). The Flats Creek fault could also be a synmetamorphic structure formed during the rotation of the common limb between the Rafter anticline and Whiteoak Flats syncline, which was subsequently reactivated in the Alleghanian orogeny. Stratigraphic correlations across the Flats Creek fault as observed in the surface geology and interpreted in cross-section (Plate III) indicate this fault has a maximum vertical displacement of approximately 800 m (2,600 ft) (Plate III), but is probably much less and decreases towards its terminus to the southwest.

Figure III-1. Abnormally tight folds in lower slate unit of Dean Formation associated with Flats Creek fault. Small faults and fault gouge occur just to right of (B). Station WOF 115; Citico Creek, Whiteoak Flats 7.5-minute quadrangle.



(A)



(B)

Cane Creek Mountain fault

The Cane Creek Mountain fault occurs in the northwest-central portion of the area along the ridgeline of Cane Creek Mountain, 700 m (2,300 ft) north of the confluence of Nickels Branch and Cane Creek, Rafter 7.5-minute quadrangle (station RAF 131, Plate II; Plate I). The fault, observed at only this one locality, juxtaposes the upper metaconglomerate unit and one body of the upper slate unit in the Rabbit Creek thrust sheet (Fig. II-3; Plate I). The Cane Creek Mountain fault is at least 1.2 km (0.75 mi) in length, but may be as long as 3.0 km (1.9 mi) if the fault forms the entire length of the contact between these two units (Plate I). Dip of the fault is approximately 60 degrees at the present surface, based on the single exposure observed and on its outcrop pattern (Plate I), but displacement on the fault is unknown. Bedding in the metaconglomerate is truncated by this fault, and slickenlines on the fault surface and on bedding surfaces were observed. The upper slate unit bodies in the Rabbit Creek thrust sheet have irregular outcrop patterns and are interpreted in this study as lenses that intertongue on their ends with the enclosing metaconglomerate (Plate I). However, the presence of the Cane Creek Mountain fault at the contact between these two units, the irregular and jagged outcrop pattern of all of the upper slate unit bodies (Plate I), and the large number of fractures in this region may suggest that the portion of the Rabbit Creek thrust sheet between Ballplay Creek and the western boundary of the study area is dissected by unrecognized faults that repeat the metaconglomerate and slate units.

Oosterneck Creek fault

The most interesting minor fault occurs along Oosterneck Creek and the base of Caney Branch Ridge, just south of Mt. Isabel Church, Bald River Falls 7.5-minute quadrangle (Plate I). This fault was recognized by topographic lineaments, small faults, deformed quartz veins, and slickenlines on fault and bedding surfaces. The outcrop length of the fault trace is approximately 3.4 km (2.1 mi). Displacement is unknown because the fault lies entirely within the upper

metasiltstone of the Wilhite formation. The fault appears to be the movement plane along which a more-indurated section of Wilhite metasiltstone was thrust over more typical metasiltstone. I envision this to have occurred during late regional folding or faulting, wherein this well-indurated section acted as a strut that moved easier as a separate unit rather than succumb to folding or move in unison with the larger thrust sheets. This structure is geomorphically well expressed by the linear trend of Caney Branch Ridge and Oosterneck Creek (Plate I).

Barkcamp Branch fault

The Barkcamp Branch fault offsets the lower metaconglomerate, middle slate, and middle metaconglomerate member in the Rabbit Creek thrust sheet on the northwest limb of the Blue Mountain anticline (Fig. II-3; Plate I). It trends northeast and is located approximately 400 m (1,300 ft) north of Barkcamp Branch, a tributary of Citico Creek in the northern portion of the study area (Plate I). The fault has a 1.0 km (3,300 ft) outcrop trace and terminates in the upper portion of the middle slate unit. The Barkcamp Branch fault was recognized on the basis of outcrop-scale faults, fault gouge, slickenlines on fault and bedding surfaces, and truncation of the northern end of the middle metaconglomerate member in the Rabbit Creek thrust sheet. The only observed exposure of the fault is on Citico Creek Road, 0.6 km (0.4 mi) north of the confluence of Barkcamp Branch and Citico Creek, Whiteoak Flats 7.5-minute quadrangle (station WOF 178, Plate II; Plate I), where a 35 degree dip of the fault plane was observed. Fault gouge indicates brittle deformation, suggesting the Barkcamp Branch fault may have formed as a splay off of the Rabbit Creek fault in the Alleghanian orogeny. It could also have been a synmetamorphic structure formed during the amplification of the Blue Mountain anticline in the Taconic orogeny, subsequently reactivated during the Alleghanian. Surface geologic data and stratigraphic offsets revealed in cross-section (Plate III) indicate less than 50 m (160 ft) of vertical displacement on the Barkcamp Branch fault.

Folds

Soft-sediment folds (F_0) and evidence for three generations of tectonic folds (F_{1-3}) were observed in the study area. Tectonic folds range from 1st-order regional structures to 4th- and higher-order mesoscopic structures, while observed syndepositional folds are only 5th- and higher-order (Table III-1). Fold chronology was determined by the relationships of the folds to axial-planar cleavage, rheological state of deformation, and to later faulting events. F_0 folds were recognized in the Rabbit Creek and Oconaluftee-Greenbrier thrust sheets. The occurrence of these folds between undeformed bedding planes indicates their syndepositional formation. Cleavage across the entire study area is axial planar to 1st- and higher-order F_1 folds, suggesting these folds formed synmetamorphically. Slaty cleavage was deformed at several localities by 5th- and higher-order F_2 folds. 2nd-order F_3 folding of the entire Blue Ridge megathrust sheet may be indicated locally in the Oconaluftee-Greenbrier thrust sheet.

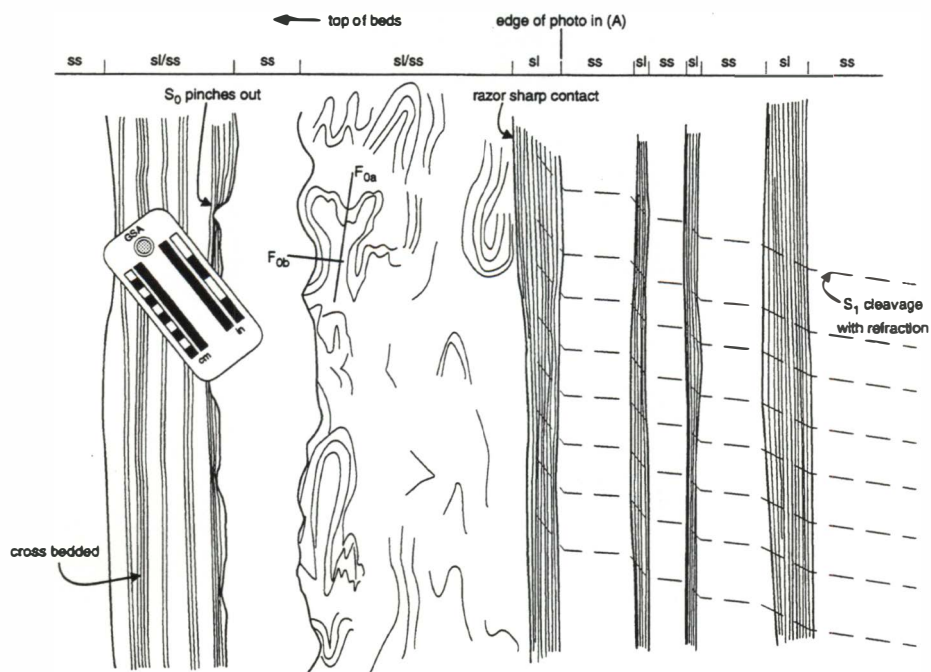
F_0 folds

Soft-sediment F_0 folds are locally preserved in the fine-grained rocks of the Wilhite Formation and Great Smoky Group formations. These folds range from open to isoclinal, with amplitudes and wavelengths approximately equal, up to 15 cm (Table III-1). F_0 fold axes generally plunge gently southeast to northwest, with vertical to steeply dipping axial surfaces. These structures were recognized on the basis of their intralayer geometry, wherein several folded beds are bounded above and below by planar unfolded layering (Fig. III-2). This observation also distinguishes F_0 folds from similar-looking, regionally dominant F_1 folds. At one location, two generations of soft-sediment folds were observed (station WOF 307, Plate II; Fig. III-2). Originally isoclinal folds with axial surfaces subparallel to bedding were refolded by loading of overlying sandstone suborthogonal to bedding. F_0 folds formed as a result of downslope movement of prelithified, water-saturated sediment, but subsequent deformation generally

Figure III-2. F_0 folds in fine-grained rocks of the Dean Formation. (A) Intralayer soft-sediment folds (convoluted layering) in banded slate and metasandstone. Photo is slightly out of focus. (B) Sketch of same outcrop showing two periods of folding (F_{0a} , F_{0b}). (sl)=slate; (ss)=metasandstone. Station WOF 307; Citico Creek, Whiteoak Flats 7.5-minute quadrangle.



(A)



(B)

obliterates or modifies original vergence of these structures. No foliations are associated with this folding event.

F₁ folds

F₁ folds are the dominant fold structures across the entire study area, and occur on all scales, from 1st- and 2nd-order folds such as the Epperson synclinorium and Rafter anticline (Fig. II-3), to mesoscopic 4th- and higher-order folds that are parasitic to these regional structures. Amplitudes range from less than 5 cm to greater than 500 m, and wavelengths range from less than 1 cm to greater than 5 km (Table III-1). All F₁ fold axes trend north-northeast to northeast. F₁ folds are recognized and distinguished from other fold generations by the axial-planar or fanning relationship of regional slaty cleavage (S₁) to these structures.

Fold geometry of F₁ folds varies with scale. 1st- and 2nd-order F₁ folds are generally upright, with axial surfaces that dip moderately southeast to vertical, hinges that plunge 10 to 20 degrees southwest, and slightly steeper dips on their northwest limbs (Plates I, III) (in regards to anticlines). Most 3rd- and higher-order F₁ folds are overturned or steeply inclined to the northwest, with axial surfaces inclined gently to steeply southeast, hinges that plunge 15 degrees or less northeast or southwest (Fig. III-3A), and much steeper dips on their northwest limbs (in regards to anticlines). All F₁ folds verge toward the northwest. Bedding-cleavage intersection lineations (S₀ × S₁) are subparallel to F₁ fold hinges (compare Figs. III-3A and III-3B), and slaty cleavage (S₁) is axial-planar to F₁ folds (compare Figs. III-3A and III-3C) or fanned around F₁ fold axial surfaces (Fig. III-4A), indicating this folding event and regional metamorphism were coeval. Most folds of this generation are open to closed, but gentle F₁ folds were also observed. Tight to isoclinal F₁ folds were only observed near faults (Fig. III-1).

F₁ folds in the study area formed by buckling, accompanied by both flexural-slip and flexural-flow mechanisms (Donath and Parker, 1964). Constant bedding thickness throughout the fold and slickensides on bedding surfaces were observed in F₁ folds in coarser-grained

Figure III-3. Characteristics of F_1 folds. (A) Lower-hemisphere equal-area projection of 106 F_1 fold axes and poles to axial surfaces. Contours represent 2, 4, 6, 8, 10, and 12 percent per 1 percent area. (B) Lower-hemisphere equal-area projection of bedding (S_0)–slaty cleavage (S_1) intersection lineations. Note relationship between lineation ($L_{1 \times 0}$) and F_1 fold axes. (C) Contoured lower-hemisphere equal-area projection of 1400 poles to slaty cleavage (S_1). Contours represent 2, 4, 6, 8, 10, 12, 14, 16 and 18 percent per 1 percent area. Note relationship between poles to S_1 cleavage and poles to F_1 axial surface measurements.

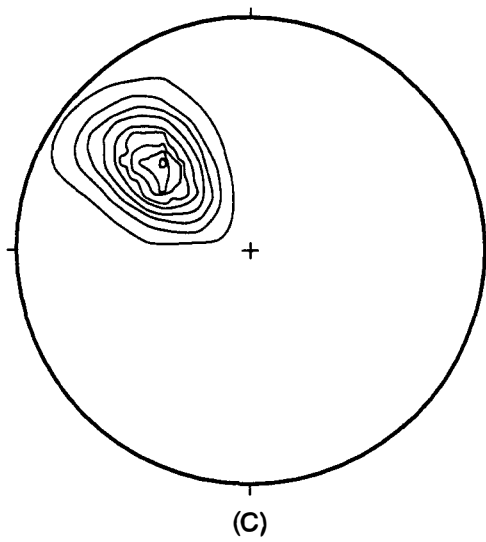
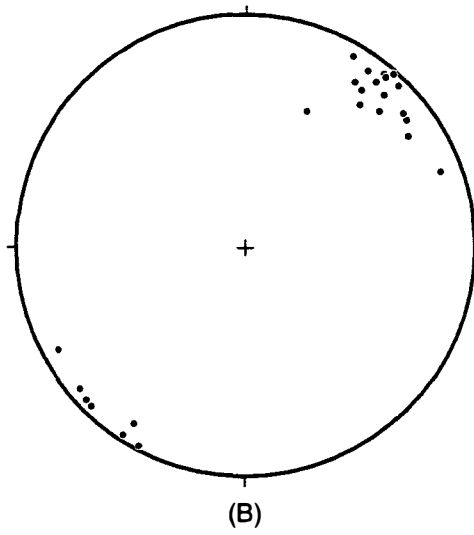
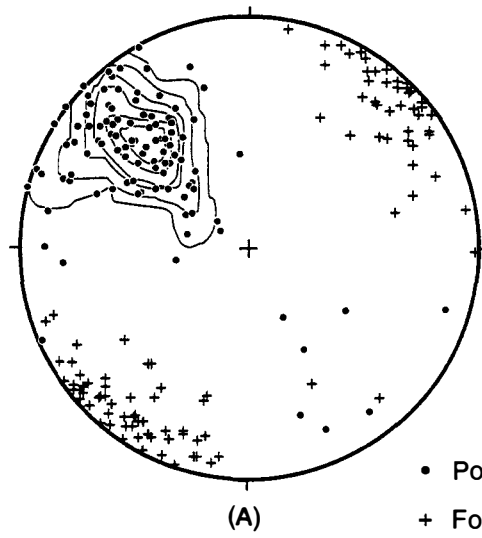


Figure III-4. Representative styles of F_1 folds. (A) 4th-order F_1 flexural-slip fold in upper metasilstone of Wilhite Formation showing slightly fanned axial-planar cleavage (S_1). Near station BRF 220; Tellico River, Bald River Falls 7.5-minute quadrangle. Outcrop is approximately 6 m in height. (B) 5th-order F_1 flexural-flow fold in banded metasilstone of Wilhite Formation. Near station BRF 976; Tellico River, Bald River Falls 7.5-minute quadrangle.



(A)



(B)

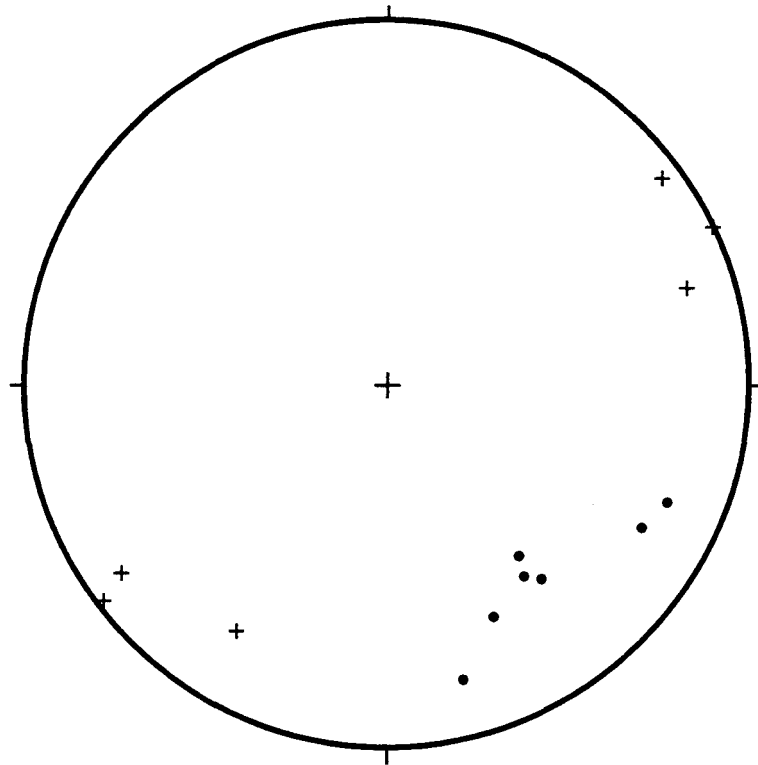
sequences and in sequences with similar lithologies throughout the fold (Fig. III-4A). These folds are interpreted to have formed by a flexural-slip mechanism. Fine-grained beds that thicken in the hinges and thin in the limbs of folds interbedded with coarser-grained beds that maintain constant-layer thickness throughout the fold and contain fractures were observed in F_1 folds in interlayered sequences (Fig. III-4B), which caused a competency and ductility contrast. These folds were also observed in finer-grained sequences that were deformed by tighter F_1 folds, and are interpreted to have formed by a flexural-flow mechanism.

F_2 folds

At several locations within the study area, slaty cleavage (S_1) is deformed by concentric, gentle to open 5th-order F_2 folds. Amplitudes range from 10 to 20 cm, and wavelengths range from approximately 15 cm to 1.0 m (Table III-1). All of these folds plunge gently northeast and southwest, with axial surfaces that dip moderately to steeply northwest (Fig. III-5A). F_2 folds are oriented very similarly to crenulation cleavage (S_2) (Fig. III-5B) observed in fine-grained rocks throughout the study area, suggesting they are related to those structures. Southwest of the present study area, Carter (1994) recognized a close spatial relationship between folds similar to these and brittle faults, but this relationship was not definitively observed in the present study. F_2 folds are probably regionally insignificant because they are small structures only observed at a limited number of localities.

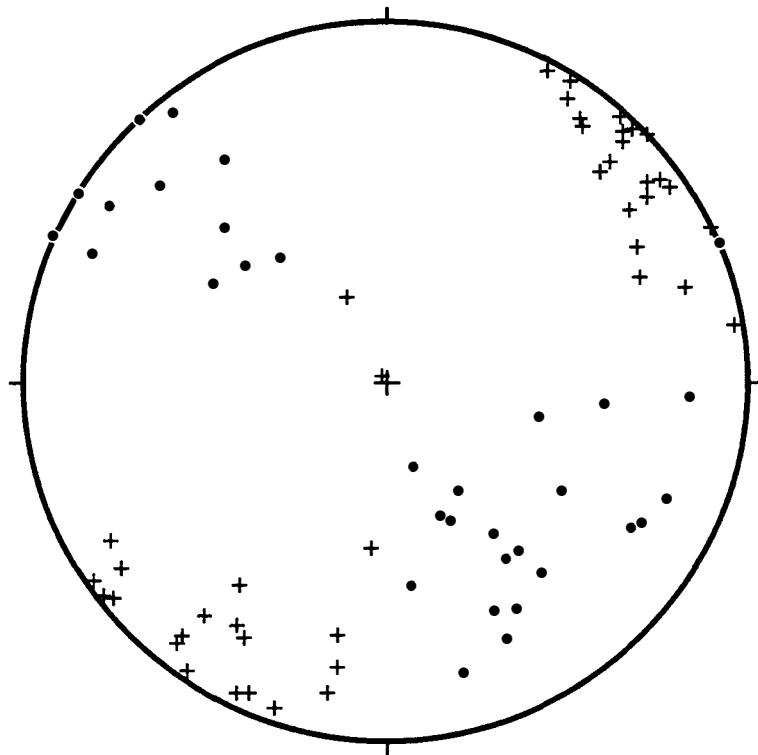
Several discrete but pervasive zones of 6th-order asymmetric near-similar chevron-style folds occur along Tellico River Road (stations BRF 983, 984, 993, Plate II), and 3.0 km (1.9 mi) to the northeast along Rafter Road (stations BRF 1008 through 1015, Plate II) in the western portion of the study area. Some of these folds deform S_1 (slaty) cleavage indicating they may be related to F_2 folding, but some have an axial-planar cleavage with a morphology similar to S_1 indicating they may be related to F_1 (Fig. III-6A). Moreover, in some of these zones the shorter limb has tightened enough to form a separate cleavage, with an associated tightly spaced joint set

Figure III-5. Characteristics of F_2 folds. (A) Lower-hemisphere equal-area projection of 6 F_2 fold axes and 7 poles to F_2 axial surfaces. (B) Lower-hemisphere equal-area projection of 43 crenulation (S_2) axes and 33 poles to crenulation (S_2) axial surfaces.



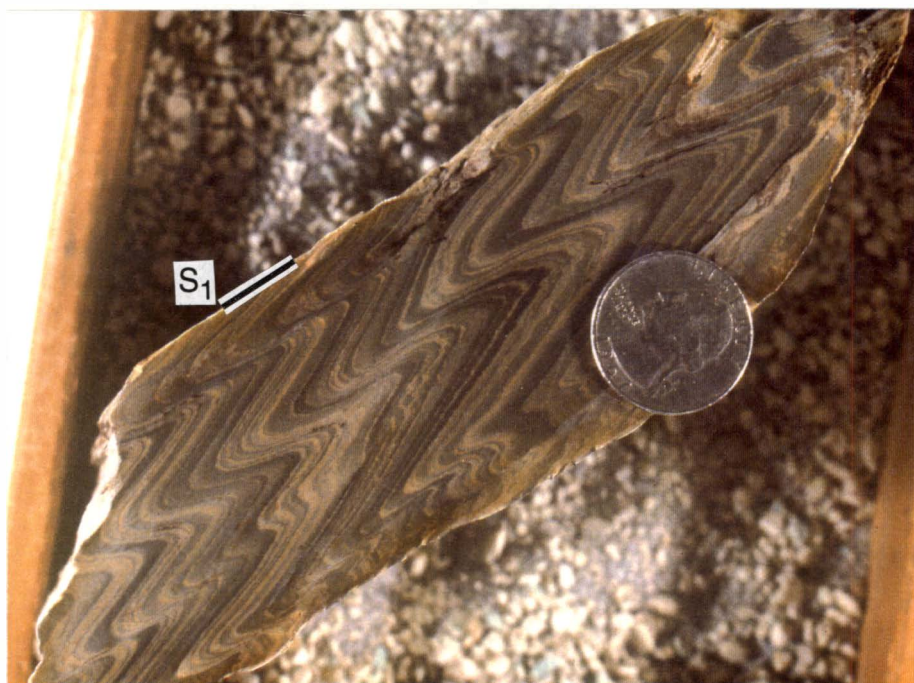
(A)

• Poles to axial surfaces
+ Fold axes

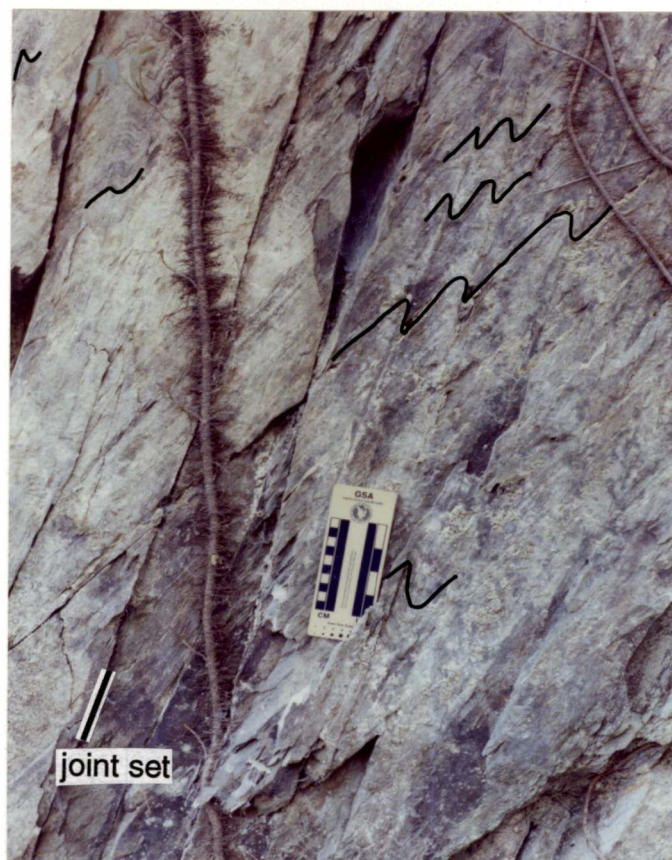


(B)

Figure III-6. Near-similar chevron folds from the western portion of the study area. (A) Cut sample showing asymmetry of folds and axial-planar relationship of S_1 cleavage. Sample BRF 1015; Rafter Road, Bald River Falls 7.5-minute quadrangle. (B) Folds from same vicinity as (A), showing tightly spaced joint set formed along tightened limbs of folds.



(A)



(B)
90

formed parallel to the shorter limbs (Fig. III-6B). These zones of chevron folds are in close proximity to the Oconaluftee-Greenbrier fault and related splays, and may be related to movement on those structures (Plate I).

F₃ folds

Interpretation of seismic data (Cook and others, 1983) acquired along the Tellico River within the present study area indicates that a major structure is present beneath the western part of the Blue Ridge thrust sheet in this region. This structure is likely the Saltville fault, which ramps from the basal clastic sequence immediately above the Grenville basement surface through Paleozoic carbonates of the Conasauga, Knox, and Chickamauga Groups along the base of the Lower Cambrian Rome Formation (Plate III), a regional décollement surface in the southern Appalachians. The seismic data also indicate northwest-dipping structures in this region, interpreted to be correlative with the Foothills duplex (Plate III), which is exposed in windows through the Great Smoky thrust sheet in the Great Smoky Mountains (Hatcher and others, 1989). The southernmost of these windows—the Calderwood window—is only 15 km (9 mi) to the northeast of the study area. Horse blocks containing unmetamorphosed Knox Group carbonates and Lenoir Limestone and Sevier Shale (Chickamauga Group) of the Valley and Ridge stratigraphic sequence are exposed in the larger windows to the north (King and others, 1958; King, 1964; Neuman and Nelson, 1965; Hatcher and others, 1989), indicating that the western Blue Ridge thrust sheet has been arched upward during imbrication and duplexing of these footwall units. Beneath the present study area, these imbricates are interpreted to contain Rome Formation sandstone and shale, and Conasauga Group and Knox Group carbonate rocks (Plate III). Lenoir Limestone and Sevier Shale (Chickamauga Group) are not interpreted to be involved in the duplexing beneath the present study area because they are not exposed in the two southernmost windows—Cades Cove and Calderwood window—indicating the Great

Smoky fault (the roof thrust to the duplex) had cut down section to a lower structural level to the south.

Although Valley and Ridge Paleozoic rocks are not exposed at the surface in the present study area, the seismic data and several lines of evidence observed in the surface geology indicate that footwall duplexing has produced 2nd-order F_3 folds in hanging-wall rocks of this region. This surface evidence includes deflection of the biotite isograd, fold-interference patterns, deflection of bedding and cleavage, and topographic expression. No foliations are related to this folding event and no mesoscale F_3 folds were recognized. F_3 folds formed by a bending mechanism probably related to post-emplacement arching of the Blue Ridge thrust sheet by the Foothills duplex.

The biotite isograd is deflected to the northwest around the north side of Whiteoak Flats (Plate I). This isograd was concluded by previous workers to parallel the structural trend and lie entirely within rocks of the Great Smoky Group in the vicinity of the study area (Neuman and Nelson, 1965; Merschat and Wiener, 1973; Lesure and others, 1977; Wiener and Merschat, 1982; Slack and others, 1984; Wiener and Merschat, 1992). In the region immediately east of Whiteoak Flats, however, Slack and others (1984) noticed that the isograd deflects sharply northward into rocks of the Wilhite Formation, into an almost east-west trend (Plate I). Thin-section analysis during the present study revealed well-crystallized biotite in clay-rich metasilstone and metasandstone of Gold Branch, located immediately south of Whiteoak Flats, Whiteoak Flats 7.5-minute quadrangle (station WOF 303, Plate II), indicating the isograd is located north of there. 8 km (5 mi) to the southwest along the Tellico River, the first appearance of biotite occurs in a more typical position immediately west of the Dean Formation/Horse Branch Member contact, entirely within Great Smoky Group rocks (Plate I). If F_1 folds (including Whiteoak Flats syncline in the vicinity of the deflected isograd) were already mostly formed and overturned prior to emplacement of the biotite isograd into its final position in the Taconic orogeny, the northwest-dipping isograd would have transected the contact between

Great Smoky and Walden Creek Groups, shifting stratigraphic levels. The rocks containing this relationship would have been transported westward with the Great Smoky thrust sheet in the Alleghanian orogeny, but the trace of the isograd would have remained linear on a later erosion surface. A small culmination on a duplex surface beneath the isograd would fold the isograd upwards, exaggerate its direction of dip, and expose its deflected trace and its change in stratigraphic level on a later erosion surface. The localized disturbance of the trend of the isograd in the present study area may be evidence for F_3 folding.

Along Citico Creek between Citico Warden Station and the confluence of Doublecamp and Citico Creeks, Whiteoak Flats 7.5-minute quadrangle, the cores of eight 3rd-order (Table III-1) doubly plunging folds expose rocks of the uppermost Dean Formation beneath lowermost Wilhite Formation (Plates I, III; Fig. II-10B). These folds were probably originally southwest-plunging parasitic folds on the 2nd-order Whiteoak Flats syncline. Although doubly plunging folds are not uncommon throughout the region, the wavelength of these structures indicates that they were at least modified, if not formed by, a later stress field oriented suborthogonally to their original axes. Arching of the Great Smoky megathrust sheet immediately to the southwest of these folds could have created this elongated dome-and-basin pattern that was subsequently exhumed by Citico Creek.

Bedding (S_0) and cleavage (S_1) measurements in the vicinity of Whiteoak Flats also suggest doming of the thrust sheet from below. Along most of the length of the hinge of Whiteoak Flats syncline, bedding measurements are very regular and reveal the nature of this structure—a shorter, steeper southeast limb and a longer, moderately dipping northwest limb (Plate I). West of Citico Warden Station, strike of bedding is more northerly and parallel to an unnamed ridge, while the dip is gently northwest and southwest (Plate I), despite the fact that these rocks are located on and near the northwest limb of Whiteoak Flats syncline and should be dipping southeast. The unnamed ridge defines the nose of Whiteoak Flats syncline, suggesting the hinge of that structure is deflected northward as well. Variation in the orientation of

cleavage is not as pronounced, but the dip of some measurements here do flatten. One outcrop revealed southwest-dipping bedding and cleavage (station WOF 310, Plate II). Northwest-dipping or horizontal cleavage in this region would be more constraining evidence for F_3 folds.

The region around Whiteoak Flats and Indian Boundary Lake is a topographic anomaly. It is a 2.6 km² (1 mi²) flat area and topographic low with an elevation of 1,800 ft (550 m), but it is bounded to the south by 3,800 ft (1,160 m) high Flats Mountain, and to the north and west by rolling hills that average 2,000 ft (610 m) in elevation (Plate I). This is the only pronounced topographic anomaly in the region south of the Great Smoky Mountains National Park, and looks very similar to the coves found in the Park. Prior to the damming of Flats Creek which created Indian Boundary Lake and flooded the area, however, L. S. Wiener (pers. comm., 1994) investigated the region and found no evidence for the presence of a window. Unfortunately, the area is covered by alluvium and colluvium (Plate IV), which may conceal any exposures of unmetamorphosed footwall rocks. Another distinctive topographic feature in the vicinity is an unnamed ridge immediately east of Indian Boundary Lake. This feature cuts across the structural and geomorphic grain of the surrounding area, and is supported by metasiltstone and metasandstone of the Wilhite Formation that strike parallel to it (Plate I). Although topography and the surface geologic data presented here are equivocal, they combine with seismic data to enhance the possibility that this area is underlain by imbricated and duplexed Paleozoic strata.

This model suggests that the upper surface of the Foothills duplex is generally a doubly plunging antiform with doubly plunging culminations at various locations on its surface (Fig. III-7). The stratigraphically and structurally highest culmination is beneath Tuckaleechee Cove (Fig. III-7). This is areally the largest window and exposes the Great Smoky fault at the highest elevation of all the windows. It also exposes Sevier Shale, which is the youngest unit found in the windows. Northeast of Tuckaleechee Cove, Wear Cove also exposes Sevier Shale, but is areally smaller and exposes the Great Smoky fault at a slightly lower elevation (Fig. III-7). Southwest of Tuckaleechee Cove, the windows become successively smaller in area, expose only

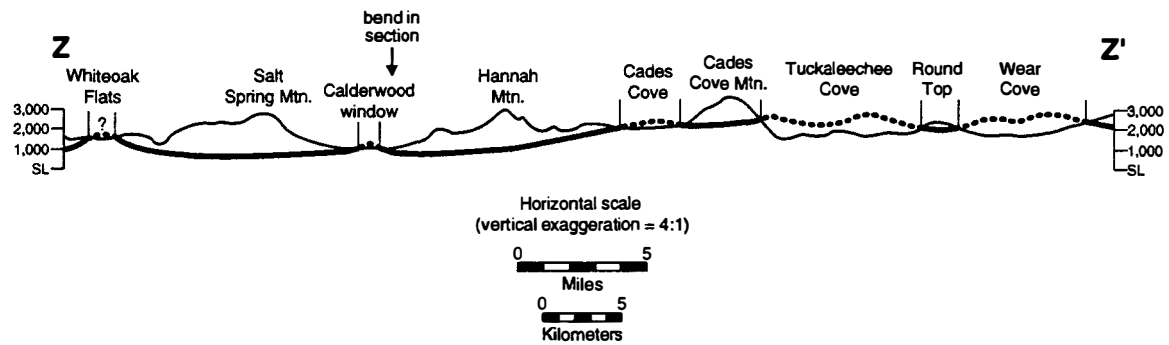


Figure III-7. Strike-parallel cross-section of the base of the Great Smoky thrust sheet along line Z-Z' (position located on Fig. I-2). Note the breached culminations on the roof of the Foothills duplex that formed the windows in the Great Smoky Mountains National Park. Vertical exaggeration is 4:1.

upper Knox Group carbonates as the youngest unit, and expose the Great Smoky fault at successively lower elevations (Fig. III-7). Utilizing structure contour maps drawn on the base of the Great Smoky thrust sheet (King, 1964; Neuman and Nelson, 1965; Hatcher and others, 1989), the overall dip of the duplex roof was calculated to be 0.6° southwest, within and between each of the windows in the Park. This overall dip was used to interpret the location and geometry of the duplex roof between Calderwood window and Whiteoak Flats in the present study area (Plate III; Fig. III-7).

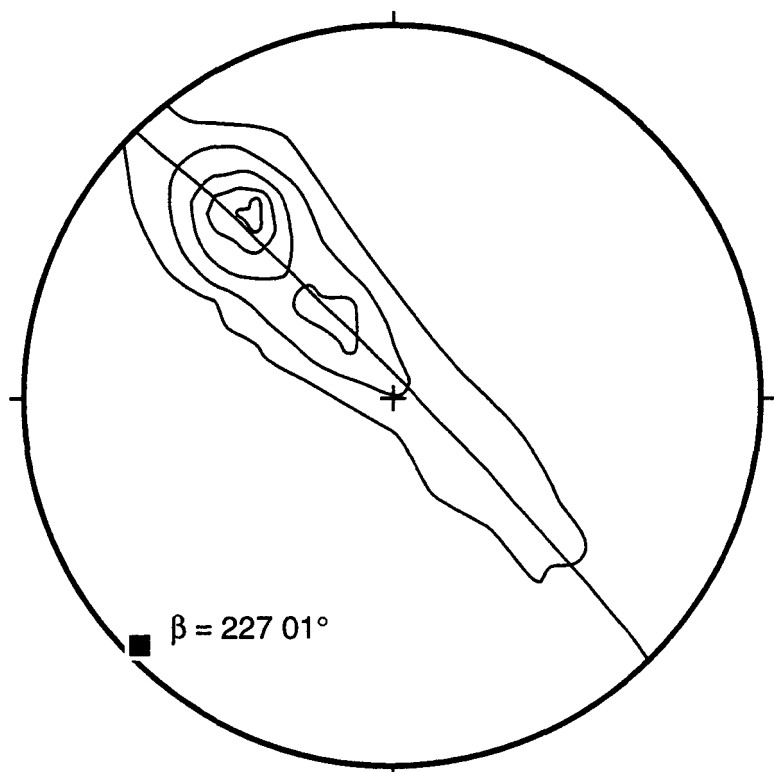
Foliations (S-surfaces)

One depositional and three tectonic foliations were recognized in the study area. They are bedding (S_0), continuous slaty and spaced cleavage (S_1), pressure-solution cleavage (S_{1a}), and crenulation cleavage (S_2). Bedding (S_0) is present throughout the study area in all but the finest-grained lithologies. Slaty and smooth disjunctive spaced cleavage (S_1) with associated anastomosing or rough disjunctive spaced cleavage in coarser-grained units is developed throughout the study area, but is most pronounced in finer-grained lithologies. Pressure-solution cleavage (S_{1a}) and crenulation cleavage (S_2) are locally developed in finer-grained rocks across the area.

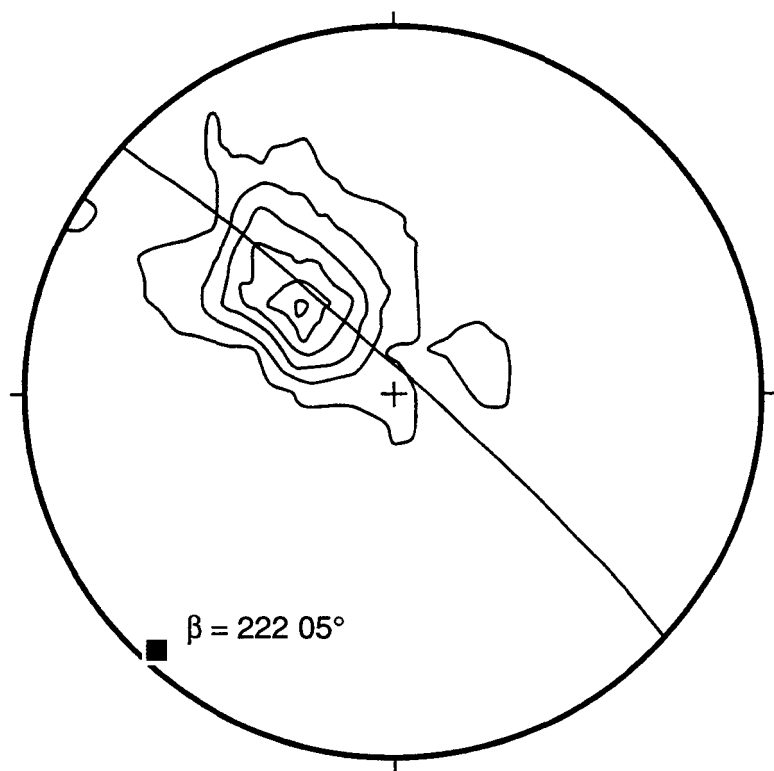
S_0 (bedding)

Bedding in the Oconaluftee-Greenbrier thrust sheet is deformed by the 1st-order Epperson synclinorium, 2nd-order Hampton Branch syncline, Rafter anticline, and Whiteoak Flats syncline, as well as innumerable 3rd- and higher-order folds (Fig. II-3; Table III-1; Plate I). Poles to bedding in the Oconaluftee-Greenbrier thrust sheet define a great circle with orientation 317.89° NE, and β pole with orientation 227.01° (Fig. III-8A). Bedding in the Rabbit Creek thrust sheet is deformed by the 2nd-order Blue Mountain anticline and numerous 3rd- and higher-order folds (Fig. II-3; Plate I). Poles to bedding in the Rabbit Creek thrust sheet

Figure III-8. Stereoplots of S_0 data in two thrust sheets in study area, with corresponding great circles and β poles (solid squares). (A) Contoured lower-hemisphere equal-area projection of 1610 poles to bedding in the Oconaluftee-Greenbrier thrust sheet. Contours represent 2, 4, 6, 8, and 10 percent per 1 percent area. (B) Contoured lower-hemisphere equal-area projection of 286 poles to bedding in the Rabbit Creek thrust sheet. Contours represent 2, 4, 6, 8, 10, and 12 percent per 1 percent area.



(A)



(B)

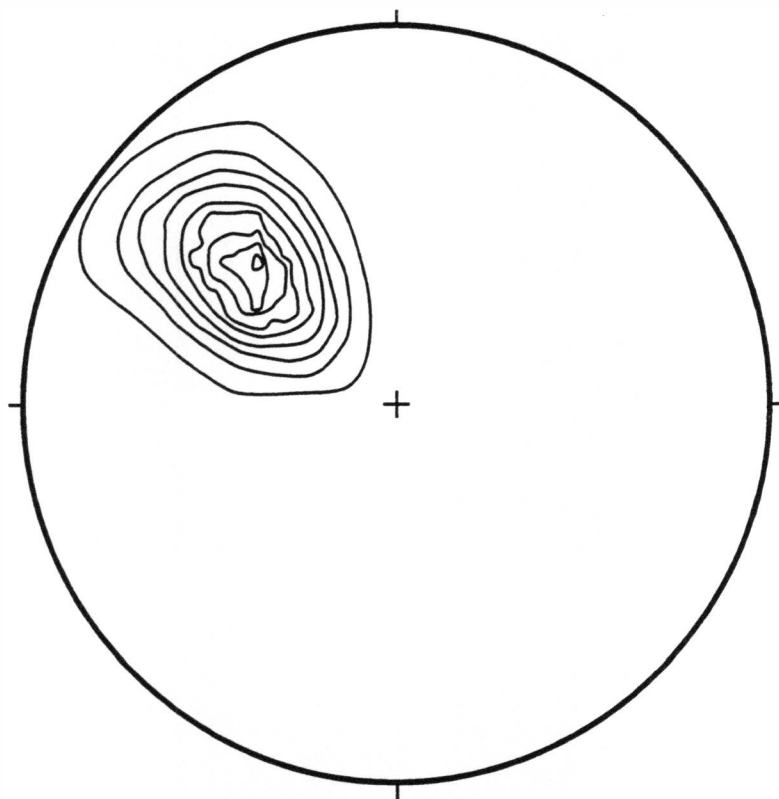
define a great circle with orientation 312 85° NE, and β pole with orientation 222 05° (Fig. III-8B).

S₁ (slaty cleavage)

The dominant tectonic foliation throughout the study area is S₁. S₁ is axial planar to, or convergently fanned about the axial surface regions of F₁ folds (Fig. III-4A; Table III-1) dipping moderately southeast (Fig. III-9A). Finer-grained rocks tend to part preferentially along S₁ planes rather than along bedding (Fig. III-9B), but this characteristic was also observed in coarse-grained rocks where S₁ is well-developed. Refraction of this foliation across layers of differing grain size is present at all scales and is common throughout the study area, but is most prevalent in banded metasiltstone lithologies (Fig. III-9B).

S₁ becomes more intensely developed from northwest to southeast, in the direction of increasing metamorphic grade. In the westernmost portion of the study area, S₁ that is suborthogonal to S₀ is formed by both spaced pressure-solution and an alignment of clay minerals recrystallized to chlorite and muscovite. Morphologically, S₁ in this region is smooth disjunctive moderately to closely spaced cleavage in fine-grained rocks (Fig. III-10), and anastomosing to rough disjunctive widely spaced cleavage in coarse-grained rocks (Powell, 1979). These pressure-solution and recrystallized clay-dominated cleavage domains are 0.05 mm- to 0.5 mm-thick and separate 0.02 mm- to 0.4 mm-thick microlithons with weak to moderate fabric alignment (Figs. III-10A, B). Also in the westernmost portion of the study area, 0.2 mm- to 5.0 mm-thick pressure-solution selvages are aligned parallel to bedding in calcareous metasiltstone, but these are overprinted by the dominant suborthogonal S₁ (Fig. III-10B). Occasionally, these bedding-parallel selvages obliterate or dominate over bedding. At one location, the bedding-parallel selvages were folded along with bedding, and S₁ fanned about the fold. Pressure shadows of quartz formed around pyrite crystals and aligned parallel to S₁ are also locally developed (Fig. III-10B).

Figure III-9. Characteristics of S_1 (slaty) cleavage. (A) Contoured lower-hemisphere equal-area projection of 1400 poles to slaty cleavage. Contours represent 2, 4, 6, 8, 10, 12, 14, 16, and 18 percent per 1 percent area. (B) S_1 cleavage in lower banded slate and metasiltstone unit of the Wilhite Formation, showing preferential parting along cleavage surfaces and refraction of cleavage across bedding. Station BRF 508; Tellico River, Bald River Falls 7.5-minute quadrangle.



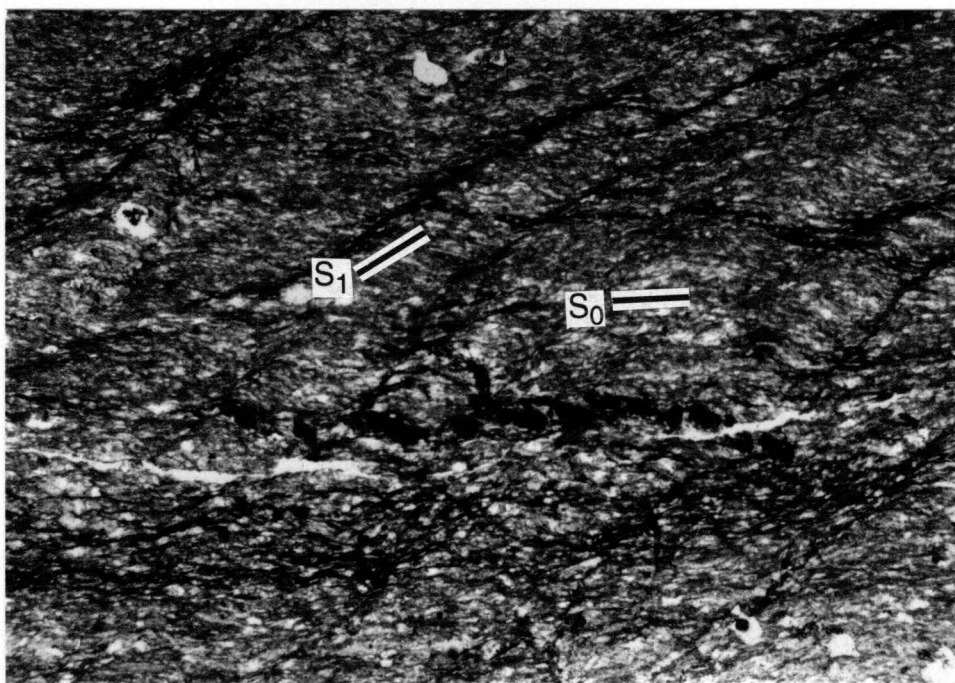
(A)



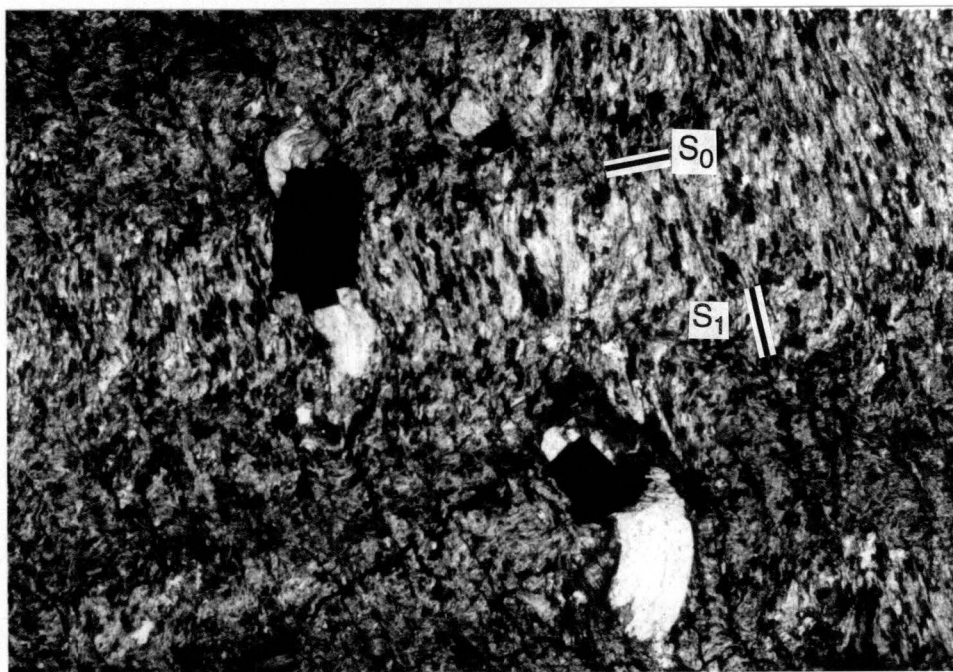
(B)

Figure III-10. Characteristics of S_1 cleavage in western portion of study area.

(A) Photomicrograph (plane light) of bedding and S_1 cleavage relationships in banded metasiltstone of Wilhite Formation. Sample RAF 597; Lost Cove Branch, Rafter 7.5-minute quadrangle. Field of view is 7.0 mm. (B) Photomicrograph (plane light) of bedding-parallel pressure-solution cleavage, S_1 cleavage, and quartz shadows in banded calcareous metasiltstone of Wilhite Formation. Sample BRF 063; Miller Ridge east of Caney Branch, Bald River Falls 7.5-minute quadrangle. Field of view is 7.0 mm.



(A)



(B)

In the eastern portion of the study area, the importance of pressure solution as a cleavage-forming mechanism declines and S_1 formed solely by recrystallization of clays to chlorite and muscovite, and the flattening of quartz grains. S_1 becomes nearly continuous in this region. Cleavage domains consist of 0.02 mm- to 0.05 mm-thick regions of strongly aligned chlorite and muscovite which separate 0.03 mm- to 0.3 mm-thick microlithons with moderate to very strong fabric alignment (Fig. III-11A). Pressure shadows of recrystallized quartz and chlorite around pyrite and ankerite crystals are locally well developed and are also aligned parallel to this cleavage surface. Slate clasts in metagraywacke were rotated and flattened into the cleavage plane in the extreme easternmost portion of the study area (Fig. III-11B).

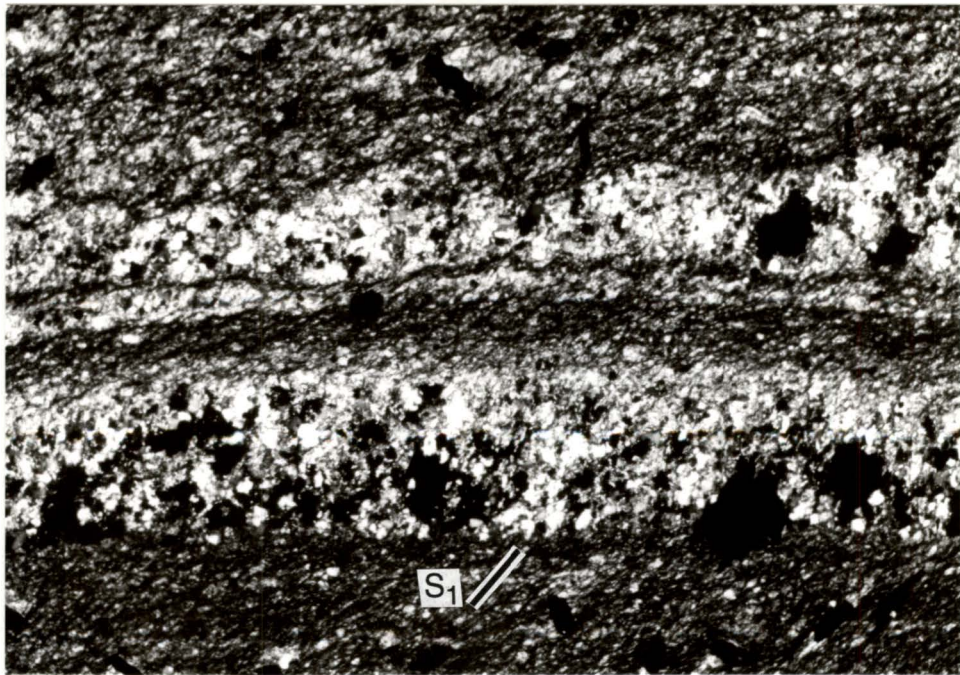
Coarse-grained rocks throughout the study area locally exhibit an anastomosing to rough disjunctive narrowly to broadly spaced cleavage (Powell, 1979) related to S_1 . Most metasandstone and metaconglomerate was deformed by this cleavage, but it is better developed in those with a greater matrix clay content (Fig. III-12A). This form of S_1 consists of 0.03 to 0.3 mm-thick seams that separate 0.5 mm to 5.0 cm-thick microlithons (Fig. III-12B). Grain size controls the thickness of the microlithons, and, in metaconglomerate where S_1 is well-developed, single vein-quartz pebbles may constitute the entire width of a microlithon. In many coarse-grained lithologies, especially in the eastern portion of the study area, quartz clasts have been flattened parallel to S_1 . The similar orientation of S_1 in both fine- and coarse-grained lithologies, as well as locally observed refraction of S_1 from one lithology into another, indicates that they are related structures that formed coevally.

S_{1a} (pressure-solution cleavage)

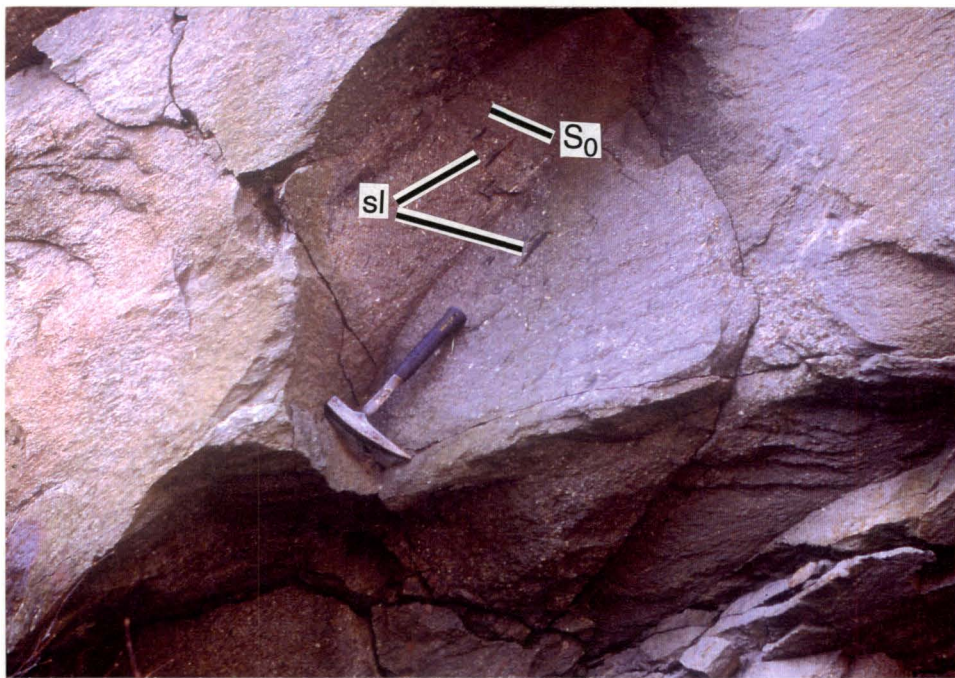
Metasiltstone in the Rabbit Creek and Oconaluftee-Greenbrier thrust sheets locally exhibits a stylolitic disjunctive broadly spaced cleavage (Powell, 1979) oriented suborthogonally to S_0 and generally at an acute angle to S_1 . S_{1a} developed as 0.05 to 0.5 mm-thick, generally dark surfaces spaced 0.1 to 1.0 cm apart (Fig. III-13A). These surfaces dip moderately to steeply

Figure III-11. Characteristics of S_1 cleavage in eastern portion of study area.

(A) Photomicrograph (plane light) of continuous S_1 cleavage in slaty metasiltstone of the Dean Formation. Note cleavage coarsen and refract across metasandstone layers. Sample BRF 671; Turkey Creek Mountain, Bald River Falls 7.5-minute quadrangle. Field of view is 3.0 mm. (B) Slate chips (sl) flattened into S_1 cleavage plane, oriented suborthogonally to bedding in metagraywacke of Horse Branch (?) Member of Ammons Formation. Hammer handle (32 cm long) is oriented parallel to S_1 and points to top of beds. Near station BJ 012; Hemlock Knob, Big Junction 7.5-minute quadrangle.



(A)

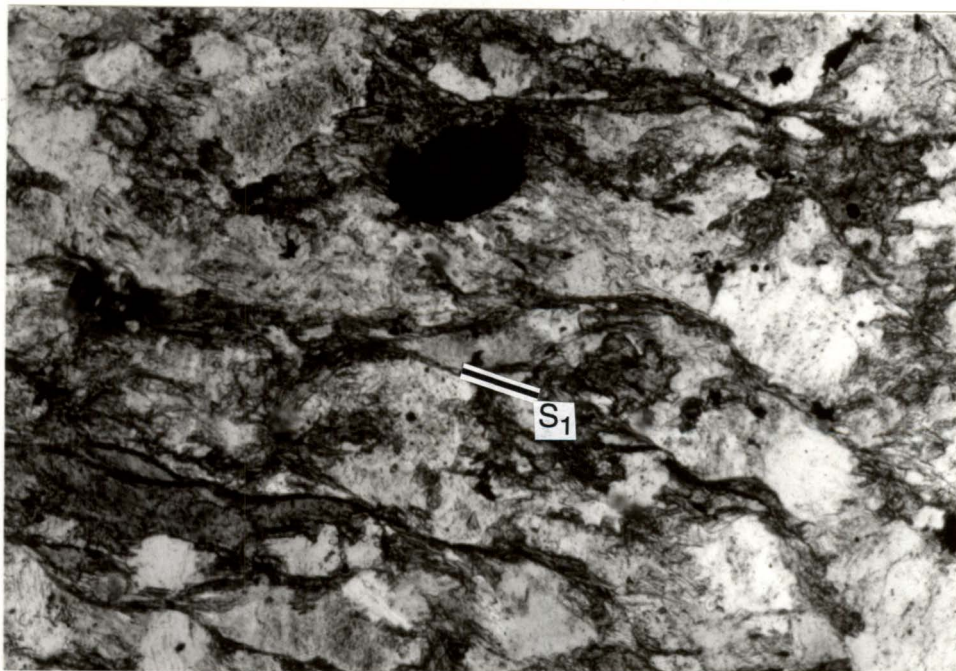


(B)

Figure III-12. Characteristics of S_1 cleavage in coarse-grained rocks. (A) Granule metaconglomerate of Dean Formation showing rough to anastomosing cleavage. Bedding is horizontal in this view. Sample WOF 087; Citico Creek, Whiteoak Flats 7.5-minute quadrangle. (B) Photomicrograph (plane light) of metagraywacke of Dean Formation showing anastomosing cleavage. Bedding is horizontal in this view. Sample BRF 688; confluence of Thrashing Branch and Tellico River, Bald River Falls 7.5-minute quadrangle. Field of view is 3.0 mm.

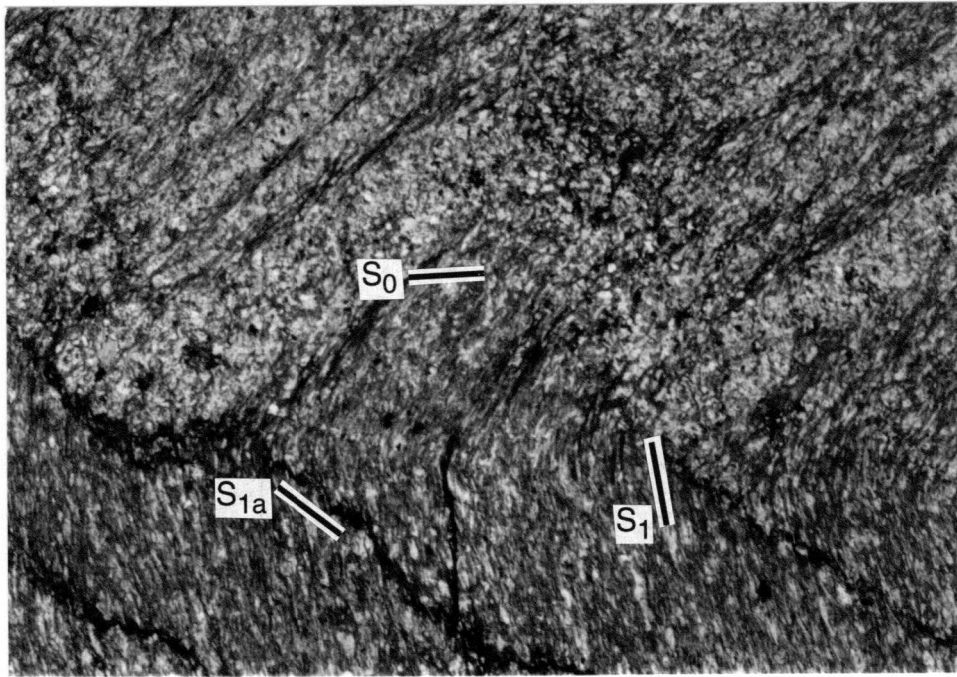


(A)

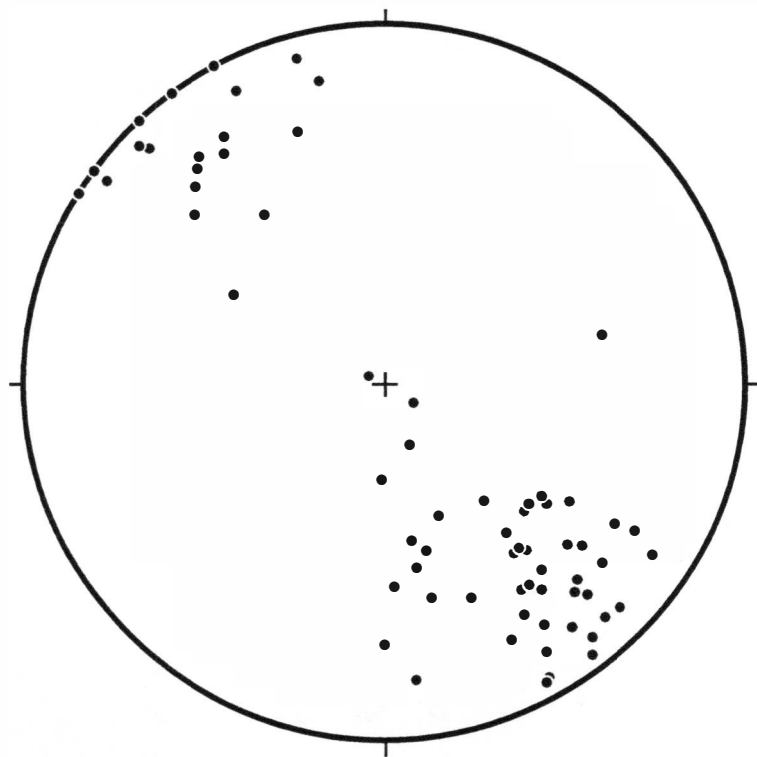


(B)

Figure III-13. Characteristics of S_{1a} (pressure-solution) cleavage. (A) Photomicrograph (plane light) of bedding, S_1 cleavage, and S_{1a} cleavage relationships in banded metasiltstone of Wilhite Formation. Sample BRF 1072; TN Hwy. 165 on Miller Ridge, Bald River Falls 7.5-minute quadrangle. Field of view is 3.0 mm. (B) Lower-hemisphere equal-area projection of 68 poles to S_{1a} cleavage.



(A)



(B)

• Poles to S_{1a} cleavage

northwest and southeast (Fig. III-13B). Although S_{1a} is generally coherent, it can strongly resemble S_0 or S_1 and rocks may part easily along the surfaces. Opaques and other insoluble minerals tend to accumulate along S_{1a} surfaces, indicating that they were formed by a pressure-solution mechanism. These cleavage selvages are distinguished from diagenetic pressure-solution selvages on the basis of their suborthogonal relationship both to S_0 and to bedding-parallel pressure-solution selvages. The relationship between S_{1a} and S_1 is not as clear. In most instances, S_{1a} clearly overprints and deforms S_1 cleavage selvages (Fig. III-13A), but in other cases S_1 has deformed S_{1a} . Reorientation of recrystallized clay minerals into parallelism with S_{1a} selvages was observed to the south of the present study area (Carter, 1994), but this relationship was not observed here. These observations suggest that S_{1a} formed at least partially coevally with S_1 , but possibly continued afterwards.

S_2 (crenulation cleavage)

S_2 , a zonal crenulation cleavage (Powell, 1979), deforms S_1 in fine-grained rocks across the study area. Mesoscopically this cleavage appears as 0.1 to 1.0 cm-thick bands that kink S_1 (Fig. III-14). Rocks were not observed to part along these surfaces. S_2 axial surfaces dip moderately to steeply northwest and southeast, and S_2 hinges plunge gently southwest or northeast (Fig. III-5B).

Although the relationships between S_2 and F_2 are not clear, they are interpreted as related because they both deform S_1 , have a similar fold style, and have similar axial-surface and hinge orientations (compare Figs. III-5A, III-5B). S_2 does not deform S_{1a} , but S_{1a} is deformed by F_2 folds at several locations, and by analogy it is inferred that S_2 postdates S_{1a} .

At several localities near the Oconaluftee-Greenbrier fault, asymmetric near-similar chevron-style folds that are spatially associated with S_2 cleavage form a tightly spaced joint set along their shorter limbs (Fig. III-6). The genetic relationships between S_2 and the joint set are

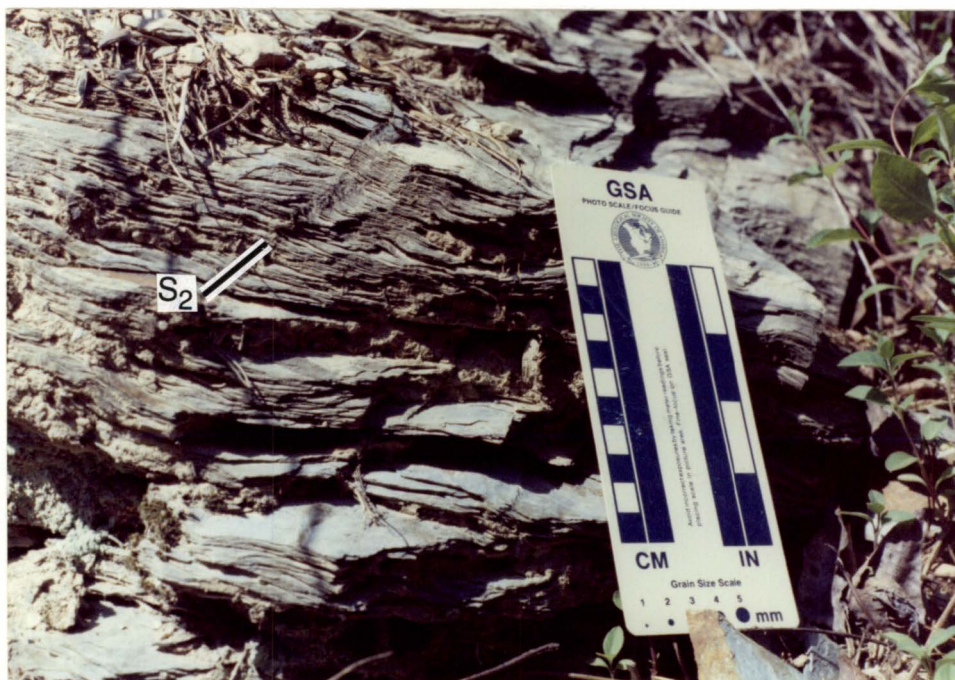


Figure III-14. Mesoscopic S_2 (crenulation) cleavage in poorly banded silty slate of Wilhite Formation. Note kinked S_1 cleavage to left of scale. Bedding dips toward right side of photograph. Station RAF 639; Rafter Road between Nickels Branch and Friends Church, Rafter 7.5-minute quadrangle.

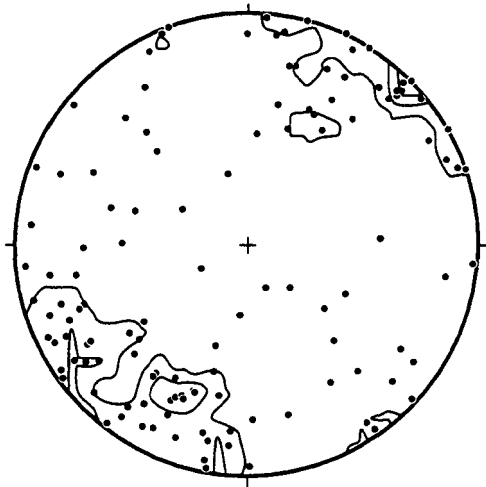
not constrained, but they may have formed coevally during displacement on the fault. These structures are not regionally significant.

Joints and Veins

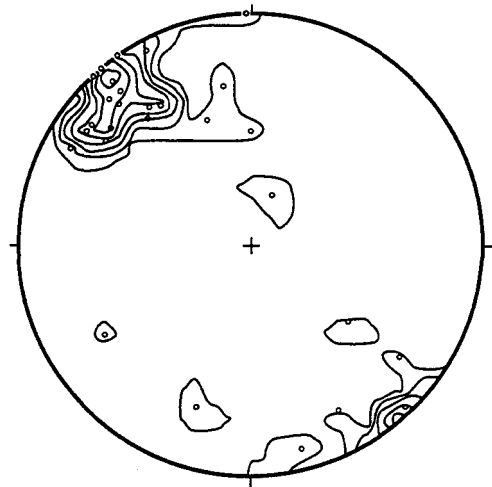
Rocks throughout the study area have been deformed by joints and associated veins. These structures transect bedding and all other structures except for the latest-stage brittle faults, which deformed the veins in many instances. Most veins are filled by white quartz, but carbonate fill is locally important and minor amounts of sulfides were observed at several localities. Joints and veins are more prevalent in the coarser-grained lithologies, but they are common in the finer-grained lithologies. Quartz veins are strongly coherent, but rocks commonly part along joint surfaces. At several localities, quartz veins had the same orientation as S_1 cleavage, and appear to have been formed along these surfaces. Joints often resemble bedding in massive metasandstone and metaconglomerate. Streamflow in several smaller creeks throughout the area is directly controlled by joints, and these creeks flow for tens of meters along a single joint trace before stepping over to another trace in the same joint set.

Mesoscopically, joints and veins commonly occur together in well-defined sets, but joint sets do not persist across the study area with a common orientation as some vein sets do. Joint sets that are revealed on stereonet trend northwest and dip steeply northeast and southwest in the Oconaluftee-Greenbrier thrust sheet (Fig. III-15A), while joints in the Rabbit Creek thrust sheet trend more east-west and dip steeply north and south (Fig. III-15C). In the Oconaluftee-Greenbrier thrust sheet, vein sets trend northeast and generally dip moderately to steeply southeast (Fig. III-15B), while vein sets in the Rabbit Creek thrust sheet trend east-northeast and generally dip steeply southeast (Fig. III-15D). Orientations for joint and vein sets vary, but they are generally oriented suborthogonally and subparallel to larger F_1 fold axes (Plate IV), indicating they formed during that period of deformation. Veins were perhaps the sites of deposition for quartz dissolved during pressure solution associated with the F_1 folding event.

Figure III-15. Orientations of joint and vein sets in two thrust sheets. (A) Lower-hemisphere equal-area projection of poles to 124 joints in Oconaluftee-Greenbrier thrust sheet. Contours represent 2, 4, and 6 percent per 1 percent area. (B) Lower-hemisphere equal-area projection of poles to 29 veins in Oconaluftee-Greenbrier thrust sheet. Contours represent 2, 4, 6, 8, 10, 12, and 14 percent per 1 percent area. (C) Lower-hemisphere equal-area projection of poles to 47 joints in Rabbit Creek thrust sheet. Contours represent 2, 4, and 6 percent per 1 percent area. (D) Lower-hemisphere equal-area projection of poles to 41 veins in Rabbit Creek thrust sheet. Contours represent 2, 4, 6, 8, 10, and 12 percent per 1 percent area.

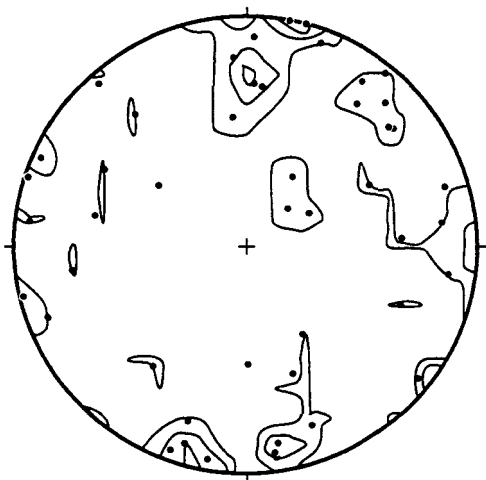


(A)

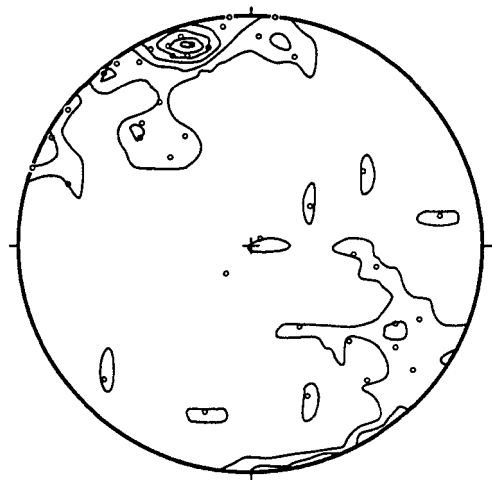


(B)

- Poles to joints
- Poles to veins



(C)



(D)

Separation ranges from less than 1.0 mm for most joints to greater than 1.0 m (3.3 ft) for some quartz veins, with an average quartz-vein thickness of about 3.0 cm. Spacing within a given set of either joints or veins averages approximately 4 cm to 10 cm, but this can also vary. Individual veins can sometimes be traced for tens of meters.

Rocks in the Rabbit Creek thrust sheet, especially the upper metaconglomerate and upper slate units between Ballplay Creek and the western boundary of the study area, contain a higher density of joint and vein sets than the rest of the study area determined by inspection of fracture data on Plate IV. This intensity increase may be related to “sandwiching” of these rocks between the Rabbit Creek and Oconaluftee-Greenbrier faults, since the two faults are close together in that region (Plates I, IV). At several localities within these units, strongly deformed quartz veins and pods were observed, especially near inferred faults (Plate IV). Deformed veins that are further away from inferred faults may be evidence for unrecognized faulting in this area.

Rocks assigned to the metasiltstone portion of the Wilhite Formation also contain abundant quartz veins (Plate IV). Quartz veins in these rocks have been known for over 100 years to be locally gold bearing, especially in the Coker Creek district 12 km (7.5 mi) southwest of the study area (e.g., Hale, 1974). Many large quartz veins occur in the Wilhite within the present study area, but their orientations were indeterminable because they occurred only as cobbles or boulders on the surface, or in colluvial boulder fields (Plate IV). Some boulders are up to 4.0 m (13 ft) in diameter, attesting to the dimensions of the original veins.

Chapter IV

ENVIRONMENTAL SITE ASSESSMENT ALONG BALLPLAY CREEK AND LOST COVE BRANCH

Introduction

Geologic data are an integral part of any environmental impact or geotechnical site assessment, which became mandatory for construction proposals upon passage of the National Environmental Policy Act of 1969. The Act requires detailed statements concerning environmental impacts, adverse environmental effects, and alternatives regarding the proposed action. Geologic information including rock discontinuities, lithologic type, surficial deposits and geomorphic features (including slope), and sulfide-rich zones are factors that must be considered during excavation for any construction project. Other important factors include the number of live streams cut by the road, degradation of water quality, and habitat destruction. This chapter attempts to apply some of the geologic data and information gathered during this study towards the initial site investigation for a hypothetical road construction project. Data and information presented herein include: discussion of discontinuities such as joints, cleavage, bedding, faults, and geologic contacts; areal extent of surficial deposits; and areal extent of sulfide-bearing map units.

Methodology

A 2.3 km (1.5 mi) corridor of undeveloped land between two existing roads on the Rafter 7.5-minute quadrangle was chosen for the hypothetical construction of a low-traffic two-lane gravel connector road (Fig. IV-1; Plate IV). This corridor was selected because it would provide a shorter alternate route between Tennessee State Highway 360 north of Chestnut Valley and the Indian Boundary Lake Recreation Area. Three alternative alignments (designated A, B, and C) within the corridor were selected and each was divided into segments

Figure IV-1. Map of proposed corridor for hypothetical road construction project. Alternative routes delineated by heavy lines and labeled according to segment designations (A1-A4, B1-B5, C1-C4). See Plate IV for location of diagram. See Plate I for explanation of geologic map symbols and details of geology. Contour interval is 40 feet.

Geologic abbreviations: Qa--undifferentiated alluvium and colluvium; Qal--alluvium; Qc--colluvium; Zcc--coarse-grained lithologies of Rabbit Creek thrust sheet; Zcs--fine-grained lithologies of Rabbit Creek thrust sheet; Zdc--coarse-grained lithologies of Dean Formation; Zds--fine-grained lithologies of Dean Formation; Zwc--coarse-grained lithologies of Wilhite Formation; Zwl--limestone of Wilhite Formation; Zws--fine-grained lithologies of Wilhite Formation.

based on bedrock characteristics (Fig. IV-1). Grade and curvature for each alignment were designed according to specifications recommended for roads in mountainous terrain with design speeds of 35 miles per hour (Wright and Paquette, 1979).

Along the proposed routes, discontinuities were measured and described in detail, surficial deposits were mapped, and rocks were visually inspected and evaluated for the presence and proportions of sulfide minerals (mainly pyrite). Each route was assessed for its viability according to these geologic influences and the potential impact on the local environment. This information is presented herein as one part of an initial environmental site investigation for the hypothetical road construction project. These data would also become part of the final data set employed during the geotechnical engineering portion of the project.

Alignment Locations and Corridor Physiography

The three proposed connector routes begin at the south end of a dead end road just south of Williamsburg Cemetery off of Monroe County Highway 57 (Fig. IV-1; Plate IV). They all trend generally south-southeast and subparallel to Ballplay Creek and Lost Cove Branch and join with U. S. Forest Service Road 2033 (Fig. IV-1; Plate IV). This road terminates at U. S. Forest Service Road 284 which subsequently terminates near Indian Boundary Lake.

Alternate route A, the westernmost route, ascends the north slope of Tyler Mountain to approximately 1,400 ft (430 m) elevation, then drops down the south side of Tyler Mountain and crosses Ballplay Creek 450 m (1,500 ft) upstream from its confluence with Lost Cove Branch. It then ascends the south-trending ridge that forms the divide between those two drainages, and joins an abandoned logging road that terminates at Forest Service Road 2033 (Fig. IV-1; Plate IV). Route A is 3.3 km (2.1 mi) long.

Alternate route B, the most centrally located route, follows the valley of Ballplay Creek to Lost Cove Branch, and then travels along the valley of Lost Cove Branch to its headwater tributaries where it ascends to the top of an unnamed ridge and joins with Forest Service Road

2033 (Fig. IV-1; Plate IV). Route B is the shortest route at 3.0 km (1.9 mi).

Alternate route C, the easternmost route, begins by following the same route as alternate route A over Tyler Mountain. On the south slope of Tyler Mountain, alternate route C veers southeast down a gently sloping spur and crosses Ballplay Creek approximately 50 m (160 ft) downstream from the mouth of Lost Cove Branch. It then ascends the south-southeast-trending ridge northeast of Lost Cove Branch and connects with an abandoned logging road which terminates at Forest Service Road 2033 (Fig. IV-1; Plate IV). Route C is 4.15 km (2.6 mi) long.

The terrain along the corridor is quite rugged, with elevations that range from 1,000 ft (300 m) at Williamsburg Cemetery to approximately 1,900 ft (580 m) at Forest Service Road 2033, and natural slopes that commonly approach 40 degrees (Fig. IV-1; Plate IV). Soils along the corridor vary greatly in thickness (several centimeters to approximately 5.0 m) and consist of both residual and transported soil. The steep topography causes south-facing slopes to receive much more sunlight than north-facing slopes, resulting in generally thicker soil cover.

Only two permanent streams—Ballplay Creek and Lost Cove Branch—are present along the corridor, but numerous intermittent streams drain into these creeks. Ballplay Creek is the dominant drainage in the area. Taken together, alternate routes A and C essentially encircle the Lost Cove Branch drainage basin.

Generalized Bedrock Geology

The proposed routes cross six of the map units as defined in the previous chapters (Fig. IV-1; Chapters II, III; Plates I, IV). All of the rocks are subchlorite- to chlorite-grade metamorphosed sedimentary rocks that are constituent units within the Late Proterozoic Ocoee Supergroup (Chapter II). The lithologies include metasiltstone and slate of the Wilhite Formation, metaconglomerate and metagraywacke in the Rabbit Creek thrust sheet (“Cades Sandstone”) (equivalent to the Dean Formation), slate and metasiltstone in the Rabbit Creek thrust sheet (“Cades Sandstone”), metaconglomerate and metagraywacke of the Dean

Formation, and slate and metasiltstone of the Dean Formation (Plate I; Chapter II). The Wilhite Formation is a unit within the Walden Creek Group, and the rocks in the Rabbit Creek thrust sheet ("Cades Sandstone") and Dean Formation are units within the Great Smoky Group (Chapter II). For the purposes of this section, "fine-grained" refers to slate and metasiltstone, and "coarse-grained" refers to metasandstone, metagraywacke, and metaconglomerate. Only two faults are encountered along the route and were located based on truncation of map-scale structures and map units. These are southeast-dipping regional structures and are correlated with the Rabbit Creek and Oconaluftee-Greenbrier faults. Minor faults are likely present but are more difficult or impossible to observe prior to excavation. Fine-grained rocks of the Rabbit Creek thrust sheet and Dean Formation are the most sulfidic lithologies, but the coarser-grained rocks within these formations also contain minor amounts of pyrite. Wilhite Formation metasiltstone and slate does not contain significant amounts of pyrite. Rabbit Creek thrust sheet lithologies are disproportionately highly fractured compared to other units along the corridor, but all units are fractured (Plate IV). Some of the fractures are open (joints), but many, especially in the coarse-grained lithologies in the Rabbit Creek thrust sheet, are filled by milky quartz (veins). All of the units are deformed by a cleavage, which is best developed and most noticeable in the fine-grained units, but which is also present in the coarser-grained units (Chapter III).

Detailed Geologic Study

The following sections tabulate and describe details of the geology along the proposed routes, each of which is divided into segments of varying length based on the gross characteristics of the bedrock (Table IV-1; Fig. IV-1; Plates I, IV). Routes A and C are ridgetop routes that are divided into four segments each, while route B is confined to valley floors and is divided into five segments (Table IV-1).

Table IV-1. Length and bedrock characteristics of each segment along alternate routes.

<i>ROUTE/SEGMENT</i>	<i>LENGTH</i>	<i>BEDROCK LITHOLOGY</i>
Alternate Route A	3.3 km (2.1 mi)	—
Segment A1	450 m (1,500 ft)	fine-grained Wilhite
A2	1.75 km (1.1 mi)	70% fine-grained Cades
		30% coarse-grained Cades
A3	1.0 km (0.6 mi)	fine-grained Wilhite
A4	100 m (330 ft)	coarse-grained Dean
Alternate Route B	3.0 km (1.9 mi)	—
Segment B1	125 m (410 ft)	fine-grained Wilhite
B2	1.25 km (0.8 mi)	90% coarse-grained Cades
		10% fine-grained Cades
B3	900 m (2,900 ft)	70% fine-grained Cades
		30% coarse-grained Cades
B4	150 m (490 ft)	coarse-grained Dean
B5	600 m (1,970 ft)	fine-grained Dean
Alternate Route C	4.15 km (2.6 mi)	—
Segment C1	450 m (1,500 ft)	fine-grained Wilhite
C2	2.25 km (1.4 mi)	80% coarse-grained Cades
		20% fine-grained Cades
C3	200 m (660 ft)	fine-grained Dean
C4	1.25 km (0.8 mi)	coarse-grained Dean

Rock Discontinuities

Discontinuities are any planar structure or feature in a rock mass along which the rock mass has broken or separated. Study of discontinuity orientations along a proposed construction route is critical because these structures provide potential glide or separation planes along which numerous types of hazardous mass wasting processes can occur. If any discontinuity dips toward the excavated area where the slope has been oversteepened, planar instability may result and rock slide, debris slide, or block slide may occur. Rock slide occurs when blocks of rock move rapidly downslope along a dominant discontinuity set. Debris slides are bodies of soil and loose rock that move downslope at moderate to rapid rates. Block slides occur when large blocks of rock glide along a weaker or plastic material such as clay, and are generally slow-moving mass wasting phenomena. Different dip on two or more discontinuities can produce conditions leading to wedge failure when the intersection lineation between the two discontinuities plunges out of the excavation or is subparallel to it. Rock fall occurs when blocks are dislodged by frost heaving along a discontinuity and fall freely away from the hillside. All of these slope instability problems are amplified by oversteepened and undercut slopes (both natural and man-made) and by heavy rainfall, which adds weight to the material above the discontinuity and accelerates weathering along the discontinuity. Important factors other than orientation to consider in this portion of the assessment include spacing and condition (roughness, separation, continuity, weathering, and infilling) of the discontinuities (Bieniawski, 1989), as these may help to accelerate or diminish the effects of discontinuity orientation, slope, and rock type on overall slope stability. These data will be collated with other observations to formulate the engineering classification of rock masses encountered along the route (Bieniawski, 1989).

Discontinuities described herein include joints, cleavage, bedding, faults, and lithologic contacts. Joints are common in all lithologies along the proposed route, but are most prevalent in the coarser-grained rocks in the Rabbit Creek thrust sheet (Plate IV). Cleavage is the dominant type of discontinuity in fine-grained rocks, but is not uncommon in coarser-grained

rocks (Fig. IV-1; Plate I). Bedding within a given rock type is generally coherent along the proposed corridor, even in weathered rocks. Only two faults were recognized along the route, but many smaller faults may remain undetected. Since rock along both walls of a fault are generally broken or disturbed, fault zones may weather out rapidly and become filled by residual soil, thus forming an efficient release surface. Contacts between different rock types are also generally coherent, but along several segments are more weathered and may cause planar or wedge instability.

Joints

Five dominant joint sets are recognized along the proposed corridor (Table IV-2; Fig. IV-2A, B; Plate IV). Of these, one set is along Segments A1, B1, and C1, and the other four sets are along Segments A2-A4, B2-B5, and C2-C4 (Fig. IV-1; Table IV-2). The joint set along the first segments dips southeast and generally into the hillslopes, and should not cause planar instability. The intersection lineations between joints and bedding and joints and cleavage along these northernmost segments plunge gently to steeply towards the north- and east-facing cuts, which creates a potential for wedge failure to occur. Coherence of bedding and tight spacing of cleavage should prevent the formation of large wedges.

Joints along the remainder of the route can be placed into one of four sets (Table IV-2; Fig. IV-2A, B). Errant measurements may fall into subordinate sets or simply be deviations from one of the master sets. Many of the joints are filled with quartz (veins), which weld the walls of the fracture together and makes them very coherent, but unfilled joints are almost always present with the veins. Joint sets dip steeply southeast, moderately to steeply southwest, and steeply northeast (Table IV-2; Fig. IV-2A, B), so cuts facing those directions may experience planar instability, especially in combination with steeper slopes. Wedge failures are likely to occur along northeast- and southwest-facing cuts, because the intersection lineations between joints and bedding or cleavage plunge moderately to steeply northeast and southwest. These

Table IV-2. Characteristics of discontinuities observed along alternate routes.

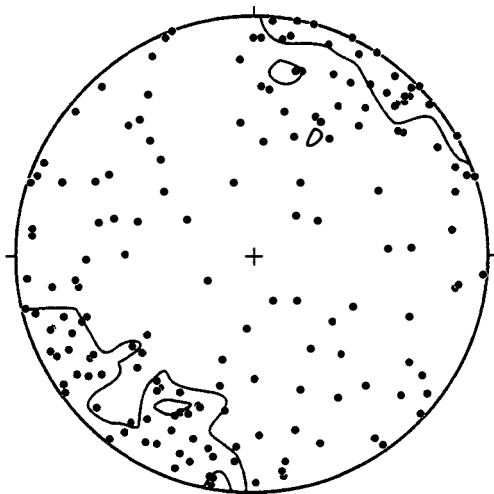
SEGMENTS AFFECTED	TYPE OF DISCONTINUITY	AVERAGE ORIENTATION	AVERAGE SPACING	SEPARATION	CONTINUITY	CONDITION ROUGHNESS	FILLING	WEATHERING
A1, B1, C1	Joint	N 50 E 83 SE	<25 cm	<0.5 mm	≤2.5 m	smooth-mod. rough	none	high
A2-A4, B2-B5, C2-C4	Joint	N 80 W 75 SW	20 cm	0.5 mm-1.0 mm	≤ 10 m	smooth-mod. rough	none/quartz	moderate
"	Joint	N 30 W 80 NE	"	"	"	smooth-mod. rough	none/quartz	moderate
"	Joint	N 50 W 80 SW	"	"	"	smooth-mod. rough	none/quartz	moderate
"	Joint	N 70 W 85 NE	"	"	"	smooth-mod. rough	none/quartz	moderate
ALL	Cleavage	N 35 E 55 SE	<1 mm-8 cm	<0.5 mm	≤10 m	smooth-mod. rough	none	moderate to high
A1, B1, C1	Bedding	N 35 E 70 SE	1 mm-2 cm	—	1 m-20 m	smooth-rough	—	slight
A2-A4, B2-B5, C2-C4 (*)	Bedding	N 45 E 30 SE	1 mm-2 m	—	≤20 m	smooth-rough	—	slight-high
(**)	Fault	N 35 E 60 SE	—	—	>50 km	—	—	—
(**)	Fault	N 60 E 30 SE	—	—	>30 km	—	—	—
A2, B3, C2 (***)	Contact	N 55 E 25 SE	1 m-100 m	<1 mm-1 cm	≤2 km	smooth-rough	—	slight-high

(*) Bedding orientations, spacing, and conditions vary greatly along these segments.

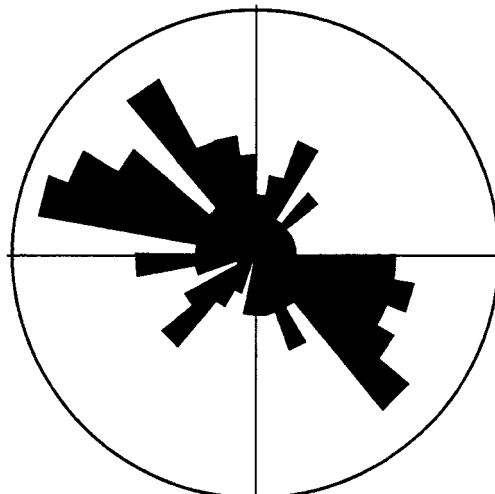
(**) Faults were used as segment boundaries, and, as such, do not affect particular segments.

(***) Contacts other than those within these segments were used as segment boundaries, and, as such, do not affect particular segments.

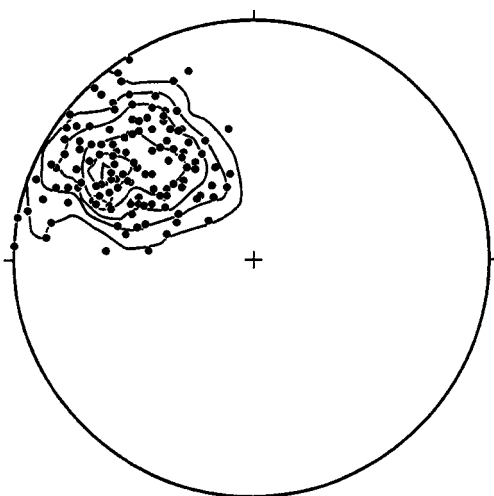
Figure IV-2. Orientation of major discontinuities. (A) Lower-hemisphere equal-area projection of 171 poles to joints. Contours represent 2 and 4 percent per 1 percent area. (B) Rose diagram of strike orientations for 171 joint measurements. Outer circle represents 7 percent of the data. (C) Lower-hemisphere equal-area projection of 118 poles to cleavage. Contours represent 2, 4, 6, 8, 10, and 12 percent per 1 percent area. (D) Rose diagram of strike orientations for 118 cleavage measurements. Outer circle represents 23 percent of the data. (E) Lower-hemisphere equal-area projection of 197 poles to bedding. Contours represent 2, 4, 6, 8, 10, and 12 percent per 1 percent area. (F) Rose diagram of strike orientations for 197 bedding measurements. Outer circle represents 13 percent of the data.



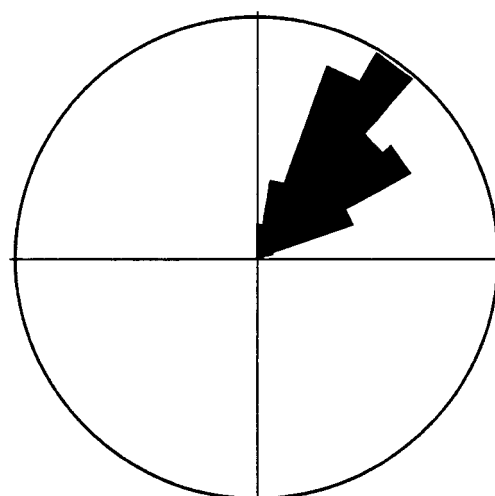
(A)



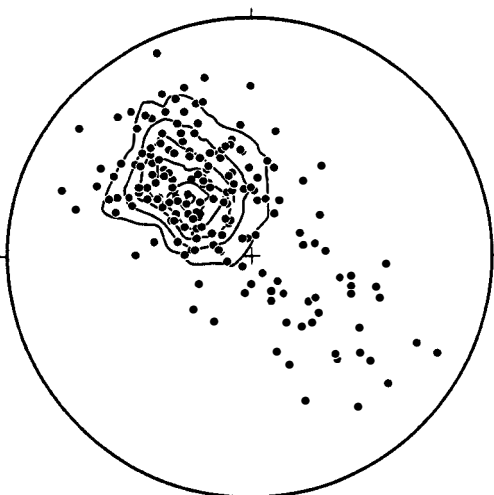
(B)



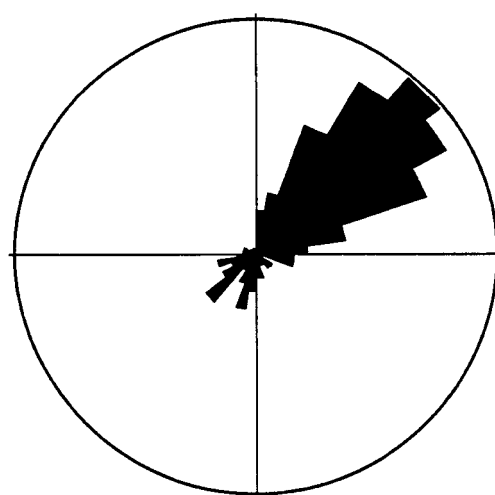
(C)



(D)



(E)



(F)

intersection lineations trend subparallel to southeast-facing slopes, which may cause instability. Slopes less than 1:1 will lessen the possibility for many wedge failures (Reed and others, 1995).

Cleavage

Cleavage is the dominant discontinuity along Segments A1, B1, and C1, and is well developed in most rocks underlying the remaining segments. This discontinuity is extremely regular and dips moderately to steeply southeast (Fig. IV-2C, D; Table IV-2). Cleavage surfaces weather readily to form excellent release surfaces, and are involved in both planar and wedge instability. Southeast-facing slopes are particularly susceptible to failure along cleavage surfaces, especially in fine-grained rocks.

Bedding

Bedding orientations are regular along the corridor and dip gently to steeply southeast and northwest (Fig. IV-2E, F; Table IV-2). In most instances, especially in finer-grained lithologies, this discontinuity is coherent and will not cause instability. Bedding in coarser-grained rocks is occasionally highly weathered and can form release surfaces. Because bedding in coarse-grained rocks is generally widely spaced, slope failures involving bedding discontinuities can produce blocks of substantial size. Southeast-facing cuts along sections with gentle southeast-dipping bedding planes will be most affected by planar instability. Bedding combined with jointing has produced numerous small-scale ($< 2 \text{ m}^3$, or 285 ft^3) natural wedge failures along northeast- and southwest-facing hillslopes.

Faults

Only two faults were recognized along the corridor (Fig. IV-1; Plates I, IV). These are regional structures that dip southeast and generally into the hillsides at the locations where the three alternate routes intersect them (Fig. IV-1; Table IV-2; Plates I, IV), and will probably not

cause slope stability problems. Numerous smaller faults and an increase in fracture density in the vicinity of these larger faults will probably be revealed upon excavation. The condition and width of the fault zones could not be directly observed because of lack of exposure, but there is most likely a zone of crushed and deformed rock along the fault trace that is up to ten meters wide.

Contacts

Lithologic contacts along the alternate routes are generally coherent and are oriented parallel to bedding (Fig. IV-1; Table IV-2; Plate I). They will not pose any stability concerns, except possibly along Segment B3, which crosses numerous contacts between fine- and coarse-grained rocks. Many of these contacts are more weathered than usual, and form discontinuities with good potential for instability, especially in combination with the steepness of slope.

Surficial Deposits

Residual and transported soils are the most unstable construction materials along the corridor. Soils generally have relatively low shear strength and are occasionally subject to shrink-swell phenomena, so special cut-and-fill methods and drainage designs may be required to prevent long-term maintenance problems.

Residual soil is ubiquitous along the proposed route, and mapping it is beyond the scope of this report. These deposits are commonly less than 2.0 m (6 ft) thick, and are better developed on southerly aspects.

Deposits of transported soil (alluvium, colluvium, or landslide deposits) that were observed are small in area and based on visual inspection are less than 4.5 m (15 ft) thick. They are most common along alternate route B (Fig. IV-1; Plate IV). Alluvium along the corridor consists of unconsolidated clay, silt, sand, and gravel, with occasional cobbles and boulders less than 2 m (6 ft) in diameter. These are present only along the larger stream valleys, and as such

will not cause stability problems. Only one body of colluvium was observed along any of the alternate routes (Segment A2), and occurs in fine-grained rocks in the Rabbit Creek thrust sheet (Fig. IV-1; Plate IV). This deposit is less than 1.0 m (3.3 ft) thick and consists of unconsolidated clay, silt, sand, and gravel, with very few cobbles and no boulders. The parent material is highly sulfidic, but the deposit appears to be in equilibrium and at present is not generating acidic drainage. Excavation will expose fresh surfaces and increase the acid drainage potential of this deposit, which, coupled with the proximity of the deposit to Ballplay Creek and its parallelism to steep slopes, make this colluvium body potentially hazardous to the downstream environment. Landslide deposits, although common at slightly higher elevations, were not observed along the proposed corridor.

Sulfidic Zones

Excavation and exposure of bedrock that contains as little as 0.5 percent sulfide mineral content (e.g., pyrite) has the potential to acidify surface water runoff and become hazardous to downstream environments (Byerly and Middleton, 1981; Winchester, 1981; Byerly, 1990; Reed and others, 1995). Construction crews must therefore consider the handling, treatment, and placement of this material when excavating roadbeds. Recommended mitigation procedures depend on the acid drainage potential estimated from net acid-base accounting analysis (Sobek and others, 1978; Byerly and Middleton, 1981; Byerly, 1990), and include treatment with agricultural lime or encapsulation in a clay-lined disposal area (Byerly, 1990), or in a geomembrane-lined disposal area (Moore, 1992).

A wide range of sulfide mineral concentrations was observed in the bedrock along the corridor (Table IV-3). Variations occur within all units, but, in general, the fine-grained lithologies contain more pyrite visible to the unaided eye than do coarser-grained lithologies. Finer-grained rocks also contain more disseminated sulfides, which are of greater concern because these smaller crystals have more surface area and thus are more readily decomposed to

Table IV-3. Sulfide mineral content of bedrock along alternate routes.

<i>ROUTE/SEGMENT</i>	<i>BEDROCK LITHOLOGY</i>	<i>SULFIDE CONTENT</i>
Alternate Route A	—	—
Segment A1	fine-grained Wilhite	<0.5%
A2	70% fine-grained Cades	0.5%-5.0%
	30% coarse-grained Cades	<0.5%, rarely up to 1.5%
A3	fine-grained Wilhite	≤1.0%, rarely up to 2.0%
A4	coarse-grained Dean	0.5%-1.0%
Alternate Route B	—	—
Segment B1	fine-grained Wilhite	<0.5%
B2	90% coarse-grained Cades	<0.5%, rarely up to 1.5%
	10% fine-grained Cades	≤3.0%
B3	70% fine-grained Cades	0.5%-5.0%
	30% coarse-grained Cades	<0.5%, up to 1.5%
B4	coarse-grained Dean	0.5%-1.0%
B5	fine-grained Dean	≤1.5%, commonly up to 10%
Alternate Route C	—	—
Segment C1	fine-grained Wilhite	<0.5%
C2	80% coarse-grained Cades	<1%, rarely up to 1.5%
	20% fine-grained Cades	0.5%-5.0%
C3	fine-grained Dean	≤1.5%, commonly up to 10%
C4	coarse-grained Dean	0.5%-1.0%

produce acid runoff (Reed and others, 1995). Segments A2, B3, B5, and C2 contain the highest proportions of sulfidic bedrock (Table IV-3; Fig. IV-1). Because of the great spatial variability of sulfide deposits and the possibility that high concentrations may not be visible to hand sample inspection, cores and samples from all excavated areas should be thoroughly tested for acidic drainage potential.

Conclusions

From a geological perspective, none of the three alternative routes studied herein are ideal for road construction. Adverse impacts on the water quality of Ballplay Creek due to acidic drainage and sedimentation are inevitable, but may be mitigated through encapsulation of pyritic material and bridging or retaining walls, respectively. Live streams will be cut by all three of the routes, but this can be minimized by selecting one of the ridgetop routes (A or C), which will lessen the sedimentation of streams along the corridor. Slope instability in both bedrock and surficial deposits will cause long-term maintenance problems along any of the routes. I recommend that a more detailed analysis of discontinuities be performed on unfavorably oriented cuts to determine the final slope angles used, and that sampling and analysis methods for water and rock quality are established prior to construction to assist in monitoring and mitigating any adverse environmental effects during and after construction. Of the three routes, alignment C is geologically the most sound. The following are advantages and disadvantages for each route as determined during the present study.

Alternate Route A

Advantages to choosing Route A are mainly the result of its being a ridgetop route. Very few streams are crossed and slope stability concerns are kept to a minimum. Most cuts would be favorably oriented in regards to discontinuities. This route crosses Ballplay Creek upstream from its confluence with Lost Cove Branch and therefore would require less disturbance along live

stream channels. Much of the southern section of Route A would be along abandoned logging roads, and would require less construction in straightening and widening them.

Disadvantages to Route A are that it crosses several extremely steep slopes, which would require large cuts and fills to bring the road to grade. Much of the bedrock along this route is sulfidic and would require extensive acid drainage mitigation measures. This sulfidic bedrock could not be used as aggregate, riprap, or fill, so other road material would need to be brought in from external sources. Alternate Route A also crosses a colluvium deposit formed from highly sulfidic parent material. This colluvium body is situated immediately above Ballplay Creek, and extensive measures would be necessary to keep the material from slumping.

Alternate Route B

There are no advantages to locating a roadway along this route. It is confined to the steep-walled valleys of Ballplay Creek and Lost Cove Branch and would require vast amounts of earthwork to stabilize the numerous unfavorably oriented cuts. The alignment is extremely close to the two live streams and would necessarily cross them many times. This would create high sedimentation rates and the need for a number of stream channel changes. The floods that occurred in Spring of 1994 devastated these two valleys, and future floods of this magnitude would destroy the roadway and possibly be hazardous to motorists. Route B also crosses a large number of pyritic zones, and encapsulation along the streambeds or removal to a waste disposal pit would be cost-prohibitive.

Alternate Route C

Alternate Route C is recommended for construction of a low-traffic two-lane gravel road along the proposed corridor. Advantages to this route are primarily the result of placement along ridgelines. Fairly regular and gentler hillslopes (compared to Route A) are present, and almost all of the cuts will be favorably oriented in regards to discontinuities. Much of the southern

section of this route is also located along abandoned or existing logging roads. The fewest number of potentially acid-producing lithologies are intersected, and no alluvium or colluvium will be crossed. This route also crosses Ballplay Creek only once, and although the crossing is below the confluence with Lost Cove Branch, adverse environmental impacts can be avoided through careful construction of bridgework at this location. One minor advantage to selecting Alternate Route C is that the stream crossing is 50 m (160 ft) upstream from Ballplay Falls, an approximately 15 m (50 ft) high scenic waterfall. A parking area and overlook could easily be included into the road construction plans.

Chapter V

CONCLUSIONS

1) Metasedimentary rocks exposed in the study area belong to the Upper Proterozoic Ocoee Supergroup, interpreted to have been deposited in rift basins during Late Proterozoic breakup along the southeastern Laurentian margin. They are assigned to the uppermost units of the older Great Smoky Group and lowermost units of the overlying Walden Creek Group. Great Smoky Group lithologies are correlated with the Horse Branch Member of the Ammons Formation, the Dean Formation, and the unit formerly known as the Cades Sandstone. These three formations were subdivided into twelve map units. Walden Creek Group lithologies are correlated with the Wilhite Formation, which was subdivided into seven map units.

2) The contact between the coarser-grained Great Smoky Group and finer-grained Walden Creek Group was previously interpreted to be the southern extension of the Greenbrier fault, but is variably sharp, intertonguing, or gradational in the study area, and is thus conformable. Great Smoky Group lithologies consist of turbiditic granule to pebble metaconglomerate, metagraywacke, metasandstone, and darker-colored sulfidic and graphitic slate and metasiltstone. Walden Creek Group lithologies consist mainly of lighter-colored banded metasiltstone and slate.

3) Rocks of the study area are folded into a 2nd-order parasitic fold pattern around the northeast end of the 1st-order Epperson synclinorium. These are southwest-plunging structures that bring down the youngest Great Smoky Group units and overlying Walden Creek Group units. This contrasts with the Great Smoky Mountains National Park, where anticlinal structures expose the oldest Great Smoky Group units.

4) Rocks in the study area were metamorphosed once, developed three foliations, and deformed by at least one period of thrust faulting and four periods of folding. Bedding (S_0) was first deformed by syndepositional (F_0) folds. Metamorphism reached chlorite and biotite grades during the Ordovician Taconic orogeny, during which regional F_1 folds with axial-planar cleavage (S_1) were formed. A pressure-solution cleavage (S_{1a}) also formed during this event. Two major thrust faults in the study area are correlated with the Rabbit Creek fault and the Oconaluftee-Greenbrier fault of the Great Smoky Mountains National Park. These faults were interpreted as Taconic structures in the Park, but are interpreted to have deformed rocks in the present study area during the Carboniferous-Permian Alleghanian orogeny, indicating reactivation along the sections of faults south of the Park. During the Alleghanian, the entire predeformed package was thrust westward as part of the Blue Ridge thrust sheet over unmetamorphosed Paleozoic platform rocks. The Rabbit Creek fault thrust Great Smoky Group rocks formerly known as the Cades Sandstone over Wilhite Formation, and the Oconaluftee-Greenbrier fault thrust Wilhite Formation and Great Smoky Group units over rocks in the Rabbit Creek thrust sheet. Crenulation cleavage (S_2) and F_2 folds also formed during the Alleghanian orogeny. Lastly, F_3 folds formed during footwall duplexing of Paleozoic platform rocks beneath the Great Smoky thrust sheet, in the waning stages of the Alleghanian orogeny.

5) The formation formerly known as the Cades Sandstone comprises the Rabbit Creek thrust sheet and is bounded to the southeast by the Oconaluftee-Greenbrier fault. In the study area the rocks in the Rabbit Creek thrust sheet are correlated with the Dean Formation, which is the youngest Great Smoky Group unit, while to the northeast in the Great Smoky Mountains the rocks in the Rabbit Creek thrust sheet are equivalent to the Elkmont and Thunderhead Sandstones, which are the oldest Great Smoky Group units. Between the present study area and the Great Smoky Mountains, the rocks in the Rabbit Creek thrust sheet are probably equivalent to the Ammons and Wehuttu Formations, the units lying stratigraphically between the Dean and

the Thunderhead. This indicates that the rocks in the Rabbit Creek thrust sheet do not consist of a separate stratigraphic or tectonic entity, but consist of the entire section of Great Smoky Group units. Upper Great Smoky Group units within the thrust sheet were brought down in southwest-plunging structure, equivalent to that observed southeast of the Oconaluftee-Greenbrier fault in the Epperson synclinorium. This model suggests that the Rabbit Creek fault broke through the northwest limb of a tightening anticline during the Taconic orogeny and was reactivated along the southern section during the Alleghanian orogeny.

6) The Epperson synclinorium is a 1st-order structure on the northwest limb of the 1st-order Ducktown anticlinorium. The Murphy synclinorium is a 1st-order structure on the southeast limb of the Ducktown anticlinorium. This correlation of regional structure permits stratigraphic correlation of Great Smoky Group units across the Ducktown anticlinorium, making at least parts of the Wilhite Formation in the present study area equivalent to the Nantahala Formation of the Murphy syncline stratigraphic sequence. The lowest map unit within the Wilhite Formation in the study area consists of pyritic slate and metasiltstone. In studies southwest of the present study area, similar lithologies at this stratigraphic level were interpreted to be correlative with the Nantahala Formation. Both the Wilhite and Nantahala Formations lie conformably above the Dean Formation.

7) Seismic evidence suggests the Foothills duplex is present beneath the study area. Surface data that supports this evidence includes a low amplitude dome-and-basin fold interference pattern, deflection of the biotite isograd, geomorphic anomalies, and rotation of bedding and cleavage. The Foothills duplex formed the windows in the Great Smoky Mountains National Park by arching the Blue Ridge thrust sheet from below during imbrication of Paleozoic footwall strata. The duplex reaches a structural high beneath Tuckaleechee Cove, the largest and most centrally located window in the Great Smoky Mountains. The windows generally decrease in

size to the southwest of this window, with the smallest one 9 km (15 mi) northeast of the present study area. The roof fault to the duplex is the Great Smoky fault, which is exposed at its highest elevation in Tuckaleechee Cove. Southwest of Tuckaleechee Cove the Great Smoky fault is exposed at successively lower elevations. This relationship suggests localized culminations on a generally southwest-plunging surface on the main part of the duplex, so that the surface is structurally deeper beneath the present study area than it is to the northeast.

8) Application of geologic data to an environmental site assessment for a hypothetical road construction project in the study area suggests that slope failure and acidic drainage are inevitable. Northeast- and south-facing slopes should be studied in more detail to determine the best candidates for slope instability. Sulfidic rocks should be encapsulated to minimize the potential for acidic drainage. Other adverse environmental impacts can be diminished or mitigated by choosing the easternmost alternate route, establishing sampling and analysis methods early during the construction phase, and by utilizing construction methods that have proven effective in reducing environmental degradation.

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APPENDICES

APPENDIX A
STRUCTURAL DATA

<u>Station*</u>	<u>Bedding measurement</u>
BRF 4	S 52 W, 44 N
7	N 35 E, 3 E
9	N 47 E, 66 S
11	N 62 E, 53 S
12	N 55 E, 57 S
13	N 60 E, 50 S
15	N 56 E, 46 S
16	N 49 E, 48 S
17	N 50 E, 39 S
20	N 46 E, 50 S
22	N 55 E, 36 S
23	N 64 E, 39 S
29	N 45 E, 55 E
30	N 42 E, 53 E
31	N 62 E, 8 S
32	S 22 W, 37 W
33	S 30 E, 26 W
34	S 33 W, 50 W
35	S 27 W, 82 W
36	S 39 W, 37 W
37	N 29 E, 17 E
38	N 38 E, 24 E
41	S 54 W, 18 N
42	S 51 W, 37 N
44	S 39 W, 48 W
45	N 60 E, 63 S
46	S 39 W, 60 W
47	S 43 W, 45 W
49	S 24 W, 9 W
64	S 35 W, 70 W
68	N 37 E, 54 E
69	N 52 E, 22 S
70	N 50 E, 44 S
72	S 34 W, 23 W
73	S 30 W, 8 W
74	N 52 E, 14 S
75	S 20 W, 38 W
76	S 34 W, 64 W
77	S 0 E, 20 W
79	S 38 W, 10 W
80	S 47 W, 72 N
81	S 32 W, 48 W
83	N 41 E, 57 E
84	N 43 E, 64 E
85	S 52 W, 69 N
86	S 40 W, 22 W
87	S 57 W, 75 N
88	S 81 W, 37 N
89	S 11 W, 29 W
90	S 67 W, 14 N
91	S 39 W, 71 W

<u>Station*</u>	<u>Bedding measurement</u>
BRF 92	N 46 E, 87 S
93	N 46 E, 54 S
94	N 43 E, 84 E
96	N 43 E, 9 E
97	S 43 W, 47 W
98	N 37 E, 34 E
99	N 48 E, 57 S
100	N 33 E, 47 E
101	N 57 E, 47 S
102	N 50 E, 55 S
103	N 41 E, 51 E
105	N 49 E, 73 S
106	N 57 E, 56 S
107	N 45 E, 55 E
108	N 56 E, 57 S
109	N 57 E, 52 S
110	N 51 E, 62 S
111	N 59 E, 69 S
112	N 61 E, 62 S
113	N 57 E, 63 S
114	N 67 E, 50 S
115	N 59 E, 66 S
116	N 66 E, 52 S
117	N 52 E, 69 S
118	N 66 E, 53 S
119	N 71 E, 57 S
120	N 72 E, 59 S
121	N 53 E, 53 S
122	N 63 E, 88 S
123	S 62 W, 57 N
124	S 57 W, 54 N
125	N 54 E, 73 S
126	S 32 W, 64 W
127	N 37 E, 81 E
128	N 58 E, 66 S
129	N 38 E, 64 E
130	N 76 E, 43 S
131	N 34 E, 54 E
132	N 51 E, 57 S
133	S 47 W, 26 N
134	N 15 E, 31 E
136	N 0 E, 0 E
137	S 33 W, 34 W
138	S 35 W, 16 W
139	S 47 W, 15 N
140	S 65 W, 33 N
141	S 50 W, 19 N
142	N 23 E, 19 E
143	N 25 E, 10 E
144	S 37 W, 70 W
145	N 49 E, 69 S

<u>Station*</u>	<u>Bedding measurement</u>	<u>Station*</u>	<u>Bedding measurement</u>
BRF 146	S 54 W, 56 N	BRF 197	S 35 W, 44 W
148	S 6 W, 32 W	198	S 27 W, 30 W
149	S 23 W, 26 W	199	S 10 W, 18 W
150	S 54 W, 49 N	200	S 13 W, 35 W
151	S 52 W, 82 N	201	S 19 W, 3 W
152	S 55 W, 55 N	202	S 46 W, 20 N
153	S 49 W, 72 N	204	S 32 W, 23 W
154	N 44 E, 77 E	205	S 36 W, 65 W
155	N 47 E, 76 S	206	S 58 W, 40 N
156	N 49 E, 88 S	207	N 70 W, 6 N
157	N 40 E, 72 E	208	N 5 E, 15 E
158	S 41 W, 73 W	209	N 44 E, 26 E
159	S 34 W, 41 W	210	N 0 E, 15 E
160	S 46 W, 46 N	211	N 20 W, 10 E
161	S 41 W, 67 W	212	N 0 E, 0 E
162	S 45 W, 69 W	213	S 39 W, 43 W
163	N 41 E, 70 E	214	S 50 W, 15 N
164	N 41 E, 62 E	215	S 33 W, 15 W
165	S 29 W, 70 W	220	S 35 W, 22 W
166	N 57 E, 63 S	221	S 38 W, 16 W
167	S 25 W, 56 W	216	N 33 E, 8 E
168	S 29 W, 57 W	217	N 20 E, 24 E
169	S 30 W, 50 W	219	N 50 E, 15 S
170	S 45 W, 57 W	218	S 35 W, 11 W
171	N 49 E, 52 S	222	S 36 W, 33 W
172	N 54 E, 52 S	223	N 37 E, 32 E
173	N 52 E, 67 S	224	N 0 E, 0 E
174	N 57 E, 46 S	225	S 36 W, 39 W
175	N 44 E, 56 E	226	N 27 E, 21 E
176	N 36 E, 60 E	227	S 40 W, 21 W
177	N 59 E, 61 S	228	N 32 E, 6 E
178	N 22 E, 27 E	229	S 34 W, 50 W
179	N 49 E, 47 S	230	N 27 E, 82 E
180	N 52 E, 38 S	231	N 31 E, 90 E
181	N 70 E, 56 S	232	S 21 W, 30 W
182	N 53 E, 46 S	233	N 37 E, 90 E
183	S 54 W, 26 N	234	S 39 W, 90 W
184	S 44 W, 25 W	235	S 19 W, 19 W
185	S 39 W, 43 W	237	N 57 E, 63 S
186	N 36 E, 20 E	238	N 54 E, 59 S
187	S 20 W, 19 W	239	S 24 W, 28 W
188	S 50 W, 78 N	240	N 54 E, 20 S
189	N 58 E, 56 S	241	N 43 E, 17 E
190	S 51 W, 47 N	242	N 25 E, 18 E
191	S 60 W, 57 N	243	N 31 E, 21 E
192	N 48 E, 85 S	244	N 20 E, 15 E
193	S 46 W, 44 N	245	S 63 W, 59 N
194	S 39 W, 15 W	246	N 37 E, 37 E
195	S 31 W, 50 W	247	N 47 E, 22 S
196	N 65 E, 22 S	248	N 32 E, 22 E

<u>Station*</u>		<u>Bedding measurement</u>
BRF	249	N 62 E, 41 S
	250	N 50 E, 57 S
	251	N 26 E, 8 E
	252	S 41 W, 84 W
	253	N 35 E, 22 E
	254	N 61 E, 20 S
	255	N 47 E, 80 S
	256	N 45 E, 64 E
	257	N 40 E, 54 E
	258	N 38 E, 58 E
	259	N 43 E, 53 E
	260	N 45 E, 82 E
	261	N 53 E, 20 S
	263	N 8 E, 21 E
	262	S 38 W, 40 W
	264	N 58 E, 27 S
	265	S 46 W, 36 N
	266	S 33 W, 18 W
	267	N 52 E, 38 S
	270	N 48 E, 52 S
	271	N 54 E, 51 S
	273	N 60 E, 45 S
	275	N 48 E, 55 S
	276	N 48 E, 50 S
	277	S 14 W, 24 W
	278	S 28 E, 38 W
	279	S 47 W, 44 N
	280	N 79 E, 80 S
	281	N 56 E, 60 S
	282	S 47 W, 79 N
	283	S 70 W, 55 N
	284	N 33 E, 76 E
	285	N 40 E, 66 E
	288	N 47 E, 14 S
	289	S 56 W, 25 N
	291	N 43 E, 55 E
	292	S 67 W, 49 N
	293	N 61 E, 87 S
	294	N 50 E, 73 S
	295	S 46 W, 90 N
	296	N 42 E, 48 E
	297	S 46 W, 73 N
	298	N 39 E, 40 E
	299	N 36 E, 39 E
	300	N 46 E, 49 S
	301	N 5 W, 40 E
	302	N 30 E, 46 E
	303	S 49 W, 90 N
	304	N 40 E, 49 E
	305	S 32 W, 56 W
	306	S 43 W, 23 W

<u>Station*</u>		<u>Bedding measurement</u>
BRF	307	N 32 E, 44 E
	309	N 61 E, 60 S
	311	N 47 E, 76 S
	312	S 65 W, 74 N
	313	N 61 E, 82 S
	314	S 82 W, 30 N
	315	N 75 E, 68 S
	317	N 62 E, 53 S
	319	N 62 E, 54 S
	321	N 72 E, 58 S
	322	S 39 W, 52 W
	323	N 57 E, 55 S
	327	N 48 E, 60 S
	328	N 46 E, 64 S
	331	N 38 E, 63 E
	332	N 50 E, 70 S
	333	N 25 E, 75 E
	335	N 44 E, 58 E
	336	N 35 E, 56 E
	339	N 20 E, 45 E
	341	N 52 E, 59 S
	344	N 66 E, 49 S
	346	N 53 E, 53 S
	347	N 35 E, 56 E
	348	N 48 E, 56 S
	349	N 42 E, 50 E
	351	N 50 E, 64 S
	352	N 56 E, 64 S
	354	N 48 E, 55 S
	355	N 49 E, 58 S
	357	N 50 E, 66 S
	359	N 35 E, 54 E
	361	N 60 E, 72 S
	362	N 46 E, 65 S
	365	S 52 W, 31 N
	366	S 62 W, 22 N
	367	S 49 W, 82 N
	368	S 56 W, 69 N
	369	S 46 W, 49 N
	370	S 67 W, 22 N
	371	S 20 W, 36 W
	372	S 46 W, 18 N
	373	S 0 E, 0 W
	374	N 52 E, 21 S
	375	S 54 W, 34 N
	375	N 54 E, 22 S
	376	S 66 W, 44 N
	377	N 55 E, 11 S
	378	N 71 E, 13 S
	379	N 69 E, 79 S

<u>Station*</u>	<u>Bedding measurement</u>	<u>Station*</u>	<u>Bedding measurement</u>
BRF 380	S 29 W, 83 W	BRF 435	S 63 W, 65 N
381	S 55 W, 67 N	436	N 72 E, 74 S
382	S 29 W, 82 W	436	S 54 W, 50 N
382	S 30 E, 13 W	437	S 44 W, 54 W
383	S 26 E, 16 W	438	N 46 E, 52 S
384	S 60 W, 56 N	439	N 40 E, 72 E
386	S 45 W, 24 W	442	S 57 W, 60 N
387	N 37 E, 63 E	443	S 42 W, 58 W
389	S 51 W, 29 N	444	N 74 E, 43 S
390	S 25 W, 8 W	445	S 68 W, 67 N
391	S 11 W, 11 W	446	S 65 W, 72 N
392	S 3 W, 42 W	447	N 67 E, 59 S
393	S 11 W, 26 W	448	S 85 W, 17 N
394	N 40 E, 73 E	449	S 82 W, 37 N
395	S 41 W, 20 W	450	S 15 E, 20 W
397	N 53 E, 70 S	452	S 61 W, 64 N
398	N 50 E, 74 S	453	S 59 W, 76 N
399	S 45 W, 86 W	454	S 87 W, 57 N
400	N 50 E, 84 S	455	S 62 W, 90 N
402	N 45 E, 84 E	456	S 57 W, 42 N
403	N 44 E, 40 E	456	N 45 E, 47 E
404	N 43 E, 34 E	457	N 77 E, 79 S
405	N 43 E, 66 E	458	N 62 E, 74 S
406	S 54 W, 58 N	459	S 63 W, 75 N
407	S 58 W, 77 N	460	N 37 E, 45 E
408	S 56 W, 60 N	461	N 35 E, 37 E
409	S 50 W, 85 N	462	S 42 W, 33 W
411	S 55 W, 60 N	463	N 62 E, 64 S
412	S 47 W, 86 N	464	N 64 E, 61 S
413	S 45 W, 40 W	465	N 44 E, 52 E
414	S 42 W, 40 W	466	N 45 E, 52 E
415	N 46 E, 74 S	467	N 46 E, 61 S
416	S 41 W, 37 W	468	N 47 E, 67 S
417	N 46 E, 58 S	469	N 40 E, 47 E
418	N 65 E, 51 S	470	S 32 W, 77 W
419	N 46 E, 65 S	471	N 48 E, 71 S
420	N 30 E, 78 E	472	S 26 W, 84 W
422	N 55 E, 80 S	473	N 42 E, 70 E
423	N 47 E, 69 S	474	N 61 E, 46 S
424	N 34 E, 72 E	475	N 62 E, 55 S
425	N 32 E, 64 E	476	N 44 E, 50 E
426	N 51 E, 74 S	478	N 49 E, 84 S
427	N 47 E, 51 S	480	N 47 E, 76 S
428	S 55 W, 90 N	481	N 34 E, 55 E
429	S 44 W, 88 W	482	N 47 E, 78 S
430	S 47 W, 31 N	483	N 42 E, 63 E
431	S 49 W, 86 N	484	N 41 E, 60 E
432	S 41 W, 82 W	486	S 55 W, 38 N
433	N 62 E, 88 S	487	N 49 E, 68 S
434	S 53 W, 72 N	488	N 57 E, 56 S

<u>Station*</u>		<u>Bedding measurement</u>	<u>Station*</u>		<u>Bedding measurement</u>
BRF	490	N 59 E, 54 S	BRF	542	N 35 E, 54 E
	491	N 53 E, 55 S		543	N 49 E, 65 S
	492	N 49 E, 55 S		544	N 45 E, 52 E
	493	N 39 E, 70 E		545	N 48 E, 51 S
	494	N 50 E, 57 S		546	N 40 E, 38 E
	495	N 49 E, 61 S		547	N 49 E, 76 S
	496	N 54 E, 67 S		549	S 50 W, 53 N
	497	N 55 E, 57 S		550	S 50 W, 64 N
	498	N 62 E, 53 S		551	N 49 E, 78 S
	499	N 53 E, 63 S		552	N 45 E, 62 E
	500	N 60 E, 62 S		553	N 52 E, 74 S
	501	N 65 E, 68 S		554	N 50 E, 62 S
	502	N 54 E, 50 S		555	N 34 E, 51 E
	503	N 49 E, 65 S		556	N 41 E, 77 E
	504	N 45 E, 59 E		557	S 45 W, 53 W
	505	S 38 W, 85 W		559	S 43 W, 77 W
	506	N 54 E, 24 S		560	N 49 E, 54 S
	507	N 43 E, 10 E		561	N 55 E, 52 S
	508	S 41 W, 6 W		562	S 48 W, 82 N
	509	N 41 E, 11 E		564	N 61 E, 46 S
	510	N 33 E, 20 E		565	N 51 E, 83 S
	511	S 6 W, 33 W		566	N 72 E, 54 S
	512	N 68 E, 10 S		567	N 62 E, 76 S
	513	N 56 E, 11 S		568	N 57 E, 60 S
	515	S 26 W, 86 W		569	N 55 E, 64 S
	516	N 19 E, 56 E		570	N 60 E, 64 S
	517	N 24 W, 54 E		571	N 53 E, 54 S
	518	N 38 E, 72 E		572	N 52 E, 61 S
	519	S 46 W, 24 N		573	N 52 E, 68 S
	520	S 42 W, 72 W		574	N 45 E, 69 E
	521	S 41 W, 62 W		575	N 58 E, 58 S
	522	S 56 W, 80 N		576	N 61 E, 62 S
	523	S 72 W, 36 N		577	N 56 E, 68 S
	524	N 52 E, 54 S		578	N 42 E, 60 E
	525	N 49 E, 76 S		579	N 45 E, 57 E
	526	N 57 E, 60 S		580	N 38 E, 82 E
	527	N 42 E, 52 E		581	N 53 E, 80 S
	528	N 47 E, 47 S		582	N 45 E, 67 E
	529	N 45 E, 56 E		584	N 41 E, 67 E
	530	N 47 E, 55 S		585	N 43 E, 71 E
	531	N 38 E, 67 E		586	N 55 E, 42 S
	532	N 43 E, 70 E		587	N 51 E, 59 S
	533	N 49 E, 69 S		588	N 35 E, 64 E
	534	N 39 E, 72 E		589	N 30 E, 38 E
	535	N 40 E, 67 E		590	N 52 E, 49 S
	536	N 39 E, 68 E		591	S 34 W, 73 W
	537	N 50 E, 80 S		592	N 22 E, 43 E
	538	S 38 W, 8 W		593	S 40 W, 46 W
	539	S 45 W, 40 W		594	N 53 E, 84 S
	540	S 39 W, 86 W		595	S 54 W, 76 N
	541	S 41 W, 79 W		596	S 41 W, 30 W

<u>Station*</u>	<u>Bedding measurement</u>	<u>Station*</u>	<u>Bedding measurement</u>
BRF	597 N 49 E, 57 S	BRF	657 N 56 E, 59 S
	598 N 61 E, 60 S		658 N 45 E, 57 E
	599 N 53 E, 59 S		659 N 46 E, 50 S
	600 N 50 E, 58 S		660 N 51 E, 51 S
	601 N 30 E, 72 E		661 N 57 E, 51 S
	602 N 54 E, 53 S		662 N 49 E, 55 S
	603 N 52 E, 52 S		663 N 25 E, 56 E
	605 S 31 W, 39 W		664 N 34 E, 59 E
	606 S 12 W, 32 W		665 N 44 E, 45 E
	607 N 44 E, 43 E		666 N 46 E, 68 S
	609 S 45 W, 26 W		667 N 52 E, 55 S
	610 N 51 E, 41 S		668 N 42 E, 48 E
	613 S 44 W, 88 W		669 N 60 E, 58 S
	614 N 36 E, 57 E		670 S 39 W, 59 W
	615 N 30 E, 71 E		671 N 62 E, 72 S
	616 N 50 E, 51 S		673 N 60 E, 60 S
	617 N 60 E, 53 S		674 S 52 W, 88 N
	618 N 29 E, 75 E		675 N 65 E, 74 S
	619 N 45 E, 79 E		676 N 10 E, 59 E
	620 N 65 E, 72 S		677 N 52 E, 55 S
	621 N 57 E, 59 S		678 S 32 W, 87 W
	622 N 48 E, 47 S		679 S 55 W, 90 N
	623 S 0 E, 0 W		680 S 32 W, 71 W
	624 N 52 E, 38 S		681 N 31 E, 57 E
	625 N 41 E, 50 E		682 S 43 W, 51 W
	626 N 48 E, 41 S		683 S 50 W, 62 N
	627 N 38 E, 69 E		684 N 38 E, 9 E
	628 N 49 E, 52 S		685 N 47 E, 16 S
	629 N 41 E, 74 E		686 N 36 E, 4 E
	630 N 49 E, 54 S		687 N 31 E, 37 E
	631 N 30 E, 55 E		688 N 24 E, 42 E
	632 N 47 E, 50 S		689 N 28 E, 25 E
	633 N 53 E, 48 S		691 N 57 E, 34 S
	634 N 45 E, 49 E		692 N 49 E, 51 S
	636 N 44 E, 54 E		694 N 45 E, 16 E
	637 N 49 E, 60 S		695 N 30 E, 22 E
	638 N 24 E, 24 E		698 N 47 E, 54 S
	639 N 29 E, 56 E		699 N 48 E, 54 S
	640 N 49 E, 64 S		700 N 37 E, 60 E
	642 S 26 W, 48 W		701 N 44 E, 61 E
	643 N 55 E, 46 S		702 N 42 E, 71 E
	645 S 62 W, 42 N		703 N 53 E, 72 S
	646 S 44 W, 90 W		704 N 56 E, 71 S
	648 S 49 W, 30 N		705 S 56 W, 42 N
	649 S 55 W, 38 N		706 N 59 E, 64 S
	651 S 30 W, 38 W		707 N 57 E, 90 S
	652 S 40 W, 74 W		708 N 65 E, 77 S
	653 S 43 W, 40 W		709 N 56 E, 59 S
	654 N 44 E, 59 E		710 N 54 E, 90 S
	655 N 39 E, 67 E		711 N 20 E, 20 E
	656 S 40 W, 71 W		712 N 50 E, 54 S

<u>Station*</u>	<u>Bedding measurement</u>	<u>Station*</u>	<u>Bedding measurement</u>
BRF	713 N 60 E, 62 S	BRF	772 S 44 W, 49 W
	714 N 46 E, 44 S	BJ	1 N 57 E, 52 S
	715 N 46 E, 20 S		2 N 58 E, 61 S
	716 N 20 E, 26 E		3 N 59 E, 37 S
	717 N 42 E, 51 E		4 N 10 E, 61 E
	718 N 55 E, 63 S		5 N 41 E, 39 E
	719 N 29 E, 45 E		6 N 58 E, 49 S
	721 N 47 E, 57 S		7 N 40 E, 51 E
	722 N 51 E, 47 S		8 N 70 E, 65 S
	723 N 62 E, 16 S		9 N 51 E, 15 S
	724 N 26 E, 45 E		10 N 57 E, 34 S
	725 S 42 W, 65 W		11 N 52 E, 55 S
	726 N 49 E, 52 S	BRF	773 N 67 E, 27 S
	729 N 32 E, 47 E	BJ	12 N 34 E, 39 E
	730 N 56 E, 67 S		13 S 51 W, 45 N
	731 N 41 E, 90 E		14 S 64 W, 80 N
	732 N 35 E, 55 E		15 N 62 E, 54 S
	733 N 34 E, 69 E		16 N 44 E, 61 E
	734 N 50 E, 75 S		17 N 41 E, 76 E
	735 N 51 E, 72 S		18 N 57 E, 48 S
	736 N 46 E, 64 S		19 S 49 W, 82 N
	737 N 52 E, 64 S		20 N 59 E, 40 S
	738 N 52 E, 74 S		21 N 62 E, 55 S
	739 N 74 E, 90 S		22 N 56 E, 90 S
	740 N 74 E, 55 S		23 N 61 E, 70 S
	742 N 42 E, 68 E		24 N 69 E, 50 S
	743 N 55 E, 52 S	BRF	774 N 50 E, 55 S
	744 N 41 E, 59 E		775 N 40 E, 42 E
	745 N 49 E, 40 S		776 N 49 E, 54 S
	746 N 52 E, 64 S		777 N 52 E, 46 S
	747 S 56 W, 75 N		778 N 49 E, 38 S
	748 N 52 E, 59 S		779 N 42 E, 59 E
	749 N 54 E, 68 S		780 N 43 E, 55 E
	750 N 51 E, 54 S		781 S 34 W, 84 W
	751 N 56 E, 54 S		782 S 40 W, 69 W
	752 N 56 E, 43 S		783 N 54 E, 90 S
	753 N 59 E, 48 S		784 N 61 E, 70 S
	754 N 57 E, 50 S		785 N 49 E, 72 S
	755 N 57 E, 56 S		786 N 49 E, 58 S
	756 N 55 E, 56 S		787 N 54 E, 57 S
	757 N 30 E, 54 E		788 S 59 W, 28 N
	759 N 76 E, 36 S		789 N 49 E, 72 S
	761 N 69 E, 72 S		790 N 45 E, 47 E
	762 N 52 E, 67 S		791 N 34 E, 41 E
	763 N 46 E, 60 S		792 N 54 E, 89 S
	764 N 69 E, 72 S		793 N 49 E, 55 S
	765 S 46 W, 84 N		794 N 47 E, 69 S
	767 S 35 W, 45 W		795 N 58 E, 51 S
	768 N 80 E, 90 S		796 N 48 E, 38 S
	769 N 50 E, 40 S		797 N 42 E, 49 E
	771 N 53 E, 38 S		798 N 50 E, 54 S

<u>Station*</u>		<u>Bedding measurement</u>	<u>Station*</u>		<u>Bedding measurement</u>
BRF	799	N 37 E, 54 E	BRF	851	N 44 E, 48 E
	800	N 50 E, 50 S		852	N 34 E, 22 E
	801	N 41 E, 88 E		853	N 51 E, 69 S
	802	N 59 E, 51 S		854	N 49 E, 66 S
	803	N 47 E, 68 S		855	N 40 E, 82 E
	805	N 35 E, 89 E		856	N 59 E, 43 S
	806	S 38 W, 17 W		857	N 49 E, 62 S
	808	S 10 E, 24 W		858	N 24 E, 43 E
	809	N 42 E, 52 E		859	N 44 E, 75 E
	810	N 36 E, 88 E		860	S 40 W, 53 W
	811	N 47 E, 76 S		861	S 29 E, 38 W
	812	N 47 E, 63 S		862	N 38 E, 90 E
BJ	25	N 61 E, 64 S		863	N 51 E, 62 S
	26	N 57 E, 60 S	BJ	34	S 40 W, 82 W
	27	N 62 E, 55 S		37	N 7 E, 29 E
	28	N 40 E, 47 E		39	S 42 W, 83 W
	29	N 62 E, 50 S		40	N 61 E, 46 S
	30	N 47 E, 52 S		41	N 53 E, 72 S
	31	N 50 E, 45 S		42	N 37 E, 59 E
	32	N 46 E, 58 S		43	N 55 E, 59 S
BRF	813	N 30 E, 62 E		44	N 69 E, 58 S
	814	N 45 E, 52 E		45	N 66 E, 52 S
	816	S 80 W, 55 N		46	N 60 E, 44 S
	817	N 56 E, 46 S		47	N 48 E, 41 S
	818	S 48 W, 28 N		48	N 44 E, 82 E
	819	S 54 W, 48 N		49	N 52 E, 63 S
	820	N 55 E, 32 S		50	N 61 E, 54 S
	822	N 24 E, 32 E		51	N 53 E, 82 S
	823	N 10 E, 30 E	BRF	865	N 42 E, 50 E
	825	N 31 E, 22 E		866	N 54 E, 59 S
	826	N 13 E, 24 E		867	N 55 E, 53 S
	827	N 30 E, 84 E	BJ	52	N 31 E, 30 E
	828	N 42 E, 53 E		53	N 32 E, 72 E
	829	N 27 E, 75 E		54	N 38 E, 20 E
	830	N 37 E, 57 E	BRF	933	S 49 W, 63 N
	831	N 39 E, 59 E		933	S 38 W, 16 N
	832	S 15 E, 30 W		933	S 37 W, 50 N
	833	N 34 E, 59 E		933	N 12 E, 8 S
	834	N 69 W, 19 N		933	S 44 W, 39 N
	836	N 51 E, 27 S		934	S 21 W, 63 N
	838	N 72 E, 36 S		934	N 30 E, 88 S
	840	S 46 W, 64 N		935	S 10 W, 10 N
	841	N 25 E, 28 E		936	S 40 W, 30 N
	842	N 37 E, 58 E		937	N 80 E, 30 S
	843	N 51 E, 58 S		938	N 90 E, 30 S
	844	N 45 E, 43 E		939	N 80 E, 40 S
	845	N 46 E, 52 S		941	S 70 E, 77 S
	846	N 48 E, 61 S		942	S 41 W, 38 N
	847	N 47 E, 83 S		943	S 75 W, 69 N
	848	N 45 E, 58 E		944	N 33 E, 3 S
	849	N 52 E, 59 S		945	N 46 E, 80 S

<u>Station*</u>		<u>Bedding measurement</u>	<u>Station*</u>		<u>Bedding measurement</u>
BRF	946	S 74 W, 20 N	RAF	86	N 50 E, 28 S
	947	S 53 W, 25 N		87	S 18 W, 36 N
	948	N 36 E, 27 S		88	N 50 E, 34 S
	949	S 38 W, 36 N		89	N 47 E, 29 S
	950	S 80 E, 8 S		90	N 65 E, 17 S
	951	N 86 E, 10 S		91	S 27 W, 29 N
	952	S 52 W, 76 N		93	N 37 E, 23 S
	953	N 52 E, 27 S		92	S 38 W, 47 N
	954	S 11 E, 26 S		94	N 44 E, 23 S
	955	N 35 E, 69 S		95	N 0 E, 0 S
	956	N 39 E, 52 S		96	N 80 E, 19 S
	957	S 40 W, 30 N		98	N 10 E, 45 S
	958	N 5 E, 6 S		99	S 21 W, 63 N
	959	S 37 W, 75 N		100	S 37 W, 36 N
	960	S 68 W, 12 N		102	S 65 W, 46 N
	961	N 13 E, 10 S		103	S 42 W, 33 N
	962	S 42 W, 62 N		104	S 76 W, 49 N
	962	S 45 W, 15 N		105	N 55 E, 46 S
	963	N 10 W, 8 N		106	N 64 E, 44 S
	964	S 0 E, 0 N		107	N 57 E, 58 S
	965	S 59 W, 26 N		108	N 44 E, 41 S
	966	S 73 W, 53 N		109	N 45 E, 26 S
RAF	14	S 18 W, 26 N		110	N 70 E, 35 S
	15	N 2 W, 78 N		152	N 42 E, 36 S
	16	S 72 W, 75 N		153	N 19 E, 67 S
	17	N 46 E, 12 S		154	N 36 E, 26 S
	17	S 62 W, 26 N		155	N 34 E, 30 S
	18	N 34 E, 28 S		165	S 71 W, 8 N
	23	N 51 E, 29 S		166	N 60 E, 40 S
	24	N 54 E, 26 S		167	N 57 E, 24 S
	25	N 40 E, 18 S		168	S 6 W, 12 N
	26	N 58 E, 28 S		169	N 10 E, 13 S
	31	S 30 W, 73 N		170	S 78 W, 14 N
	32	N 76 E, 20 S		173	N 74 E, 37 S
	33	N 30 E, 22 S		174	N 63 E, 26 S
	34	N 60 E, 42 S		174	S 17 E, 39 S
	35	N 62 E, 36 S		175	S 64 E, 18 S
	38	N 48 E, 41 S		175	S 86 E, 22 S
	39	S 70 E, 18 S		176	N 78 E, 24 S
	40	N 60 E, 16 S		179	S 43 W, 60 N
	41	N 6 W, 68 N		180	S 12 W, 70 N
	42	N 74 E, 54 S		181	N 36 E, 90 S
	43	N 72 E, 14 S		183	S 55 W, 40 N
	44	N 51 E, 32 S		186	N 46 E, 33 S
	45	N 76 E, 42 S		187	N 38 E, 31 S
	46	N 51 E, 39 S		188	N 36 E, 72 S
	47	N 57 E, 27 S		189	N 38 E, 86 S
	48	N 57 E, 36 S		189	N 69 E, 74 S
	83	N 52 E, 30 S		190	N 44 E, 35 S
	84	N 50 E, 26 S		191	N 51 E, 58 S
	85	N 54 E, 45 S		192	S 33 W, 54 N

<u>Station*</u>	<u>Bedding measurement</u>	<u>Station*</u>	<u>Bedding measurement</u>
RAF 194	S 39 W, 88 N	RAF 266	N 57 E, 20 S
196	N 48 E, 31 S	267	N 35 E, 62 S
197	N 46 E, 43 S	268	N 84 E, 8 S
198	N 36 E, 40 S	269	N 88 E, 17 S
199	N 48 E, 13 S	270	N 89 E, 17 S
200	N 49 E, 59 S	271	N 66 E, 24 S
201	N 46 E, 75 S	272	N 81 E, 21 S
202	S 37 W, 71 N	273	S 6 W, 43 N
203	N 49 E, 68 S	276	N 80 E, 44 S
204	N 25 E, 70 S	277	S 58 W, 22 N
206	N 65 E, 40 S	278	S 55 W, 46 N
207	N 72 E, 15 S	281	N 55 E, 43 S
208	N 50 E, 8 S	282	S 8 E, 54 S
209	S 12 W, 53 N	283	N 50 E, 64 S
210	N 44 E, 29 S	284	S 55 W, 70 N
211	S 56 W, 80 N	285	N 46 E, 13 S
212	S 44 W, 36 N	287	N 38 E, 52 S
213	S 5 W, 17 N	288	N 49 E, 41 S
214	S 4 E, 13 S	289	N 68 E, 44 S
216	N 53 E, 51 S	291	N 46 E, 56 S
217	N 42 E, 8 S	292	N 43 E, 49 S
218	N 49 E, 57 S	293	N 41 E, 45 S
220	N 75 E, 14 S	294	N 33 E, 36 S
221	S 71 W, 50 N	295	S 88 E, 14 S
223	N 64 E, 32 S	296	S 37 E, 11 S
225	S 34 W, 77 N	297	N 55 E, 32 S
226	N 45 E, 73 S	298	S 57 E, 16 S
227	S 20 W, 11 N	299	N 62 E, 38 S
228	S 22 W, 65 N	300	N 42 E, 35 S
229	N 54 E, 52 S	301	N 65 E, 15 S
230	S 44 W, 44 N	302	N 66 E, 25 S
231	N 0 E, 0 S	303	N 57 E, 32 S
232	S 43 W, 60 N	304	N 84 E, 31 S
233	N 43 E, 69 S	305	N 78 E, 34 S
234	S 10 W, 40 N	306	N 46 E, 90 S
435	N 76 E, 35 S	307	N 44 E, 87 S
238	N 60 E, 23 S	308	N 81 E, 66 S
239	N 57 E, 30 S	309	N 56 E, 70 S
240	N 50 E, 63 S	310	N 66 E, 70 S
241	N 52 E, 38 S	311	N 64 E, 65 S
242	N 61 E, 36 S	312	N 51 E, 34 S
243	N 69 E, 25 S	313	N 68 E, 23 S
244	N 68 E, 20 S	314	N 49 E, 38 S
247	N 37 E, 46 S	315	N 58 E, 25 S
248	N 55 E, 15 S	315	S 0 E, 15 W
257	N 58 E, 32 S	316	N 49 E, 36 S
259	N 59 E, 23 S	317	N 52 E, 37 S
262	N 61 E, 26 S	318	N 34 E, 30 S
263	S 21 E, 11 S	319	N 65 E, 34 S
264	N 44 E, 75 S	320	N 43 E, 30 S
265	N 81 E, 11 S	321	N 48 E, 90 S

<u>Station*</u>		<u>Bedding measurement</u>	<u>Station*</u>		<u>Bedding measurement</u>
RAF	322	N 62 E, 47 S	RAF	414	N 65 E, 70 S
	323	S 38 W, 80 N		415	S 63 W, 35 N
	324	S 8 E, 21 S		418	S 54 W, 40 N
	325	S 79 E, 25 S		419	N 42 E, 54 S
	327	N 52 E, 31 S		420	N 60 W, 3 N
	328	N 46 E, 37 S		421	S 41 W, 33 N
	329	S 35 E, 15 S		423	N 56 E, 72 S
	330	N 70 E, 26 S		424	S 26 W, 13 N
	331	N 55 E, 32 S		425	S 31 W, 51 N
	332	N 64 E, 39 S		426	N 49 E, 23 S
	333	S 75 E, 22 S		427	S 30 W, 19 N
	334	N 65 E, 30 S		428	S 41 W, 75 N
	335	N 56 E, 22 S		429	N 62 E, 14 S
	336	N 68 E, 30 S		430	N 10 W, 5 N
	337	N 30 E, 30 S		431	S 67 W, 37 N
	338	N 76 E, 35 S		432	N 50 E, 17 S
	339	N 70 E, 38 S		433	S 28 W, 43 N
	340	N 47 E, 23 S		434	S 22 E, 21 S
	341	S 34 W, 17 N		435	N 52 E, 20 S
	343	N 65 E, 71 S		436	N 70 E, 18 S
	345	N 48 E, 60 S		437	N 60 E, 25 S
	346	S 70 W, 35 N		438	N 77 E, 35 S
	347	S 58 W, 30 N		439	S 48 W, 80 N
	348	S 43 W, 42 N		440	S 77 E, 37 S
	349	S 14 E, 17 W		442	N 31 E, 55 S
	350	N 51 E, 50 S		480	N 40 E, 34 S
	353	N 63 E, 24 S		481	N 42 E, 50 S
	354	S 47 W, 23 N		482	N 36 E, 35 S
	357	N 59 E, 23 S		485	N 76 E, 38 S
	358	N 35 E, 42 S		487	N 39 E, 73 S
	359	N 31 E, 68 S		488	S 67 E, 22 S
	360	N 43 E, 40 S		489	S 7 W, 32 N
	361	N 85 E, 29 S		489	N 17 E, 11 S
	362	S 85 E, 11 S		490	S 8 W, 20 N
	363	S 5 E, 30 S		507	S 86 E, 19 S
	364	N 42 E, 31 S		507	N 55 E, 24 S
	365	N 31 E, 29 S		508	N 60 E, 50 S
	366	S 23 E, 11 S		509	S 82 E, 20 S
	367	N 71 E, 27 S		510	N 76 E, 25 S
BJ	74	N 46 E, 26 S		511	S 43 E, 34 S
	75	N 41 E, 79 S		512	S 10 E, 28 S
RAF	376	S 64 E, 24 S		514	N 51 E, 23 S
	377	N 13 E, 39 S		515	N 47 E, 45 S
	392	N 54 E, 47 S		516	N 0 E, 0 S
	393	S 10 W, 15 N		517	S 33 W, 17 N
BRF	967	N 14 E, 27 S		518	N 48 E, 10 S
	968	N 85 W, 36 N		519	N 0 E, 8 E
	969	S 32 W, 37 N		520	S 37 W, 11 N
	970	S 40 W, 67 N		521	S 68 W, 17 N
	971	N 56 E, 12 S		522	N 0 E, 0 S
	972	S 64 W, 82 N		523	N 88 E, 13 S

<u>Station*</u>		<u>Bedding measurement</u>	<u>Station*</u>		<u>Bedding measurement</u>
RAF	524	N 85 E, 23 S	RAF	628	S 5 W, 42 N
	525	S 7 W, 15 N		629	N 81 E, 10 S
	527	S 12 W, 15 N		630	N 52 E, 17 S
	528	N 21 E, 20 S		631	N 72 E, 15 S
	529	S 41 W, 19 N		632	S 30 W, 40 N
	530	S 67 W, 21 N		633	N 87 E, 21 S
	531	S 76 W, 33 N		634	S 42 E, 15 S
	533	S 58 W, 14 N		637	S 50 E, 10 S
	534	N 84 E, 12 S		638	N 50 E, 25 S
	535	N 42 E, 27 S		640	N 76 E, 26 S
	537	S 88 E, 14 S		642	S 28 E, 35 S
	538	S 30 W, 57 N		643	S 46 E, 44 S
	540	N 40 E, 8 S		644	S 18 E, 37 S
	556	N 28 E, 74 S		645	S 9 W, 33 N
	577	S 18 E, 42 S		646	S 34 W, 38 N
	578	N 40 E, 87 S		647	S 43 W, 58 N
BRF	973	N 36 E, 29 S		648	S 34 W, 73 N
	974	N 41 E, 40 S		649	N 63 E, 26 S
	975	N 24 E, 21 S		650	S 35 W, 21 N
	978	N 42 E, 48 S		651	S 57 E, 17 W
	978	N 53 E, 18 S		652	N 43 E, 25 S
	980	N 58 E, 46 S		653	N 67 E, 22 S
	983	N 58 E, 59 S		654	N 55 E, 46 S
	985	S 35 W, 41 N		655	N 36 E, 3 S
	986	N 36 E, 44 S		656	N 56 E, 38 S
	987	N 38 E, 43 S		657	S 40 W, 60 N
	988	N 37 E, 35 S		658	S 2 W, 10 N
	989	S 50 W, 17 N		659	N 67 E, 37 S
	991	N 30 E, 54 S		660	N 57 E, 42 S
	992	N 24 E, 36 S		661	S 67 W, 45 N
	994	N 40 E, 33 S		662	N 52 E, 63 S
	995	N 70 W, 25 N		665	S 51 W, 27 N
RAF	608	N 58 E, 19 S		666	S 17 W, 17 N
	609	N 71 E, 21 S		667	S 52 W, 27 N
	610	N 79 E, 15 S		668	S 26 W, 5 N
	611	S 5 E, 12 S		669	N 54 E, 19 S
	612	S 16 W, 17 N		670	N 63 E, 30 S
	613	S 30 W, 5 N		671	N 52 E, 23 S
	614	S 36 W, 29 N		672	N 73 E, 26 S
	615	S 6 W, 13 N		674	N 73 E, 34 S
	616	S 12 W, 25 N		675	N 62 E, 37 S
	617	S 44 W, 34 N		676	N 70 E, 23 S
	618	N 0 E, 0 S		677	N 55 E, 46 S
	619	S 15 W, 4 N		678	S 30 W, 38 N
	620	S 20 W, 13 N		680	N 71 E, 19 S
	621	N 58 E, 25 S		681	N 72 E, 23 S
	622	N 64 E, 15 S		682	N 68 E, 22 S
	623	N 50 E, 13 S		683	N 86 E, 18 S
	624	N 85 E, 13 S		684	N 70 E, 26 S
	625	S 0 E, 8 W		685	N 35 E, 33 S
	626	S 20 W, 49 N		686	S 38 W, 44 N

<u>Station*</u>		<u>Bedding measurement</u>	<u>Station*</u>		<u>Bedding measurement</u>
RAF	687	S 28 W, 81 N	BRF	1020	N 50 E, 35 S
	687	N 41 E, 85 S		1021	N 50 E, 40 S
	689	S 50 W, 57 N		1022	N 44 E, 50 S
	690	S 5 E, 39 S		1023	N 49 E, 51 S
	692	S 28 W, 26 N		1024	N 35 E, 67 S
	693	S 34 W, 67 N		1040	N 47 E, 52 S
	698	S 48 W, 29 N		1041	N 30 E, 55 S
	699	S 15 W, 85 N		1042	N 0 E, 31 E
	700	S 8 W, 46 N		1042	N 30 E, 42 S
	701	N 39 E, 71 S	RAF	721	S 33 W, 10 N
	702	S 22 E, 20 S		722	N 24 E, 23 S
	703	S 20 W, 44 N		723	N 14 E, 12 S
	704	N 24 E, 3 S		724	S 43 W, 21 N
	705	S 87 W, 17 N		725	S 49 W, 32 N
	706	N 34 W, 21 N		726	N 73 E, 9 S
	707	N 22 E, 19 S		727	N 48 E, 18 S
	708	N 70 E, 36 S		728	N 63 E, 18 S
	709	N 26 E, 25 S		729	N 60 E, 20 S
	710	N 53 E, 22 S		730	N 35 E, 12 S
	711	N 38 W, 9 E		731	S 71 W, 8 N
	712	N 46 E, 8 S		732	N 53 E, 34 S
	713	S 34 W, 22 N		733	N 69 E, 5 S
	714	S 80 W, 12 N		739	S 62 W, 18 N
	715	S 47 W, 22 N		735	S 59 W, 56 N
	716	N 58 E, 12 S		736	S 17 W, 25 N
	717	S 52 W, 7 N		737	N 48 E, 25 S
	718	S 46 W, 12 N		738	S 26 W, 12 N
	719	S 20 W, 16 N		739	S 33 W, 20 N
	720	S 25 W, 6 N		740	S 66 W, 12 N
BRF	996	N 29 E, 28 S		741	N 67 E, 22 S
	997	N 36 E, 33 S		742	N 37 E, 15 S
	998	N 34 E, 25 S		743	S 24 W, 30 N
	999	N 39 E, 67 S		744	S 55 W, 27 N
	1000	S 42 W, 13 N	WOF	1	S 58 W, 45 N
	1001	S 3 E, 44 S		2	S 44 W, 45 N
	1003	N 57 E, 32 S	RAF	745	N 66 E, 15 S
	1004	S 46 W, 49 N	WOF	3	S 52 W, 14 N
	1005	S 14 W, 61 N	RAF	4	N 46 E, 25 S
	1006	N 13 E, 46 S		746	S 48 W, 40 N
	1007	N 21 E, 37 S		747	N 30 E, 16 S
	1009	N 43 E, 42 S		748	S 29 W, 23 N
	1010	N 65 E, 54 S		749	N 46 E, 14 S
	1012	N 65 E, 33 S		750	S 42 W, 45 N
	1013	N 23 W, 7 N		751	S 34 W, 36 N
	1014	N 44 E, 25 S		752	N 51 E, 10 S
	1015	N 16 E, 75 S		753	N 65 E, 21 S
	1015	N 74 E, 48 E		754	N 53 E, 6 S
	1016	N 18 E, 65 S	BRF	1044	N 28 E, 41 S
	1017	N 43 E, 52 S		1045	N 22 E, 58 S
	1018	N 44 E, 24 S		1046	N 49 E, 51 S
	1019	N 54 E, 38 S		1047	N 52 E, 54 S

<u>Station*</u>	<u>Bedding measurement</u>	<u>Station*</u>	<u>Bedding measurement</u>
BRF 1049	N 53 E, 50 S	WOF 50	S 36 W, 60 N
1050	N 42 E, 49 S	51	S 40 W, 76 N
1051	N 44 E, 50 S	52	S 20 W, 32 N
1052	N 54 E, 54 S	53	N 49 E, 15 S
1053	N 40 E, 46 S	54	N 47 E, 10 S
1054	N 40 E, 38 S	55	N 47 E, 30 S
1055	N 63 E, 40 S	56	N 52 E, 21 S
1056	N 47 E, 47 S	57	N 44 E, 44 S
1057	N 36 E, 75 S	58	N 35 E, 36 S
WOF 5	N 40 E, 23 S	59	N 65 E, 16 S
6	S 10 E, 11 S	61	S 12 E, 5 S
7	N 60 E, 16 S	62	N 14 W, 3 N
8	S 85 E, 10 S	63	S 43 W, 83 N
10	N 75 E, 10 S	64	S 44 W, 55 N
11	N 82 E, 18 S	65	N 44 E, 23 S
12	N 82 E, 25 S	66	S 84 E, 40 S
13	N 77 E, 25 S	68	S 72 W, 20 N
14	N 66 E, 28 S	69	S 71 W, 23 N
15	N 22 E, 77 S	70	S 37 W, 11 N
16	S 28 E, 32 S	71	S 66 E, 10 S
17	N 63 E, 23 S	72	S 29 W, 8 N
18	N 86 E, 10 S	73	S 42 E, 10 S
19	S 73 E, 15 S	74	N 15 W, 8 N
20	N 81 E, 20 S	75	N 0 E, 0 S
21	S 56 E, 15 S	76	N 40 E, 30 S
22	S 55 E, 8 S	77	N 52 E, 37 S
23	S 25 E, 12 S	78	S 30 E, 15 S
24	S 37 E, 15 S	79	N 70 E, 20 S
25	S 41 E, 13 S	80	S 24 W, 26 N
26	S 75 E, 13 S	81	S 24 W, 20 N
27	N 88 E, 16 S	82	S 20 W, 35 N
28	N 70 E, 23 S	83	S 20 W, 16 N
31	N 49 E, 12 S	84	N 0 E, 0 S
33	S 5 E, 16 S	85	N 40 E, 14 S
34	S 38 W, 15 N	86	N 62 E, 27 S
35	S 25 W, 17 N	87	S 49 W, 71 N
36	S 10 W, 18 N	88	N 75 E, 70 S
37	N 53 E, 12 S	89	N 35 E, 38 S
38	S 10 W, 31 N	90	S 42 W, 78 N
40	S 31 W, 40 N	91	N 0 E, 0 S
41	N 75 E, 10 S	92	N 76 E, 20 S
43	S 36 E, 10 S	93	N 54 E, 40 S
44	N 70 W, 64 N	95	S 52 E, 6 S
45	S 46 W, 10 N	96	S 0 E, 43 W
47	S 0 E, 44 W	97	N 32 E, 49 S
48	S 39 W, 46 N	98	N 51 E, 26 S
BRF 1069	S 56 W, 47 N	99	N 28 E, 37 S
1070	S 57 W, 3 N	100	N 28 E, 36 S
1071	S 84 W, 14 N	101	N 14 E, 34 S
1072	S 45 W, 20 N	102	N 61 E, 6 S
WOF 49	S 66 W, 21 N	103	S 22 W, 40 N

<u>Station*</u>		<u>Bedding measurement</u>	<u>Station*</u>		<u>Bedding measurement</u>
WOF	104	N 72 E, 10 S	WOF	187	N 54 E, 59 S
	105	N 48 E, 11 S		188	N 71 E, 45 S
	106	N 63 E, 22 S		189	N 41 E, 44 S
	107	N 60 E, 39 S		190	N 36 E, 54 S
	108	N 37 E, 51 S		191	S 54 W, 54 N
	109	N 42 E, 27 S		192	S 46 W, 53 N
	110	N 57 E, 34 S		193	S 41 W, 83 N
	111	N 64 E, 25 S		194	N 50 E, 15 S
	112	N 66 E, 32 S		195	N 40 E, 71 S
	114	N 45 E, 34 S		197	S 43 W, 34 N
	115	N 48 E, 36 S		198	N 62 E, 68 S
	116	N 46 E, 79 S		199	N 44 E, 90 S
	117	S 23 W, 84 N		200	N 64 E, 46 S
	118	S 71 E, 12 S		201	S 57 W, 65 N
	119	S 76 E, 22 S		202	N 29 E, 77 S
	120	N 40 E, 44 S		203	N 51 E, 79 S
	121	N 67 E, 33 S		204	N 48 E, 73 S
	123	N 27 E, 25 S		205	S 32 W, 27 N
	124	N 29 E, 37 S		206	S 25 W, 73 N
	125	N 25 E, 29 S		207	S 18 W, 84 N
	126	N 90 E, 37 S		208	S 33 W, 39 N
	127	N 44 E, 37 S		209	S 56 W, 25 N
	128	N 31 E, 45 S		210	S 56 W, 27 N
	130	N 49 E, 36 S		211	N 80 W, 27 N
	131	N 31 E, 30 S		212	S 24 W, 25 N
	133	S 10 W, 70 N		213	S 38 W, 77 N
	134	N 42 E, 60 S		214	S 61 W, 22 N
	135	N 35 E, 40 S		215	N 90 E, 49 S
	136	N 57 E, 35 S		216	S 67 W, 88 N
	137	N 52 E, 51 S		217	N 55 E, 90 S
	138	N 51 E, 44 S		218	N 69 E, 72 S
	139	N 21 E, 44 S		219	S 52 W, 60 N
	142	N 34 E, 58 S		220	S 56 W, 62 N
	144	N 56 E, 46 S		221	N 19 E, 57 S
	145	N 5 E, 7 S		222	N 69 E, 34 S
	146	S 36 W, 57 N		223	S 90 W, 24 N
	147	N 46 E, 63 S		224	S 52 W, 29 N
	148	N 75 W, 34 N		225	S 20 W, 72 N
	149	S 34 W, 73 N		226	S 31 E, 9 S
	150	S 6 E, 17 S		227	N 36 W, 42 N
	151	N 55 E, 49 S		228	S 62 E, 15 S
	154	N 62 E, 32 S		229	N 74 E, 56 S
	155	N 72 E, 76 S		230	S 82 W, 50 N
	156	S 57 W, 44 N		231	S 49 E, 29 S
	157	N 76 E, 46 S		232	S 52 E, 12 S
	158	S 72 W, 40 N		233	S 59 E, 24 S
RAF	756	S 55 E, 15 S		234	N 45 E, 90 S
WOF	182	N 51 E, 66 S		235	S 51 W, 49 N
	183	N 57 E, 53 S		236	S 76 E, 32 S
	185	S 52 W, 56 N	RAF	757	N 75 E, 12 S
	186	N 61 E, 56 S	WOF	237	S 43 E, 14 S

<u>Station*</u>		<u>Bedding measurement</u>	<u>Station*</u>		<u>Bedding measurement</u>
WOF	238	S 64 E, 16 S	RAF	798	S 32 W, 63 N
	241	N 27 E, 45 S		799	N 55 E, 62 S
	242	N 70 E, 29 S		800	S 50 E, 13 S
	245	N 44 E, 29 S		801	S 40 W, 10 N
	246	N 44 E, 26 S		802	N 0 E, 0 S
	248	N 39 E, 21 S		803	S 41 W, 5 N
	249	N 58 E, 5 S		804	S 10 W, 7 N
	250	S 32 W, 52 N		805	N 39 E, 5 S
	251	S 11 E, 31 S		806	N 0 E, 0 S
	252	S 18 E, 15 S		807	S 13 W, 38 N
	253	S 54 E, 20 S		808	S 28 E, 23 S
	254	S 74 W, 36 N		809	S 30 W, 80 N
	255	N 36 E, 54 S		810	S 58 E, 10 S
	257	N 58 E, 23 S		811	N 47 E, 18 S
	258	S 35 E, 25 S		812	N 52 E, 5 S
	259	S 85 E, 27 S		813	S 14 W, 28 N
	260	N 44 E, 53 S		814	N 44 E, 15 S
	261	N 45 E, 20 S		815	N 60 E, 24 S
	262	S 10 E, 59 S		816	S 33 W, 54 N
	264	N 57 E, 36 S	BRF	1074	N 49 E, 33 S
	265	N 60 E, 47 S		1076	N 59 E, 46 S
	266	N 22 E, 42 S		1077	N 50 E, 25 S
	267	N 42 E, 50 S		1078	N 41 E, 41 S
	268	S 26 W, 62 N		1080	N 43 E, 44 S
	269	S 24 E, 44 S		1081	N 44 E, 58 S
	270	N 46 E, 35 S		1082	S 40 W, 63 N
	271	N 48 E, 60 S		1083	S 53 W, 61 N
	272	N 62 E, 17 S	WOF	301	N 42 E, 56 S
	273	S 63 E, 23 S		302	N 58 E, 45 S
	274	N 29 E, 15 S		303	N 61 E, 53 S
	275	N 74 E, 26 S	RAF	19	N 53 E, 51 S
RAF	766	N 44 E, 69 S		20	N 60 E, 42 S
	767	N 48 E, 50 S		21	N 18 E, 48 S
	768	N 45 E, 51 S		22	N 46 E, 23 S
	769	S 46 W, 82 N		49	N 59 E, 50 S
	770	N 47 E, 15 S		50	S 71 W, 40 N
	771	N 54 E, 47 S		51	S 10 W, 54 N
	772	N 46 E, 47 S		52	S 72 W, 57 N
	773	N 55 E, 63 S		53	N 84 E, 23 S
	774	S 50 W, 34 N		54	N 86 E, 46 S
	775	N 53 E, 42 S		55	N 60 E, 59 S
	776	N 48 E, 23 S		56	N 60 E, 29 S
	777	S 42 W, 30 N		57	S 79 E, 44 S
	778	S 10 E, 20 S		58	N 58 E, 33 S
	793	N 41 E, 21 S		59	S 58 W, 7 N
	795	S 38 W, 36 N		60	N 39 E, 23 S
	796	N 51 E, 6 S		61	S 10 E, 18 S
WOF	292	N 5 E, 20 S		62	N 79 E, 6 S
	293	N 36 E, 59 S		63	N 44 E, 47 S
	300	S 42 W, 46 N		64	N 78 E, 29 S
RAF	797	S 49 W, 54 N		65	S 80 E, 33 S

<u>Station*</u>	<u>Bedding measurement</u>	<u>Station*</u>	<u>Bedding measurement</u>
RAF 66	N 44 E, 52 S	RAF 370	N 73 E, 35 S
67	S 25 W, 83 N	371	N 54 E, 44 S
68	S 84 E, 19 S	372	N 43 E, 53 S
69	S 41 E, 21 S	373	N 40 E, 49 S
70	N 66 E, 47 S	375	S 50 W, 45 N
71	N 46 E, 49 S	378	S 8 W, 73 N
72	N 31 E, 61 S	379	S 46 W, 55 N
73	N 39 E, 51 S	381	S 30 E, 33 S
74	S 51 W, 47 N	382	N 85 E, 37 S
75	N 30 E, 71 S	382	S 28 W, 76 N
76	N 49 E, 60 S	383	S 85 E, 27 S
77	N 32 E, 45 S	384	S 8 W, 56 N
79	N 38 E, 41 S	385	N 54 E, 44 S
80	N 48 E, 51 S	386	N 40 E, 22 S
81	S 9 W, 68 N	387	N 48 E, 34 S
82	N 53 E, 33 S	388	S 75 E, 31 S
111	N 32 E, 37 S	389	N 57 E, 29 S
112	N 45 E, 37 S	391	S 16 W, 52 N
113	N 46 E, 42 S	396	N 58 E, 23 S
115	N 36 E, 56 S	397	S 60 E, 16 S
117	N 35 E, 90 S	398	S 75 W, 34 N
118	N 39 E, 32 S	399	S 70 W, 64 N
121	N 5 E, 20 S	400	S 17 E, 17 S
122	S 2 W, 62 N	401	S 11 E, 22 S
123	S 15 W, 45 N	403	S 4 W, 25 N
124	N 75 E, 28 S	404	N 61 E, 49 S
125	N 52 E, 71 S	405	N 71 E, 57 S
126	N 29 E, 60 S	406	S 2 E, 18 S
127	N 29 E, 34 S	407	S 25 E, 18 S
128	N 41 E, 47 S	408	N 32 E, 23 S
130	N 37 E, 31 S	409	S 40 W, 25 N
132	N 45 E, 30 S	410	S 55 W, 30 N
133	N 55 E, 34 S	411	S 70 W, 54 N
134	N 59 E, 40 S	412	N 75 W, 33 N
135	N 46 E, 40 S	413	N 34 E, 42 S
136	N 53 E, 46 S	443	N 29 E, 70 S
137	N 60 E, 46 S	444	S 17 E, 79 S
138	N 85 E, 36 S	445	N 23 E, 44 S
141	N 40 E, 44 S	446	S 42 E, 20 S
142	N 53 E, 23 S	446	N 22 E, 20 S
143	N 73 E, 37 S	447	N 41 E, 34 S
144	N 31 E, 55 S	449	N 32 E, 45 S
146	N 66 E, 83 S	450	N 50 E, 52 S
147	N 81 E, 41 S	451	S 63 W, 26 N
148	N 36 E, 22 S	452	N 66 E, 21 S
149	N 76 E, 66 S	453	N 43 E, 20 S
151	N 51 E, 67 S	454	N 40 E, 78 S
157	N 33 E, 90 S	455	N 26 E, 46 S
159	N 64 E, 6 S	457	S 42 E, 19 S
161	N 63 E, 38 S	458	N 28 E, 79 S
162	N 34 E, 25 S	459	N 23 E, 24 S

<u>Station*</u>	<u>Bedding measurement</u>	<u>Station*</u>	<u>Bedding measurement</u>
RAF	460 S 67 W, 17 N	RAF	562 N 39 E, 28 S
	461 N 70 W, 32 N		563 N 50 E, 32 S
	463 N 55 E, 60 S		564 N 67 E, 19 S
	465 N 34 E, 33 S		565 N 56 E, 15 S
	469 S 45 W, 13 N		566 N 43 E, 20 S
	471 N 8 E, 10 S		567 N 37 E, 23 S
	472 N 61 W, 26 N		568 N 51 E, 22 S
	476 N 41 E, 23 S		569 N 53 E, 49 S
	477 N 57 E, 13 S		579 S 31 E, 27 S
	478 N 50 E, 52 S		580 N 50 E, 66 S
	479 N 25 E, 59 S		582 N 37 E, 78 S
	483 N 29 E, 58 S		583 S 82 W, 83 N
	486 S 87 E, 22 S		584 N 66 E, 19 S
	491 N 29 E, 46 S		585 S 19 W, 47 N
	492 S 4 W, 47 N		586 N 10 E, 25 S
	494 S 18 W, 36 N		587 N 27 E, 20 S
	495 S 76 E, 7 S		590 N 37 E, 90 S
	497 N 49 E, 40 S		591 N 30 E, 44 S
	498 N 30 W, 20 N		592 N 60 E, 27 S
	499 S 62 E, 21 S		593 N 90 E, 23 S
	500 N 0 E, 39 E		594 N 64 E, 20 S
	501 N 48 E, 52 S		595 N 67 E, 68 S
	502 N 43 E, 40 S		596 N 69 E, 38 S
	504 N 29 E, 34 S		597 N 75 E, 38 S
	505 N 52 E, 50 S		598 N 89 E, 30 S
	506 N 44 E, 36 S		600 N 63 E, 33 S
	541 N 40 E, 22 S		601 N 65 E, 34 S
	542 N 70 E, 23 S		602 N 30 E, 19 S
	543 N 75 E, 23 S		603 N 47 E, 69 S
	544 N 60 E, 14 S		604 S 10 E, 34 S
	545 N 45 E, 40 S		605 N 47 E, 42 S
	546 N 47 E, 25 S	BRF	1025 N 29 E, 40 S
	547 N 46 E, 23 S		1026 N 46 E, 34 S
	548 N 77 E, 25 S		1027 N 42 E, 35 S
	550 S 85 W, 65 N		1028 N 53 E, 46 S
	551 N 0 E, 22 E		1029 S 43 W, 67 N
	552 N 15 E, 19 S		1030 S 37 W, 87 N
	553 S 85 W, 4 N		1031 N 65 E, 62 S
	554 N 35 E, 12 S		1032 N 69 E, 50 S
	555 N 52 E, 27 S		1033 S 32 E, 25 S
	570 N 80 E, 39 S		1034 N 62 E, 85 S
	571 N 47 E, 46 S		1036 N 24 E, 50 S
	572 N 24 E, 29 S		1037 N 80 E, 88 S
	573 S 55 W, 66 N		1038 N 38 W, 34 N
	575 N 33 E, 37 S		1039 N 63 E, 60 S
	576 N 30 E, 29 S	WOF	152 S 19 E, 20 S
	557 N 19 E, 71 S		153 N 55 E, 53 S
	558 N 15 E, 13 S		159 N 62 E, 80 S
	559 S 15 W, 31 N		161 N 54 E, 85 S
	560 S 62 W, 14 N		162 N 55 E, 80 S
	561 N 30 E, 15 S		163 N 54 E, 62 S

<u>Station*</u>		<u>Bedding measurement</u>	<u>Station*</u>		<u>Bedding measurement</u>
WOF	164	N 62 E, 66 S	RAF	789	N 44 W, 27 N
	166	N 73 E, 57 S		790	S 42 W, 51 N
	167	N 69 E, 65 S		791	N 27 E, 56 S
	168	N 70 E, 59 S		792	S 52 E, 39 S
	169	S 85 E, 90 S	WOF	294	N 32 E, 45 S
	170	S 48 W, 80 N		296	N 32 E, 37 S
	171	S 23 W, 85 N		297	S 55 E, 31 S
	172	S 28 W, 67 N		298	S 49 W, 31 N
	173	S 42 W, 56 N		299	S 75 E, 42 S
	174	N 90 E, 61 S			
	175	N 80 W, 31 N			
	176	N 35 E, 86 S			
	177	N 0 E, 0 S			
	178	N 51 E, 34 S			
	179	N 54 W, 5 N			
	180	S 14 W, 55 N			
	181	N 55 E, 73 S			
RAF	755	S 15 W, 45 N			
WOF	276	N 25 E, 28 S			
	277	N 47 E, 22 S			
	278	N 18 E, 49 S			
	279	N 40 E, 42 S			
	280	N 5 E, 19 S			
	281	N 58 E, 30 S			
	282	N 66 E, 56 S			
	283	N 15 E, 64 S			
	284	N 8 E, 33 S			
	285	N 22 E, 90 S			
	286	S 12 W, 35 N			
	287	N 10 E, 11 S			
	288	S 52 W, 17 N			
WOF	289	N 29 E, 15 S			
	290	N 62 E, 53 S			
	291	S 71 W, 35 N			
RAF	758	N 16 W, 8 N			
	759	N 27 E, 43 S			
	760	S 41 W, 30 N			
	761	N 77 E, 39 S			
	762	S 75 E, 20 S			
	763	N 45 E, 30 S			
	764	N 18 E, 19 S			
	765	S 2 E, 25 S			
	779	S 34 W, 45 N			
	780	S 44 W, 55 N			
	781	N 22 E, 53 S			
	782	S 63 W, 24 N			
	783	S 22 W, 37 N			
	784	S 34 W, 26 N			
	785	N 81 W, 13 N			
	787	N 52 E, 80 S			
	788	S 90 W, 10 N			

<u>Station*</u>	<u>Cleavage measurement</u>	<u>Station*</u>	<u>Cleavage measurement</u>
BRF 4	N 40 E, 37 E	BRF 75	N 20 E, 22 E
5	N 33 E, 64 E	76	N 34 E, 36 E
6	N 15 E, 41 E	77	N 14 E, 25 E
7	N 24 E, 34 E	78	N 40 E, 37 E
8	N 33 E, 39 E	79	N 38 E, 37 E
10	N 63 E, 47 S	80	N 24 E, 40 E
12	N 55 E, 57 S	81	N 32 E, 50 E
14	N 65 E, 54 S	82	N 25 E, 41 E
18	N 25 E, 38 E	83	N 41 E, 85 E
19	N 71 E, 44 S	84	N 39 E, 54 E
21	N 43 E, 52 E	85	N 40 E, 43 E
24	N 53 E, 34 S	86	N 38 E, 48 E
26	N 64 E, 46 S	87	N 38 E, 48 E
27	N 45 E, 54 E	88	N 38 E, 48 E
28	N 50 E, 69 S	89	N 38 E, 51 E
31	N 45 E, 38 E	90	N 27 E, 43 E
32	N 27 E, 38 E	91	N 33 E, 34 E
33	N 25 E, 33 E	92	N 36 E, 49 E
34	N 22 E, 37 E	94	N 47 E, 47 S
36	N 39 E, 37 E	95	N 46 E, 39 S
37	N 62 E, 40 S	96	N 41 E, 37 E
38	N 37 E, 54 E	97	N 27 E, 31 E
39	N 42 E, 41 E	100	N 7 E, 46 E
40	N 9 E, 48 E	104	N 36 E, 73 E
41	N 54 E, 59 S	108	N 29 E, 69 E
42	N 51 E, 54 S	109	N 38 E, 57 E
43	N 37 E, 59 E	110	N 29 E, 49 E
44	S 9 E, 40 W	111	N 32 E, 63 E
45	N 60 E, 63 S	114	N 69 E, 37 S
46	N 34 E, 30 E	115	N 33 E, 54 E
47	N 43 E, 44 E	117	N 28 E, 33 E
48	N 35 E, 30 E	120	N 37 E, 43 E
49	N 26 E, 34 E	122	N 31 E, 44 E
50	N 52 E, 62 S	123	N 32 E, 44 E
51	N 36 E, 46 E	124	N 33 E, 39 E
52	N 30 E, 32 E	125	N 32 E, 51 E
53	S 15 W, 75 W	126	N 12 E, 57 E
54	N 25 E, 66 E	127	N 23 E, 47 E
55	N 28 E, 10 E	128	N 32 E, 41 E
56	N 25 E, 8 E	129	N 32 E, 32 E
57	N 47 E, 59 S	130	N 32 E, 52 E
58	N 42 E, 50 E	131	N 28 E, 46 E
59	N 33 E, 40 E	132	N 33 E, 24 E
60	N 30 E, 52 E	133	N 48 E, 32 S
61	N 25 E, 32 E	134	N 15 E, 31 E
62	N 32 E, 16 E	135	N 42 E, 65 E
66	N 34 E, 30 E	136	N 36 E, 76 E
67	N 24 E, 37 E	137	N 25 E, 51 E
71	N 20 E, 58 E	138	N 30 E, 70 E
72	N 20 E, 60 E	139	N 25 E, 42 E
73	N 51 E, 48 S	140	N 29 E, 46 E

<u>Station*</u>	<u>Cleavage measurement</u>	<u>Station*</u>	<u>Cleavage measurement</u>
BRF 141	N 37 E, 14 E	BRF 200	N 41 E, 34 E
142	N 33 E, 49 E	201	N 35 E, 44 E
143	N 42 E, 49 E	202	N 31 E, 25 E
144	N 35 E, 35 E	203	N 28 E, 48 E
145	N 45 E, 34 E	204	N 28 E, 39 E
146	N 34 E, 28 E	205	N 21 E, 29 E
148	N 0 E, 20 E	206	N 64 E, 60 S
149	N 19 E, 22 E	207	N 2 E, 51 E
150	N 50 E, 19 S	208	N 40 E, 51 E
151	N 44 E, 29 E	209	N 26 E, 51 E
152	N 45 E, 32 E	210	N 23 E, 45 E
153	N 50 E, 35 S	211	N 26 E, 47 E
154	N 25 E, 40 E	212	N 3 E, 40 E
155	N 28 E, 37 E	213	N 27 E, 35 E
156	N 42 E, 41 E	214	N 55 E, 46 S
157	N 34 E, 40 E	215	N 35 E, 42 E
159	N 49 E, 25 S	216	N 25 E, 46 E
160	N 36 E, 30 E	217	N 35 E, 29 E
161	N 43 E, 25 E	218	N 17 E, 43 E
162	N 46 E, 38 S	219	N 31 E, 23 E
163	N 25 E, 22 E	220	N 35 E, 38 E
164	N 25 E, 34 E	221	N 34 E, 17 E
165	N 45 E, 44 E	222	N 33 E, 34 E
166	N 28 E, 31 E	223	N 56 E, 65 S
167	N 33 E, 46 E	224	N 39 E, 30 E
168	N 44 E, 50 E	225	N 49 E, 38 S
169	N 40 E, 33 E	226	N 23 E, 65 E
170	N 54 E, 33 S	227	N 22 E, 43 E
172	N 28 E, 38 E	228	N 34 E, 52 E
173	N 20 E, 41 E	229	N 22 E, 26 E
175	N 54 E, 37 S	230	N 37 E, 29 E
176	N 36 E, 60 E	231	N 31 E, 20 E
177	N 59 E, 61 S	232	N 10 E, 26 E
178	N 42 E, 61 E	233	N 37 E, 30 E
181	N 19 E, 33 E	234	N 32 E, 30 E
182	N 26 E, 16 E	235	N 20 E, 29 E
184	N 20 E, 33 E	237	N 15 E, 12 E
185	N 40 E, 47 E	238	N 36 E, 44 E
186	N 26 E, 27 E	239	N 24 E, 35 E
187	N 34 E, 27 E	240	N 22 E, 39 E
188	N 11 E, 45 E	241	N 33 E, 45 E
189	N 14 E, 23 E	242	N 33 E, 46 E
190	N 22 E, 37 E	243	N 34 E, 55 E
191	N 27 E, 26 E	244	N 33 E, 42 E
192	N 29 E, 19 E	245	N 30 E, 40 E
193	N 28 E, 19 E	246	N 41 E, 50 E
194	N 28 E, 50 E	247	N 36 E, 62 E
195	N 40 E, 34 E	248	N 35 E, 46 E
196	N 15 E, 50 E	249	N 33 E, 65 E
198	N 52 E, 52 S	250	N 49 E, 64 S
199	N 44 E, 66 E	251	N 52 E, 62 S

<u>Station*</u>	<u>Cleavage measurement</u>	<u>Station*</u>	<u>Cleavage measurement</u>
BRF 252	N 45 E, 53 E	BRF 323	N 32 E, 55 E
253	N 45 E, 52 E	326	N 39 E, 62 E
254	N 39 E, 52 E	328	N 40 E, 56 E
255	N 52 E, 43 S	329	N 25 E, 44 E
256	N 45 E, 64 E	332	N 42 E, 53 E
257	N 40 E, 54 E	335	N 36 E, 52 E
259	N 28 E, 49 E	336	N 20 E, 44 E
260	N 34 E, 32 E	341	N 30 E, 48 E
261	N 52 E, 48 S	342	N 50 E, 53 S
263	N 61 E, 43 S	343	N 50 E, 48 S
262	N 38 E, 52 E	344	N 43 E, 64 E
264	N 76 E, 50 S	345	N 56 E, 50 S
266	N 42 E, 41 E	346	N 32 E, 55 E
267	N 58 E, 72 S	347	N 15 E, 51 E
268	N 38 E, 42 E	348	N 16 E, 45 E
269	N 46 E, 57 S	351	N 38 E, 38 E
270	N 48 E, 52 S	354	N 49 E, 66 S
272	N 70 E, 51 S	355	N 49 E, 58 S
277	N 35 E, 54 E	356	N 47 E, 61 S
278	N 32 E, 40 E	357	N 50 E, 66 S
279	N 41 E, 54 E	360	N 45 E, 61 E
280	N 46 E, 52 S	361	N 60 E, 72 S
281	N 40 E, 41 E	363	N 46 E, 51 S
282	N 7 E, 40 E	364	N 38 E, 68 E
284	N 56 E, 32 S	365	N 45 E, 44 E
285	N 32 E, 30 E	366	N 35 E, 35 E
286	N 38 E, 39 E	367	N 27 E, 34 E
287	N 37 E, 54 E	368	N 49 E, 29 S
288	N 44 E, 49 E	369	N 29 E, 30 E
289	N 40 E, 43 E	370	N 36 E, 24 E
291	N 30 E, 42 E	371	N 28 E, 28 E
292	N 62 E, 72 S	372	N 56 E, 28 S
296	N 30 E, 78 E	373	N 35 E, 28 E
297	N 46 E, 66 S	374	N 38 E, 46 E
298	N 39 E, 70 E	375	N 36 E, 27 E
299	N 33 E, 72 E	376	N 45 E, 18 E
300	N 46 E, 72 S	377	N 25 E, 47 E
301	N 22 E, 73 E	378	N 34 E, 40 E
302	N 26 E, 74 E	379	N 47 E, 30 S
303	N 49 E, 72 S	380	N 39 E, 23 E
304	N 30 E, 74 E	381	N 35 E, 17 E
306	N 22 E, 64 E	382	N 29 E, 29 E
307	N 46 E, 77 S	383	N 22 E, 28 E
309	N 37 E, 46 E	384	N 34 E, 22 E
313	N 20 E, 50 E	386	N 29 E, 29 E
314	N 56 E, 41 S	387	N 21 E, 23 E
315	N 50 E, 34 S	388	N 12 E, 22 E
317	N 20 E, 40 E	389	N 48 E, 25 S
319	N 39 E, 39 E	390	N 30 E, 34 E
320	N 67 E, 50 S	391	N 37 E, 22 E
322	N 48 E, 61 S	392	N 15 E, 16 E

<u>Station*</u>	<u>Cleavage measurement</u>	<u>Station*</u>	<u>Cleavage measurement</u>
BRF 393	N 42 E, 38 E	BRF 451	N 46 E, 37 S
394	N 48 E, 32 S	452	N 60 E, 34 S
395	N 16 E, 21 E	453	N 47 E, 25 S
396	N 49 E, 15 S	454	N 39 E, 21 E
397	N 53 E, 34 S	455	N 61 E, 34 S
398	N 50 E, 24 S	457	N 46 E, 52 S
399	N 45 E, 34 E	459	N 31 E, 34 E
400	N 56 E, 50 S	431	N 35 E, 37 E
401	N 50 E, 50 S	462	N 47 E, 53 S
402	N 44 E, 36 E	463	N 70 E, 61 S
403	N 44 E, 73 E	466	N 40 E, 17 E
405	N 43 E, 20 E	467	N 58 E, 19 S
406	N 40 E, 40 E	469	N 45 E, 46 E
407	N 54 E, 37 S	472	N 34 E, 57 E
408	N 46 E, 46 S	477	N 52 E, 65 S
409	N 50 E, 41 S	478	N 29 E, 51 E
410	N 40 E, 34 E	482	N 38 E, 49 E
416	N 37 E, 36 E	486	N 39 E, 36 E
417	N 31 E, 27 E	487	N 47 E, 41 S
418	N 43 E, 28 E	488	N 42 E, 34 E
419	N 46 E, 22 S	490	N 63 E, 12 S
420	N 27 E, 20 E	491	N 29 E, 37 E
421	N 41 E, 21 E	492	N 43 E, 22 E
422	N 25 E, 47 E	493	N 51 E, 21 S
423	N 30 E, 42 E	494	N 26 E, 36 E
424	N 32 E, 32 E	495	N 26 E, 37 E
425	N 32 E, 26 E	496	N 53 E, 24 S
426	N 51 E, 26 S	499	N 52 E, 31 S
427	N 47 E, 34 S	501	N 46 E, 42 S
428	N 45 E, 37 E	504	N 39 E, 31 E
429	N 45 E, 39 E	505	S 38 W, 85 W
430	N 41 E, 35 E	508	N 37 E, 46 E
431	N 49 E, 34 S	509	N 36 E, 40 E
432	N 33 E, 42 E	512	N 49 E, 56 S
433	N 62 E, 22 S	515	N 46 E, 52 S
434	N 38 E, 52 E	517	N 29 E, 18 E
435	N 25 E, 51 E	518	N 34 E, 42 E
436	N 46 E, 49 S	519	N 32 E, 42 E
436	N 36 E, 54 E	520	N 52 E, 30 S
437	N 38 E, 49 E	521	N 20 E, 46 E
440	N 72 E, 40 S	522	N 52 E, 82 S
441	N 46 E, 46 S	523	N 46 E, 58 S
442	N 60 E, 40 S	525	N 52 E, 42 S
443	N 42 E, 54 E	529	N 45 E, 56 E
444	N 50 E, 38 S	530	N 31 E, 22 E
445	N 32 E, 34 E	531	N 39 E, 36 E
446	N 26 E, 33 E	532	N 43 E, 48 E
447	N 36 E, 37 E	535	N 40 E, 41 E
448	N 45 E, 50 E	536	N 39 E, 12 E
449	N 33 E, 70 E	537	N 30 E, 39 E
450	N 39 E, 50 E	538	N 38 E, 20 E

<u>Station*</u>	<u>Cleavage measurement</u>	<u>Station*</u>	<u>Cleavage measurement</u>
BRF 539	N 35 E, 39 E	BRF 594	N 47 E, 34 S
540	N 53 E, 29 S	595	N 42 E, 42 E
541	N 34 E, 46 E	596	N 55 E, 42 S
542	N 35 E, 26 E	597	N 28 E, 39 E
543	N 42 E, 15 E	598	N 34 E, 39 E
544	N 40 E, 34 E	604	N 42 E, 42 E
545	N 48 E, 20 S	605	N 40 E, 35 E
546	N 40 E, 10 E	606	N 37 E, 42 E
547	N 58 E, 28 S	607	N 44 E, 43 E
548	N 45 E, 49 E	608	N 26 E, 44 E
549	N 52 E, 39 S	609	N 44 E, 41 E
550	N 40 E, 39 E	612	N 37 E, 42 E
551	N 48 E, 35 S	613	N 51 E, 44 S
553	N 52 E, 36 S	614	N 36 E, 57 E
554	N 39 E, 25 E	620	N 65 E, 60 S
555	N 42 E, 28 E	623	N 51 E, 37 S
556	N 43 E, 35 E	627	N 47 E, 42 S
557	N 45 E, 26 E	631	N 39 E, 42 E
558	N 45 E, 70 E	632	N 47 E, 50 S
559	N 32 E, 41 E	635	N 47 E, 52 S
560	N 49 E, 54 S	641	N 27 E, 41 E
561	N 55 E, 25 S	642	N 43 E, 56 E
562	N 60 E, 43 S	643	N 55 E, 46 S
563	N 45 E, 38 E	644	N 41 E, 40 E
564	N 30 E, 40 E	645	N 34 E, 48 E
565	N 30 E, 38 E	646	N 51 E, 42 S
566	N 44 E, 53 E	647	N 46 E, 41 S
567	N 68 E, 58 S	648	N 62 E, 72 S
568	N 57 E, 52 S	649	N 40 E, 49 E
569	N 55 E, 51 S	650	N 41 E, 69 E
570	N 32 E, 50 E	651	N 27 E, 42 E
571	N 48 E, 42 S	652	N 40 E, 12 E
572	N 57 E, 33 S	653	N 43 E, 45 E
573	N 40 E, 53 E	654	N 44 E, 49 E
574	N 45 E, 16 E	655	N 39 E, 33 E
577	N 56 E, 46 S	656	N 40 E, 26 E
578	N 14 E, 45 E	657	N 35 E, 44 E
579	N 39 E, 30 E	658	N 22 E, 55 E
580	N 32 E, 35 E	660	N 36 E, 41 E
581	N 32 E, 33 E	661	N 29 E, 32 E
582	N 41 E, 40 E	663	N 6 E, 36 E
584	N 31 E, 54 E	664	N 30 E, 46 E
585	N 39 E, 43 E	667	N 17 E, 30 E
586	N 41 E, 21 E	669	N 40 E, 55 E
587	N 25 E, 21 E	673	N 35 E, 32 E
588	N 10 E, 53 E	674	N 29 E, 35 E
589	N 11 E, 36 E	675	N 36 E, 23 E
590	N 31 E, 23 E	676	N 0 E, 34 E
591	N 15 E, 40 E	677	N 25 E, 15 E
592	N 22 E, 43 E	679	N 32 E, 55 E
593	N 35 E, 62 E	680	N 33 E, 65 E

<u>Station*</u>	<u>Cleavage measurement</u>	<u>Station*</u>	<u>Cleavage measurement</u>
BRF 682	N 51 E, 67 S	BRF 769	N 66 E, 33 S
683	N 51 E, 68 S	770	N 52 E, 65 S
684	N 25 E, 28 E	771	N 26 E, 46 E
685	N 45 E, 44 E	772	N 20 E, 45 E
686	N 60 E, 34 S	BJ 3	N 49 E, 30 S
687	N 30 E, 46 E	6	N 46 E, 23 S
688	N 42 E, 57 E	7	N 10 E, 28 E
690	N 41 E, 52 E	13	N 70 E, 51 S
691	N 48 E, 55 S	14	N 38 E, 55 E
692	N 49 E, 51 S	16	N 43 E, 50 E
693	N 47 E, 46 S	17	N 30 E, 39 E
694	N 55 E, 42 S	18	N 56 E, 40 S
695	N 22 E, 67 E	19	N 51 E, 48 S
697	N 36 E, 46 E	20	N 49 E, 37 S
698	N 47 E, 54 S	21	N 62 E, 49 S
701	N 44 E, 61 E	22	N 42 E, 53 E
703	N 53 E, 72 S	23	N 53 E, 52 S
704	N 39 E, 40 E	24	N 60 E, 40 S
705	N 35 E, 55 E	BRF 774	N 48 E, 41 S
706	N 48 E, 39 S	775	N 52 E, 59 S
707	N 41 E, 38 E	778	N 49 E, 35 S
708	N 45 E, 29 E	779	N 42 E, 55 E
709	N 41 E, 19 E	781	N 55 E, 42 S
710	N 50 E, 37 S	792	N 43 E, 45 E
716	N 36 E, 47 E	783	N 48 E, 46 S
717	N 30 E, 39 E	784	N 70 E, 32 S
720	N 5 E, 36 E	785	N 25 E, 36 E
722	N 19 E, 48 E	789	N 34 E, 55 E
724	N 36 E, 52 E	790	N 41 E, 52 E
725	N 54 E, 56 S	791	N 34 E, 36 E
727	N 39 E, 62 E	794	N 41 E, 49 E
730	N 59 E, 46 S	797	N 48 E, 35 S
731	N 52 E, 42 S	800	N 49 E, 29 S
732	N 40 E, 50 E	801	N 35 E, 58 E
733	N 28 E, 48 E	803	N 39 E, 47 E
734	N 25 E, 67 E	804	N 50 E, 53 S
735	N 41 E, 58 E	805	N 39 E, 44 E
736	N 46 E, 60 S	807	N 32 E, 64 E
740	N 62 E, 43 S	810	N 55 E, 56 S
741	N 39 E, 49 E	BJ 25	N 35 E, 54 E
748	N 52 E, 38 S	26	N 39 E, 48 E
752	N 56 E, 22 S	29	N 48 E, 41 S
758	N 57 E, 56 S	32	N 42 E, 54 E
759	N 61 E, 60 S	33	N 56 E, 54 S
760	N 55 E, 38 S	BRF 813	N 32 E, 70 E
762	N 60 E, 59 S	814	N 45 E, 52 E
763	N 46 E, 45 S	815	N 67 E, 50 S
765	N 58 E, 44 S	816	N 80 E, 35 S
766	N 53 E, 56 S	817	N 56 E, 46 S
767	N 41 E, 60 E	818	N 38 E, 58 E
768	N 40 W, 28 E	819	N 51 E, 41 S

<u>Station*</u>	<u>Cleavage measurement</u>	<u>Station*</u>	<u>Cleavage measurement</u>
BRF	820 N 35 E, 55 E	BRF	938 N 31 E, 45 S
	821 N 37 E, 52 E		939 N 35 E, 37 S
	822 N 24 E, 44 E		940 N 49 E, 30 S
	823 N 27 E, 43 E		941 N 28 E, 33 S
	824 N 40 E, 45 E		942 N 51 E, 35 S
	825 N 45 E, 65 E		943 N 16 E, 37 S
	826 N 32 E, 52 E		944 N 34 E, 57 S
	827 N 42 E, 60 E		945 N 26 E, 41 S
	828 N 42 E, 53 E		946 N 28 E, 42 S
	829 N 10 E, 89 E		947 N 41 E, 57 S
	830 N 42 E, 65 E		948 N 42 E, 40 S
	831 N 28 E, 89 E		949 N 2 E, 39 S
	834 N 47 E, 87 S		950 N 46 E, 36 S
	835 N 43 E, 65 E		951 N 53 E, 32 S
	836 N 49 E, 67 S		952 N 47 E, 32 S
	837 N 65 E, 64 S		953 N 31 E, 48 S
	840 N 47 E, 90 S		954 N 33 E, 65 E
	843 N 51 E, 56 S		955 N 26 E, 43 S
	844 N 39 E, 83 E		956 N 35 E, 68 S
	845 N 43 E, 45 E		957 N 36 E, 52 S
	848 N 41 E, 56 E		958 N 29 E, 69 S
	849 N 46 E, 52 S		959 N 29 E, 35 S
	850 N 62 E, 50 S		960 N 30 E, 55 S
	853 N 32 E, 41 E		961 N 42 E, 44 S
	855 N 62 E, 51 S		962 N 52 E, 46 S
	856 N 50 E, 51 S		963 N 33 E, 51 S
	858 N 47 E, 60 S		965 N 37 E, 53 S
	859 N 47 E, 48 S		966 N 39 E, 43 S
	860 N 36 E, 59 E	RAF	13 N 62 E, 35 S
	863 N 39 E, 42 E		14 N 62 E, 36 S
BJ	37 N 64 E, 45 S		15 N 26 E, 50 S
	38 N 53 E, 63 S		16 N 7 E, 64 S
	40 N 46 E, 39 S		17 N 51 E, 54 S
	41 N 32 E, 55 E		18 N 17 E, 50 S
	42 N 46 E, 47 S		23 N 47 E, 66 S
	44 N 45 E, 40 E		24 N 66 E, 54 S
	46 N 42 E, 47 E		25 N 27 E, 66 S
	48 N 29 E, 68 E		26 N 36 E, 74 S
	49 N 69 E, 54 S		27 N 35 E, 69 S
	50 N 46 E, 50 S		28 N 41 E, 71 S
BRF	864 N 44 E, 43 E		29 N 39 E, 72 S
	866 N 29 E, 49 E		30 N 20 E, 88 S
	933 N 27 E, 62 S		31 N 49 E, 67 S
	933 N 25 E, 46 S		32 N 35 E, 76 S
	933 N 25 E, 50 S		33 N 39 E, 53 S
	933 N 23 E, 54 S		34 N 20 E, 62 S
	933 N 17 E, 46 S		35 N 18 E, 78 S
	933 N 10 E, 56 S		36 N 44 E, 68 S
	934 N 16 E, 74 S		37 N 20 E, 75 S
	935 N 25 E, 51 S		39 N 27 E, 72 S
	936 N 19 E, 49 S		38 N 32 E, 84 S

<u>Station*</u>	<u>Cleavage measurement</u>	<u>Station*</u>	<u>Cleavage measurement</u>
RAF 40	N 39 E, 73 S	RAF 183	N 65 E, 60 S
41	N 4 E, 67 S	186	N 45 E, 65 S
43	N 36 E, 77 S	188	N 25 E, 78 S
44	N 54 E, 86 S	189	N 60 E, 71 S
46	N 36 E, 79 S	193	N 43 E, 57 S
48	N 59 E, 67 S	194	N 50 E, 87 S
83	N 45 E, 56 S	195	N 49 E, 61 S
84	N 41 E, 47 S	196	N 48 E, 68 S
86	N 20 E, 80 S	198	N 34 E, 65 S
87	N 15 E, 54 S	200	N 50 E, 72 S
88	N 35 E, 56 S	201	N 68 E, 55 S
89	N 27 E, 86 S	205	N 80 E, 33 S
90	N 26 E, 74 S	206	N 32 E, 54 S
91	N 16 E, 62 S	207	N 34 E, 37 S
93	N 38 E, 90 S	208	N 37 E, 62 S
94	N 21 E, 80 S	209	N 51 E, 60 S
96	N 36 E, 75 S	211	N 55 E, 71 S
97	N 31 E, 77 S	212	N 64 E, 45 S
99	N 42 E, 65 S	213	N 56 E, 51 S
100	N 40 E, 73 S	214	N 76 E, 76 S
101	N 36 E, 63 S	216	N 53 E, 51 S
103	N 40 E, 75 S	219	N 43 E, 64 S
104	N 71 E, 74 S	220	N 38 E, 57 S
105	N 26 E, 68 S	221	N 39 E, 54 S
107	N 37 E, 60 S	223	N 45 E, 61 S
109	N 45 E, 55 S	226	N 45 E, 73 S
110	N 49 E, 60 S	227	N 30 E, 49 S
152	N 52 E, 36 S	228	N 34 E, 42 S
154	N 27 E, 63 S	229	N 54 E, 70 S
155	N 18 E, 84 S	230	N 50 E, 53 S
156	N 10 E, 26 S	231	N 49 E, 22 S
164	N 34 E, 67 S	232	N 39 E, 36 S
165	N 39 E, 53 S	235	N 72 E, 58 S
166	N 53 E, 45 S	236	N 39 E, 35 S
167	N 48 E, 52 S	237	N 51 E, 27 S
168	N 35 E, 55 S	238	N 66 E, 41 S
169	N 32 E, 60 S	241	N 28 E, 83 S
170	N 50 E, 45 S	243	N 30 E, 73 S
171	N 35 E, 34 S	244	N 28 E, 58 S
172	N 31 E, 32 S	245	N 35 E, 34 S
173	N 57 E, 60 S	246	N 44 E, 60 S
174	N 38 E, 65 S	247	N 25 E, 73 S
174	N 66 E, 38 S	248	N 55 E, 28 S
175	N 66 E, 43 S	249	N 44 E, 31 S
176	N 54 E, 57 S	250	N 40 E, 10 S
177	N 48 E, 45 S	251	N 69 E, 17 S
178	N 36 E, 81 S	252	N 60 E, 41 S
179	N 56 E, 45 S	253	N 54 E, 26 S
180	N 46 E, 81 S	254	N 55 E, 53 S
181	N 40 E, 75 S	255	N 52 E, 50 S
182	N 55 E, 85 S	256	N 41 E, 43 S

<u>Station*</u>	<u>Cleavage measurement</u>	<u>Station*</u>	<u>Cleavage measurement</u>
RAF 257	N 52 E, 40 S	RAF 351	N 36 E, 56 S
258	N 60 E, 26 S	353	N 63 E, 53 S
260	N 42 E, 46 S	354	N 35 E, 50 S
261	N 71 E, 26 S	355	N 58 E, 67 S
262	N 47 E, 73 S	356	N 34 E, 65 S
263	N 60 E, 44 S	363	N 33 E, 60 S
264	N 29 E, 34 S	365	N 44 E, 47 S
265	N 67 E, 26 S	BJ 73	N 53 E, 41 S
268	N 49 E, 49 S	79	N 40 E, 52 S
269	N 55 E, 38 S	80	N 48 E, 56 S
270	N 50 E, 49 S	83	N 61 E, 54 S
271	N 50 E, 33 S	RAF 376	N 35 E, 78 S
273	N 58 E, 23 S	377	N 37 E, 90 S
274	N 50 E, 40 S	BRF 968	N 32 E, 62 S
275	N 48 E, 75 S	970	N 40 E, 34 S
276	N 80 E, 71 S	971	N 57 E, 42 S
277	N 56 E, 70 S	972	N 47 E, 38 S
278	N 62 E, 50 S	RAF 414	N 57 E, 54 S
279	N 46 E, 60 S	415	N 49 E, 34 S
280	N 46 E, 72 S	416	N 52 E, 69 S
281	N 31 E, 53 S	417	N 40 E, 44 S
284	N 34 E, 63 S	418	N 55 E, 25 S
285	N 32 E, 70 S	420	N 56 E, 54 S
286	N 42 E, 63 S	421	N 31 E, 55 S
287	N 30 E, 73 S	422	N 45 E, 75 S
289	N 44 E, 80 S	424	N 37 E, 38 S
293	N 21 E, 59 S	425	N 44 E, 56 S
295	N 59 E, 49 S	426	N 39 E, 62 S
296	N 83 E, 24 S	427	N 50 E, 52 S
297	N 61 E, 64 S	428	N 6 E, 16 S
298	N 58 E, 28 S	429	N 54 E, 27 S
301	N 55 E, 53 S	430	N 86 E, 36 S
310	N 39 E, 79 S	431	N 52 E, 35 S
312	N 45 E, 53 S	433	N 81 E, 38 S
319	N 50 E, 63 S	435	N 27 E, 56 S
323	N 49 E, 44 S	439	N 46 E, 61 S
324	N 59 E, 46 S	442	N 14 E, 77 S
326	N 50 E, 55 S	RAF 480	S 31 W, 69 N
327	N 49 E, 42 S	482	N 23 E, 75 S
328	N 51 E, 72 S	484	N 30 E, 59 S
330	N 40 E, 64 S	485	N 59 E, 79 S
331	N 43 E, 84 S	487	N 39 E, 73 S
332	N 55 E, 72 S	488	N 32 E, 87 S
333	N 56 E, 50 S	489	N 26 E, 86 S
338	N 63 E, 55 S	490	S 15 W, 87 N
342	N 60 E, 77 S	507	N 14 E, 74 S
343	N 42 E, 28 S	509	N 40 E, 57 S
347	N 70 E, 64 S	510	N 23 E, 85 S
348	N 56 E, 77 S	513	N 15 E, 90 S
349	N 45 E, 80 S	515	N 38 E, 70 S
350	N 48 E, 66 S	516	N 46 E, 37 S

<u>Station*</u>	<u>Cleavage measurement</u>	<u>Station*</u>	<u>Cleavage measurement</u>
RAF 517	N 37 E, 33 S	RAF 637	N 56 E, 51 S
518	N 59 E, 19 S	639	N 58 E, 29 S
519	N 61 E, 39 S	640	N 49 E, 35 S
520	N 41 E, 45 S	641	N 35 E, 60 S
521	N 29 E, 30 S	642	N 44 E, 55 S
522	N 62 E, 38 S	643	N 62 E, 53 S
523	N 53 E, 39 S	644	N 31 E, 38 S
525	N 62 E, 64 S	645	N 54 E, 41 S
526	N 52 E, 39 S	650	N 39 E, 72 S
527	N 27 E, 41 S	651	N 47 E, 58 S
529	N 57 E, 51 S	652	N 19 E, 70 S
530	N 50 E, 32 S	653	N 36 E, 61 S
531	N 60 E, 25 S	654	N 50 E, 71 S
532	N 62 E, 57 S	655	N 36 E, 62 S
533	N 39 E, 52 S	656	N 45 E, 64 S
538	N 53 E, 56 S	658	N 51 E, 64 S
539	N 34 E, 59 S	659	N 43 E, 52 S
540	N 34 E, 33 S	660	N 56 E, 70 S
556	N 30 E, 61 S	662	N 44 E, 78 S
607	N 43 E, 90 S	663	N 54 E, 52 S
BRF 973	N 28 E, 48 S	665	N 58 E, 76 S
974	N 32 E, 45 S	666	N 44 E, 59 S
975	N 34 E, 41 S	667	N 55 E, 57 S
985	N 28 E, 68 S	668	N 47 E, 43 S
986	N 43 E, 73 S	669	N 58 E, 57 S
990	N 35 E, 50 S	670	N 44 E, 60 S
992	N 45 E, 72 S	671	N 50 E, 31 S
994	N 20 E, 47 S	672	N 60 E, 70 S
995	N 36 E, 65 S	673	N 36 E, 72 S
RAF 608	N 54 E, 55 S	674	N 47 E, 50 S
609	N 57 E, 55 S	675	N 46 E, 72 S
611	N 45 E, 53 S	676	N 32 E, 72 S
613	N 55 E, 45 S	677	N 56 E, 73 S
614	N 10 E, 22 S	678	N 46 E, 72 S
615	N 32 E, 41 S	679	N 42 E, 71 S
616	N 32 E, 42 S	680	N 40 E, 58 S
617	N 32 E, 39 S	682	N 59 E, 47 S
620	N 47 E, 38 S	684	N 47 E, 86 S
621	N 51 E, 50 S	690	N 35 E, 57 S
623	N 51 E, 34 S	691	N 62 E, 37 S
624	N 44 E, 38 S	693	N 42 E, 40 S
625	N 53 E, 38 S	694	N 60 E, 64 S
626	N 28 E, 35 S	695	N 56 E, 47 S
627	N 36 E, 53 S	696	N 55 E, 50 S
628	N 40 E, 42 S	697	N 31 E, 74 S
630	N 46 E, 42 S	699	N 44 E, 60 S
631	N 48 E, 62 S	700	N 47 E, 57 S
633	N 43 E, 86 S	701	N 46 E, 40 S
634	N 50 E, 62 S	702	N 34 E, 56 S
635	N 62 E, 55 S	703	N 31 E, 46 S
636	N 37 E, 40 S	704	N 49 E, 30 S

<u>Station*</u>	<u>Cleavage measurement</u>	<u>Station*</u>	<u>Cleavage measurement</u>
RAF	705 N 44 E, 27 S	RAF	744 N 49 E, 58 S
	706 N 24 E, 76 S	WOF	1 N 42 E, 79 S
	709 N 29 E, 49 S		2 N 56 E, 43 S
	711 N 27 E, 30 S	RAF	745 N 64 E, 50 S
	712 N 40 E, 54 S	WOF	3 N 35 E, 49 S
	713 N 40 E, 30 S	RAF	746 N 50 E, 40 S
	714 N 19 E, 23 S		747 N 34 E, 72 S
	715 N 42 E, 29 S		748 N 37 E, 54 S
	716 N 62 E, 80 S		750 N 46 E, 57 S
	717 N 44 E, 44 S		751 N 47 E, 59 S
	719 N 47 E, 28 S		752 N 36 E, 49 S
	720 N 50 E, 34 S		753 N 65 E, 30 S
BRF	996 N 42 E, 54 S		754 N 45 E, 44 S
	997 N 50 E, 79 S	BRF	1043 N 35 E, 67 S
	998 N 43 E, 67 S		1044 N 46 E, 67 S
	999 N 29 E, 83 S		1046 N 49 E, 51 S
	1000 N 50 E, 52 S		1048 N 46 E, 50 S
	1001 N 55 E, 63 S		1049 N 53 E, 48 S
	1002 N 34 E, 86 S		1053 N 47 E, 44 S
	1003 N 44 E, 70 S		1057 N 27 E, 56 S
	1004 S 40 W, 38 N	WOF	5 N 67 E, 37 S
	1005 N 17 E, 68 S		6 N 50 E, 53 S
	1006 N 35 E, 83 S		7 N 31 E, 52 S
	1007 N 31 E, 74 S		8 N 46 E, 65 S
	1008 N 59 E, 65 S		9 N 40 E, 52 S
	1009 N 45 E, 69 S		10 N 42 E, 54 S
	1010 N 43 E, 60 S		11 N 39 E, 68 S
	1011 N 39 E, 72 S		12 N 45 E, 67 S
	1012 N 83 E, 82 S		13 N 33 E, 86 S
	1013 N 46 E, 79 S		14 N 39 E, 85 S
	1014 N 42 E, 68 S		15 N 22 E, 77 S
	1016 S 15 W, 76 N		18 N 48 E, 54 S
	1017 N 40 E, 73 S		19 N 53 E, 47 S
	1018 N 38 E, 75 S		20 N 50 E, 55 S
	1040 N 56 E, 83 S		21 N 72 E, 43 S
RAF	721 N 44 E, 25 S		22 N 62 E, 40 S
	723 N 48 E, 43 S		26 N 36 E, 66 S
	725 N 54 E, 34 S		29 N 60 E, 53 S
	726 N 50 E, 58 S		30 N 32 W, 17 N
	727 N 39 E, 57 S		31 N 49 E, 12 S
	728 N 43 E, 55 S		32 N 33 E, 55 S
	730 N 47 E, 45 S		33 N 55 E, 47 S
	731 N 48 E, 55 S		34 N 49 E, 23 S
	732 N 54 E, 60 S		35 N 32 E, 29 S
	733 N 52 E, 78 S		36 N 24 E, 53 S
	734 N 53 E, 58 S		39 N 40 E, 62 S
	739 N 52 E, 61 S		40 N 38 E, 45 S
	740 N 51 E, 44 S		41 N 38 E, 45 S
	741 N 55 E, 56 S		42 N 46 E, 47 S
	742 N 46 E, 47 S		44 S 3 W, 20 N
	743 N 27 E, 20 S		45 N 37 E, 42 S

<u>Station*</u>	<u>Cleavage measurement</u>	<u>Station*</u>	<u>Cleavage measurement</u>
WOF 46	N 57 E, 33 S	WOF 158	N 21 E, 51 S
47	N 36 E, 44 S	183	N 27 E, 48 S
BRF 1069	N 43 E, 42 S	184	N 46 E, 30 S
1070	N 51 E, 38 S	185	N 26 E, 36 S
1071	N 40 E, 46 S	186	N 45 E, 42 S
1072	N 47 E, 47 S	189	N 41 E, 44 S
WOF 49	N 25 E, 27 S	191	N 52 E, 53 S
50	N 36 E, 35 S	192	N 44 E, 53 S
51	N 45 E, 32 S	193	N 41 E, 56 S
60	N 41 E, 42 S	194	N 46 E, 50 S
61	N 44 E, 42 S	196	N 55 E, 44 S
62	N 50 E, 40 S	197	N 10 E, 11 S
63	N 42 E, 58 S	201	N 43 E, 29 S
64	N 47 E, 34 S	203	N 51 E, 53 S
65	N 46 E, 58 S	205	N 28 E, 43 S
66	N 36 E, 33 S	209	N 42 E, 43 S
67	N 85 E, 33 S	210	N 42 E, 40 S
68	N 50 E, 35 S	211	N 44 E, 52 S
70	N 26 E, 32 S	212	N 2 E, 40 S
71	N 28 E, 50 S	215	N 11 E, 31 S
72	N 44 E, 29 S	217	N 52 E, 25 S
74	N 33 E, 52 S	226	N 39 E, 42 S
75	N 30 E, 32 S	240	N 52 E, 31 S
83	N 44 E, 48 S	243	N 62 E, 33 S
85	N 40 E, 45 S	244	N 46 E, 48 S
86	N 50 E, 52 S	247	N 53 E, 41 S
87	N 54 E, 56 S	250	N 56 E, 50 S
93	N 37 E, 80 S	254	N 20 E, 29 S
94	N 73 E, 40 S	255	N 13 E, 26 S
95	N 34 E, 64 S	256	N 61 E, 30 S
96	N 27 E, 30 S	263	N 55 E, 72 S
101	N 14 E, 34 S	274	N 27 E, 50 S
102	N 23 E, 37 S	RAF 776	N 38 E, 73 S
103	N 21 E, 17 S	797	N 58 E, 65 S
104	N 58 E, 49 S	810	N 41 E, 68 S
107	N 61 E, 44 S	813	N 36 E, 52 S
109	N 46 E, 51 S	BRF 1074	N 55 E, 65 S
115	N 39 E, 43 S	1077	N 46 E, 63 S
116	N 49 E, 51 S	1078	N 41 E, 64 S
117	N 32 E, 48 S	1080	S 76 W, 53 N
119	N 30 E, 72 S	WOF 301	N 42 E, 56 S
124	N 44 E, 69 S	RAF 19	N 60 E, 52 S
125	N 39 E, 63 S	20	N 30 E, 57 S
139	N 40 E, 58 S	21	N 47 E, 83 S
144	N 52 E, 17 S	22	N 16 E, 81 S
145	N 51 E, 60 S	50	N 10 E, 75 S
147	N 22 E, 31 S	52	N 37 E, 82 S
148	N 60 E, 57 S	54	N 79 E, 46 S
150	N 66 E, 80 S	55	N 64 E, 40 S
151	N 51 E, 27 S	56	N 60 E, 29 S
156	N 45 E, 60 S	57	N 54 E, 51 S

<u>Station*</u>	<u>Cleavage measurement</u>	<u>Station*</u>	<u>Cleavage measurement</u>
RAF 58	N 41 E, 20 S	RAF 372	N 14 E, 49 S
59	N 39 E, 38 S	374	N 25 E, 56 S
60	N 16 E, 31 S	375	N 50 E, 28 S
63	N 34 E, 67 S	378	N 32 E, 83 S
64	N 30 E, 56 S	380	N 66 E, 34 S
65	N 30 E, 56 S	381	N 68 E, 44 S
66	N 44 E, 52 S	387	N 54 E, 39 S
68	N 43 E, 38 S	389	N 62 E, 27 S
70	N 48 E, 77 S	390	N 35 E, 37 S
71	N 35 E, 72 S	394	N 69 E, 26 S
72	N 17 E, 70 S	395	N 63 E, 25 S
73	N 22 E, 68 S	397	N 61 E, 46 S
74	S 31 W, 83 N	399	N 61 E, 27 S
75	N 21 E, 72 S	402	N 57 E, 25 S
76	N 26 E, 70 S	405	N 48 E, 36 S
78	N 38 E, 52 S	409	N 15 E, 42 S
79	N 28 E, 45 S	411	N 32 E, 51 S
81	N 20 E, 54 S	412	N 34 E, 39 S
82	N 38 E, 62 S	443	N 32 E, 75 S
111	N 29 E, 58 S	445	N 63 E, 59 S
113	N 31 E, 59 S	446	N 66 E, 70 S
114	N 39 E, 54 S	447	N 25 E, 62 S
115	N 24 E, 68 S	448	N 11 E, 45 S
116	N 31 E, 69 S	449	N 28 E, 58 S
117	N 33 E, 55 S	450	N 39 E, 65 S
119	N 9 E, 65 S	453	N 57 E, 44 S
120	N 20 E, 61 S	454	N 30 E, 35 S
121	N 12 E, 76 S	455	N 47 E, 28 S
122	N 19 E, 53 S	456	N 3 E, 90 S
124	N 36 E, 62 S	457	N 27 E, 70 S
125	N 44 E, 88 S	458	N 6 E, 76 S
126	N 26 E, 60 S	459	N 5 E, 36 S
129	N 29 E, 80 S	460	N 20 E, 45 S
130	N 22 E, 60 S	461	N 25 E, 47 S
131	N 19 E, 59 S	462	N 53 E, 63 S
132	N 33 E, 59 S	463	N 31 E, 70 S
134	N 48 E, 61 S	464	N 15 E, 45 S
137	N 43 E, 63 S	465	N 24 E, 47 S
138	N 71 E, 72 S	466	N 37 E, 70 S
142	N 41 E, 38 S	467	N 20 E, 77 S
144	N 25 E, 62 S	468	N 20 E, 44 S
146	N 69 E, 83 S	469	N 3 E, 52 S
149	N 49 E, 66 S	470	N 37 E, 52 S
150	N 37 E, 69 S	471	N 10 E, 90 S
158	N 54 E, 68 S	472	N 40 E, 46 S
159	N 40 E, 59 S	473	N 34 E, 77 S
160	N 50 E, 64 S	474	N 38 E, 80 S
162	N 67 E, 34 S	475	N 31 E, 90 S
163	N 38 E, 48 S	478	N 34 E, 68 S
368	N 26 E, 44 S	483	N 38 E, 88 S
369	N 52 E, 50 S	486	N 40 E, 68 S

<u>Station*</u>	<u>Cleavage measurement</u>	<u>Station*</u>	<u>Cleavage measurement</u>
RAF	491 S 26 W, 65 N	WOF	161 N 35 E, 42 S
	492 N 12 E, 86 S		163 N 52 E, 58 S
	493 N 4 E, 80 S		172 N 57 E, 54 S
	496 N 23 E, 90 S		173 N 44 E, 37 S
	498 N 27 E, 72 S		175 N 35 E, 85 S
	501 N 20 E, 86 S		177 N 75 E, 30 S
	503 N 40 E, 90 S		179 N 28 E, 40 S
	504 S 24 W, 62 N		180 N 31 E, 30 S
	506 N 25 E, 80 S		181 N 36 E, 37 S
	544 N 49 E, 45 S		282 N 25 E, 56 S
	549 N 59 E, 39 S		283 N 30 E, 84 S
	550 N 46 E, 62 S		285 N 25 E, 59 S
	551 N 90 E, 45 S		286 N 24 E, 59 S
	552 N 45 E, 35 S	RAF	760 N 36 E, 37 S
	553 N 40 E, 54 S		779 N 62 E, 24 S
	554 N 50 E, 51 S	WOF	289 N 18 E, 39 S
	555 N 49 E, 44 S		291 N 58 E, 45 S
	556 N 57 E, 58 S		298 N 60 E, 52 S
	557 N 55 E, 43 S		
	558 N 52 E, 62 S		
	560 N 59 E, 61 S		
	561 N 54 E, 41 S		
	565 N 53 E, 75 S		
	566 N 56 E, 65 S		
	567 N 57 E, 65 S		
	568 N 58 E, 60 S		
	569 N 47 E, 52 S		
	579 N 39 E, 77 S		
	581 N 28 E, 84 S		
	582 N 54 E, 47 S		
	584 N 61 E, 52 S		
	585 N 26 E, 42 S		
	586 N 34 E, 60 S		
	587 N 57 E, 37 S		
	588 N 48 E, 37 S		
	590 N 42 E, 68 S		
	592 N 53 E, 82 S		
	594 N 46 E, 63 S		
	596 N 58 E, 88 S		
	597 N 42 E, 70 S		
	600 N 66 E, 46 S		
BRF	1028 N 31 E, 83 S		
	1029 N 47 E, 87 S		
	1031 N 52 E, 71 S		
	1032 N 54 E, 86 S		
	1033 N 59 E, 68 S		
	1035 N 47 E, 74 S		
	1036 N 25 E, 83 S		
	1038 N 28 E, 54 S		
	1039 N 26 E, 29 S		
WOF	160 N 32 E, 52 S		

<u>Station*</u>	<u>Fracture measurement</u>	<u>Station*</u>	<u>Fracture measurement</u>
BRF	92 S 27 W, 39 W	BRF	867 S 82 E, 80 S
	92 S 43 W, 88 W	BJ	53 S 75 E, 90 S
	579 S 45 E, 80 W	RAF	13 N 55 W, 59 N
	590 S 9 W, 76 W		14 N 18 W, 73 N
✓	607 S 43 W, 75 W		17 N 9 W, 75 N
	642 S 55 W, 87 N		32 S 30 E, 80 S
	643 N 23 W, 72 E		33 N 70 W, 57 N
	661 N 6 W, 85 E		34 S 30 E, 90 S
	672 S 80 E, 82 S		37 N 27 W, 76 N
	702 N 32 W, 68 E		37 S 38 W, 45 N
	715 S 35 W, 77 W		39 N 34 W, 86 N
	718 N 44 W, 57 E		84 S 46 E, 82 S
	719 S 40 E, 88 W		101 N 37 W, 46 N
	722 N 77 W, 72 N		110 S 59 W, 59 N
	728 N 20 E, 86 E		110 S 20 E, 86 S
	734 N 32 W, 70 E		165 N 73 W, 38 N
	734 S 3 E, 48 W		185 N 62 E, 85 S
	741 N 64 W, 64 N		185 N 90 E, 41 S
	742 N 36 W, 75 E		188 S 57 E, 49 S
	746 N 48 E, 55 S		190 N 48 E, 89 S
	747 S 66 E, 54 S		203 N 70 E, 90 S
	753 S 5 W, 88 W		203 N 67 W, 60 N
	754 N 15 W, 84 E		206 N 41 W, 52 N
BJ	5 S 49 W, 62 N		208 S 88 W, 65 N
	9 S 63 E, 53 S		212 S 34 W, 69 N
	9 S 60 E, 61 S		216 N 17 E, 42 S
	9 S 75 E, 69 S		216 N 71 W, 57 N
	21 S 71 E, 44 S		228 N 63 W, 78 N
BRF	785 N 70 W, 78 N		228 N 57 E, 70 S
	786 N 20 W, 64 E		230 S 77 E, 68 S
	797 S 85 E, 40 S		258 N 76 W, 47 N
	798 S 40 W, 36 W		271 N 50 E, 90 S
	800 S 45 W, 22 W		271 S 37 W, 70 N
	801 N 36 W, 88 E		271 N 46 E, 77 S
	807 S 46 E, 77 S		281 N 85 W, 70 N
	808 N 65 W, 62 N		287 N 36 E, 66 S
BJ	30 N 55 W, 57 N		294 N 72 W, 63 N
	31 N 52 W, 88 N		294 N 55 E, 90 S
BRF	822 S 89 W, 85 N		301 N 85 W, 76 N
	824 N 27 W, 82 E		301 N 5 E, 83 S
	828 S 45 E, 84 W		345 N 57 E, 61 S
	829 S 58 E, 90 S		345 N 44 W, 81 N
	831 S 19 E, 90 W		361 N 89 E, 90 S
	844 N 10 W, 64 E		364 S 65 E, 90 S
	857 N 80 W, 56 N		364 N 85 W, 25 N
	859 N 29 W, 18 E		418 N 68 W, 61 N
BJ	35 S 50 E, 60 S		435 N 75 E, 26 S
	36 N 34 W, 79 E		507 N 79 W, 84 N
	41 N 32 W, 68 E		507 N 21 E, 75 S
	43 S 23 E, 83 W		526 S 60 E, 72 S
	45 S 68 E, 19 S		535 N 40 E, 68 S

<u>Station*</u>	<u>Fracture measurement</u>	<u>Station*</u>	<u>Fracture measurement</u>
RAF	536 S 76 W, 80 N	RAF	19 S 21 W, 61 N
	536 N 51 E, 60 S		19 S 34 E, 25 S
	537 N 54 E, 63 S		22 N 13 W, 88 N
	537 N 28 E, 77 S		50 S 36 W, 66 N
	540 N 54 W, 76 N		51 S 10 W, 46 N
	556 N 63 E, 83 S		51 N 51 W, 13 N
BRF	973 N 21 W, 66 N		54 S 39 E, 71 S
	974 S 78 E, 52 S		54 S 87 E, 60 S
	975 S 50 E, 78 S		57 N 7 E, 83 S
	975 N 20 W, 79 N		57 N 24 E, 86 S
	991 S 65 E, 90 S		57 N 36 E, 38 S
RAF	609 N 1 W, 60 N		58 S 27 E, 50 S
	609 N 37 W, 53 N		59 S 51 E, 86 S
	619 N 25 E, 63 S		68 S 24 W, 69 N
	623 N 15 E, 51 S		79 N 12 E, 56 S
	640 N 37 E, 75 S		79 N 53 W, 56 N
	682 N 68 E, 88 S		80 S 45 W, 50 N
	682 N 60 W, 80 N		80 N 73 W, 80 N
	682 N 25 W, 84 N		82 S 82 W, 83 N
BRF	1023 N 71 E, 48 S		113 S 82 W, 81 N
	1023 N 32 W, 63 N		116 N 29 E, 59 S
RAF	727 S 66 W, 17 N		116 N 49 E, 43 S
	727 S 45 E, 90 S		117 N 29 E, 87 S
	729 S 85 E, 88 S		122 N 20 E, 90 S
	729 N 38 W, 70 N		139 S 70 W, 50 N
	731 N 62 W, 55 N		140 S 70 E, 83 S
	731 N 1 E, 45 S		143 N 70 W, 85 N
	739 S 46 E, 87 S		145 S 79 E, 90 S
	739 N 57 W, 71 N		145 S 60 W, 34 N
BRF	1053 S 56 W, 82 N		150 S 34 E, 49 S
	1063 N 28 E, 26 S		161 S 29 W, 61 N
	1063 S 66 E, 72 S		163 S 89 W, 43 N
WOF	8 N 46 E, 65 S		163 S 81 W, 77 N
	13 S 46 W, 87 N		379 S 77 E, 73 S
	18 N 65 W, 70 N		379 N 78 E, 77 S
	26 N 54 W, 81 N		382 N 49 E, 60 S
	43 S 76 W, 65 N		382 S 84 E, 90 S
BRF	1071 S 48 W, 47 N		384 S 40 E, 70 S
WOF	49 N 46 E, 47 S		384 S 58 W, 38 N
	56 N 35 E, 75 S		384 N 48 E, 85 S
	56 S 62 W, 70 N		402 S 34 E, 4 S
	90 N 50 E, 82 S		402 N 72 W, 70 N
	90 N 90 E, 80 S		444 S 17 E, 79 S
	91 S 62 E, 85 S		446 S 42 E, 20 S
	91 N 39 E, 86 S		446 N 18 E, 88 S
	93 N 50 E, 76 S		462 N 60 E, 46 S
	93 N 80 E, 59 S		463 S 8 W, 77 N
	110 N 47 E, 90 S		465 S 52 E, 67 S
	110 N 47 E, 72 S		467 N 50 E, 64 S
	114 N 79 W, 75 N		473 N 19 E, 72 S
	225 N 80 W, 88 N		477 N 63 E, 85 S

<u>Station*</u>	<u>Fracture measurement</u>
RAF	477
	477
	497
	500
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	606
BRF	1030
WOF	294
	294

<u>Station*</u>		<u>Fold axial plane measurement</u>		<u>Fold hinge measurement</u>
BRF	45	N 41 E, 51 E	221	2
	64	S 62 W, 28 N	242	16
	90	N 27 E, 43 E	51	7
	96		57	8
	147	N 39 E, 14 E	24	3
	221	N 27 E, 25 E		
	219	N 31 E, 23 E	90	2
	232	N 10 W, 26 E	215	8
	236	N 31 E, 11 E	200	18
	247	S 60 W, 42 N	240	5
	248	N 55 E, 33 S	235	2
	263	N 10 E, 78 E	10	3
	322	N 28 E, 50 E	195	9
	372	N 36 E, 35 E	41	3
	385	N 47 E, 41 S	44	2
	388	N 12 E, 22 E	45	2
	479	S 72 W, 65 N	252	11
	485	S 32 W, 42 W	222	12
	487	N 40 E, 44 E	42	5
	489	N 48 E, 46 S	56	7
	514	N 51 E, 42 S	231	11
	579		203	5
	583	N 38 E, 29 E	79	5
	611	N 45 E, 42 E	37	2
	644	N 41 E, 40 E	221	2
	696	N 51 E, 84 S	51	24
	766	N 53 E, 56 S	49	26
BJ	12		234	10
	815	N 67 E, 50 S	75	35
BRF	933	N 23 E, 54 S	20	6
	940	N 49 E, 30 S	53	2
	947	N 41 E, 57 S	31	3
	962	N 52 E, 46 S	27	5
RAF	27	N 35 E, 69 S	41	17
	28	N 41 E, 71 S	203	13
	29	N 39 E, 72 S	36	19
	30	N 20 E, 88 S	199	3
	36	N 44 E, 68 S	214	2
	37	N 20 E, 75 S	209	10
	37	N 20 E, 72 S		
	97	N 31 E, 77 S	219	4
	101	N 22 E, 72 S	200	17
	184	N 47 E, 82 S	222	35
	185	N 51 E, 62 S	49	7
	193	N 43 E, 57 S	219	20
	224	N 58 E, 55 S	231	6
	260	N 42 E, 46 S	29	2
	290	N 54 E, 85 S		
	315	N 51 E, 50 S		
	324	N 59 E, 46 S	225	13

<u>Station*</u>		<u>Fold axial plane measurement</u>	<u>Fold hinge measurement</u>	
RAF	333	N 56 E, 50 S	213	30
	344	N 30 E, 48 S	33	8
	351	N 36 E, 56 S	49	2
	377	N 37 E, 90 S	213	26
	416	N 52 E, 69 S	238	10
	417	N 40 E, 44 S	227	16
	422	N 45 E, 75 S	226	11
	441	N 39 E, 58 S	212	14
	513	N 15 E, 90 S	194	9
	526	N 52 E, 39 S	45	3
	532	N 62 E, 57 S	230	6
	535	N 45 E, 73 S	221	8
	536	N 39 E, 66 S	208	3
	537	N 42 E, 58 S	226	10
BRF	976	N 58 E, 53 S	68	14
	977	N 54 E, 71 S	53	15
	979	S 66 W, 75 N	233	5
	981	N 35 E, 80 S	39	7
	982	N 51 E, 87 S	50	3
RAF	664	N 32 E, 90 S	214	10
	688	N 53 E, 60 S	235	2
BRF	1008	N 59 E, 65 S	213	13
	1011	N 39 E, 72 S	229	18
	1014	N 42 E, 68 S	231	8
	1015	N 39 E, 80 S	28	35
	1043	N 35 E, 67 S	40	17
	1045	N 42 E, 82 S	45	16
WOF	1069		229	3
	67	N 85 E, 33 S	79	5
	110	N 36 E, 60 S	211	7
	113	N 19 E, 85 S	22	14
	115	N 52 E, 49 S	217	11
	116	N 49 E, 51 S		
	116	N 32 E, 39 S	208	10
	122	S 17 W, 79 N	193	19
	129	N 40 E, 64 S	138	16
	132	N 37 E, 50 S	215	14
	140	N 60 E, 78 S	62	21
	141	N 50 E, 57 S	38	6
	143	N 5 W, 70 N	195	16
	154	N 24 W, 88 N	154	37
	184	N 46 E, 30 S	57	17
	239	N 0 E, 78 E	188	11
RAF	794	S 53 W, 78 N	226	4
BRF	1073	N 53 E, 56 S	235	34
	1075	N 37 E, 76 S	46	10
	1077	N 46 E, 63 S	55	17
RAF	66	N 44 E, 52 S	196	35
	79	N 50 E, 78 S	41	34
	129	N 29 E, 80 S	200	18

<u>Station*</u>		<u>Fold axial plane measurement</u>		<u>Fold hinge measurement</u>
RAF	131	N 19 E, 59 S	205	15
	368	N 26 E, 44 S	190	8
	382		215	15
	383	N 30 E, 70 S	197	33
	455	N 47 E, 28 S	35	11
	594	N 61 E, 88 S	232	3
	599	N 44 E, 90 S	221	36
WOF	161	N 74 E, 61 S	71	26
	165	N 72 E, 71 S	251	7

* Station numbers correspond to stations on Plate II.

Stations with a BRF prefix are located on the Bald River Falls 7.5-minute quadrangle.

Stations with a BJ prefix are located on the Big Junction 7.5-minute quadrangle.

Stations with an RAF prefix are located on the Rafter 7.5-minute quadrangle.

Stations with a WOF prefix are located on the Whiteoak Flats 7.5-minute quadrangle.

Stations are listed in the order in which they were visited along successive traverses.

APPENDIX B
MODAL ANALYSIS DATA

Formation		<i>Dean</i>		<i>Formation</i>	
Map unit	<i>Upper metaconglomerate</i>	<i>Upper metaconglomerate</i>	<i>Upper metaconglomerate</i>	<i>Upper metaconglomerate</i>	<i>Upper metaconglomerate</i>
Sample #	BRF 658	BRF 688	RAF 202	WOF 025	WOF 087
Quartz	52.9	51.3	55.9	50.8	57.4
Plagioclase	4.8	2.2	4.8	2.8	2.8
(comp.) *	(An 32)	(An 30)	(An 29)	(An 31)	(An 30)
Microcline					
Perthite	0.6	0.2	1.3	0.2	2.5
Chlorite	29.2	18.5	25.3	22	17
Muscovite	6.7	13.2	3.1	12.1	6
Sericite	3.1	1.2	0.6	0.2	0.9
Biotite	Trace				
Pyrite					0.1
Pyrrhotite				0.8	
Hematite	1.6	1.6	3.9	1.8	1.2
Magnetite					0.7
Carbonate		10.3	3.6	8.6	10.3
Ankerite					
Tourmaline	0.8	0.6	0.9	0.5	0.4
Zircon	0.4	0.9	0.6	0.4	0.6
Apatite					
Lithic Frag.'s				Trace	0.1
TOTAL	100.1	100	100	100	100
# of points					
counted	1001	1009	1000	1004	1000

* Plagioclase compositions determined using the Michel-Lévy (1877) method.

Formation	<i>Ammons</i>	<i>Formation</i>		<i>Cades Sandstone</i>	
Map unit	<i>Horse Branch (?) Member</i>	<i>Horse Branch (?) Member</i>	<i>Upper metaconglomerate</i>	<i>Upper metaconglomerate</i>	<i>Upper metaconglomerate</i>
Sample #	BJ 013	BRF 811B	RAF 465	RAF 595	RAF 792
Quartz	54.5	46	43.5	51.6	61.5
Plagioclase	4.6	4	3	2.2	4.1
(comp.) *	(An 28)	(An 28)	(An 31)	(An 30)	(An 30)
Microcline	5.2	2.9		0.9	
Perthite	0.1		0.3	0.4	1.1
Chlorite	10	12.6	27.8	27.2	12.8
Muscovite	1.6	2.6	2	0.6	0.6
Sericite	2.8	4.8	6.3	4.2	5.4
Biotite	0.4	0.4			
Graphite	7.8	17.8			
Pyrite	0.2	3		0.6	
Pyrrhotite	2				
Hematite	1		5.6	4	6.1
Magnetite					0.1
Carbonate	8.1	4.8	10.8	6.8	7.4
Ankerite					
Tourmaline	0.5	0.3	0.2	0.6	0.5
Zircon	0.9	0.4	0.5	0.6	0.3
Apatite				0.3	0.1
Lithic Frag.'s	0.3	0.4			
TOTAL	100	100	100	100	100
# of points					
counted	1000	1000	1000	1000	1000

* Plagioclase compositions determined using the Michel-Lévy (1877) method.

Formation	<i>Wilhite Formation</i>		
Map unit	<i>Ankeritic metasiltstone</i>	<i>Lower metasiltstone</i>	<i>Conglomeratic metasandstone</i>
Sample #	RAF 538	WOF 303B	WOF 036
Quartz	33.2	28.3	50
Plagioclase	1	0.9	2.4
(comp.) *	(An 30)	(An 30)	(An 28)
Microcline			Trace
Perthite			0.9
Chlorite	45.6	21.8	40.4
Muscovite	7	40.8	1.6
Sericite	2.1	1.1	1.5
Biotite		0.1	
Pyrite			
Pyrrhotite		2.8	
Hematite	1.6	3	2.1
Magnetite	1.8		
Carbonate		0.1	0.3
Ankerite	7.4		
Tourmaline	0.2	0.6	0.5
Zircon	0.1	0.2	0.4
Apatite		0.3	
Lithic Frag.'s			
TOTAL	100	100	100.1
# of points			
counted	1000	1000	1001

* Plagioclase compositions determined using the Michel-Lévy (1877) method.

VITA

Donald James Geddes, Jr. was born in Tuxedo, New York on March 20, 1966 to Donald James, Sr., and Carol Ann Geddes. He attended Sloatsburg Elementary and Suffern High School in the public Ramapo Central School District, from which he graduated in June, 1984. Having grown up in Rockland County, New York, he has never questioned his early and inevitable choice to become a geologist. He entered the State University of New York at Geneseo in September, 1984, where in May, 1988, he received a Bachelor of Arts in Geological Sciences with teaching certification in secondary education. He abandoned his potential teaching career and moved to Menlo Park, California to work as a summer intern with the U. S. Geological Survey, accompanied by his future wife, Mary Ellen. The summer position evolved into four one-year appointments at the U. S. G. S., during which he worked on the California Network Seismic Telemetry project and numerous seismic refraction projects. But the life of a traveling geophysicist was not what it seemed cut out to be, so in August, 1992, he and Mary Ellen moved back east and he entered the Master's program in Geological Sciences at The University of Tennessee, Knoxville. The Master of Science degree was received August, 1995. He is presently employed at Operational Technologies Corporation in Oak Ridge, Tennessee.

PLATE I

Bedrock Geologic Map of Parts of the Rafter, Whiteoak Flats, Bald River Falls, and Big Junction 7.5-Minute Quadrangles, Southeastern Tennessee

by
Donald J. Geddes, Jr.
1995

Explanation

Lithostratigraphy of the Hanging Wall of the Oconaluftee-Greenbrier Fault

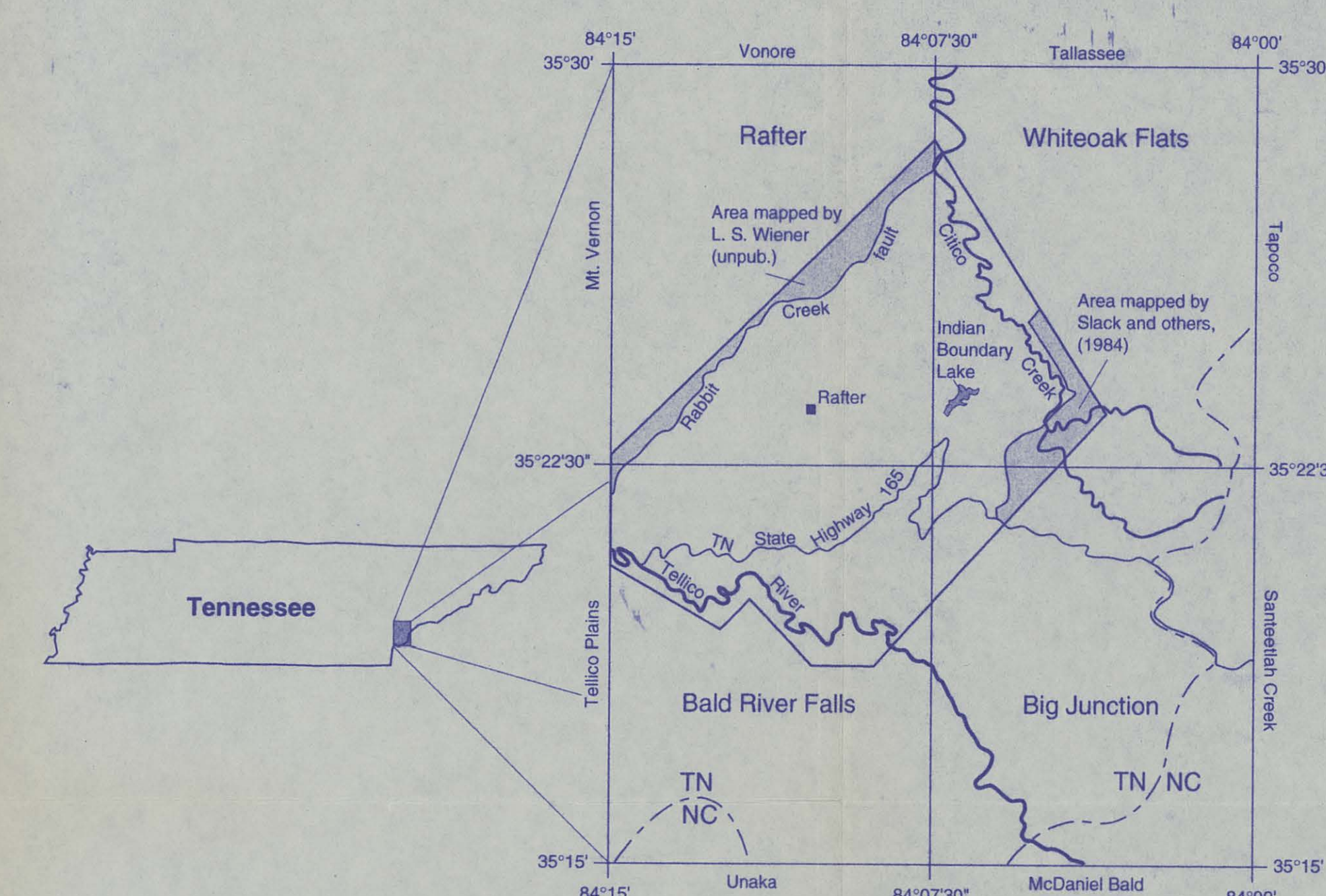
Lithostratigraphy of the Footwall of the Oconaluftee-Greenbrier Fault

Late Proterozoic (?)	Walden Creek Group	
	Formation	Member
	Walden	Zwsu upper metasilstone and slate; metasilstone dominant
	Walden	Zwa ankeritic metasilstone and metasandstone
	Walden	Zwsl lower slate and metasilstone; slate dominant
	Walden	Zwcl conglomeratic metagraywacke member
Proterozoic	Great Smoky Group	
	Formation	Member
	Dean	Zdcu upper metaconglomerate, metagraywacke, and metasandstone
	Dean	Zdsu—slate and metasilstone member
	Dean	Zdsl lower slate and metasilstone
	Dean	Zdcm conglomeratic metagraywacke member
	Dean	Zdcl lower metaconglomerate, metasandstone, metagraywacke, and slate; coarser-grained lithologies dominant to north
	Ammons	Zahb Horse Branch (?) Member metagraywacke, slate, metasilstone, and metasandstone; coarser-grained lithologies dominant to south

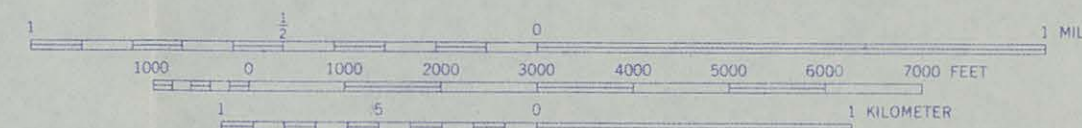
Late Proterozoic (?)	Walden Creek Group	
	Formation	Member
	Walden	Zws metasilstone and slate (undivided)
	Walden	Zwc—metaconglomerate and metasandstone member
	Walden	Zwl—limestone member
Proterozoic	Great Smoky Group	
	Formation	Member
	Dean	Zdcu upper metaconglomerate, metagraywacke, and metasandstone
	Dean	Zdsu—upper slate and metasilstone member
	Dean	Zdsl middle slate and metasilstone
	Dean	Zdcm—metaconglomerate member
	Dean	Zdcl lower metaconglomerate, metagraywacke, and slate; coarser-grained lithologies dominant to north
	Ammons	Zahb lower slate and metasilstone

- 42 Strike and dip of bedding
 - 87 Strike and dip of overturned bedding
 - Horizontal bedding
 - Strike of vertical bedding
 - 65 Strike and dip of slaty cleavage
 - Strike of vertical cleavage
 - 85 Strike and dip of pressure-solution cleavage
 - 79 Strike and dip of joint
 - 11 Trend and plunge of intersection lineation
 - 05, 10 Trend and plunge of mesoscale anticline, syncline
 - 07, 13 Trend and plunge of overturned mesoscale anticline, syncline
 - 05, 15 Trend and plunge of axis of crenulation cleavage
 - 15 Trend and plunge of mesoscale S-fold
 - 12, 20 Trend and plunge of mesoscale Z-fold
- Stratigraphic contact: exact, approximate, inferred, concealed
- Fault contact: exact, approximate, inferred
- Barbs on upper plate
- Axial trace of map-scale syncline, overturned syncline: exact, approximate, inferred, concealed
- Axial trace of map-scale anticline: exact, approximate
- Axial trace of doubly plunging map-scale syncline, anticline, overturned anticline
- chlorite
biotite
- Approximate location of biotite isograd

Location Map and Index to 7.5-Minute Quadrangles



Additional data compiled from University of Tennessee-Knoxville Geology summer field camp, 1993 and Professor Kauko Laajoki, University of Oulu, Finland



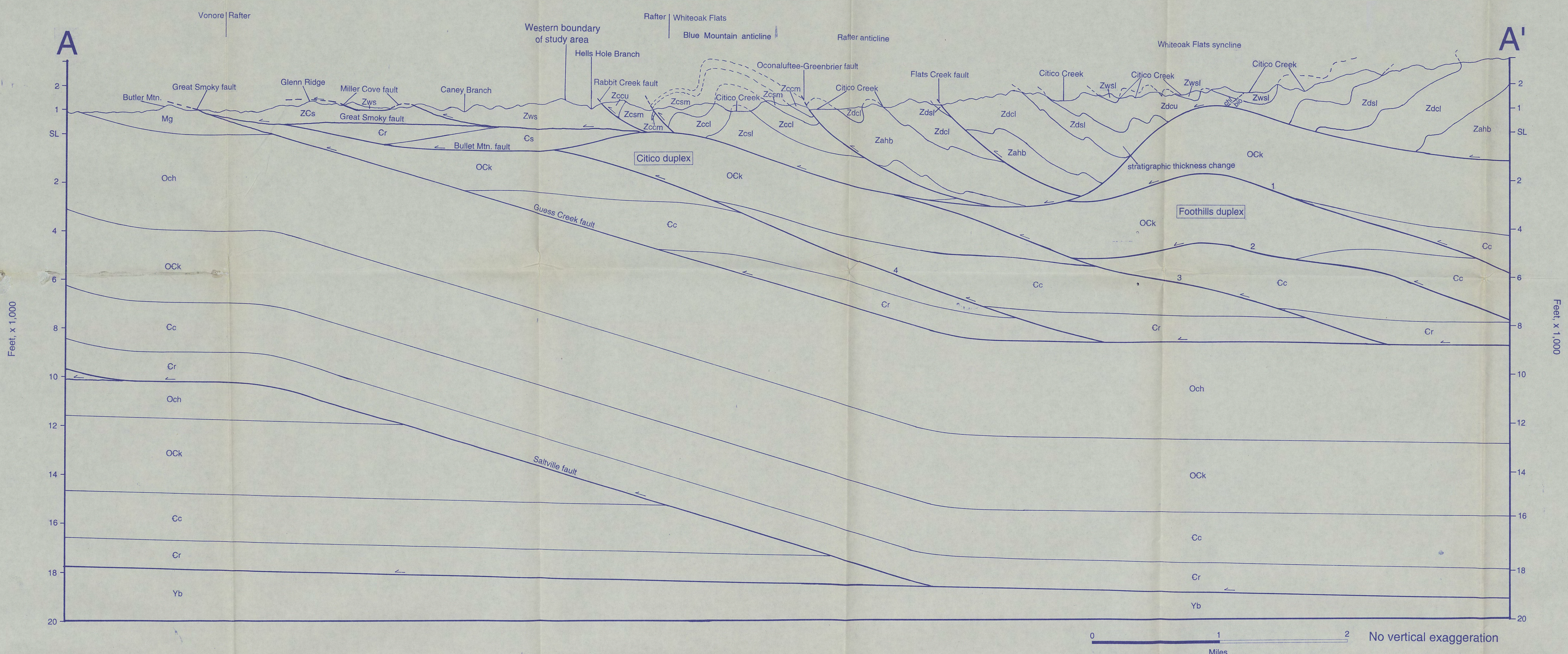
Scale 1: 24,000
Contour interval 40 feet

The map displays the study area in southeastern Tennessee, bounded by coordinates 84°00' to 84°15' longitude and 35°15' to 35°30' latitude. Key features include:

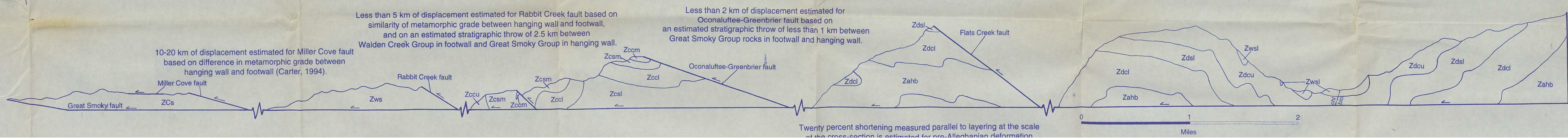
- Geographical Features:** Whiteoak Flats, Bald River Falls, Big Junction, and the TN/NC border.
- Water Bodies:** Indian Boundary Lake, Bald River, and various creeks (Creek, Creek, Creek).
- Infrastructure:** TN State Highway 168.
- Locations:** Rafter (marked with a square), Unaka, McDaniel Bald, and Tallapoosa.
- Map Areas:** Area mapped by L. S. Wiener (unpub.), Area mapped by Slack and others (1984), and the area mapped by the authors (shaded area).
- Inset Map:** A small map of Tennessee showing the location of the study area in the southeastern corner.

Stations RAF 817-897 and WOF 328-330 located by L. S. Wiener (unpub.).
Stations WOF 311-327 and BJ 084-088 located by Slack and others (1984)

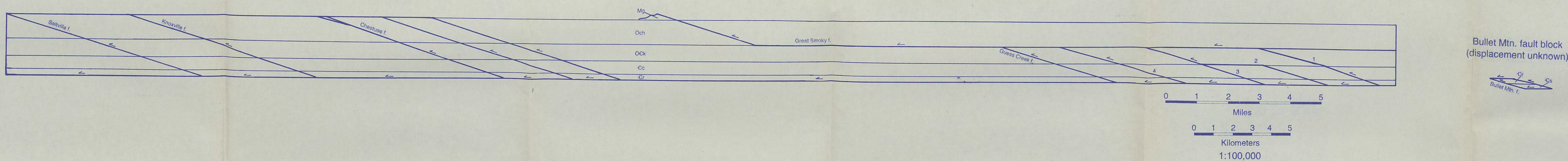
PLATE III
Retrodeformed Cross Sections Along
Lines A-A' and B-B' on Plate I



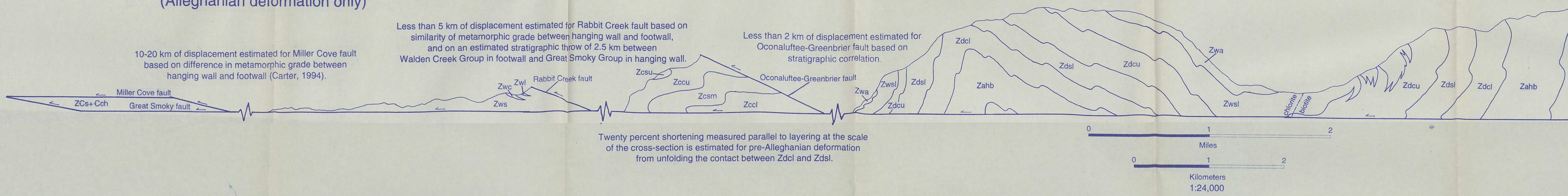
Area-conserved hanging wall strata, A-A'
(Alleghenian deformation only)



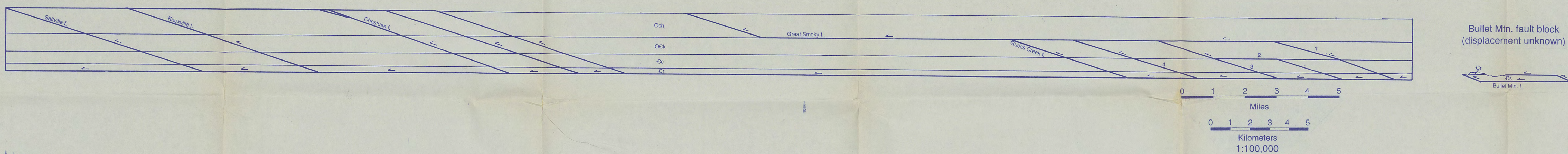
Line-balanced footwall strata, A-A'



Area-conserved hanging wall strata, B-B'
(Alleghenian deformation only)



Line-balanced footwall strata, B-B'



Explanation

Lithostratigraphy of the Hanging Wall of the Oconaluftee-Greenbrier Fault

Mg	Grainger Formation	Cr	Rome Formation
Och	Chickamauga Group	Cs	Shady Dolomite
Ock	Knox Group	Cch	Chilhowee Group
Cc	Conasauga Group	ZCs	Sanduck Formation

Walden Creek Group	White Formation	Zwa	ankeritic metasilstone and metasandstone
		Zwal	lower slate and metasilstone
		Zdcu	upper metaconglomerate, metagraywacke, and metasandstone
		Zdcl	lower slate and metasilstone
		Zdl	lower metaconglomerate, metasandstone, and metagraywacke
		Zhb	Horse Branch (?) Member metagraywacke, slate, metasilstone, and metasandstone

Great Smoky Group	White Formation	Zwa	ankeritic metasilstone and metasandstone
		Zwal	lower slate and metasilstone
		Zdcu	upper metaconglomerate, metagraywacke, and metasandstone
		Zdcl	lower slate and metasilstone
		Zdl	lower metaconglomerate, metasandstone, and metagraywacke
		Zhb	Horse Branch (?) Member metagraywacke, slate, metasilstone, and metasandstone

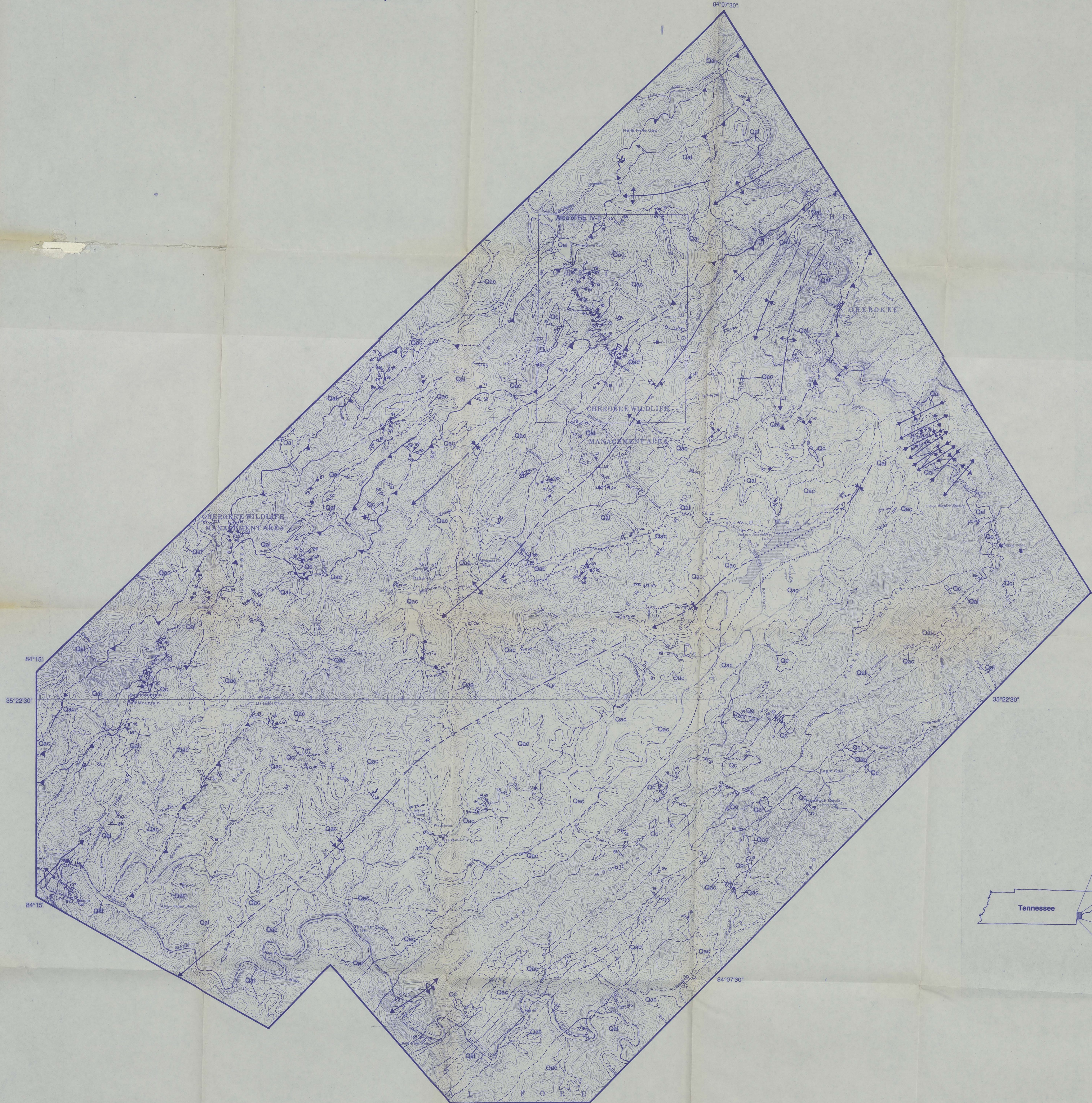
Lithostratigraphy of the Footwall of the Oconaluftee-Greenbrier Fault

Walden Creek Group	White Formation	Zwa	ankeritic metasilstone and metasandstone
		Zwal	lower slate and metasilstone
		Zdcu	upper metaconglomerate, metagraywacke, and metasandstone
		Zdcl	lower slate and metasilstone
		Zdl	lower metaconglomerate, metasandstone, and metagraywacke
		Zhb	Horse Branch (?) Member metagraywacke, slate, metasilstone, and metasandstone

Great Smoky Group	White Formation	Zwa	ankeritic metasilstone and metasandstone
		Zwal	lower slate and metasilstone
		Zdcu	upper metaconglomerate, metagraywacke, and metasandstone
		Zdcl	lower slate and metasilstone
		Zdl	lower metaconglomerate, metasandstone, and metagraywacke
		Zhb	Horse Branch (?) Member metagraywacke, slate, metasilstone, and metasandstone

Additional data west of study area compiled from Wiener (unpub.) and Hardeman (1966).

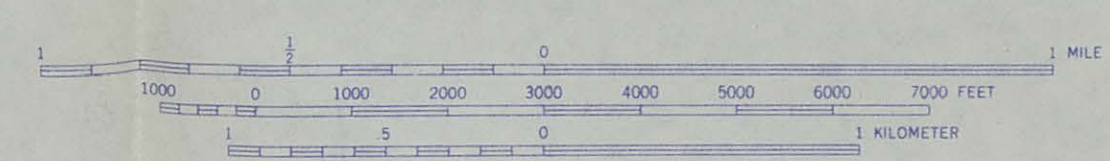
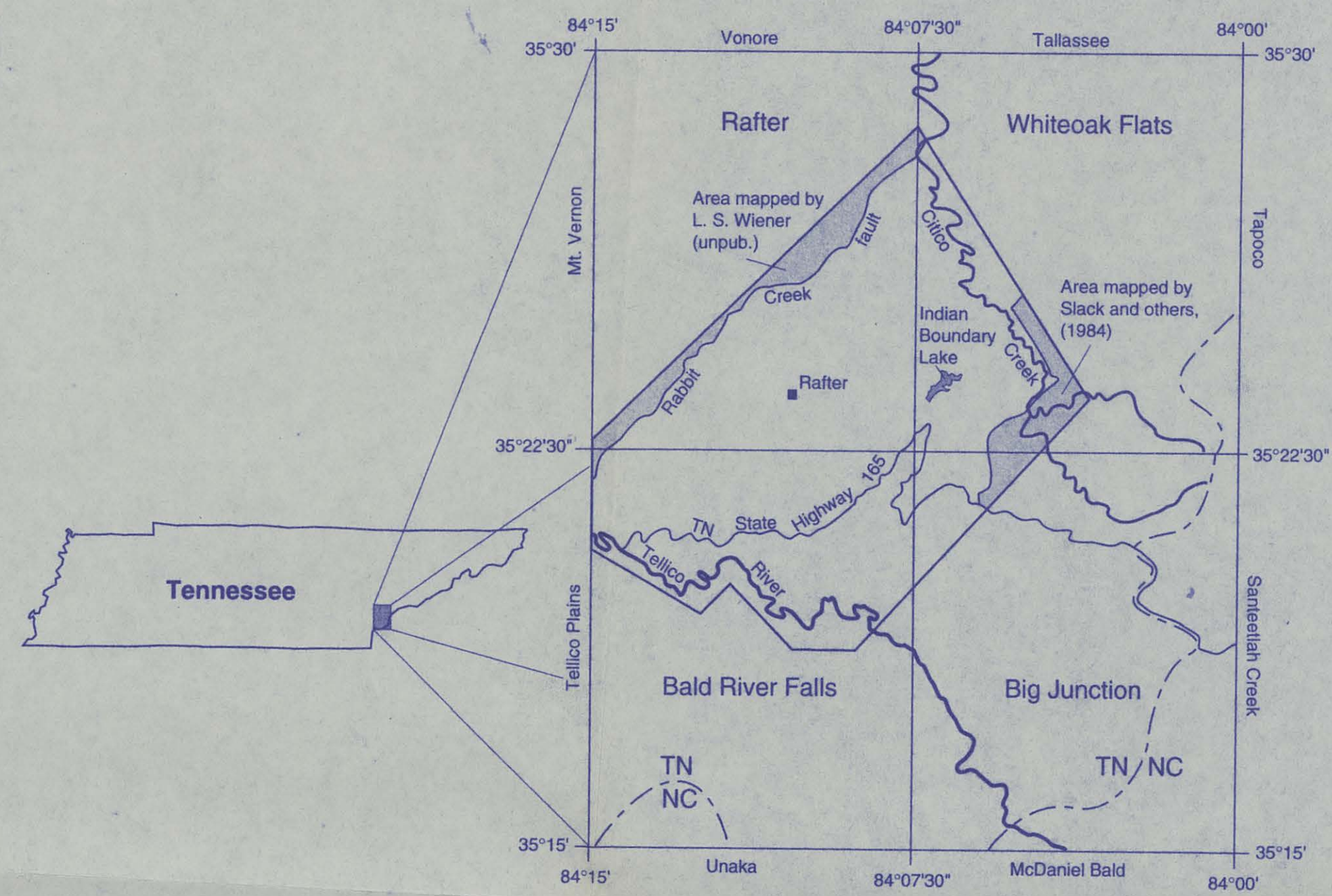
PLATE IV
Fracture Measurements and Surficial Deposits



Explanation

- Quaternary
- Qal alluvium—unconsolidated clay, silt, sand, pebbles, cobbles, and boulders in stream valleys
 - Qc colluvium—unconsolidated clay, silt, sand, pebbles, cobbles, and boulders on hill slopes
 - Qac alluvium and colluvium, undivided—unconsolidated clay, silt, sand, pebbles, cobbles, and boulders in stream valleys and on hill slopes
- 79 Strike and dip of joint
- 85 Strike and dip of quartz vein
- Strike of vertical joint, quartz vein
- Location of deformed quartz veins
- Approximate orientation of large quartz vein, determined from orientation of quartz boulders
- Quaternary deposit contact: exact, approximate, inferred
- Stratigraphic contact: exact, approximate, inferred, concealed
- Fault contact: exact, approximate, inferred
- Barbs on upper plate
- Axial trace of map-scale syncline, overturned syncline: exact, approximate, inferred, concealed
- Axial trace of map-scale anticline: exact, approximate
- Axial trace of doubly plunging map-scale syncline, anticline, overturned anticline
- Bedrock contacts, fold axes, and faults included for reference only—see Plate I for bedrock geology

Location Map and Index to 7.5-Minute Quadrangles



Scale 1: 24,000
Contour interval 40 feet