VIRGINIA DIVISION OF MINERAL RESOURCES PUBLICATION 16

GEOLOGY OF THE ABINGDON, WYNDALE, HOLSTON VALLEY AND SHADY VALLEY QUADRANGLES

Charles S. Bartlett, Jr. and Thomas H. Biggs

COMMONWEALTH OF VIRGINIA

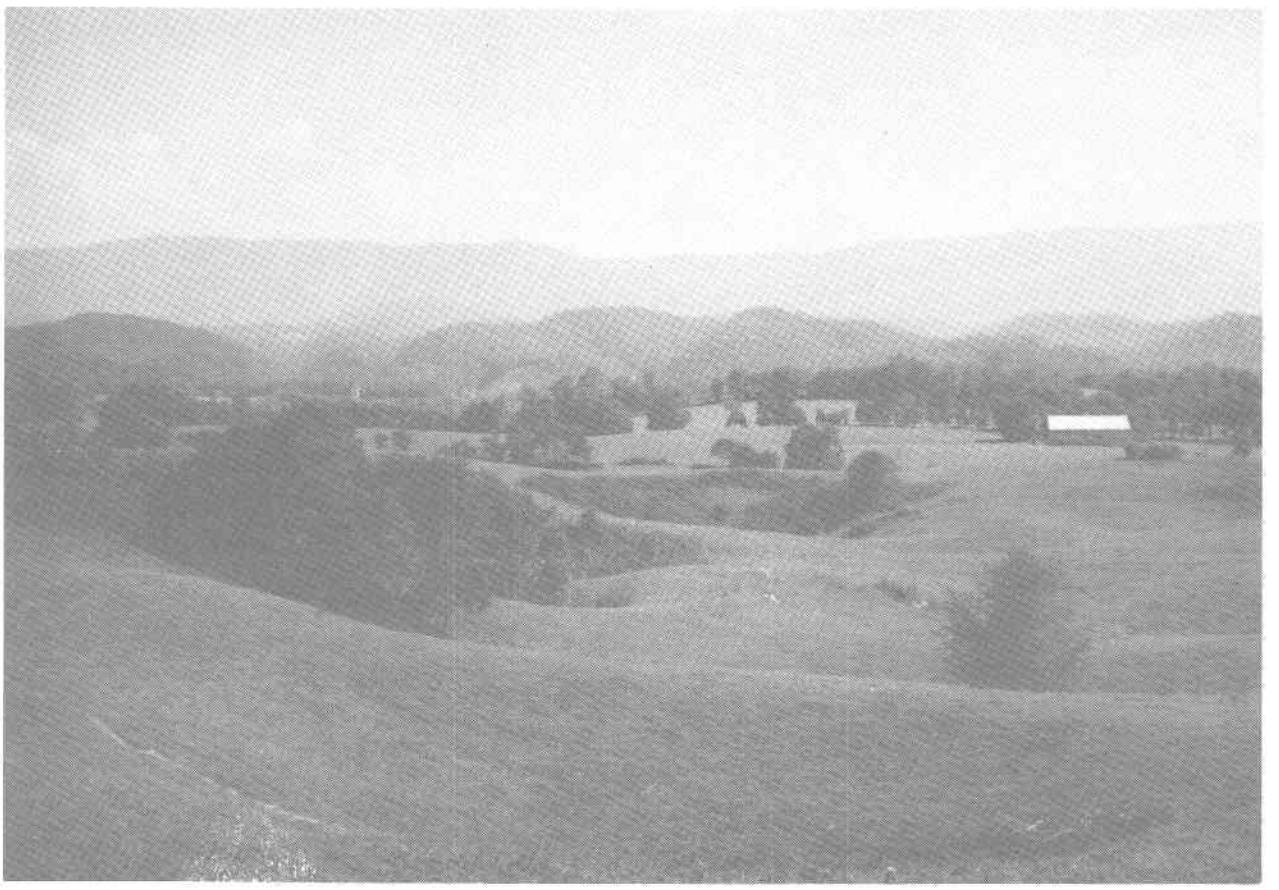
DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT
DIVISION OF MINERAL REOURCES
Robert C. Milici, Commissioner of Mineral Resources and State Geologist

CHARLOTTESVILLE, VIRGINIA
1980

VIRGINIA DIVISION OF MINERAL RESOURCES PUBLICATION 16

GEOLOGY OF THE ABINGDON, WYNDALE, HOLSTON VALLEY AND SHADY VALLEY QUADRANGLES

Charles S. Bartlett, Jr. and Thomas H. Biggs



COMMONWEALTH OF VIRGINIA

DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT
DIVISION OF MINERAL REOURCES
Robert C. Milici, Commissioner of Mineral Resources and State Geologist

CHARLOTTESVILLE, VIRGINIA
1980

FRONT COVER: Well developed karst topography with numerous sinkholes in Conococheague Formation limestone and dolomite viewed to south from State Road 675 about 0.6 mile (1.0 km) south of its junction with State Road 829 (Plate 1).

VIRGINIA DIVISION OF MINERAL RESOURCES PUBLICATION 16

GEOLOGY OF THE ABINGDON, WYNDALE, HOLSTON VALLEY AND SHADY VALLEY QUADRANGLES

Charles S. Bartlett, Jr. and Thomas H. Biggs

COMMONWEALTH OF VIRGINIA

DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT
DIVISION OF MINERAL REOURCES
Robert C. Milici, Commissioner of Mineral Resources and State Geologist

CHARLOTTESVILLE, VIRGINIA
1980

COMMONWEALTH OF VIRGINIA

Department of Purchases and Supply

Richmond

1980

Portions of the publication may be quoted if credit is given to the Virginia Division of Mineral Resources. It is recommended that reference to this report be made in the following form:
Bartlett, C. S., Jr. and Biggs, T. H., 1980, Geology of the Abingdon, Wyndale, Holston Valley and Shady Valley quadrangles, Virginia: Virginia Division of Mineral Resources Publication 16, 39 p.

DEPARTMENT OF CONSERVATION
AND ECONOMIC DEVELOPMENT

Richmond, Virginina

FRED W. WALKER, Director
JERALD F. MOORE, Deputy Director

BOARD

J. H. JOHNSON, West Point, Chairman
A. R. DUNNING, Millwood, Vice Chairman
MYRON P. ERKILETIAN, Alexandria
ARTHUR P. FLIPPO, Doswell
HENRY T. N. GRAVES, Luray
MILDRED LAYNE, Williamsburg
FREDERIC S. REED, Manakin-Sabot
GEORGE P. SHAFRAN, Arlington
SHELDON H. SHORT, III, Chase City
NICHOLAS D. STREET, Grundy
SHERMAN WALLACE, Cleveland
E. FLOYD YATES, Powhatan

CONTENTS

PAGE

Abstract 1
Introduction 1
Stratigraphy 2
Cambrian System 2
Unicoi Formation 2
Rome Formation 2
Honaker Formation 2
Nolichucky Formation 6
Maynardville Formation 7
Conococheague-Copper Ridge Formations 7
Ordovician System 7
Chepultepec limestone 7
Knox Group, upper part 8
Lenoir-Moshein limestones 9
Athens Formation (of Butts, 1933) 10
Mississippian System 11
Ste. Genevieve limestone 11
Gasper limestone 11
Fido Sandstone 11
Cove Creek Limestone 12
Pennington Formation 12
Quaternary System 12
Colluvium 13
Terrace deposits 13
Alluvium 13
Structure 13
Greendale syncline 13
Complexly thrust-faulted belt 14
Saltville fault and fault block 14
Pulaski fault 14
Cummings Heights syncline 15
Spurgeon fault 15
Abingdon syncline 15
Stone Mill anticline 15
Alvarado transverse and thrust fault 15
Southern fold belt 16
Great Knobs syncline 16
Watauga anticline 16
River Knobs syncline 17
Parks Mill anticline 17
South Holston syncline 17
Frontal Blue Ridge belt 17
Sweet Hollow anticline 17
Holston Mountain fault 18

Economic geology 18
Industrial limestone and dolomite 18
High-calcium limestone 19
High-magnesium dolomite 19
Impure limestone 19
Crushed and broken stone 20
Clay, shale and related material 20
Miscellaneous resources 21
Environmental geology 23
Unit 1 23
Unit 2 23
Unit 3 24
Unit 4 24
Unit 5 24
Unit 6 24
Unit 7 24
Unit 8 25
Unit 9 25
Unit 10 25
Unit 11 25
Unit 12 25
Examples of failed projects 26
References 26
Appendix: Stratigraphic sections 28
Index 38

ILLUSTRATIONS

PLATE PAGE

1. Geologic Map of the Abingdon and Shady Valley quadrangles, Virginia ..... In pocket
2. Geologic Map of the Wyndale and Holston Valley quadrangles, Virginia ..... In pocket

FIGURE

1. Index map 1
2. Dolomite and chert of the Honaker Formation 5
3. Fractured Honaker dolomite, Pulaski fault zone 5
4. Nolichucky limestone 6
5. Chepultepec limestone 8
6. Erosional or cave-fill breccia in the Knox Group, upper part 8
7. Erosional conglomerate at base of the Lenoir-Mosheim 9
8. Typical terrain of the Knox Group, upper part, the Lenoir-Mosheim, and the Athens formations 10
9. Polymictic conglomerate in the Athens Formation 11
10. Penecontemporaneous deformation in the Pennington Formation 12
11. Crumpled shaly dolomite of the Honaker Formation 14
12. "Halls Bottom Cave" 16
13. Series of folds in Athens Formation on South Holston Lake shore 17
14. Acme Stone Corporation quarry, Abingdon 20
15. Abandoned quarry in the Athens Formation 20
16. Large, recurring soil slump along U.S. Highway 19-58A 23

TABLES

1. Geologic formations in the Abingdon, Wyndale, Holston Valley and Shady Valley quadrangles 3
2. Chemical requirements for uses of limestone and dolomite 18
3. Chemical composition of carbonate rocks from selected localities in the Abingdon, Wyndale, Holston Valley and Shady Valley quadrangles 19
4. Physical tests of aggregate samples 20
5. Potential uses of clay and shale materials from the Abingdon, Wyndale, Holston Valley and Shady Valley quadrangles 21
6. Summary of soil types 22

GEOLOGY OF THE ABINGDON, WYNDALE, HOLSTON VALLEY AND SHADY VALLEY QUADRANGLES, VIRGINIA

By
Charles S. Bartlett, Jr.[1] and Thomas H. Biggs[1]

ABSTRACT

The Abingdon, Wyndale, and Virginia portions of the Holston Valley and Shady Valley quadrangles, Virginia, consisting of approximately 142.9 square miles, are in Washington County (southwestern Virginia) and entirely within the Valley and Ridge physiographic province. The quadrangles are underlain by bedrock ranging in age from Lower Cambrian through Upper Mississippian, although the stratigraphic sequence from the Middle Ordovician to the Lower Mississippian is absent from outcrop due to erosion and/or structural complications. The outcropping rocks are assigned to 17 formations of which 15 are lithologically distinct and separately mapped, as were Quaternary alluvial, colluvial and terrace deposits.

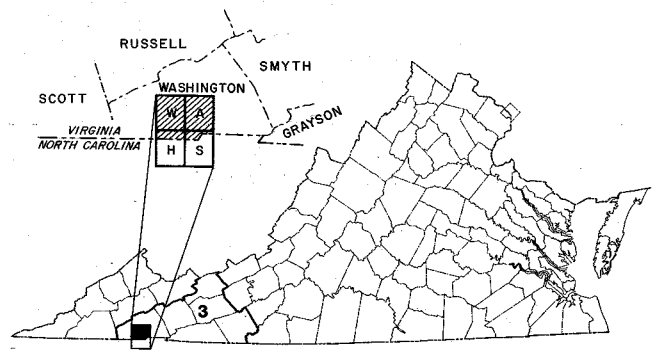
The major structural features consist of parts of the Greendale, Abingdon, and South Holston synclines, the Cummings Heights, Stone Mill, Parks Mill, and Sweet Hollow anticlines, and the Saltville, Pulaski, Spurgeon and Alvarado fault systems. The formational outcrop belts and major fault traces are mostly aligned northeast-southwest. In contrast, the Alvarado and Dry Run transverse faults have a northwest-southeast trace. The largest stratigraphic displacement of geologic units is about 16,000 feet (4800 m) along the Saltville fault trace, where the Cambrian Honaker Formation is in contact with the Mississippian Pennington Formation.

Crushed stone is produced from limestone and dolomite. Limestone, dolomite, and shale were tested for potential economic use. Small quantities of iron and travertine have been mined in the past.

Data for land-use decisions is provided by environmental geologic information such as lithology, slope, soil type, geologic structure, and topographic features.

INTRODUCTION

The Abingdon, Wyndale, and Virginia portions of the Holston Valley and Shady Valley 7.5-minute quadrangles (Plates 1 and 2) located in Washington County, southwestern Virginia (Figure 1) include approximately 142.9 square miles; the area is bounded by longitudes 81°52′30″W and 82°07′30″W, latitude 36°45′00″N, and the Virginia-Tennessee state line and is within the Valley and Ridge physiographic province. It is characterized by broad rolling hills and lowlands of limestone and dolomite and by dissected ridges of sandstone and shale. The regional trend of the ridges is northeast-southwest. Walker Mountain forms a general divide between streams flowing northerly to the North Fork of the Holston River and those flowing southerly to the Middle Fork and South Fork of the Holston River. These forks of the Holston all flow southwestward into Tennessee. There are numerous sinkholes, caves, and subterranean streams in the lands underlain by limestone and dolomite.



1. Index map showing the location of the Abingdon, Wyndale, Holston Valley and Shady Valley quadrangles, Washington County, Virginia.

The highest elevation, approximately 2580 feet (786.9 m) above sea level, is on the crest of Walker Mountain 2.7 miles (4.3 km) northwest of Wyndale (Plate 2) and on a bend in the Virginia-Tennessee state line on the slope of Little Mountain (Plate 1); the lowest point, approximately 1500 feet (457.5 m), is along Smith Creek in the northwest corner of the area. Maximum relief in the quadrangles is over 1080 feet (329.4 m). With the exception of Rich Valley, the region northwest of Walker Mountain is mostly rugged, hilly to mountainous, forested, and sparsely populated. The rest of the area, except for the Great Knobs, the River Knobs and that south of the South Holston Lake, has gentle topography. Much of this land has been cleared and converted to various cultural uses. In addition to numerous secondary roads, the transportation network includes Interstate Highway 81, U.S. Highways 11 (Lee Highway), 19, and 58 (J.E.B. Stuart Highway), State Highway 75, and one line of the Norfolk and Western Railway. The region along the Interstate Highway 81 corridor has experienced rapid and extensive industrial, commercial and residential development over the past ten years.

The geology of portions of the area were studied by Campbell (1899) and Butts (1933, 1940-41). Other work includes two unpublished theses, one by Berryhill (1949) on the Wyndale quadrangle and the other by Tyler (1960) on the Abingdon and Shady Valley quadrangles. Data on the adjoining portion of Tennessee compiled by King and Fer-

[1]Consultant geologist, 102 South Court Street, Abingdon, Va. 24210

guson (1960) and the 1966 Geologic Map of Tennessee were of assistance; additional information was obtained from the references listed.

Field work was completed during approximately two 13-week field seasons in the summers of 1974 and 1975. The study was financed by the Virginia Division of Mineral Resources and authorized by Dr. James L. Calver, Virginia State Geologist (now retired). Harry W. Webb and Donald Le Van, Division geologists, participated in some field sampling, and Chris Halladay and Oliver Fordham, Division geochemists, made many of the carbonate rock analyses. J. Van Dine and R. L. Googins, U.S. Soil Conservation Service, furnished soils information used in the Environmental Geology section. The cooperation of area citizens who allowed access to their properties is appreciated.

On the maps, numbers preceded by "R" in parentheses (R-6213) correspond to localities where rock samples were collected; similarly, fossil-collection localities are indicated by "F" (Plates 1, 2). These samples and fossils are on file in the repository of the Virginia Division of Mineral Resources where they are available for examination. Fossil identification was accomplished primarily using Butts (1940-41) and Shimer and Shrock (1944). Additional structural data are on file with the Division of Mineral Resources.

STRATIGRAPHY

Paleozoic rocks of sedimentary origin exposed in the study area are assigned to 17 formations of which 15 are lithologically distinct and separately mapped (Table 1). The Lenoir and Mosheim limestones are mapped together throughout the project area, and the Maynardville Formation is included with the northern outcrop belt of the Copper Ridge Formation as shown on Plate 2. Stratigraphic sections were measured and described in megascopic and microscopic detail (Appendix). The stratigraphic sequence is incomplete due to structural complexity; however, the combined maximum thickness for the exposed rocks may exceed 18,700 feet (5701 m). The area northwest of Rich Valley in the Wyndale quadrangle area is underlain by Mississippian limestones, sandstones, and shales; the rest of the study area is underlain by limestones, dolomites, sandstones, and shales ranging in age from the Lower Cambrian Unicoi Formation to the Middle Ordovician Athens Formation. Sand, clay, and gravel alluvium and colluvium of Quaternary age are on slopes and floodplains, and form terrace deposits along the South Fork and Middle Fork of the Holston River.

CAMBRIAN SYSTEM

Unicoi Formation

The Unicoi Formation is exposed at fault contacts in two areas along the western edge of the Blue Ridge mountains. One area is along the southeastern margin of Denton Valley, where no outcrops were seen, but where soil color and composition, along with large quantities of sandstone talus, are indicative of Unicoi rocks. The other is east of Sweet Hollow where white to light-brown, medium-bedded quartzite crops out (Plate 1).

The Unicoi mostly is covered by colluvium composed of quartz sandstone, quartz-pebble conglomerate, and angular quartzite boulders up to 8 feet (2.4 m) long dimension. Some boulders contain recemented angular clasts of quartzite (Plate 1, R-6350), which probably represent brecciation along the Holston Mountain fault. Most of the boulders are stained brown to rusty red by iron oxides. The Unicoi is unfossiliferous.

Rome Formation

An outcrop belt of the Rome Formation in Denton Valley (Plate 1) has an observed thickness of approximately 1400 feet (427 m). The base of the formation is not exposed because it is faulted. The top of the formation was placed above the youngest pale-red shales that are below the thin-bedded, argillaceous, shaly-weathering dolomite of the overlying Honaker Formation.

The Rome Formation consists predominantly of pale-red, micaceous, clay shales and siltstones (Plate 1, R-6342), which weather to a distinctive, dark-red soil and which form equally distinctive steep-sided, conical hills. Minor amounts of pale-gray-green clay shales, light-gray, very fine-grained, thin-bedded dolomites, and red sandy siltstones are also found in this unit. Black, algal-banded chert (Plate 1, R-6342) float is abundant on slopes underlain by the Rome Formation. The only fossils are rare vertical worm borings.

A small outcrop of greenish-gray clay shale thought to be Rome (Plate 2, R-6369) was found along the Saltville fault, 200 feet (61 m) south of State Road 700. There is another, smaller and unmapped, area which may be Rome in a hillside 3500 feet (1068 m) north of the Clear Creek Lake Dam (Plate 2).

Honaker Formation

The Honaker Formation is exposed in five principal belts. The order of descriptions will be from northwest to southeast. In the northernmost outcrop belt, which extends in a northeasterly direction along Rich Valley, the Honaker forms the leading edge of the Saltville block; the full thickness is not exposed. Here the formation is primarily medium-light-gray, very fine-grained dolomite (R-6213) with "butcher-block" weathering. The bedding ranges from medium to thick except near the top of the unit where the beds are thin. These uppermost beds are more calcareous than the rest of the unit, reflecting the transition from

Table 1.—Geologic formations in the Abingdon, Wyndale, Holston Valley and Shady Valley quadrangles

AGE	NAME	CHARACTER	Thickness In Feet (meters)
Quaternary	Alluvium	Varicolored, unconsolidated sand, clay and gravel. Some travertine deposits in creeks.	0-35± (0-11±)
	Terrace deposits	Gravels and cobbles, mainly sandstones, conglomeratic sandstones, and quartzites, in sand, silt, and clay matrix.	0-15± (0-5±)
	Colluvium (Plate 1 only)	Unconsolidated pebbles, cobbles, and boulders, mainly sandstones, conglomeratic sandstones, and quartzites.	0-25± (0-8±)
----------2---			
Mississippian	Pennington Formation	Interbedded gray and brown siltstone, shaly sandstone, with some argillaceous limestone, and silty shale; mostly maroon and greenish-gray in upper portion; abundant fossils.	1300± (396±)
	Cove Creek Limestone (Plate 2 only)	Gray, argillaceous limestone, most of which is thinly laminated, weathers to pale-gray slightly fossiliferous.	1100± (335±)
	Fido Sandstone (Plate 2 only)	Maroon to brown, calcareous, fine-grained sandstone, cross-bedded, thick-bedded, friable when weathered; limestone, thin-bedded in upper part; fossiliferous.	50-75± (15-23±)
	Gasper limestone (Plate 2 only)	Gray to light-gray, argillaceous shaly-weathering limestone, thin- to thick-bedded, partly crinoidal; fossiliferous.	800± (244±)
	Ste. Genevieve limestone (Plate 2 only)	Gray, argillaceous limestone, medium-bedded; uppermost beds are maroon, sandy to argillaceous, crinoidal limestone; fossiliferous. (Only upper portion exposed).	200± (61±)
----------3---			
Ordovician	Athens Formation (of Butts, 1933)	Olive-gray to dark-gray, fissile shale with minor gray, argillaceous siltstones, thin-bedded in lower part (200 to 2300 feet; 61-701.5 m), fossiliferous in basal portion; buff-brown shales, siltstones, fine- to coarse-grained lithic sandstones and polymictic conglomerates in middle to upper portion (800-3400 feet; 244-1037 m); some siltstones and sandstones calcareous.	1000±-57000± (305±-1739±)
	Lenoir and Mosheim limestones	Lenoir Limestone: Gray to dark-gray argillaceous limestone, fine-grained, medium-bedded, silty laminations; fossiliferous (0-68 feet; 0-20.7 m). Mosheim Limestone: Light-gray limestone, micro-grained, medium-bedded with calcite crystal clusters (0-150 feet; 0-45.8 m); sparsely fossiliferous; rare thin interbedded medium-gray dolomite, fine-grained. Common occurrence of limestone, dolomite and chert clasts in micrite matrix at base (1-15 feet; 0.3-5.0 m); lower contact unconformable.	0-218± (0-66±)
----------2---			
	Knox Group upper part	Light-gray cherty dolomite, micro to coarse-grained; near top variable amounts of blue-gray fossiliferous limestone, micrograined; abundant white chert float with dolomolds; zones of erosional breccia in upper part; upper contact unconformable.	600±-1255± (183±-383±)
	Chepultepec limestone	Dark-blue-gray limestone, micrograined, thick-bedded, with scattered black chert nodules, worm trail-like features common; sparingly fossiliferous; with minor medium-gray dolomite, fine-grained.	0-1000± (0-305±)

Table 1. (Continued)

AGE	NAME		CHARACTER	Thickness In Feet (meters)
Cambrian	Copper Ridge Formation (Plate 2, cross section of Plate 1)	Conococheague Formation	Copper Ridge Formation: more than one-half medium- to light-gray dolomite, very fine- to coarse-grained with medium- to dark-gray limestones, micrograined and scattered thin beds of gray to brown sandstone, fine to medium-grained, well rounded; some algal chert. Conococheague Formation: More than one-half dark-gray to blue-gray laminated limestone, fine-grained, with light- to medium-gray dolomite, fine-grained and scattered thin beds of brown to light- to medium-gray sandstone, fine- to medium-grained.	1323± 1698± (404±) (518±)
	Maynardville Formation (Plate 2 only)		Medium-dark to medium-gray silty "ribbon-banded" limestone, micrograined, dense, with some micrograined limestone-pebble conglomerate in coarse-grained matrix. (Only on Saltville fault block).	72± (22±)
	Nolichucky Formation (Plate 2) Nolichucky limestone (Plate 1)		North of the Pulaski and associated faults: Light-olive-gray to gray-green, silty, fissile shale; blue-gray argillaceous limestone, micro- to fine-grained, medium- to thin-bedded with some limestone-pebble conglomerates and oolitic limestones; partly glauconitic, fossiliferous (451 feet; 137.6 m). South of Pulaski and associated faults: medium-gray limestone, very fine to micro-grained, medium- to thin-bedded, with distinctive closely spaced, light-gray, silty laminations which weather to brownish-gray, crinkly, raised laminations. Rare occurrences of oolitic limestone and limestone-pebble conglomerate lenses. Sparsely fossiliferous (125-200 feet; 38.1-61 m).	125±-451± (38±-138±)
	Honaker Formation		Gray to light gray dolomite, micro- to fine-grained, mostly medium-bedded, cherty in part; abundant algal chert float; interbeds of medium-gray limestone, thin- to medium-bedded, partly algal-banded in middle portion south of Pulaski fault.	700±-2000± (214±-610±)
	Rome Formation		Predominately pale-red clay shale and siltstone with minor amounts of pale-gray-green shale, light-gray dolomite, very fine-grained, thin-bedded, and pale-maroon siltstone. Algal-banded, gray chert float.	1400± (427±)
[1]	Unicoi Formation (Plate 1 only)		White to light-brown quartz sandstone and quartzite, coarse-grained, subrounded, medium-bedded, occasional iron and manganese cemented float blocks; some interbedded coarse siltstones and silty shales, weathered brownish-orange. Some float boulders of quartz-pebble conglomerate, massive-bedded.	

[1]Hampton, Erwin and Shady formations omitted by faulting.
[2]Erosional unconformity.
[3]Upper Middle Ordovician through Lower Mississippian formations omitted by faulting.

the Honaker depositional environment to that of the younger Nolichucky Formation. The Honaker contains black algal chert (Figure 2) which may be abundant in float (Plate 2, R-6367). Along Garrett Creek, the incomplete Honaker Formation in the Saltville fault hanging wall was measured to be 927 feet (287.7 m) thick (Plate 2, Section A). There is a good exposure of the Honaker along U.S. Highway 19-58A at Greendale (Plate 2).

2. Thinly-laminated dolomite (light beds) and algal-banded chert (dark layers) in Honaker Formation exposed on the west side of U.S. Highway 19-58A about 700 feet (213.5 m) south of the junction with State Road 700 at Greendale (Plate 2).

The next belt of the Honaker Formation forms the leading edge of the Pulaski fault complex. The formation has been partially repeated along the Spurgeon fault (Plate 2) and its lower contact is not exposed. The upper contact is marked by a distinctive zone of thick-bedded, coarse-grained dolomite which underlies the basal limestone of the Nolichucky. Light-gray, fine-grained dolomite is the primary lithology; calcareous dolomite and limestone in the middle of the formation compose aproximately 20 percent of the total formation. The limestones are medium gray, fine grained, and weather bluish gray. Some appear to be of algal origin and there are some peletoidal limestones (Plate 1, R-6338). Portions of the Honaker are well exposed along State Road 692 (White Mill Road) northwest of its junction with State Road 693 (Chip Ridge Road).

In both the Saltville and the Pulaski blocks, the Honaker consists of highly brecciated, crushed, and recemented masses along the fault zones (Figure 3). The angular fragments are chiefly dolomite and range in size from about 0.5 inch (1.27 mm) to two feet (0.6 m); the cement matrix is primarily dark-gray limestone deposited from solution (Plate 1, R-6336).

The third belt of the Honaker Formation is south of and parallel to Lee Highway; the exposure is in a breached and faulted anticline. Limestone composes approximately 30 percent of the portion of the formation found here and sinkholes are more numerous than to the north. The limestone, which weathers blue, is medium to dark gray and very fine grained; the bedding surfaces are often covered with silt-filled "worm-trails." The formation crops out in the fields east of State Road 808 and Sinking Creek (Plate 2). The dolomite is well exposed in the Acme Stone Quarry (active quarry number 11; Plate 1, R-6214, R-6347) and is primarily light gray and fine grained, with zones of dark-gray, very coarse-grained dolomite at the top. The contact with the overlying Nolichucky can be seen in an unnamed creek just southwest of the Southwest Virginia 4-H Center (Plate 1, R-6363).

The fourth belt of the Honaker caps the Parks Mill anticline and crops out from just east of Fifteenmile Creek to the Middle Fork Holston River. The partial thickness of the unit is approximately 700 feet (213.5 m) at the fold; the upper 350 feet (106.8 m) is composed of light- to medium-dark-gray, coarse- to fine-grained dolomite (Plate 1, R-6212), and the remainder of the exposure is interbedded limestones and dolomites. The limestone is medium gray and fine grained with irregular laminations of silt; the dolomite is medium light gray, fine grained and slightly argillaceous.

The southernmost belt, located in Denton Valley (Plate 1), is the only complete exposure of the Honaker Formation mapped. The upper contact of the formation is marked by the distinctive, coarse-grained beds described above; the lower portion of the formation is composed of thin-bedded, shaly weathering, fine-grained dolomite. There is a good

3. Highly fractured Honaker dolomite in the Pulaski fault zone exposed in the east roadbank of White Mill Road (State Road 692) near White Branch (Plate 1).

the Honaker depositional environment to that of the younger Nolichucky Formation. The Honaker contains black algal chert (Figure 2) which may be abundant in float (Plate 2, R-6367). Along Garrett Creek, the incomplete Honaker Formation in the Saltville fault hanging wall was measured to be 927 feet (287.7 m) thick (Plate 2, Section A). There is a good exposure of the Honaker along U.S. Highway 19-58A at Greendale (Plate 2).

2. Thinly-laminated dolomite (light beds) and algal-banded chert (dark layers) in Honaker Formation exposed on the west side of U.S. Highway 19-58A about 700 feet (213.5 m) south of the junction with State Road 700 at Greendale (Plate 2).

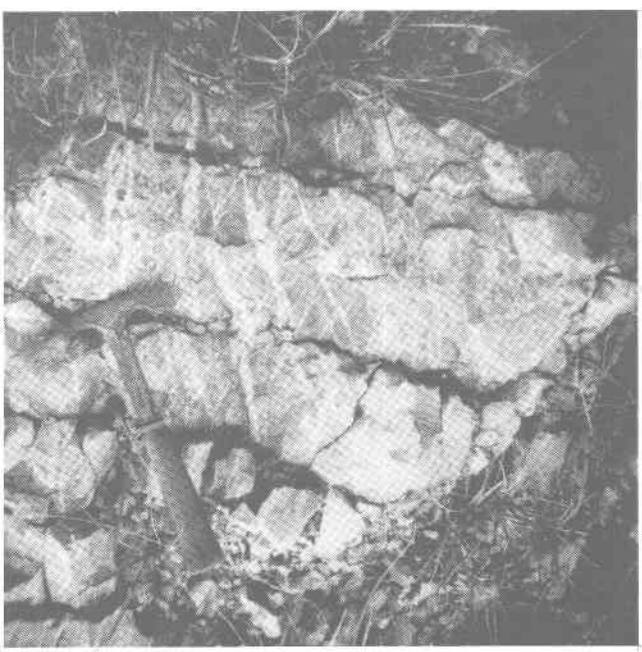
The next belt of the Honaker Formation forms the leading edge of the Pulaski fault complex. The formation has been partially repeated along the Spurgeon fault (Plate 2) and its lower contact is not exposed. The upper contact is marked by a distinctive zone of thick-bedded, coarse-grained dolomite which underlies the basal limestone of the Nolichucky. Light-gray, fine-grained dolomite is the primary lithology; calcareous dolomite and limestone in the middle of the formation compose aproximately 20 percent of the total formation. The limestones are medium gray, fine grained, and weather bluish gray. Some appear to be of algal origin and there are some peletoidal limestones (Plate 1, R-6338). Portions of the Honaker are well exposed along State Road 692 (White Mill Road) northwest of its junction with State Road 693 (Chip Ridge Road).

In both the Saltville and the Pulaski blocks, the Honaker consists of highly brecciated, crushed, and recemented masses along the fault zones (Figure 3). The angular fragments are chiefly dolomite and range in size from about 0.5 inch (1.27 mm) to two feet (0.6 m); the cement matrix is primarily dark-gray limestone deposited from solution (Plate 1, R-6336).

The third belt of the Honaker Formation is south of and parallel to Lee Highway; the exposure is in a breached and faulted anticline. Limestone composes approximately 30 percent of the portion of the formation found here and sinkholes are more numerous than to the north. The limestone, which weathers blue, is medium to dark gray and very fine grained; the bedding surfaces are often covered with silt-filled "worm-trails." The formation crops out in the fields east of State Road 808 and Sinking Creek (Plate 2). The dolomite is well exposed in the Acme Stone Quarry (active quarry number 11; Plate 1, R-6214, R-6347) and is primarily light gray and fine grained, with zones of dark-gray, very coarse-grained dolomite at the top. The contact with the overlying Nolichucky can be seen in an unnamed creek just southwest of the Southwest Virginia 4-H Center (Plate 1, R-6363).

The fourth belt of the Honaker caps the Parks Mill anticline and crops out from just east of Fifteenmile Creek to the Middle Fork Holston River. The partial thickness of the unit is approximately 700 feet (213.5 m) at the fold; the upper 350 feet (106.8 m) is composed of light- to medium-dark-gray, coarse- to fine-grained dolomite (Plate 1, R-6212), and the remainder of the exposure is interbedded limestones and dolomites. The limestone is medium gray and fine grained with irregular laminations of silt; the dolomite is medium light gray, fine grained and slightly argillaceous.

The southernmost belt, located in Denton Valley (Plate 1), is the only complete exposure of the Honaker Formation mapped. The upper contact of the formation is marked by the distinctive, coarse-grained beds described above; the lower portion of the formation is composed of thin-bedded, shaly weathering, fine-grained dolomite. There is a good



3. Highly fractured Honaker dolomite in the Pulaski fault zone exposed in the east roadbank of White Mill Road (State Road 692) near White Branch (Plate 1).

exposure of the lower Honaker on a hillside 400 feet (122 m) east of Cox Mill Creek. King and Ferguson, (1960, p. 126-127) measured 2000 feet (610 m) of section in Denton Valley.

Samples collected from the most northerly belt (Plate 2, R-6213) and from the third (Plate 1, R-6214) and fourth plate (Plate 1, R-6212) belts were tested to determine the potential economic uses of the formation (See Table 3).

There is abundant dark-gray, algal-banded chert in all areas underlain by the Honaker Formation and there are algal features in some of the limestones of the middle portion of the unit. Other fossils are rare, although a species of the brachiopod *Acrotreta* was found just northeast of the U.S. Highway 19-U.S. Highway 58A intersection (Plate 1, F-911). A few limestone beds contain silt-filled surface markings; these are suggestive of worm trails.

Nolichucky Formation

The Nolichucky crops out in six of the major structures of the area. It is probably the most distinctive unit in carbonate portions of the Cambro-Ordovician stratigraphic section and is also one of the more variable ones in both thickness and lithology. The base of the Nolichucky is placed above the youngest dolomite of the Honaker Formation. The top of the formation is placed below the oldest distinctive quartz sandstone of the Conococheague and Copper Ridge formations.

The northernmost outcrop of the Nolichucky is on the Saltville fault block. The unit forms a continuous belt of knobby hills and ridges with steep slope along the southeastern side of Rich Valley. The Nolichucky Formation here is composed of fossiliferous, olive- to grayish-green shales (R-6210; Reference Locality 13, Plate 2), some with glauconite; thin- to medium-bedded, medium-gray limestones, with silty partings; oolitic limestones; and limestone-pebble conglomerates. Shale comprises approximately 70 percent of the unit here. Parts of the Nolichucky are very fossiliferous and bear cystoid plates, trilobites, inarticulate brachiopods and ostracodes. Trails or irregular markings, probably the result of trilobite or worm activity, are on some bedding surfaces. The Nolichucky measured 451.5 feet (137.7 m) along Garrett Creek (Plate 2, Section A).

Outcrops between the Pulaski and the Spurgeon fault systems are similar in lithology to those on the Saltville fault block. The small syncline which forms Countiss Ridge and the three fault-bounded areas along the Pulaski fault (Plate 2) are all primarily composed of olive- to grayish-green, slightly calcareous shale. These areas possibly represent exposed portions of a syncline on the Saltville fault block; the putative syncline is elsewhere obscured by the Pulaski fault.

Exposures of the Nolichucky in the four major outcrop belts south of the Spurgeon fault are radically different from those farther north. The formation to the south is much

4. Nearly vertical beds of Nolichucky limestone on Fifteenmile Creek about 2000 feet (610 m) northeast of the intersection of Interstate Highway 81 and U.S. Highway 58 (Plate 1).

thinner, probably never reaching a thickness of more than 200 feet (60 m), is eroded to a more gentle topography and is composed of distinctive, laminated limestone rather than shale. The limestone is an important mapping unit. It is medium gray, very fine- to micrograined, medium- to thin-bedded, with distinctive, closely spaced, light-gray silty laminations (Plate 1; R-6366, R-6372). On the weathered rock, these laminations are brownish-gray, crinkly, raised ribs (Figure 4; Reference Locality 4, Plate 1). Some limestone-pebble conglomerates are scattered through the formation. The dark-gray, micrite pebbles are held by a medium-dark-gray, medium-grained limestone matrix. In places the formation includes lenses of oolitic limestone (Plate 1, R-6340). The Nolichucky measured 168 feet (51.2 m) (Plate 1, R-6366) in an unnamed creek approximately 2000 feet (610 m) southwest of the entrance to the Southwest Virginia 4-H Center (Plate 1) and 155 feet (47.3 m) on the south flank of the Parks Mill anticline along an unnamed creek 7800 feet (2379 m) northeast of Parks Mill (Plate 1). The Nolichucky is also well exposed on Fifteenmile Creek 300 feet (91.5 m) northwest of Highway 58 (Figure 4), on Lee Highway 1200 feet (366 m) west of its junction with J.E.B. Stuart Highway, and in Denton Valley (Plate 1, R-6372).

The shales and siltstones of the northern Nolichucky Formation were sampled and tested for potential economic value (Plate 2, R-6210). The results of the tests are in Table 5.

Fossils are numerous in several zones in the Nolichucky. North of the Spurgeon fault, the calcareous shales and siltstones contain the brachiopod *Dicellomus appalachia*

exposure of the lower Honaker on a hillside 400 feet (122 m) east of Cox Mill Creek. King and Ferguson, (1960, p. 126-127) measured 2000 feet (610 m) of section in Denton Valley.

Samples collected from the most northerly belt (Plate 2, R-6213) and from the third (Plate 1, R-6214) and fourth plate (Plate 1, R-6212) belts were tested to determine the potential economic uses of the formation (See Table 3).

There is abundant dark-gray, algal-banded chert in all areas underlain by the Honaker Formation and there are algal features in some of the limestones of the middle portion of the unit. Other fossils are rare, although a species of the brachiopod *Acrotreta* was found just northeast of the U.S. Highway 19-U.S. Highway 58A intersection (Plate 1, F-911). A few limestone beds contain silt-filled surface markings; these are suggestive of worm trails.

Nolichucky Formation

The Nolichucky crops out in six of the major structures of the area. It is probably the most distinctive unit in carbonate portions of the Cambro-Ordovician stratigraphic section and is also one of the more variable ones in both thickness and lithology. The base of the Nolichucky is placed above the youngest dolomite of the Honaker Formation. The top of the formation is placed below the oldest distinctive quartz sandstone of the Conococheague and Copper Ridge formations.

The northernmost outcrop of the Nolichucky is on the Saltville fault block. The unit forms a continuous belt of knobby hills and ridges with steep slope along the southeastern side of Rich Valley. The Nolichucky Formation here is composed of fossiliferous, olive- to grayish-green shales (R-6210; Reference Locality 13, Plate 2), some with glauconite; thin- to medium-bedded, medium-gray limestones, with silty partings; oolitic limestones; and limestone-pebble conglomerates. Shale comprises approximately 70 percent of the unit here. Parts of the Nolichucky are very fossiliferous and bear cystoid plates, trilobites, inarticulate brachiopods and ostracodes. Trails or irregular markings, probably the result of trilobite or worm activity, are on some bedding surfaces. The Nolichucky measured 451.5 feet (137.7 m) along Garrett Creek (Plate 2, Section A).

Outcrops between the Pulaski and the Spurgeon fault systems are similar in lithology to those on the Saltville fault block. The small syncline which forms Countiss Ridge and the three fault-bounded areas along the Pulaski fault (Plate 2) are all primarily composed of olive- to grayish-green, slightly calcareous shale. These areas possibly represent exposed portions of a syncline on the Saltville fault block; the putative syncline is elsewhere obscured by the Pulaski fault.

Exposures of the Nolichucky in the four major outcrop belts south of the Spurgeon fault are radically different from those farther north. The formation to the south is much thinner, probably never reaching a thickness of more than 200 feet (60 m), is eroded to a more gentle topography and is composed of distinctive, laminated limestone rather than shale. The limestone is an important mapping unit. It is medium gray, very fine- to micrograined, medium- to thin-bedded, with distinctive, closely spaced, light-gray silty laminations (Plate 1; R-6366, R-6372). On the weathered rock, these laminations are brownish-gray, crinkly, raised ribs (Figure 4; Reference Locality 4, Plate 1). Some limestone-pebble conglomerates are scattered through the formation. The dark-gray, micrite pebbles are held by a medium-dark-gray, medium-grained limestone matrix. In places the formation includes lenses of oolitic limestone (Plate 1, R-6340). The Nolichucky measured 168 feet (51.2 m) (Plate 1, R-6366) in an unnamed creek approximately 2000 feet (610 m) southwest of the entrance to the Southwest Virginia 4-H Center (Plate 1) and 155 feet (47.3 m) on the south flank of the Parks Mill anticline along an unnamed creek 7800 feet (2379 m) northeast of Parks Mill (Plate 1). The Nolichucky is also well exposed on Fifteenmile Creek 300 feet (91.5 m) northwest of Highway 58 (Figure 4), on Lee Highway 1200 feet (366 m) west of its junction with J.E.B. Stuart Highway, and in Denton Valley (Plate 1, R-6372).

4. Nearly vertical beds of Nolichucky limestone on Fifteenmile Creek about 2000 feet (610 m) northeast of the intersection of Interstate Highway 81 and U.S. Highway 58 (Plate 1).

The shales and siltstones of the northern Nolichucky Formation were sampled and tested for potential economic value (Plate 2, R-6210). The results of the tests are in Table 5.

Fossils are numerous in several zones in the Nolichucky. North of the Spurgeon fault, the calcareous shales and siltstones contain the brachiopod *Dicellomus appalachia*

Walcott (F-923, F-925) and the trilobites *Terranovella bristolensis* Resser (F-920) and *Tricrepicephalus* sp. (F-923) and numerous unidentiable trilobite fragments and cystoid plates (F-924). The limestone facies to the south contained *Dicellomus appalachia* Walcott (F-914, F-919), the trilobites *Tricrepicephalus* sp (F-914, F-919) and *Homagnostus bulbus* (Butts) (F-914) as well as numerous trilobite fragments, cystoid plates, possible ostracodes, and a nautiloid cephalopod, *Albertoceras* sp (F-919). F-914 and F-919 are on Plate 1; the other fossil localities are on Plate 2.

Maynardville Formation

The Maynardville (Plate 2 only) was mapped with the basal part of the Copper Ridge Formation due to its narrow and irregular outcrop and its lithologic similarity to the Copper Ridge. Its base is recognizable as the lowest ribbon-banded limestone above the shales or silty limestones of the Nolichucky. A yellowish-gray, very fine-grained argillaceous sandstone is at the base of the Maynardville in some places, as along Garrett Creek (Plate 2, Section A). The lowest dolomite or sandy dolomite of the Copper Ridge above the ribbon-banded limestone marks the top of the Maynardville.

The Maynardville is composed mainly of medium- to thick-bedded, medium- to medium-dark-gray, micrograined limestone. The limestone is dense and breaks with conchoidal fracture. Its characteristic ribbon-banding is caused by argillaceous and dolomitic laminations. The formation contains an occasional rounded-pebble conglomerate composed of micritic limestone pebbles in a coarse-grained matrix. The unit is well exposed along Garrett Creek (Plate 2, Section A), where it is 72 feet (22 m) thick. The formation was recognized only on the Saltville fault block.

Conococheague — Copper Ridge Formations

The Conococheague and Copper Ridge are mostly time-equivalent formations. Each contains varying proportions of limestone, dolomite, and sandstone, and the formations were distinguished as follows. Where more than 50 percent of the exposed carbonates were dolomite, the rock was mapped as Copper Ridge; where more than 50 percent was limestone, as Conococheague.

The Copper Ridge is found only on the Saltville fault block. The base of the Copper Ridge Formation was placed beneath the lowest dolomite or sandy dolomite above the ribbon-banded limestones of the Maynardville Formation. The base of the Conococheague was placed below the oldest sandstone or sandy dolomite above the highest Nolichucky limestones. The tops of the formations were placed below the medium-dark-gray, fossiliferous limestones of the overlying Chepultepec.

The single belt of Copper Ridge crops out along the northwest side of Walker Mountain (Plate 2). It measured 1323 feet (403.5 m) along Garrett Creek (Plate 2, Section A). The Copper Ridge is a light-gray, fine- to coarse-grained dolomite with thin beds of light- to dark-gray micrograined limestone in the middle and upper parts of the formation. The limestone units commonly contain fossil fragments, clay laminations, and limestone-pebble conglomerates. Nodules of gray chert occur in both limestone and dolomite beds; oolitic chert float is common in areas of sparse outcrop. Scattered, fine-grained, well-rounded, quartz grains are common in both limestone and dolomite beds. The most distinctive property of the Copper Ridge and Conococheague formations is beds of gray to brown, friable sandstone, composed of fine- to medium-grained, well-rounded quartz, interbedded with the carbonates. The sandstones are generally less than one foot thick and are generally in the upper and lower portions of the formations. When fresh, the carbonate matrix of the sandstone makes them appear similar to the bounding carbonate beds. Solution weathering produces blocks of friable sandstone float.

The Conococheague is exposed in six outcrop belts south of the Pulaski fault and southeast of Walker Mountain (Plates 1, 2). The most northerly belt is composed of three separate exposures within one mile (1.6 km) south of the Pulaski fault, and the southernmost belt is in Denton Valley south of South Holston Lake. The most continuous exposed belt is along King Ridge and the Abingdon syncline. Many of the Conococheague sections are folded and faulted and incomplete. The dominant lithology is medium-dark-gray to blue-gray, fine-grained, medium-bedded cherty limestone with occasional beds of fossil hash, limestone-pebble conglomerates, (Plate 1, R-6339), and raised laminations. Light- to medium-gray, fine-grained dolomites are scattered through the unit; these decrease to the southeast. Brown to light- to medium-gray, fine- to medium-grained, friable sandstone (Plate 1, R-6364) and sandstone float are common in areas underlain by the Conococheague. The formation measured 1698 feet (517.8 m) along Spring Creek (Plate 2, Section C); a partial thickness measured 1378 feet (420.1 m) along Crooked Branch (Plate 1, Section E). Typical lithologies are at Reference Localities 2 and 9 (Plate 1).

There are few complete fossils in the Copper Ridge-Conococheague formations. Fragments of brachiopods, gastropods, and ostracodes were found in Copper Ridge limestones (Plate 2, Section A); algal mounds, fragments of brachiopods and gastropods, and worm trails and borings were noted in the Conococheague (Plate 2, Section C).

ORDOVICIAN SYSTEM

Chepultepec Limestone

The base of the Chepultepec was mapped at the base of the oldest dark-gray, micrograined, fossiliferous limestone above the sandstone-bearing, dolomite-limestone beds of the Conococheague and Copper Ridge formations. The top

was placed below the chert-bearing dolomites of the Knox Group, upper part.

The Chepultepec limestone is exposed in six belts; the northernmost is along Walker Mountain (Plate 2) and the southernmost is in Denton Valley (Plate 1). The unit is thin along Walker Mountain and appears to be absent just west of Barnes Chapel (Plate 2). Due to scarcity of outcrops along Walker Mountain the position of the Chepultepec is highly interpretive. At many places the unit was mapped according to the position of the lowest common occurrence of white, porcellaneous chert of the Knox Group, upper part and the highest sandstone float from the Copper Ridge Formation. It measured 77 feet (23.5 m) on Garrett Creek (Plate 2, Section A). The Chepultepec is predominantly dark-blue-gray, micrograined, thick-bedded, fossiliferous limestone and commonly contains worm trails and borings-like features which weather out in relief; it includes flat-pebble conglomerates. There is a 2- to 3-foot (0.6- to 0.9-m) thick bed of medium-gray, very fine-grained dolomite in the middle portion of the formation along Garrett Creek and U.S. Highway 19-58A.

A partial thickness of 745 feet (227.2 m) was measured along Spring Creek (Plate 2, Section C). The Chepultepec here (Plate 1, R-6362) is as described earlier and also includes wavy argillaceous laminations, scattered, black chert nodules, streaks of limestone with scattered, rounded quartz grains, and a 2- to 3-foot (0.60- to 0.09-m) thick bed of chert with algal-banded spheres up to one foot (0.3 m) in diameter. The unit also contains several thin beds of medium-gray, fine-grained dolomite.

The Chepultepec was measured and sampled (Plate 1, R-6219) south of the Great Knobs along Crooked Branch (Plate 1, Section E) and found to be very similar in thickness (855 feet, 260.8 m) and in lithology to exposures at Section C, although it contained less dolomite. It is estimated that there is 1000 feet (305 m) of overturned Chepultepec (Figure 5) in Denton Valley where it was mostly typical medium-dark-gray, micrograined limestone with occasional thin beds of dolomite- and limestone-pebble conglomerate (Plate 1, R-6341).

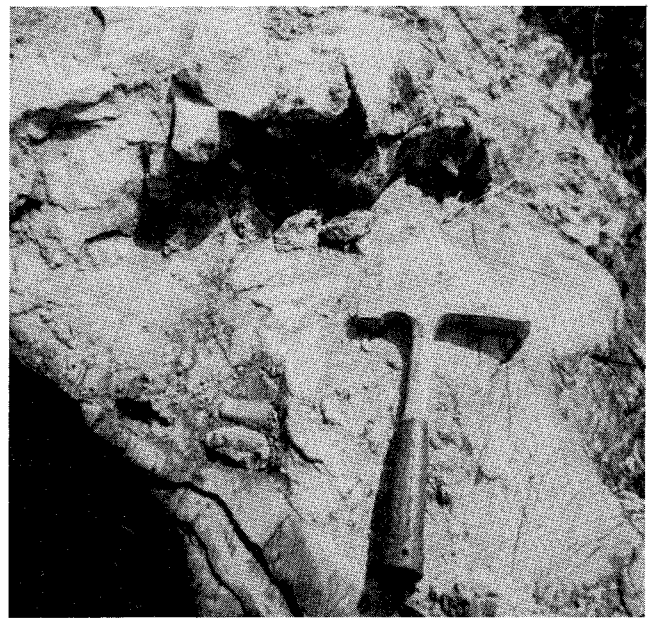
The Chepultepec limestone was sampled in several localities (Plate 2, R-6215; Plate 1, R-6217, R-6219) to determine potential economic uses. The results of the tests appear in Table 3.

There are fossils, especially low-spired gastropods and curved cephalopods, in many Chepultepec outcrops. Beds of fossil fragments firmly embedded in limestone matrix are common; worm-trail and borings-like features are also characteristic.

Knox Group, Upper Part

There seem to be no mappable criteria for subdiving the upper part of the Knox Group in this area. The base of the Knox is mapped at the contact of the porcellaneous, chert-bearing dolomites and the underlying dark-gray, fossiliferous limestone of the Chepultepec. The top is located at the post-Knox unconformity, which has been documented as one of the most significant and widespread erosional unconformities in the Appalachian province (Butts, 1940-1941, p. 119; Rodgers, 1953, p. 53-54; 59; Harris, 1960, p. B186-B188). This unconformity is accompanied by: (1) great var-

5. Weathered, smooth and fluted limestone ledges in the Chepultepec limestone in Denton Valley on State Road 673 about 400 yards (366 m) east of Pleasant View Church (Plate 1).



6. Unusual erosional or cave-fill breccia of dolomite clasts in lower parts of beds mapped as Knox Group, upper part, exposed in pasture south of Wolf Creek about one-half mile (0.8 km) northwest of Green Spring community (Plate 1).

was placed below the chert-bearing dolomites of the Knox Group, upper part.

The Chepultepec limestone is exposed in six belts; the northernmost is along Walker Mountain (Plate 2) and the southernmost is in Denton Valley (Plate 1). The unit is thin along Walker Mountain and appears to be absent just west of Barnes Chapel (Plate 2). Due to scarcity of outcrops along Walker Mountain the position of the Chepultepec is highly interpretive. At many places the unit was mapped according to the position of the lowest common occurrence of white, porcellaneous chert of the Knox Group, upper part and the highest sandstone float from the Copper Ridge Formation. It measured 77 feet (23.5 m) on Garrett Creek (Plate 2, Section A). The Chepultepec is predominantly dark-blue-gray, micrograined, thick-bedded, fossiliferous limestone and commonly contains worm trails and borings-like features which weather out in relief; it includes flat-pebble conglomerates. There is a 2- to 3-foot (0.6- to 0.9-m) thick bed of medium-gray, very fine-grained dolomite in the middle portion of the formation along Garrett Creek and U.S. Highway 19-58A.

A partial thickness of 745 feet (227.2 m) was measured along Spring Creek (Plate 2, Section C). The Chepultepec here (Plate 1, R-6362) is as described earlier and also includes wavy argillaceous laminations, scattered, black chert nodules, streaks of limestone with scattered, rounded quartz grains, and a 2- to 3-foot (0.60- to 0.09-m) thick bed of chert with algal-banded spheres up to one foot (0.3 m) in diameter. The unit also contains several thin beds of medium-gray, fine-grained dolomite.

The Chepultepec was measured and sampled (Plate 1, R-6219) south of the Great Knobs along Crooked Branch (Plate 1, Section E) and found to be very similar in thickness (855 feet, 260.8 m) and in lithology to exposures at Section C, although it contained less dolomite. It is estimated that there is 1000 feet (305 m) of overturned Chepultepec (Figure 5) in Denton Valley where it was mostly typical medium-dark-gray, micrograined limestone with occasional thin beds of dolomite- and limestone-pebble conglomerate (Plate 1, R-6341).

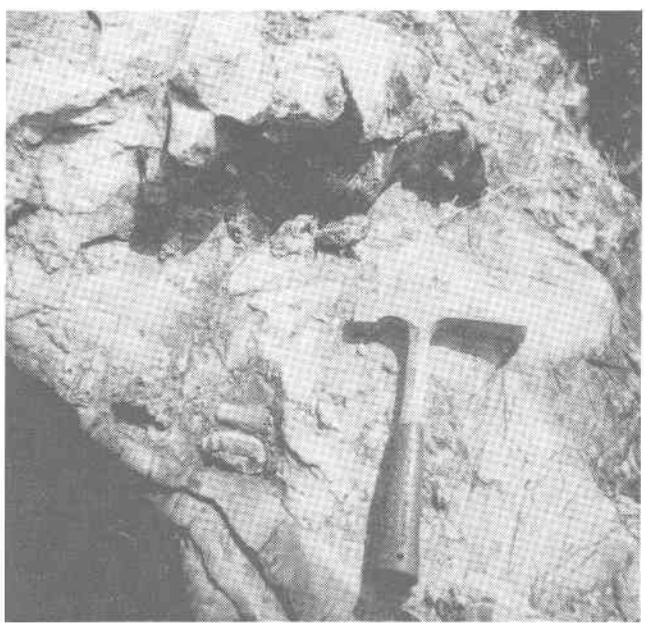
The Chepultepec limestone was sampled in several localities (Plate 2, R-6215; Plate 1, R-6217, R-6219) to determine potential economic uses. The results of the tests appear in Table 3.

There are fossils, especially low-spired gastropods and curved cephalopods, in many Chepultepec outcrops. Beds of fossil fragments firmly embedded in limestone matrix are common; worm-trail and borings-like features are also characteristic.

Knox Group, Upper Part

There seem to be no mappable criteria for subdiving the upper part of the Knox Group in this area. The base of the Knox is mapped at the contact of the porcellaneous, chert-bearing dolomites and the underlying dark-gray, fossiliferous limestone of the Chepultepec. The top is located at the post-Knox unconformity, which has been documented as one of the most significant and widespread erosional unconformities in the Appalachian province (Butts, 1940-1941, p. 119; Rodgers, 1953, p. 53-54; 59; Harris, 1960, p. B186-B188). This unconformity is accompanied by: (1) great var-

5. Weathered, smooth and fluted limestone ledges in the Chepultepec limestone in Denton Valley on State Road 673 about 400 yards (366 m) east of Pleasant View Church (Plate 1).



6. Unusual erosional or cave-fill breccia of dolomite clasts in lower parts of beds mapped as Knox Group, upper part, exposed in pasture south of Wolf Creek about one-half mile (0.8 km) northwest of Green Spring community (Plate 1).

iation in thickness of the Knox Group, upper part; (2) presence of Mosheim-type limestones locally within the Knox; (3) karst topography and erosional breccias (Figure 6); (4) variation in thicknesses of overlying limestone units; (5) commonly abrupt lithologic change from Knox dolomite to Mosheim limestone; (6) presence of clasts of Knox Group, upper part dolomite in the basal portion of the Mosheim (Plate 1, R-6349; Figure 7); and (7) occasional exposures of the irregular contact itself. Some of the zones of erosional breccia have been indicated on Plates 1 and 2 by symbol "cg".

7. Conglomerate composed of dolomite, limestone and chert cobbles commonly found above the erosional unconformity at the base of the Lenoir-Mosheim limestones. Outcrop is the most northerly one found of this feature and is located about 200 yards (183 m) west of the abandoned Abingdon sewage lagoons and 200 yards (183 m) south of State Road 670 (Plate 1).

The Knox Group, upper part is exposed in five major structural belts. The northernmost and thickest section is on Walker Mountain. Along Garrett Creek (Plate 2, Section A) it measured 1255 feet (382.8 m). Light- to medium-light-gray, fine- to micrograined dolomite is the main lithology on Walker Mountain. Minor parts consist of medium- to coarse-grained dolomite. There are some interbedded limestones scattered through the unit. These are generally medium-dark-gray, micrograined, laminated rocks with rare fossils, including the gastropod *Ceratopea,* preserved on bedding surfaces. There are also beds and nodules of light-gray to white chert and great quantites of angular chert, from pebble to boulder size, on hillsides of Knox Group, upper part. Most of the chert float is white, vuggy, and porcellaneous; some is algal-banded. The Knox Group, upper part can often be recognized by white chert with dolomolds (Plate 2, R-6371).

South of Walker Mountain, the Knox Group, upper part is exposed on the Stone Mill anticline-Abingdon syncline structure, and on the Watauga, the Parks Mill, and the Sweet Hollow anticlines. The thickness of the formation on these four structures is approximately one-half that on Walker Mountain; thickness appears to decrease slightly to the south. It measured 742 feet (226.1 m) along Wolf Creek (Plate 1, Section F) and 701 feet (214.5 m) along Hickey Gap Road (Plate 2, Section D) on the south flank of the Stone Mill anticline. On the Watauga anticline, 653 feet (199.0 m) were measured along Crooked Branch (Plate 1, Section E). Figure 8 shows Watauga Valley terrain.

The lithology of the Knox Group, upper part remains similar across these structures, except that amounts of limestone vary within the upper portion. The predominant rock type is medium-light-gray, micro- to coarse-grained, thick-bedded dolomite (Reference Locality 6, Plate 1) with abundant cherty layers or nodules. The dolomite usually weathers with a distinctive "butcher-block" appearance. Chert weathered from the unit usually contains abundant dolomolds and is common on hill slopes. Locally, there are thin beds of limestone in the middle portion of the unit. In places, the top portion of the formation contains thick sequences of medium- light-gray, micrograined, fossiliferous limestones similar to the overlying Mosheim. A good exposure of this unusual feature is in the open fields on both sides of State Road 663, Hickey Gap Road (Plate 2, Section D).

Samples of the Knox Group, upper part dolomites and limestones were collected and analysed for potential economic value (Plate 1, R-6222 and Plate 2, R-6220, R-6221, R-6223, R-6225). The results of these tests are in Table 3. Streaks of hematitic iron (Plate 1, R-6345, R-6353) are rare in the Knox Group, upper part.

There are fossils in the limestones (Plate 2, F-926) and occasionally, in the cherts (Plate 2; F-921, F-922, F-927) of the Knox Group, upper part; algal-banded chert is common. Fossils include the gastropods *Lecanospira* sp., *Orospira* sp., *Ecculiomphalus* sp., *Ceratopea* sp., and *Murchisonia* sp. Limestone bedding surfaces expose nautiloids, brachiopods, sponges, trilobite fragments, and worm-trail-like features.

Lenoir and Mosheim Limestones

The Lenoir and Mosheim limestones were mapped as a single unit because their outcrop belts are generally too narrow to map. The combined thickness of the two limestones is highly variable. For example, together they are 145 feet (44.2 m) thick along the Norfolk and Western Railway on the south end of the River Knobs (Plate 1, R-6229) and they are absent 900 feet (275 m) southwest of Spring Creek on the northwest flank of the Great Knobs (Plate 2). The thickness of the individual limestones also fluctuates greatly and it is not uncommon for one of the units, especially the

iation in thickness of the Knox Group, upper part; (2) presence of Mosheim-type limestones locally within the Knox; (3) karst topography and erosional breccias (Figure 6); (4) variation in thicknesses of overlying limestone units; (5) commonly abrupt lithologic change from Knox dolomite to Mosheim limestone; (6) presence of clasts of Knox Group, upper part dolomite in the basal portion of the Mosheim (Plate 1, R-6349; Figure 7); and (7) occasional exposures of the irregular contact itself. Some of the zones of erosional breccia have been indicated on Plates 1 and 2 by symbol "cg".

7. Conglomerate composed of dolomite, limestone and chert cobbles commonly found above the erosional unconformity at the base of the Lenoir-Mosheim limestones. Outcrop is the most northerly one found of this feature and is located about 200 yards (183 m) west of the abandoned Abingdon sewage lagoons and 200 yards (183 m) south of State Road 670 (Plate 1).

The Knox Group, upper part is exposed in five major structural belts. The northernmost and thickest section is on Walker Mountain. Along Garrett Creek (Plate 2, Section A) it measured 1255 feet (382.8 m). Light- to medium-light-gray, fine- to micrograined dolomite is the main lithology on Walker Mountain. Minor parts consist of medium- to coarse-grained dolomite. There are some interbedded limestones scattered through the unit. These are generally medium-dark-gray, micrograined, laminated rocks with rare fossils, including the gastropod *Ceratopea,* preserved on bedding surfaces. There are also beds and nodules of light-gray to white chert and great quantites of angular chert, from pebble to boulder size, on hillsides of Knox Group, upper part. Most of the chert float is white, vuggy, and porcellaneous; some is algal-banded. The Knox Group, upper part can often be recognized by white chert with dolomolds (Plate 2, R-6371).

South of Walker Mountain, the Knox Group, upper part is exposed on the Stone Mill anticline-Abingdon syncline structure, and on the Watauga, the Parks Mill, and the Sweet Hollow anticlines. The thickness of the formation on these four structures is approximately one-half that on Walker Mountain; thickness appears to decrease slightly to the south. It measured 742 feet (226.1 m) along Wolf Creek (Plate 1, Section F) and 701 feet (214.5 m) along Hickey Gap Road (Plate 2, Section D) on the south flank of the Stone Mill anticline. On the Watauga anticline, 653 feet (199.0 m) were measured along Crooked Branch (Plate 1, Section E). Figure 8 shows Watauga Valley terrain.

The lithology of the Knox Group, upper part remains similar across these structures, except that amounts of limestone vary within the upper portion. The predominant rock type is medium-light-gray, micro- to coarse-grained, thick-bedded dolomite (Reference Locality 6, Plate 1) with abundant cherty layers or nodules. The dolomite usually weathers with a distinctive "butcher-block" appearance. Chert weathered from the unit usually contains abundant dolomolds and is common on hill slopes. Locally, there are thin beds of limestone in the middle portion of the unit. In places, the top portion of the formation contains thick sequences of medium- light-gray, micrograined, fossiliferous limestones similar to the overlying Mosheim. A good exposure of this unusual feature is in the open fields on both sides of State Road 663, Hickey Gap Road (Plate 2, Section D).

Samples of the Knox Group, upper part dolomites and limestones were collected and analysed for potential economic value (Plate 1, R-6222 and Plate 2, R-6220, R-6221, R-6223, R-6225). The results of these tests are in Table 3. Streaks of hematitic iron (Plate 1, R-6345, R-6353) are rare in the Knox Group, upper part.

There are fossils in the limestones (Plate 2, F-926) and occasionally, in the cherts (Plate 2; F-921, F-922, F-927) of the Knox Group, upper part; algal-banded chert is common. Fossils include the gastropods *Lecanospira* sp., *Orospira* sp., *Ecculiomphalus* sp., *Ceratopea* sp., and *Murchisonia* sp. Limestone bedding surfaces expose nautiloids, brachiopods, sponges, trilobite fragments, and worm-trail-like features.

Lenoir and Mosheim Limestones

The Lenoir and Mosheim limestones were mapped as a single unit because their outcrop belts are generally too narrow to map. The combined thickness of the two limestones is highly variable. For example, together they are 145 feet (44.2 m) thick along the Norfolk and Western Railway on the south end of the River Knobs (Plate 1, R-6229) and they are absent 900 feet (275 m) southwest of Spring Creek on the northwest flank of the Great Knobs (Plate 2). The thickness of the individual limestones also fluctuates greatly and it is not uncommon for one of the units, especially the

8. Typical terrain underlain by Knox Group, upper part (in gentle sloping pasture in foreground), Lenoir-Mosheim limestones (rocky ledges at far edge of field) and Athens Formation shales (steep slopes and forested area). This view is to the south from State Road 677 in Watauga Valley near the Alvarado fault about 0.7 miles (1.1 km) east of the Bristol Water Filtration Plant.

Mosheim, to be absent. Measured sections A and B (shown on Plate 2) illustrate the absence of the Mosheim and the great fluctuations in thickness of the Lenoir over short distances. This variation in thickness accompanies the Middle Ordovician unconformity at the top of the Knox Group. The stratigraphic disconformity is further indicated by a basal conglomerate which was found in numerous places along the Knox Group, upper part-Mosheim contact. The conglomerate increases in thickness in belts to the southeast. The conglomerate consists of subangular clasts (up to 15 inches, 38.1 cm, long dimension) of Knox Group, upper part dolomite and chert in a matrix of Mosheim-type, light-gray micrite (Plate 1, R-6349; Figure 7). Generally these conglomerates, indicated by a letter "cg" on Plates 1 and 2, are about one to five feet (0.3 to 1.5 m) thick, but occasionally are up to 15 feet (4.6 m) thick.

The Mosheim, in places a source of high-calcium limestone (see Economic Geology section), is light-gray micrite to medium-grained, medium-bedded limestone (Plate 2, R-6358). Calcite crystal "bird's-eyes" and conchoidal fracture are also characteristic. There are thin interbeds of medium-gray, fine-grained dolomite at a few exposures. Beds of fossil fragments in a limestone matrix (Reference Locality 18, Plate 2) include gastropods, crinoids, oncolites, cephalopods, and coelenterates. The high-spired gastropod *Trochonemella* sp. was identified (Plate 2, F-928).

The Lenoir is gray to dark-gray, fine-grained, medium-bedded, argillaceous limestone (Plate 1, R-6365) with wavy, silty laminations which produce a lumpy appearance. Portions of the Lenoir are very fossiliferous; forms include gastropods (*Maclurites* sp.), brachiopods, ostracodes, crinoids, echinoderns, and sponges (Plate 1, F-912).

Cross faults are common along the Lenoir-Mosheim outcrop belts; displacement is generally less than 100 feet (30.5 m).

Athens Formation (of Butts, 1933)

The Athens Formation is used in this report as it was used by Butts (1933). It underlies the three ranges of knobs south of Abingdon and is the most topographically prominent unit in the mapped area. The four smaller areas of Athens mapped north of the Great Knobs contain only the lower portion of the formation. The base of the formation was mapped below the sequence of dark-gray shales which are above the limestones of the Lenoir-Mosheim. The stratigraphic top of the Athens has been removed by erosion or else is concealed beneath fault blocks.

The Athens can be divided into two distinct lithologic members, corresponding approximately to the Athens shale-Tellico sandstone units of Kellberg and Grant (1956, p. 700-705). The lower member consists of olive-gray to medium-dark-gray fissile shale with minor gray, thin-bedded argillaceous siltstones and medium-dark-gray, calcareous shales (Reference Locality 5, Plate 1). Some of the shales of the lower member show possible economic potential (see Economic Geology section). One thin bed of sooty-gray, low-density shale occurs on U.S. Highway 58 about 0.5 mile (0.8 km) south of the Middle Fork of the Holston River. X-ray and thin-section studies of samples show that this may be a deposit of bentonite (Plate 1, R-6777). Several zones of the lower Athens are very fossiliferous; graptolites (Reference Locality 20, Plate 1) make up the majority of the fauna. Species include: *Climacograptus scharenbergi* Lapworth (Plate 1; F-909, F-910, F-917, F-918), *Dicellograptus* sp. (F-909, F-918), *Diplograptus calcaratus* Lapworth (F-909, F-917, F-918), and *Glossograptus* sp. (F-917). Also present are the brachiopod *?Schizambon* sp. (F-910) and unidentified brachiopods and crinoids.

The upper member of the Athens Formation is composed of interbedded, buff-brown shales and siltstones; greenish-brown, fine- to coarse-grained lithic sandstones; and polymictic conglomerates. There are some interbeds of highly calcareous sandstones or sandy limestones. The conglomerates (Figure 9; Reference Locality 8, Plate 1) are composed of rounded to subrounded clasts of limestone, dolomite, sandstone, quartzite, vein quartz, shale, black chert, and feldspar in an olive-green to gray-brown, sandy, calcareous matrix. The clasts represent erosional reworking of formations from the Athens through the Unicoi formations. In places the carbonate clasts have dissolved, leaving voids in the matrix material. There are clasts up to four inches (10.2 cm) long-dimension and clasts up to three feet (91.4 cm) long have been reported (Leible, 1973, p. 412). The conglomerates seem to occur as discontinuous lenses within the upper Athens, though structural complexities, poor exposures, and rugged terrain handicap efforts to trace the conglomerate beds from one exposure to another. The thickest lenses of conglomerate are in the knobs south of South Holston Lake (the South Holston syncline) where

8. Typical terrain underlain by Knox Group, upper part (in gentle sloping pasture in foreground), Lenoir-Mosheim limestones (rocky ledges at far edge of field) and Athens Formation shales (steep slopes and forested area). This view is to the south from State Road 677 in Watauga Valley near the Alvarado fault about 0.7 miles (1.1 km) east of the Bristol Water Filtration Plant.

Mosheim, to be absent. Measured sections A and B (shown on Plate 2) illustrate the absence of the Mosheim and the great fluctuations in thickness of the Lenoir over short distances. This variation in thickness accompanies the Middle Ordovician unconformity at the top of the Knox Group. The stratigraphic disconformity is further indicated by a basal conglomerate which was found in numerous places along the Knox Group, upper part-Mosheim contact. The conglomerate increases in thickness in belts to the southeast. The conglomerate consists of subangular clasts (up to 15 inches, 38.1 cm, long dimension) of Knox Group, upper part dolomite and chert in a matrix of Mosheim-type, light-gray micrite (Plate 1, R-6349; Figure 7). Generally these conglomerates, indicated by a letter "cg" on Plates 1 and 2, are about one to five feet (0.3 to 1.5 m) thick, but occasionally are up to 15 feet (4.6 m) thick.

The Mosheim, in places a source of high-calcium limestone (see Economic Geology section), is light-gray micrite to medium-grained, medium-bedded limestone (Plate 2, R-6358). Calcite crystal "bird's-eyes" and conchoidal fracture are also characteristic. There are thin interbeds of medium-gray, fine-grained dolomite at a few exposures. Beds of fossil fragments in a limestone matrix (Reference Locality 18, Plate 2) include gastropods, crinoids, oncolites, cephalopods, and coelenterates. The high-spired gastropod *Trochonemella* sp. was identified (Plate 2, F-928).

The Lenoir is gray to dark-gray, fine-grained, medium-bedded, argillaceous limestone (Plate 1, R-6365) with wavy, silty laminations which produce a lumpy appearance. Portions of the Lenoir are very fossiliferous; forms include gastropods (*Maclurites* sp.), brachiopods, ostracodes, crinoids, echinoderms, and sponges (Plate 1, F-912).

Cross faults are common along the Lenoir-Mosheim outcrop belts; displacement is generally less than 100 feet (30.5 m).

Athens Formation (of Butts, 1933)

The Athens Formation is used in this report as it was used by Butts (1933). It underlies the three ranges of knobs south of Abingdon and is the most topographically prominent unit in the mapped area. The four smaller areas of Athens mapped north of the Great Knobs contain only the lower portion of the formation. The base of the formation was mapped below the sequence of dark-gray shales which are above the limestones of the Lenoir-Mosheim. The stratigraphic top of the Athens has been removed by erosion or else is concealed beneath fault blocks.

The Athens can be divided into two distinct lithologic members, corresponding approximately to the Athens shale-Tellico sandstone units of Kellberg and Grant (1956, p. 700-705). The lower member consists of olive-gray to medium-dark-gray fissile shale with minor gray, thin-bedded argillaceous siltstones and medium-dark-gray, calcareous shales (Reference Locality 5, Plate 1). Some of the shales of the lower member show possible economic potential (see Economic Geology section). One thin bed of sooty-gray, low-density shale occurs on U.S. Highway 58 about 0.5 mile (0.8 km) south of the Middle Fork of the Holston River. X-ray and thin-section studies of samples show that this may be a deposit of bentonite (Plate 1, R-6777). Several zones of the lower Athens are very fossiliferous; graptolites (Reference Locality 20, Plate 1) make up the majority of the fauna. Species include: *Climacograptus scharenbergi* Lapworth (Plate 1; F-909, F-910, F-917, F-918), *Dicellograptus* sp. (F-909, F-918), *Diplograptus calcaratus* Lapworth (F-909, F-917, F-918), and *Glossograptus* sp. (F-917). Also present are the brachiopod *?Schizambon* sp. (F-910) and unidentified brachiopods and crinoids.

The upper member of the Athens Formation is composed of interbedded, buff-brown shales and siltstones; greenish-brown, fine- to coarse-grained lithic sandstones; and polymictic conglomerates. There are some interbeds of highly calcareous sandstones or sandy limestones. The conglomerates (Figure 9; Reference Locality 8, Plate 1) are composed of rounded to subrounded clasts of limestone, dolomite, sandstone, quartzite, vein quartz, shale, black chert, and feldspar in an olive-green to gray-brown, sandy, calcareous matrix. The clasts represent erosional reworking of formations from the Athens through the Unicoi formations. In places the carbonate clasts have dissolved, leaving voids in the matrix material. There are clasts up to four inches (10.2 cm) long-dimension and clasts up to three feet (91.4 cm) long have been reported (Leible, 1973, p. 412). The conglomerates seem to occur as discontinuous lenses within the upper Athens, though structural complexities, poor exposures, and rugged terrain handicap efforts to trace the conglomerate beds from one exposure to another. The thickest lenses of conglomerate are in the knobs south of South Holston Lake (the South Holston syncline) where

9. Polymictic conglomerate in Athens Formation containing pebbles of limestone, dolomite, chert, jasper and quartzite exposed in several layers on the southwest side of State Road 670 about 0.6 mile (1.0 km) south of Avens Bridge (Plate 1).

they are exposed at several locations along the creeks which cut through these knobs. The conglomerate is indicated on Plates 1 and 2 by the symbol "cg" (Plate 1; R-6337, R-6343, R-6344, R-6348). The thickness and lateral extent of the lenses and the size of the clasts appear to decrease to the northeast in the syncline. There are no exposures of the conglomerates in the River Knobs, but the syncline on which the topography is formed contains only a small portion of the upper Athens. In the next range of knobs to the northwest, the Great Knobs which is also a syncline, thin lenses of conglomerate are on both flanks. These conglomerates are much less extensive and contain much smaller clasts than those south of South Holston Lake; the maximum dimensions of clasts here is less than 0.5 inch (8 mm). Sampling sites of the conglomerates in the Great Knobs are shown on Plate 1 (R-6360, R-6370).

The thickness of the Athens is estimated to be 1000 feet (305 m) in the Great Knobs syncline and 5700 feet (1740 m) in the South Holston syncline.

MISSISSIPPIAN SYSTEM

Ste. Genevieve Limestone

The Ste. Genevieve limestone is the oldest unit of the Greendale syncline mapped. Only the upper approximately 200 feet (61 m) are exposed. The contact with the overlying Gasper limestone is at the top of a distinctive 15- to 20-foot-thick (4.6-6.1 m) section of maroon, crinoidal limestone (R-6357; Reference Locality 15, Plate 2). The remaining portion of the Ste. Genevieve consists mainly of gray, argillaceous, shaly weathering, medium-bedded limestone. An exposure of part of the formation is on State Road 614 about 1.9 miles (3.1 km) north of Withers. The formation has many fossils, including the guide fossil *Platycrinus penicillus* Meek and Worthen, a crinoid (Plate 2, F-930). Other fossils include *Fenestrellina* sp. (F-930), trepostome byrozoans, the mollusk *Dentalium* sp., a spiriferid and a productid brachiopod, (F-930) and unidentified crinoids.

Gasper Limestone

The Gasper limestone is bounded by the maroon, crinoidal limestone at the top of the Ste. Genevieve and by the dark-maroon sandstones of the overlying Fido Sandstone. The unit crops out for approximately one mile (1.6 km) along Rich Valley in the Wyndale quadrangle where it underlies a rugged terrain marked by numerous sinkholes. Formation thickness was not measured; it is estimated to be about 800 feet (240 m) thick.

The Gasper consists of light-gray, argillaceous, thin- to thick-bedded limestones which often weather to a shaly appearance, an effect caused by clay laminae in the fine-grained limestone. Zones of reddish, crinoidal limestone are in the middle of the formation. Gasper limestones are much like those of the Cove Creek, a younger formation. The formations may be distinguished in reference to the Fido Sandstone which lies between them and by distinctive lithologies and abundant fossils in the Gasper. The Gasper contains numerous crinoids, brachiopods, and blastoids (particularly *Pentremites* sp.). Other fossils include rugose corals and the bryozoans *Meekopora* sp. and *Fenestrella* sp. (Plate 2, F-929).

Fido Sandstone

The formation was named for exposures near the old post office of Fido about 20 miles (32.2 km) southwest of Greendale, which is in the same structural belt as that mapped as Fido. This thin sandstone is an important marker horizon in the Mississippian section. It is exposed for about 2.5 miles (4.0 km) northwest of Rich Valley in the Wyndale quadrangle. There are two additional, incomplete exposures in a fault-bounded area adjacent to the Saltville fault aproximately 1.2 miles (1.9 km) southwest of Greendale.

The Fido is the most distinctive formation mapped north of the Saltville fault (Reference Locality 16, Plate 2). It is easily recognized by dark-maroon outcrops or by maroon residual soil. The boundaries are the top of the youngest maroon or brown sandstone and the bottom of the oldest similar sandstone. The Fido is consistently 50 to 75 feet (15.3-22.9 m) thick.

It is primarily maroon to dark-brown, fine- to medium-grained, much cross-bedded and ripple-marked, calcareous sandstone (R-6361) and is generally thick-bedded with fos-

9. Polymictic conglomerate in Athens Formation containing pebbles of limestone, dolomite, chert, jasper and quartzite exposed in several layers on the southwest side of State Road 670 about 0.6 mile (1.0 km) south of Avens Bridge (Plate 1).

they are exposed at several locations along the creeks which cut through these knobs. The conglomerate is indicated on Plates 1 and 2 by the symbol "cg" (Plate 1; R-6337, R-6343, R-6344, R-6348). The thickness and lateral extent of the lenses and the size of the clasts appear to decrease to the northeast in the syncline. There are no exposures of the conglomerates in the River Knobs, but the syncline on which the topography is formed contains only a small portion of the upper Athens. In the next range of knobs to the northwest, the Great Knobs which is also a syncline, thin lenses of conglomerate are on both flanks. These conglomerates are much less extensive and contain much smaller clasts than those south of South Holston Lake; the maximum dimensions of clasts here is less than 0.5 inch (8 mm). Sampling sites of the conglomerates in the Great Knobs are shown on Plate 1 (R-6360, R-6370).

The thickness of the Athens is estimated to be 1000 feet (305 m) in the Great Knobs syncline and 5700 feet (1740 m) in the South Holston syncline.

MISSISSIPPIAN SYSTEM

Ste. Genevieve Limestone

The Ste. Genevieve limestone is the oldest unit of the Greendale syncline mapped. Only the upper approximately 200 feet (61 m) are exposed. The contact with the overlying Gasper limestone is at the top of a distinctive 15- to 20-foot-thick (4.6-6.1 m) section of maroon, crinoidal limestone (R-6357; Reference Locality 15, Plate 2). The remaining portion of the Ste. Genevieve consists mainly of gray, argillaceous, shaly weathering, medium-bedded limestone. An exposure of part of the formation is on State Road 614 about 1.9 miles (3.1 km) north of Withers. The formation has many fossils, including the guide fossil *Platycrinus penicillus* Meek and Worthen, a crinoid (Plate 2, F-930). Other fossils include *Fenestrellina* sp. (F-930), trepostome byrozoans, the mollusk *Dentalium* sp., a spiriferid and a productid brachiopod, (F-930) and unidentified crinoids.

Gasper Limestone

The Gasper limestone is bounded by the maroon, crinoidal limestone at the top of the Ste. Genevieve and by the dark-maroon sandstones of the overlying Fido Sandstone. The unit crops out for approximately one mile (1.6 km) along Rich Valley in the Wyndale quadrangle where it underlies a rugged terrain marked by numerous sinkholes. Formation thickness was not measured; it is estimated to be about 800 feet (240 m) thick.

The Gasper consists of light-gray, argillaceous, thin- to thick-bedded limestones which often weather to a shaly appearance, an effect caused by clay laminae in the fine-grained limestone. Zones of reddish, crinoidal limestone are in the middle of the formation. Gasper limestones are much like those of the Cove Creek, a younger formation. The formations may be distinguished in reference to the Fido Sandstone which lies between them and by distinctive lithologies and abundant fossils in the Gasper. The Gasper contains numerous crinoids, brachiopods, and blastoids (particularly *Pentremites* sp.). Other fossils include rugose corals and the bryozoans *Meekopora* sp. and *Fenestrella* sp. (Plate 2, F-929).

Fido Sandstone

The formation was named for exposures near the old post office of Fido about 20 miles (32.2 km) southwest of Greendale, which is in the same structural belt as that mapped as Fido. This thin sandstone is an important marker horizon in the Mississippian section. It is exposed for about 2.5 miles (4.0 km) northwest of Rich Valley in the Wyndale quadrangle. There are two additional, incomplete exposures in a fault-bounded area adjacent to the Saltville fault aproximately 1.2 miles (1.9 km) southwest of Greendale.

The Fido is the most distinctive formation mapped north of the Saltville fault (Reference Locality 16, Plate 2). It is easily recognized by dark-maroon outcrops or by maroon residual soil. The boundaries are the top of the youngest maroon or brown sandstone and the bottom of the oldest similar sandstone. The Fido is consistently 50 to 75 feet (15.3-22.9 m) thick.

It is primarily maroon to dark-brown, fine- to medium-grained, much cross-bedded and ripple-marked, calcareous sandstone (R-6361) and is generally thick-bedded with fos-

sil crinoid fragments weathered out in relief. The upper few feet consist of light-gray, slightly maroon, argillaceous limestone and appear to be a transition zone between the Fido and the overlying Cove Creek. The fresh sandstone is very hard, but weathering and leaching of the calcareous cement causes the Fido to become friable and porous. A good exposure of the Fido is along State Road 616 where the road crosses and recrosses the outcrop belt.

Cove Creek Limestone

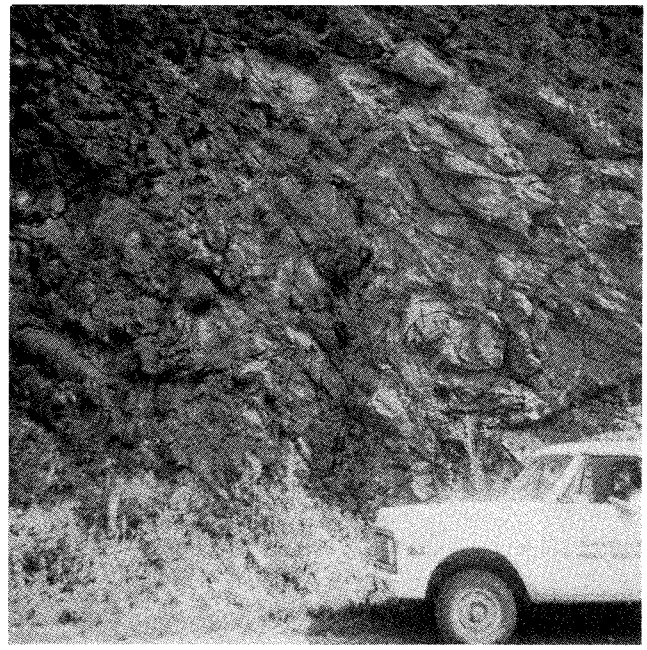
Cove Creek outcrops parallel State Road 616. The base of the Cove Creek Limestone is placed above the maroon-tinted limestone of the Fido transition zone and its top is placed below the shales and sandstones of the overlying Pennington Formation. The Cove Creek underlies the steep northwestern side of the ridge north of Rich Valley. Small fault-bounded areas of Cove Creek limestones are also along the Saltville fault trace in Rich Valley; the beds appear to have been emplaced by the thrust sheet as it moved across the southeastern limb of the Greendale syncline.

The Cove Creek consists primarily of medium-gray to greenish-gray, argillaceous limestones (Plate 2, R-6368) which have thin, wavy clay laminae on weathered surfaces. The upper portion is much thinner bedded and much of it weathers to a crumbly shaly residue. The formation is usually poorly exposed due to the weathering of the argillaceous limestone which weathers pale gray; thickness is estimated at 1100 feet (335.5 m). Fossils include *Fenestrellina* sp. and trepostome bryozoans; *Dentalium* sp., a mollusk; the brachiopods *Spirifer keokuk* Hall, *Dictyoclostus inflatus* (McChesney) and a productid and loose productid spines; and unidentified crinoid stems and calyx plates (Plate 2; F-931, F-932).

Pennington Formation

The Pennington is the youngest Mississippian formation exposed in the Greendale syncline. Its outcrop is about 3000 feet (914.4 m) wide just north of Rich Valley, shown on Plate 2. The base of the unit is above the youngest argillaceous limestones of the Cove Creek and below the overlying interbedded shales and sandstones. The upper contact is concealed by the Cambrian Honaker Formation along the Saltville fault in Rich Valley. Because the top of the Pennington is covered by the Saltville fault sheet a total original thickness is undeterminable.

The Pennington Formation is largely composed of siltstone and sandstone; it contains some argillaceous or sandy limestone. There are four lithologic members which are exposed along the roads but are not traceable due to rugged terrain and poor exposures. The basal member, a shale unit, is silty, slightly calcareous, fissile and predominantly gray to greenish gray. Scattered thin beds of greenish-gray argillaceous sandstones form some of this member. A turbidite member near the middle of the formation contains large rounded blocks of siltstone or argillaceous sandstone enclosed by shale (Figure 10). The sandstones are fine grained and brown; the siltstones are gray to greenish gray. The third member of the Pennington is highly variable in lithology; it consists of interfingering shales, siltstones, and sandstones with minor amounts of very argillaceous limestone. The shales and siltstones are generally greenish gray though some are drab maroon or brown. The sandstones are fine grained, argillaceous, and brown, maroon or greenish gray. They are often thick-bedded and fossiliferous. The limestones are argillaceous, silty, or sandy, and grade into calcareous siltstones. The upper shale member is composed of maroon and green shales, siltstones, and mudstones; soils formed on this member are red. The proportion of the formation formed by each of the members changes from west to east. From State Road 614 eastward to State Road 626 and Possum Hollow (Plate 2), the middle and turbidite members thin, whereas the lower member thickens.



10. Slump-rolled layers of calcareous siltstone in the Pennington Formation caused by penecontemporaneous plastic flow; exposure on east bank of U.S. Highway 19-58A near Greendale (Plate 2).

The fossil content of the Pennington is as highly variable as its lithology. Fossils are most abundant in the non-redbeds of the middle member, especially in the siltstones and sandstones, and in the lower shale member. Forms include the blastoid *Pentremites* sp. and the crinoid *Platycrinus penicillus* Meek and Worthen.

QUATERNARY SYSTEM

Surficial deposits include (1) colluvium, (2) terrace deposits, (3) alluvium, and (4) soils. The first three types were

sil crinoid fragments weathered out in relief. The upper few feet consist of light-gray, slightly maroon, argillaceous limestone and appear to be a transition zone between the Fido and the overlying Cove Creek. The fresh sandstone is very hard, but weathering and leaching of the calcareous cement causes the Fido to become friable and porous. A good exposure of the Fido is along State Road 616 where the road crosses and recrosses the outcrop belt.

Cove Creek Limestone

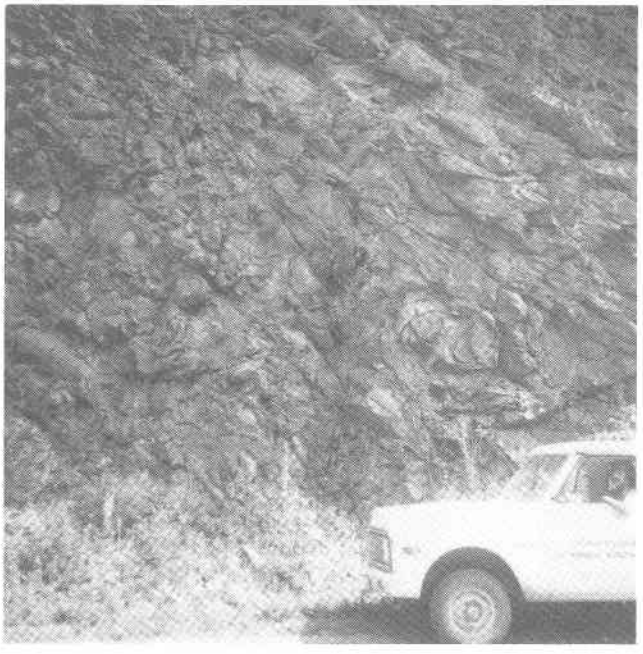
Cove Creek outcrops parallel State Road 616. The base of the Cove Creek Limestone is placed above the maroon-tinted limestone of the Fido transition zone and its top is placed below the shales and sandstones of the overlying Pennington Formation. The Cove Creek underlies the steep northwestern side of the ridge north of Rich Valley. Small fault-bounded areas of Cove Creek limestones are also along the Saltville fault trace in Rich Valley; the beds appear to have been emplaced by the thrust sheet as it moved across the southeastern limb of the Greendale syncline.

The Cove Creek consists primarily of medium-gray to greenish-gray, argillaceous limestones (Plate 2, R-6368) which have thin, wavy clay laminae on weathered surfaces. The upper portion is much thinner bedded and much of it weathers to a crumbly shaly residue. The formation is usually poorly exposed due to the weathering of the argillaceous limestone which weathers pale gray; thickness is estimated at 1100 feet (335.5 m). Fossils include *Fenestrellina* sp. and trepostome bryozoans; *Dentalium* sp., a mollusk; the brachiopods *Spirifer keokuk* Hall, *Dictyoclostus inflatus* (McChesney) and a productid and loose productid spines; and unidentified crinoid stems and calyx plates (Plate 2; F-931, F-932).

Pennington Formation

The Pennington is the youngest Mississippian formation exposed in the Greendale syncline. Its outcrop is about 3000 feet (914.4 m) wide just north of Rich Valley, shown on Plate 2. The base of the unit is above the youngest argillaceous limestones of the Cove Creek and below the overlying interbedded shales and sandstones. The upper contact is concealed by the Cambrian Honaker Formation along the Saltville fault in Rich Valley. Because the top of the Pennington is covered by the Saltville fault sheet a total original thickness is undeterminable.

The Pennington Formation is largely composed of siltstone and sandstone; it contains some argillaceous or sandy limestone. There are four lithologic members which are exposed along the roads but are not traceable due to rugged terrain and poor exposures. The basal member, a shale unit, is silty, slightly calcareous, fissile and predominantly gray to greenish gray. Scattered thin beds of greenish-gray argillaceous sandstones form some of this member. A turbidite member near the middle of the formation contains large rounded blocks of siltstone or argillaceous sandstone enclosed by shale (Figure 10). The sandstones are fine grained and brown; the siltstones are gray to greenish gray. The third member of the Pennington is highly variable in lithology; it consists of interfingering shales, siltstones, and sandstones with minor amounts of very argillaceous limestone. The shales and siltstones are generally greenish gray though some are drab maroon or brown. The sandstones are fine grained, argillaceous, and brown, maroon or greenish gray. They are often thick-bedded and fossiliferous. The limestones are argillaceous, silty, or sandy, and grade into calcareous siltstones. The upper shale member is composed of maroon and green shales, siltstones, and mudstones; soils formed on this member are red. The proportion of the formation formed by each of the members changes from west to east. From State Road 614 eastward to State Road 626 and Possum Hollow (Plate 2), the middle and turbidite members thin, whereas the lower member thickens.



10. Slump-rolled layers of calcareous siltstone in the Pennington Formation caused by penecontemporaneous plastic flow; exposure on east bank of U.S. Highway 19-58A near Greendale (Plate 2).

The fossil content of the Pennington is as highly variable as its lithology. Fossils are most abundant in the non-redbeds of the middle member, especially in the siltstones and sandstones, and in the lower shale member. Forms include the blastoid *Pentremites* sp. and the crinoid *Platycrinus penicillus* Meek and Worthen.

QUATERNARY SYSTEM

Surficial deposits include (1) colluvium, (2) terrace deposits, (3) alluvium, and (4) soils. The first three types were

mapped in the field and from aerial photographs. Soils are described in the Environmental Geology section of the report.

Colluvium

There are large colluvial deposits in two areas southeast of Sweet Hollow and southeast of Denton Valley (Plate 1). The rock fragments are angular and composed of sandstones, conglomeratic sandstones, and quartzites; the bedrock under most of the colluvium is carbonate. The thickness of the colluvium is highly variable and is estimated to be up to 25 feet (0-8 m). The rock fragments range in size from 1 inch (3 cm) to 10 feet (3 m) long dimension.

Terrace Deposits

Terrace deposits were mapped along the Middle Fork and South Fork of the Holston River and along the shoreline of South Holston Lake. These sediments are composed of unconsolidated gravels and cobbles of sandstone and quartzite in a sand, silt, and clay matrix. Along the shore of South Holston Lake much matrix has been removed. Middle Fork of the Holston River terraces are not as continuous nor as extensive as those along South Fork of the Holston River. The deposits may be as much as 15 feet (4.6 m) thick.

Alluvium

Floodplain alluvium along the rivers and major streams of the area may be as thick as 35 feet (10.5 m); lesser thicknesses are along most smaller streams. The alluvium is composed of unconsolidated sand and clay with intermixed pebbles or subrounded cobbles of chert, limestone, and siltstone derived from nearby rocks. Shells of diverse fresh-water animals are also plentiful.

Travertine, a porous precipitate of calcium carbonate, occurs along portions of some streams draining areas of carbonate-bedrock. A particularly good deposit is along Wolf Creek just south of the abandoned Abingdon sewage lagoons (Plate 1, R-6346).

STRUCTURE

The structural features of the mapped area can be placed in four major belts which trend northeasterly. From the northwest to southeast these are:

(1) Greendale syncline. Geologic relationships are shown in cross section B-B′ on Plate 2.

(2) Complexly thrust-faulted belt. This area is bounded on the north by the Saltville fault and on the south by the Great Knobs syncline. Located within this belt are the Pulaski, Spurgeon and Alvarado thrust faults and several anticlines and synclines whose axes are offset or overridden by these faults. Geologic relationships are shown in cross sections on Plate 2 and in B-B′ and C-C′ on Plate 1.

(3) Southern fold belt. This area has relatively simple folds including the Great Knobs, River Knobs and South Holston synclines and the Watauga and Parks Mill anticlines; the Alvarado cross fault is the major fault in this zone. Geologic relationships are shown in portions of each cross section on Plates 1 and 2.

(4) Frontal Blue Ridge belt. The area is complexly faulted and contains partially overturned folds including the Sweet Hollow anticline. The south boundary of this belt is marked by the Holston Mountain thrust fault which was mapped in the southeast portion of the area in two places. Geologic relationships are shown in cross sections A-A′ and B-B′ on Plate 1.

Most of the major fault traces and formational outcrops have northeast-southwest strike and southeasterly dip. The Alvarado and Dry Run faults are subparallel lateral or cross faults which trend southeasterly and cut across structural axes and formational contacts. The largest stratigraphic displacement of geologic units is about 16,000 feet (4880 m) along the Saltville fault trace near the western edge of the Wyndale quadrangle where the Cambrian Honaker Formation is in contact with the Mississippian Pennington Formation. None of the fault planes are well exposed, but, based on calculations determined from irregularities in fault traces, most of the thrust faults are believed to have angles of inclination of less than 25 degrees. However, judging from the low amount of sinuousity of its fault trace, portions of the Saltville fault plane may be inclined as much as 40 degrees.

GREENDALE SYNCLINE

The rocks northwest of the Saltville fault are part of the northwestern limb of the Greendale syncline (Plate 2, unlabeled), one of the major regional structures of southwestern Virginia. The small portion of the syncline present in the area consists of the Ste. Genevieve through the Pennington formations, which are all Mississippian. The dip of these formations is 15 to 35 degrees to the southeast, except where affected by the Saltville fault. The major axis and the southeastern limb of the syncline are concealed beneath the Saltville thrust sheet.

Five fault-bounded areas of Gasper, Fido, Cove Creek and Pennington rocks were mapped in Rich Valley. These areas apparently are portions of the southeastern limb of the Greendale syncline broken from it by movement on the Saltville fault. There are small drag folds in the Pennington Formation near the Saltville fault trace. At Garrett Creek adjacent to State Road 700, the stratigraphic sequence is reversed; the Fido Sandstone overlies the Cove Creek Limestone.

COMPLEXLY THRUST-FAULTED BELT

This structural belt extends from the Saltville fault located in Rich Valley on the northwest to the north flank of the Great Knobs syncline at the Great Knobs topographic feature (Plates 1, 2). It includes four major thrust faults; at least two of these (Saltville and Pulaski faults) have great regional extent and large displacements. Three prominent folds, the Cummings Heights and Abingdon synclines and the Stone Mill anticline, are disrupted by the major faults.

Saltville Fault and Fault Sheet

The Saltville thrust fault, which extends from Virginia into Georgia, is one of the major fault systems of the Southern Appalachians. In Rich Valley (Plate 2) the fault trace forms the southeastern boundary of the Greendale syncline. The exposed portion of the Saltville fault sheet is approximately 1.7 miles (2.7 km) wide and is bounded on the south by the Pulaski thrust sheet. Rocks exposed in the thrust block range from Lower Cambrian Honaker Formation to the Middle Ordovician Athens Formation and mostly dip between 20 to 35 degrees to the southeast. Along the entire fault trace, the Honaker Formation forms the hanging wall and Upper Mississippian rocks, the footwall; the stratigraphic displacement is about 16,000 feet (4880 m). Five separate fault-bounded areas of Mississippian rocks (Reference Locality 14, Plate 2) were emplaced along the sole of the Saltville fault. The fault plane is not exposed, but calcite fracture filling in Honaker dolomite (Figure 3) and numerous springs mark the fault trace.

It is postulated that the Rome Formation shales facilitated movement on the Saltville fault because: the lower part of the overlying Honaker Formation is exposed at the fault trace; the Rome is partially exposed at the fault a few miles to the west on the Wallace quadrangle (Bartlett and Webb, 1971, Plate 1); and, near the western edge of the Wyndale quadrangle, some greenish-gray shales, believed to be Rome, are at the fault trace.

Pulaski Fault

The Pulaski fault sheet (Figures 3, 11) consists of an intensely faulted and folded area of Middle and Upper Cambrian carbonates and shales. At five separate locations between State Road 611 and Toole Creek, erosion has exposed portions of the underlying Middle Ordovician rocks which are mainly concealed by the thrust sheet. Gray shales of the Athens Formation are at two of these locations and it is probable that this unit facilitated movement on the fault. In the northwest corner of the Wyndale quadrangle, the Honaker Formation has been thrust over the Athens; the stratigraphic displacement is about 5000 feet (1525 m). Between U.S. Highway 19-58A (northeast corner of the Wyndale quadrangle) and State Road 614 (about 4.0 miles, 6.4 km, to the southwest) the Upper Cambrian Conococheague Formation is in fault contact with Ordovician rock units; displacement is less than 3000 feet (915 m).

11. Crumpled shaly dolomite in Honaker Formation distorted by movement on Pulaski fault zone exposed on east side of Black Hollow Road (State Road 661) 200 yards (183 m) northeast of Maple Grove Church (Plate 2).

At Countiss Ridge (Plate 2) a small syncline, which is largely made up of Honaker and Nolichucky rocks, extends northeastward for two miles (3.2 km) to the Pulaski fault trace. This syncline is bounded on the south by a fault having only a few hundred feet displacement — Honaker rocks are on both sides of the fault trace.

An unnamed thrust fault is subparallel to and generally about 0.5 mile (0.8 km) south of the Pulaski fault (Plate 2). Along most of the fault trace, the lower portion of the Honaker is severely brecciated. About one mile (1.6 km) east of U.S. Highway 19-58A (northeast portion of the Wyndale quadrangle) this fault is joined to the Pulaski fault or terminates at it. Two small folds located about one mile (1.6 km) west of U.S. Highway 19-58A are offset 0.4 mile (0.6 km) along this fault. Near these offset folds the dip of the fault plane is about four degrees southeast.

Just east of the folds, near Cummings Heights, another unnamed fault has offset the axis of the Cummings Height syncline. The fault continues to the east as three separate thrust faults. Movement on the two southerly faults has shifted and terminated the narrow outcrop belts of the distinctive Nolichucky limestones north of Abingdon (Plate 1). Displacement on these two faults diminishes eastward and is indiscernible east of Jordan Hollow. About 0.5 mile (0.8 km) west of White Mill Road (State Road 692) each of these two faults has Honaker beds upon Conococheague rock; stratigraphic displacements exceed 500 feet (152.5 m). The

COMPLEXLY THRUST-FAULTED BELT

This structural belt extends from the Saltville fault located in Rich Valley on the northwest to the north flank of the Great Knobs syncline at the Great Knobs topographic feature (Plates 1, 2). It includes four major thrust faults; at least two of these (Saltville and Pulaski faults) have great regional extent and large displacements. Three prominent folds, the Cummings Heights and Abingdon synclines and the Stone Mill anticline, are disrupted by the major faults.

Saltville Fault and Fault Sheet

The Saltville thrust fault, which extends from Virginia into Georgia, is one of the major fault systems of the Southern Appalachians. In Rich Valley (Plate 2) the fault trace forms the southeastern boundary of the Greendale syncline. The exposed portion of the Saltville fault sheet is approximately 1.7 miles (2.7 km) wide and is bounded on the south by the Pulaski thrust sheet. Rocks exposed in the thrust block range from Lower Cambrian Honaker Formation to the Middle Ordovician Athens Formation and mostly dip between 20 to 35 degrees to the southeast. Along the entire fault trace, the Honaker Formation forms the hanging wall and Upper Mississippian rocks, the footwall; the stratigraphic displacement is about 16,000 feet (4880 m). Five separate fault-bounded areas of Mississippian rocks (Reference Locality 14, Plate 2) were emplaced along the sole of the Saltville fault. The fault plane is not exposed, but calcite fracture filling in Honaker dolomite (Figure 3) and numerous springs mark the fault trace.

It is postulated that the Rome Formation shales facilitated movement on the Saltville fault because: the lower part of the overlying Honaker Formation is exposed at the fault trace; the Rome is partially exposed at the fault a few miles to the west on the Wallace quadrangle (Bartlett and Webb, 1971, Plate 1); and, near the western edge of the Wyndale quadrangle, some greenish-gray shales, believed to be Rome, are at the fault trace.

Pulaski Fault

The Pulaski fault sheet (Figures 3, 11) consists of an intensely faulted and folded area of Middle and Upper Cambrian carbonates and shales. At five separate locations between State Road 611 and Toole Creek, erosion has exposed portions of the underlying Middle Ordovician rocks which are mainly concealed by the thrust sheet. Gray shales of the Athens Formation are at two of these locations and it is probable that this unit facilitated movement on the fault. In the northwest corner of the Wyndale quadrangle, the Honaker Formation has been thrust over the Athens; the stratigraphic displacement is about 5000 feet (1525 m). Between U.S. Highway 19-58A (northeast corner of the Wyndale quadrangle) and State Road 614 (about 4.0 miles, 6.4 km, to the southwest) the Upper Cambrian Conococheague Formation is in fault contact with Ordovician rock units; displacement is less than 3000 feet (915 m).

11. Crumpled shaly dolomite in Honaker Formation distorted by movement on Pulaski fault zone exposed on east side of Black Hollow Road (State Road 661) 200 yards (183 m) northeast of Maple Grove Church (Plate 2).

At Countiss Ridge (Plate 2) a small syncline, which is largely made up of Honaker and Nolichucky rocks, extends northeastward for two miles (3.2 km) to the Pulaski fault trace. This syncline is bounded on the south by a fault having only a few hundred feet displacement — Honaker rocks are on both sides of the fault trace.

An unnamed thrust fault is subparallel to and generally about 0.5 mile (0.8 km) south of the Pulaski fault (Plate 2). Along most of the fault trace, the lower portion of the Honaker is severely brecciated. About one mile (1.6 km) east of U.S. Highway 19-58A (northeast portion of the Wyndale quadrangle) this fault is joined to the Pulaski fault or terminates at it. Two small folds located about one mile (1.6 km) west of U.S. Highway 19-58A are offset 0.4 mile (0.6 km) along this fault. Near these offset folds the dip of the fault plane is about four degrees southeast.

Just east of the folds, near Cummings Heights, another unnamed fault has offset the axis of the Cummings Height syncline. The fault continues to the east as three separate thrust faults. Movement on the two southerly faults has shifted and terminated the narrow outcrop belts of the distinctive Nolichucky limestones north of Abingdon (Plate 1). Displacement on these two faults diminishes eastward and is indiscernible east of Jordan Hollow. About 0.5 mile (0.8 km) west of White Mill Road (State Road 692) each of these two faults has Honaker beds upon Conococheague rock; stratigraphic displacements exceed 500 feet (152.5 m). The

more northerly fault was traced from Cummings Heights northeastward to Toole Creek (Plate 1) where it nearly joins the main Pulaski fault. About 0.4 mile (0.6 km) west of White Mill Road the fault overlies the axis of Cummings Heights syncline; along the road and to the east of it are highly fractured dolomites belonging to the lower portion of the Honaker. Maximum displacement is probably less than 400 feet (122 m).

Cummings Heights Syncline

This gently folded syncline, herein named for the community of Cummings Heights located near its axis, extends from north of Clear Creek Lake to White Branch (Plates 1 and 2), a distance of about nine miles (14.5 km). The syncline has a maximum width of 1.3 miles (2.1 km) near Rust Hollow. Within the syncline, beds are inclined less than 30 degrees but higher dips are common near bounding faults. Except for an erosional remnant of Nolichucky and Conococheague beds (Plate 2), the outcrops on this structure are Honaker.

Spurgeon Fault

The Spurgeon fault has been traced from near Clear Creek Lake (Plate 2), through Abingdon and northeast beyond the intersection of Hillman Highway and State Road 704 in the northeast part of the mapped area. Along most of the fault trace shown on Plate 2, middle and lower portions of the Honaker dolomites are in contact with other Honaker beds. Although stratigraphic displacement is only several hundred feet, complex fracturing and brecciation is common in exposures as far as 1000 feet (305 m) south of the fault trace.

At a bend in the fault trace in and near Abingdon, there is a prominent termination of the Nolichucky (Reference Locality 12, Plate 2) and associated formations. Displacement increases toward eastern Abingdon. Near the old fairground, the middle portion of the Honaker is in contact with the Knox Group, upper part dolomites; estimated displacement is 3,600 feet (1098 m). Farther east stratigraphic displacement is confined to the Honaker and gradually diminishes to a minimum of probably less than 400 feet (122 m) in the most northern exposure.

An excellent exposure of brecciated Honaker dolomite is just east of Abingdon along the J.E.B. Stuart-Lee Highway at the high point on the road about 2,000 feet (610 m) southeast of the Norfolk and Western Railway overpass (Reference Locality 3, Plate 1).

Abingdon Syncline

A synclinal fold, herein named for the town of Abingdon, was mapped from north of Hayter (Plate 1) through Abingdon and southwestward for several miles to an area near the intersection of State Road 611 and Lee Highway where the fold is covered by the Alvarado fault sheet (Plate 2). Near the eastern town limits of Abingdon, movement on the Spurgeon fault caused a westward shift of 1.2 miles (1.9 km) of the syncline axis.

The syncline, which has a plunge to the southwest, is asymmetrical — the south flank is steeper. The syncline near Mobley Hollow (shown on Plate 2) is possibly another faulted segment of the Abingdon syncline and is partially formed by relatively resistant beds of Athens shale and siltstone which produce a rugged terrain.

Stone Mill Anticline

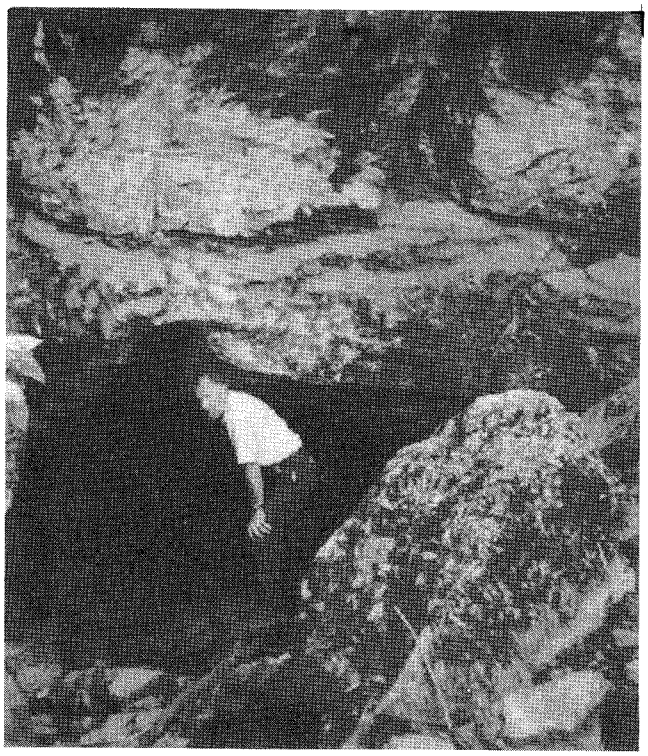
The complementary upwarp between the Abingdon syncline and the Great Knobs syncline is herein named the Stone Mill anticline for the landmark in the south part of Abingdon (Plate 1). The anticlinal axis is offset and probably concealed by the Spurgeon fault trace east of Abingdon. Near the old fairground in east Abingdon, its plunge is westward. At the Acme Stone Company quarry (Active quarry No. 11), the axial plunge reverses to an eastward direction. Westward it is concealed by the Spurgeon fault for a distance of about two miles (3.2 km). From near Spring Creek Church to near Preston Spring (Plate 2), the Stone Mill anticline has a southwestward trend and plunge direction; the distance is about four miles (6.4 m).

The anticline is uniquely asymmetrical, for the southeastern limb is very steep to overturned with dips to the northwest in many places. The distinctive Nolichucky limestones aided in mapping this structure.

A closely related anticline mapped in the Halls Bottom area (Plate 2) may be the fault-offset continuation of the Stone Mill anticline. The anticlinal axis of this structure is visible at the entrance to the cave into which Sinking Creek flows (Figure 12). This fold is doubly-plunging with an apex located about 0.5 mile (0.8 km) north of High Point Church and is asymmetrical with the steeper flank of the south side.

Alvarado Transverse and Thrust Fault

The Alvarado fault was mapped through the community of Alvarado where it causes an obvious offset in the trend of River Knobs (Plate 1). From Alvarado to near Abingdon the fault is transverse and has a fairly straight trace, indicating a steep fault plane. The strike of the fault cuts across the main structural trend at an angle of 50 to 60 degrees. This agrees with the expected angle of shear fractures (Billings, 1972, p. 161-164). West of the intersection of U.S. Highway 58 and Town Creek (Reference Locality 11, Plate 1), the Alvarado is a thrust fault which is generally parallel to the structural grain. About 0.7 miles (1.1 km) west of Stone Mill, this fault offsets the outcrop belts of the Nolichucky about 3500 feet (1067.5 m). Near Old Jonesboro Road



12. "Halls Bottom Cave" at anticlinal axis in limestone of the Chepultepec limestone, located 2100 feet (640.5 m) north of Old Jonesboro Road (State Road 647) where Sinking Creek enters a subsurface course (Plate 2).

(State Road 647) the leading edge of this thrust sheet conceals the axial traces of the Stone Mill anticline and the Abingdon syncline.

About one mile (1.6 km) northeast of Spring Creek Church (Plate 2) the thrust fault branches into two faults and there are at least two smaller breaks between these faults. This complex is particularly well shown at two small outcrop areas of distinctive Nolichucky limestone beds and associated Honaker and Conococheague rocks northeast of the church.

Along the more northerly fault trace, displacement increases westward to near Hilander Park where the Conococheague Formation is in contact with the Knox Group, upper part; the maximum displacement is about 1000 feet (305 m). South of Preston Hills the trace of this northern branch is offset by the more southerly branch. The system ends near Colonial Heights.

Another unnamed thrust fault adjoins the Alvarado transverse fault near the junction of the Middle Fork and South Fork of the Holston River (Plate 1) and extends northeastward into the Damascus quadrangle across the south flank of the Parks Mill anticline and an unnamed syncline near Bethel.

SOUTHERN FOLD BELT

The Great Knobs syncline and synclines and anticlines to the southeast of it are complex, open to overturned folds; intensity of deformation increases to the southeast. Portions of these folds extend across adjacent quadrangles to the east and into Tennessee.

Great Knobs Syncline

This broad syncline is well expressed by a wide belt of Athens in the trough of the syncline underlying Great Knobs (Plate 1, 2). Because this formation is principally composed of relatively incompetent shales and thin-bedded siltstones, it has been more intensely deformed by compression than the thick-bedded limestones and dolomites exposed in the adjacent anticlines. The Athens belt here contains six small synclines and corresponding anticlines. These structures are exposed along Spoon Gap Road (Reference Locality 19, Plate 2) and along Town Creek (Plate 1). No attempt was made to trace all of these folds; the complexity is indicated on Plates 1 and 2 by the numerous reversals of dip direction in some areas in the Athens. These folds extend into Ordovician carbonate units in three localities: on the south flank of the Great Knobs syncline at Negro Hollow (Plate 2); at Berry Creek (north flank); and near Rosedale Church (north flank). The latter two localities are shown on Plate 1. Faulting, with minor displacement, was noted in several roadcut exposures (Reference Locality 10, Plate 1) in the Athens, but these could not be traced into the adjacent wooded and soil-covered areas.

Watauga Anticline

The Watauga anticline is located between the Great Knobs and River Knobs synclines (Plates 1, 2) and is herein named for the community of Watauga and the Watauga Valley (Plate 1). The fold is somewhat asymmetrical with south flank dips being steeper than those to the north. Throughout the Watauga anticline there are two, and in places three, subparallel axes. At the community of Watauga there is a subsidiary anticlinal fold which can be traced for about one mile (1.6 km). The axial trace of the Watauga anticline plunges and rises to apex points at several places. The highest structural apex is near the head of Honey Locust Branch (Plate 1) and the lowest saddle is near the filtration plant at the south end of State Road 677 (Plate 1). In addition to the Alvarado fault, which effects large displacement, there are at least five normal or transverse faults with small displacements on the flanks of the Watauga anticline. These small faults were mapped by tracing the narrow outcrop belt of the Lenoir and Mosheim limestones to their terminations against Athens shale. Small offset such as these would be difficult to delineate within the underlying carbonate units.

12. "Halls Bottom Cave" at anticlinal axis in limestone of the Chepultepec limestone, located 2100 feet (640.5 m) north of Old Jonesboro Road (State Road 647) where Sinking Creek enters a subsurface course (Plate 2).

(State Road 647) the leading edge of this thrust sheet conceals the axial traces of the Stone Mill anticline and the Abingdon syncline.

About one mile (1.6 km) northeast of Spring Creek Church (Plate 2) the thrust fault branches into two faults and there are at least two smaller breaks between these faults. This complex is particularly well shown at two small outcrop areas of distinctive Nolichucky limestone beds and associated Honaker and Conococheague rocks northeast of the church.

Along the more northerly fault trace, displacement increases westward to near Hilander Park where the Conococheague Formation is in contact with the Knox Group, upper part; the maximum displacement is about 1000 feet (305 m). South of Preston Hills the trace of this northern branch is offset by the more southerly branch. The system ends near Colonial Heights.

Another unnamed thrust fault adjoins the Alvarado transverse fault near the junction of the Middle Fork and South Fork of the Holston River (Plate 1) and extends northeastward into the Damascus quadrangle across the south flank of the Parks Mill anticline and an unnamed syncline near Bethel.

SOUTHERN FOLD BELT

The Great Knobs syncline and synclines and anticlines to the southeast of it are complex, open to overturned folds; intensity of deformation increases to the southeast. Portions of these folds extend across adjacent quadrangles to the east and into Tennessee.

Great Knobs Syncline

This broad syncline is well expressed by a wide belt of Athens in the trough of the syncline underlying Great Knobs (Plate 1, 2). Because this formation is principally composed of relatively incompetent shales and thin-bedded siltstones, it has been more intensely deformed by compression than the thick-bedded limestones and dolomites exposed in the adjacent anticlines. The Athens belt here contains six small synclines and corresponding anticlines. These structures are exposed along Spoon Gap Road (Reference Locality 19, Plate 2) and along Town Creek (Plate 1). No attempt was made to trace all of these folds; the complexity is indicated on Plates 1 and 2 by the numerous reversals of dip direction in some areas in the Athens. These folds extend into Ordovician carbonate units in three localities: on the south flank of the Great Knobs syncline at Negro Hollow (Plate 2); at Berry Creek (north flank); and near Rosedale Church (north flank). The latter two localities are shown on Plate 1. Faulting, with minor displacement, was noted in several roadcut exposures (Reference Locality 10, Plate 1) in the Athens, but these could not be traced into the adjacent wooded and soil-covered areas.

Watauga Anticline

The Watauga anticline is located between the Great Knobs and River Knobs synclines (Plates 1, 2) and is herein named for the community of Watauga and the Watauga Valley (Plate 1). The fold is somewhat asymmetrical with south flank dips being steeper than those to the north. Throughout the Watauga anticline there are two, and in places three, subparallel axes. At the community of Watauga there is a subsidiary anticlinal fold which can be traced for about one mile (1.6 km). The axial trace of the Watauga anticline plunges and rises to apex points at several places. The highest structural apex is near the head of Honey Locust Branch (Plate 1) and the lowest saddle is near the filtration plant at the south end of State Road 677 (Plate 1). In addition to the Alvarado fault, which effects large displacement, there are at least five normal or transverse faults with small displacements on the flanks of the Watauga anticline. These small faults were mapped by tracing the narrow outcrop belt of the Lenoir and Mosheim limestones to their terminations against Athens shale. Small offset such as these would be difficult to delineate within the underlying carbonate units.

River Knobs Syncline

A generally much narrower outcrop belt of Athens than found in the Great Knobs syncline marks the position of the River Knobs syncline (Plate 1, 2). Only a few subsidiary folds were noted on this structure. Some of the Athens may be overturned near the axis from near Wolf Creek to Shallow Ford Bridge on the J.E.B. Stuart Highway (Plate 1). The syncline and the Athens outcrop belt are widest in the area where the axial trace is offset approximately 1500 feet (457.5 m) along the Alvarado fault. The south flank of the River Knobs syncline 1.2 miles (1.9 km) east of Watauga comprises a fold and fault complex involving Athens shale and parts of the Lenoir, Mosheim and Knox Group, upper part carbonate beds.

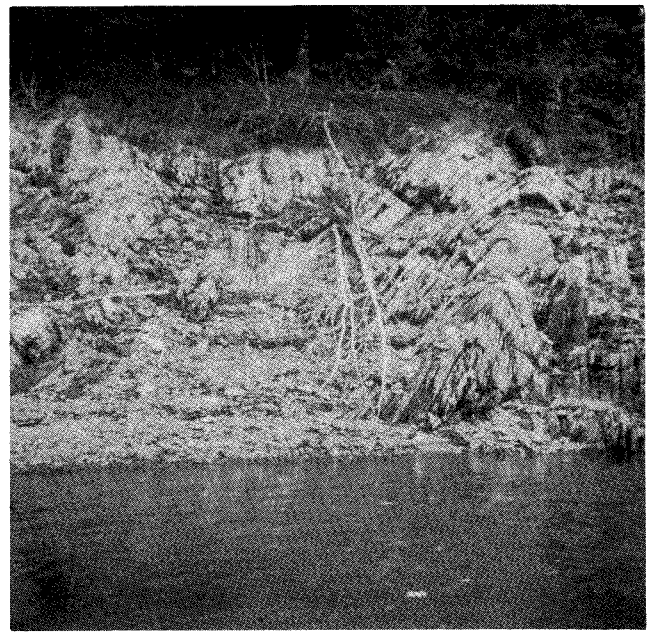
Parks Mill Anticline

This doubly plunging structure is herein named for the mill which bears this name and which is still in operation on Fifteenmile Creek (Plate 1). At Spring Creek (Plate 2) the major axis is composed of two subparallel folds which can be seen in exposures along the creek. The Parks Mill anticline is relatively simple and nearly symmetrical; dips are as high as 85 degrees. The axis plunges southwest and northeast from a structural high area northeast of Parks Mill (Plate 1); beds of the Nolichucky and Honaker formations mark this axial apex. Near Bethel the northeast-plunging nose is broad and gently folded. In addition to the Alvarado fault, along which displacement was large, seven small normal, transverse fractures account for minor offset in the Lenoir and Mosheim limestones on the flanks of the Parks Mill anticline. One of these zones of offset is especially noticeable on Wolf Creek at South Holston Lake.

Adjacent to the anticline in the area about 0.3 mile (0.5 km) south of Bethel, is an unnamed syncline marked by an exposure of Athens shales. The axis of this syncline is concealed by a thrust fault about 3000 feet (915 m) east of Bethel; the fault is in the Damascus quadrangle. The syncline lies within a major bifurcation of the axis of the Parks Mills anticline. A southern anticlinal nose branches and plunges eastward onto the Damascus quadrangle near Louse Creek about one-half mile (0.8 km) north of Alvarado.

South Holston Syncline

The major fold axis of this syncline appears to plunge southwestward for several miles from near Alvarado (Plate 1). The south flank is overturned except for a small area between Alvarado and Larimer Branch. Numerous minor folds and faults on both flanks of the syncline make the positioning of the major axis highly questionable. In one small area on the south side of South Holston Lake near the marker "Mile 65" (Plate 1), axial plane cleavage is inclined 75 degrees southeast (Figure 13). In some areas, the axial trace was placed at one-half the distance from the most northwesterly to the most southeasterly exposures of conglomeratic sandstone beds in the Athens Formation. Structural complexities and sparcity of good exposures prevented accurate location of the major syncline axis southwest of the Dry Run fault and west of Denton Valley (Plate 1).



13. Series of folds in shales of Athens Formation exposed at draindown of South Holston Lake on south shore near "mile 65" mark (Plate 1). Cleavage and axial planes are inclined at 75 degrees to the southeast.

The Dry Run fault transects the South Holston syncline on the north side of Denton Valley. The western terminus of the fault now lies beneath South Holston Lake; a former bend in the South Fork of the Holston River near Mile 67 may have been caused by this fracture zone.

FRONTAL BLUE RIDGE BELT

This narrow belt is situated between the South Holston syncline and the Holston Mountain thrust fault — an area expressed topographically by Sweet Hollow and Denton valleys (Plate 1). It is characterized by complexly faulted and partially overturned folds.

Sweet Hollow Anticline

Between Alvarado and the rugged mountains to the south there is a two-mile (3.2 km) wide valley formed on an anticlinal fold in Cambrian and Ordovician carbonate rocks (Plate 1). A portion of the axial trace lies in or parallel to Sweet Hollow. About one-half mile (0.8 km) south of the South Fork Holston River the axial trace trends west-east and continues into the Damascus quadrangle. The axial trace is concealed beneath the Holston Mountain fault by

River Knobs Syncline

A generally much narrower outcrop belt of Athens than found in the Great Knobs syncline marks the position of the River Knobs syncline (Plate 1, 2). Only a few subsidiary folds were noted on this structure. Some of the Athens may be overturned near the axis from near Wolf Creek to Shallow Ford Bridge on the J.E.B. Stuart Highway (Plate 1). The syncline and the Athens outcrop belt are widest in the area where the axial trace is offset approximately 1500 feet (457.5 m) along the Alvarado fault. The south flank of the River Knobs syncline 1.2 miles (1.9 km) east of Watauga comprises a fold and fault complex involving Athens shale and parts of the Lenoir, Mosheim and Knox Group, upper part carbonate beds.

Parks Mill Anticline

This doubly plunging structure is herein named for the mill which bears this name and which is still in operation on Fifteenmile Creek (Plate 1). At Spring Creek (Plate 2) the major axis is composed of two subparallel folds which can be seen in exposures along the creek. The Parks Mill anticline is relatively simple and nearly symmetrical; dips are as high as 85 degrees. The axis plunges southwest and northeast from a structural high area northeast of Parks Mill (Plate 1); beds of the Nolichucky and Honaker formations mark this axial apex. Near Bethel the northeast-plunging nose is broad and gently folded. In addition to the Alvarado fault, along which displacement was large, seven small normal, transverse fractures account for minor offset in the Lenoir and Mosheim limestones on the flanks of the Parks Mill anticline. One of these zones of offset is especially noticeable on Wolf Creek at South Holston Lake.

Adjacent to the anticline in the area about 0.3 mile (0.5 km) south of Bethel, is an unnamed syncline marked by an exposure of Athens shales. The axis of this syncline is concealed by a thrust fault about 3000 feet (915 m) east of Bethel; the fault is in the Damascus quadrangle. The syncline lies within a major bifurcation of the axis of the Parks Mills anticline. A southern anticlinal nose branches and plunges eastward onto the Damascus quadrangle near Louse Creek about one-half mile (0.8 km) north of Alvarado.

South Holston Syncline

The major fold axis of this syncline appears to plunge southwestward for several miles from near Alvarado (Plate 1). The south flank is overturned except for a small area between Alvarado and Larimer Branch. Numerous minor folds and faults on both flanks of the syncline make the positioning of the major axis highly questionable. In one small area on the south side of South Holston Lake near the marker "Mile 65" (Plate 1), axial plane cleavage is inclined

13. Series of folds in shales of Athens Formation exposed at draindown of South Holston Lake on south shore near "mile 65" mark (Plate 1). Cleavage and axial planes are inclined at 75 degrees to the southeast.

75 degrees southeast (Figure 13). In some areas, the axial trace was placed at one-half the distance from the most northwesterly to the most southeasterly exposures of conglomeratic sandstone beds in the Athens Formation. Structural complexities and sparcity of good exposures prevented accurate location of the major syncline axis southwest of the Dry Run fault and west of Denton Valley (Plate 1).

The Dry Run fault transects the South Holston syncline on the north side of Denton Valley. The western terminus of the fault now lies beneath South Holston Lake; a former bend in the South Fork of the Holston River near Mile 67 may have been caused by this fracture zone.

FRONTAL BLUE RIDGE BELT

This narrow belt is situated between the South Holston syncline and the Holston Mountain thrust fault — an area expressed topographically by Sweet Hollow and Denton valleys (Plate 1). It is characterized by complexly faulted and partially overturned folds.

Sweet Hollow Anticline

Between Alvarado and the rugged mountains to the south there is a two-mile (3.2 km) wide valley formed on an anticlinal fold in Cambrian and Ordovician carbonate rocks (Plate 1). A portion of the axial trace lies in or parallel to Sweet Hollow. About one-half mile (0.8 km) south of the South Fork Holston River the axial trace trends west-east and continues into the Damascus quadrangle. The axial trace is concealed beneath the Holston Mountain fault by

Lower Cambrian clastic rocks a short distance south of the mapped area. There is a slight saddle on the axis near the intersection of State Road 710 and Rockhouse Run; northward older beds are exposed down to the Conococheague Formation. The western flank is generally steeper than the eastern one and there are some overturned beds locally. Just west of the sharp axial bend, a thrust fault with small displacement provided some release for the compressional forces.

South of Alvarado is a complexly folded and faulted section on the northwest side of the Sweet Hollow anticline. The main fault trends southwest from near Alvarado to just north of Larimer Branch and bounds the northwest flank of a tight synclinal fold involving beds of the Athens shale and Lenoir, Mosheim and Knox Group, upper part carbonates. Several small-displacement fractures interrupt the outcrop trace of beds near Alvarado and also near Greenwood Church, to the south.

Beds of the anticline in Denton Valley are offset one mile (1.6 km) by the Dry Run transverse fault. This anticline is considered to be a continuation of the Sweet Hollow anticline. Within one mile (1.6 km) south of Dry Run and the Dry Run fault, all outcrops in Denton Valley become steeper and then increasingly overturned as they are traced southwestward. Just west of Denton Valley, an unnamed thrust fault has dolomites of the Knox Group, upper part against contorted shales of the Athens Formation. Small-displacement faults near Cox Mill Creek offset the outcrop belts of the Lenior and Mosheim limestones and the trace of the Dry Run fault.

Holston Mountain Fault

The trace of the Holston Mountain fault, which lies in the western part of the Blue Ridge province, was mapped in two small areas within the Shady Valley quadrangle (see cross section B-B′, Plate 1). In the south part of Denton Valley, conglomeratic sandstones, siltstones and shales of the Lower Cambrian Unicoi Formation (King and Ferguson, 1960, Plate 1) are thrust upon steeply inclined and overturned maroon shales of the Rome Formation; displacement is several thousand feet.

The second area is east of Sweet Hollow where huge blocks of a thick-bedded conglomerate belonging to the Unicoi are on cavernous Chepultepec limestones. Total displacement here is about 5,000 feet (1525 m) more than that in Denton Valley.

ECONOMIC GEOLOGY

Limestone, dolomite, and shale are the most abundant raw materials available. Crushed stone is produced from the carbonate rock units and shale, potentially useful for brick-making, is abundant near transportation lines. Travertine, decorative sandstone, and iron ore have been extracted in the past. Geologically similar areas nearby do produce or have produced gas, oil, gypsum, anhydrite and salt.

INDUSTRIAL LIMESTONE AND DOLOMITE

More than one-half of the area is underlain by limestone and dolomite, which may be subdivided according to industrial use as follows: *high-calcium limestone,* rocks which contain more than 95 percent calcium carbonate; *high-magnesium dolomite,* rocks which contain more than 40 percent magnesium carbonate and generally less than 4 percent noncarbonates; and *impure limestone,* a broad term used to describe rocks which are commonly low in magnesium carbonate or which contain more than 5 percent non-carbonates (Edmundson, 1945, p. 5). The non-carbonate constituents of these rocks, chiefly silica, alumina, and iron oxides, also have potential commercial value.

The chemical requirements for some standard commercial uses of limestone and dolomite are listed in Table 2. Chemical analyses of samples from areas depicted on Plates 1 and 2 are shown in Table 3.

Table 2. Chemical requirements for uses of limestone and dolomite (from O'Neill, B. J., 1964, Table 2)

Uses	Chemical Requirements
Lime (calcium)	$CaCO_3$ not less than 97%, preferably 98% or more.
Steel flux (open hearth)	$CaCO_3$ content should exceed 98%, but some limestone as low as 97% is sometimes accepted.
General chemical use	$CaCO_3$ content should exceed 98%, but limestone as low as 97% is sometimes used.
Glass (calcium)	$CaCO_3$ content should exceed 98%, and Fe_2O_3 not more than 0.05%.
Paint and filler	$CaCO_3$ content should exceed 96%; $MgCO_3$ not more than 1%. Other maxima: Fe_2O_3, 0.25%; SiO_2, 2.0%; and SO_3, 0.1%.
Glass (magnesium)	$CaCO_3$-$MgCO_3$ content should exceed 98% and Fe_2O_3 not more than 0.05%.
Refractories	$MgCO_3$ not less than 37.5%. SiO_2, Fe_2O_3, and Al_2O_3 not to exceed 1% each.
Portland cement	$MgCO_3$ not more than 6.3%. Minimum $CaCO_3$ content varies from plant to plant depending on availability of other raw materials.
Lime (magnesium)	$MgCO_3$ content should be between the limits of 21 and 31.5%.
Steel flux (blast furnace)	$MgCO_3$ less than 8% to less than 31%. SiO_2 less than 5%, Al_2O_3 less than 2%. Phosphorous content should not exceed 0.01%.
Agricultural limestone	Minimum of 85% $CaCO_3$.
Agricultural dolomite	$CaCO_3$-$MgCO_3$ content should total at least 85%.

High-Calcium Limestone

Formations which generally can be classified as high-calcium limestone include the Mosheim limestone, the Chepultepec limestone, where it is free of chert and dolomite interbeds, and, locally, the upper micrites of the Knox Group, upper part. The Mosheim is rarely more than 80 feet (24 m) thick and generally is much thinner or absent. The micrites of the Knox Group, upper part are not extensive and only near Hickey Gap Road (Plate 2; Section D) is the formation sufficiently thick for commercial use. The Chepultepec in places is a high-calcium grade rock; an example is along Crooked Branch (Plate 1; Section E). There are now no active quarries in high-calcium limestones in the area. Results of chemical analyses are in Table 3.

High-Magnesium Dolomite

The Honaker Formation and the Knox Group, upper part may contain dolomite units which meet the specifications for high-magnesium dolomite. Several samples listed in Table 3 from the upper portion of the Honaker are high enough in magnesium and low enough in impurities to be commercially developed. Tests on the Knox Group, upper part show fairly high magnesium content, but the impurity percentage, particularly silica, is high. At present there is no high-magnesium carbonate production in the area.

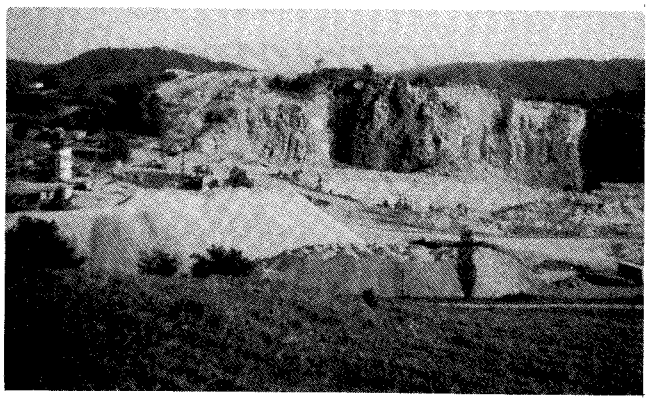
Impure Limestone

Impure limestone formations include the Cono-

Table 3. Chemical composition[1] of carbonate rocks from selected localities in the Abingdon, Wyndale, Holston Valley and Shady Valley quadrangles

Formation	Sample No.	Location	Sampled Interval FT (m)	$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	Total
Honaker	R-6212	1.5 miles northeast of Parks Mill (Pl. 1)	350 (106.8)	55.53	39.03	2.67	0.37	0.54	98.13
Honaker	R-6213	U.S. Highway 19-58 just south of Greendale (Pl. 2)	103 (31.4)	57.92	38.62	1.23	0.10	0.24	98.12
Honaker	R-6214	Acme Stone Co. Quarry 0.25 mile southeast of Stone Mill (Pl. 1)	±200 (61.0)	56.83	39.76	1.26	0.24	0.27	98.36
Chepultepec	R-6215A	Along Spoon Gap Road in Watauga Valley	±700 (213.5)	78.87	9.10	8.13	0.40	0.74	97.24
Chepultepec	R-6215B	(Pl. 2)	±100 (30.5)	86.24	3.84	6.59	0.36	0.75	97.78
Chepultepec	R-6217A	Along Wolf Creek	±200 (61.0)	82.46	7.57	6.68	0.40	0.82	97.93
Chepultepec	R-6217B	(Measured Section F, Pl. 1)	±400 (122.0)	88.51	4.04	4.92	0.33	0.71	98.51
Chepultepec	R-6219	Along Crooked Branch (Measured Section E., Pl. 1)	560 (170.8)	93.33	0.29	4.10	0.24	0.61	98.57
Knox Group, upper part	R-6220	Along Hickey Gap Road (Measured Section D, Pl. 2)	±250 (76.3)	56.51	33.13	6.08	0.52	1.03	97.27
Knox Group, upper part	R-6221	U.S. Highway 19-58 0.25 mile south of Carvosso Church (Pl. 2)	±100 (30.5)	57.99	34.20	4.61	0.42	0.77	97.99
Knox Group, upper part	R-6222	Along Crooked Branch (Measured Section, E, Pl. 1)	417 (127.2)	53.69	37.46	5.56	0.41	0.71	97.83
Knox Group, upper part	R-6223A	Along Hickey Gap Road (Measured Section D, Pl. 2)	32 (9.8)	76.32	16.48	4.99	0.39	0.93	99.11
Knox Group, upper part	R-6223B		26.5 (8.1)	78.30	12.55	6.48	0.44	0.99	98.76
Knox Group, upper part	R-6225	Along Hickey Gap Road approximately 0.25 mile northeast of Measured Section D (Pl. 2)	55 (16.8)	82.72	9.50	5.45	0.34	0.95	98.96
Mosheim	R-6226	Approx. 0.7 mi. south of I-81 State Road 658 junction (Pl. 2)	82 (25.0)	87.51	9.60	2.26	0.16	0.50	100.03
Lenoir	R-6227A	Approx. 0.1 mile west of Fifteenmile Creek, on	25 (7.6)	75.46	12.19	8.47	0.77	1.69	98.58
Mosheim	R-6227B	northwestward flank of River Knobs (Pl. 1)	120 (36.6)	83.72	13.01	2.40	0.24	0.68	100.05
Mosheim	R-6229	Along Norfolk and Western Railway, southeast flank of River Knobs (Pl. 1)	85 (25.9)	74.89	15.60	6.21	0.66	1.32	98.68

[1]Analyses performed by U.S. Bureau of Mines on composite samples collected from measured sections. Chert units were excluded.



14. Acme Stone Corporation Abingdon quarry (active quarry no. 11) in upper dolomite of Honaker Formation near crest of Stone Mill anticline. Quarry is located just south of Interstate Highway 81 about 0.6 mile (1.0 km) west of Exit 8 (Plate 1).

cocheague, the Lenoir-Mosheim and Chepultepec (where not of high-calcium grade), and the Gasper. Other relatively impure limestones interbedded with dolomites are referred to under "Crushed and Broken Stone."

The Conococheague crops out in several major belts south of Walker Mountain (Plates 1 and 2); the percentage of limestone increases in successive structures to the southeast. Some portions of the formation, particularly near the top and base, have interbedded sandstones which may reduce the potential value of the formation. The Gasper limestone is northwest of Rich Valley, shown on Plate 2, and contains scattered layers of impure limestone, but much of the formation is argillaceous and it may be too impure for use.

CRUSHED AND BROKEN STONE

Physical rather than chemical properties determine the quality of rock for dimension stone, rip-rap, and crushed stone for construction. The most abundant use of crushed stone today is in highway construction. Rock from Honaker dolomite at the Acme Stone quarry (Plate 1, active quarry 11) (Figure 14) is used for roadstone, concrete aggregate, and agstone.

Materials used in construction must have desirable characteristics relating to abrasion, absorption, specific gravity, freeze-thaw breakdown, and affinity for bituminous substances. Samples from several of the carbonate rock units have been tested (Parrott, 1954); the full test data are shown in Table 4.

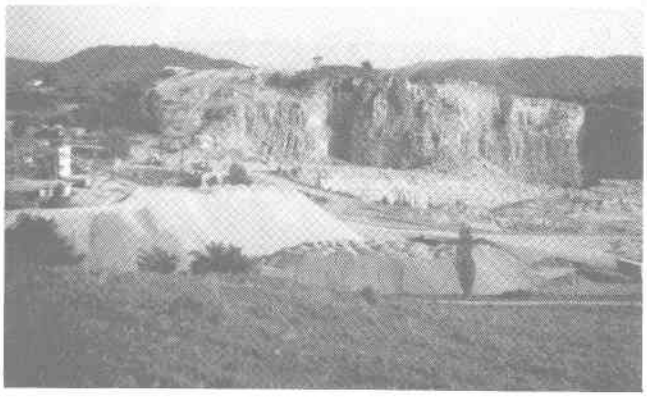
CLAY, SHALE AND RELATED MATERIAL

Shale of potentially commercial value is available from the Nolichucky (north of the Spurgeon fault), the Athens, and the Pennington formations. Several small quarries (Reference Locality 17, Plate 2; abandoned quarries numbers 8, 12, 14, 18, 20, 24) produced shale for road building and fill (Figure 15). Shale samples from eight localities were tested

15. Shale and very thin-bedded siltstone of the Athens Formation inclined 43 degrees to the north on the south flank of the Great Knobs syncline exposed in a borrow pit (abandoned quarry no. 14) on the east side of State Road 75 about 0.2 mile (0.3 km) north of the Bristol water plant (Plate 1).

Table 4.-Physical tests of aggregate samples (data modified from Parrott, 1954, p. 63, 64.)

Location	Quarry No.	Rock Type	Specific Gravity	Los Angeles Loss: Absorption	Los Angeles Loss: Abrasion	Los Angeles Loss: Grading	Los Angeles Loss: Soundness	Bituminous Adhesion: Weight	Bituminous Adhesion: Estimated
Withers	22	Honaker dolomite	2.72	.55	23.4	B	3.13	-----	-----
White Corner	27	Conococheague limestone	2.80	.195	19.2	A	Ok	69	90
Abingdon	7	Conococheague limestone	2.71	.20	23.2	A	Ok	74	92
Ashleys	9	Lenoir-Mosheim limestone	2.73	.28	23.4	A	-----	98	99
Vance Mill	13	Conococheague limestone	2.69	.062	23.2	A	Ok	88	95
Green Springs	16 (?)	Lenoir-Mosheim limestone	2.69	.37	22.2	A	-----	97	99
Wallace	29	Honaker dolomite	2.74	.44	19.9	A	Ok	86	88
Butts	23	Knox Group, upper part	2.83	.18	22.4	A	Ok	-----	-----
Gose Garage	1	Conococheague limestone	2.69	.64	23.0	A	Ok	86	98
Green Springs	25	Conococheague limestone	2.75	.23	19.0	A	Ok	100	100



14. Acme Stone Corporation Abingdon quarry (active quarry no. 11) in upper dolomite of Honaker Formation near crest of Stone Mill anticline. Quarry is located just south of Interstate Highway 81 about 0.6 mile (1.0 km) west of Exit 8 (Plate 1).

cocheague, the Lenoir-Mosheim and Chepultepec (where not of high-calcium grade), and the Gasper. Other relatively impure limestones interbedded with dolomites are referred to under "Crushed and Broken Stone."

The Conococheague crops out in several major belts south of Walker Mountain (Plates 1 and 2); the percentage of limestone increases in successive structures to the southeast. Some portions of the formation, particularly near the top and base, have interbedded sandstones which may reduce the potential value of the formation. The Gasper limestone is northwest of Rich Valley, shown on Plate 2, and contains scattered layers of impure limestone, but much of the formation is argillaceous and it may be too impure for use.

CRUSHED AND BROKEN STONE

Physical rather than chemical properties determine the quality of rock for dimension stone, rip-rap, and crushed stone for construction. The most abundant use of crushed stone today is in highway construction. Rock from Honaker dolomite at the Acme Stone quarry (Plate 1, active quarry 11) (Figure 14) is used for roadstone, concrete aggregate, and agstone.

Materials used in construction must have desirable characteristics relating to abrasion, absorption, specific gravity, freeze-thaw breakdown, and affinity for bituminous substances. Samples from several of the carbonate rock units have been tested (Parrott, 1954); the full test data are shown in Table 4.

CLAY, SHALE AND RELATED MATERIAL

Shale of potentially commercial value is available from the Nolichucky (north of the Spurgeon fault), the Athens, and the Pennington formations. Several small quarries (Reference Locality 17, Plate 2; abandoned quarries numbers 8, 12, 14, 18, 20, 24) produced shale for road building and fill (Figure 15). Shale samples from eight localities were tested

15. Shale and very thin-bedded siltstone of the Athens Formation inclined 43 degrees to the north on the south flank of the Great Knobs syncline exposed in a borrow pit (abandoned quarry no. 14) on the east side of State Road 75 about 0.2 mile (0.3 km) north of the Bristol water plant (Plate 1).

Table 4.-Physical tests of aggregate samples (data modified from Parrott, 1954, p. 63, 64.)

Location	Quarry No.	Rock Type	Specific Gravity	Los Angeles Loss: Absorption	Los Angeles Loss: Abrasion	Los Angeles Loss: Grading	Los Angeles Loss: Soundness	Bituminous Adhesion: Weight	Bituminous Adhesion: Estimated
Withers	22	Honaker dolomite	2.72	.55	23.4	B	3.13	-----	-----
White Corner	27	Conococheague limestone	2.80	.195	19.2	A	Ok	69	90
Abingdon	7	Conococheague limestone	2.71	.20	23.2	A	Ok	74	92
Ashleys	9	Lenoir-Mosheim limestone	2.73	.28	23.4	A	-----	98	99
Vance Mill	13	Conococheague limestone	2.69	.062	23.2	A	Ok	88	95
Green Springs	16 (?)	Lenoir-Mosheim limestone	2.69	.37	22.2	A	-----	97	99
Wallace	29	Honaker dolomite	2.74	.44	19.9	A	Ok	86	88
Butts	23	Knox Group, upper part	2.83	.18	22.4	A	Ok	-----	-----
Gose Garage	1	Conococheague limestone	2.69	.64	23.0	A	Ok	86	98
Green Springs	25	Conococheague limestone	2.75	.23	19.0	A	Ok	100	100

to determine their suitability for structural clay or other ceramic products as was a sample of Chepultepec residual clay (R-6211, Plate 1). The results of these tests are reported in Table 5. There are clay deposits in some stream valleys which have been used as potter's clay (Napps, 1972).

MISCELLANEOUS RESOURCES

There is no gas or oil production to date. A test hole was drilled in 1932 just northeast of the Abingdon quadrangle along the Saltville fault. The hole was drilled to a depth of 5240 feet (1598 m) and showed minor gas and salt.

Table 5.-Potential uses of clay and shale materials from the Abingdon, Wyndale, Holston Valley, and Shady Valley quadrangles

Repository Number*	Location	Geologic Unit	Sampled Interval	Potential Use	Remarks
R-2514[1]	Abandoned pit, 2.75 miles south of Abingdon, on the northeast side of State Highway 75 approximately 0.4 mile by road northwest of the intersection with State Road 677 (Abandoned quarry no. 14).	Athens	40 feet (12.2 m) of fresh and weathered shale and siltstone	Lightweight aggregate	Short vitrification range, highly efferverscent with HCL
R-6205[2]	In a small valley 1.1 mile south of the intersection of Interstate Highway 81 and State Road 658, approximately 0.25 mile southeast of the Bristol Area VA. Highway Department headquarters.	Athens	120 feet (36.6 m) composite	Lightweight aggregate	Abrupt vitrification (2200°-2100° F)
R-6206[2]	Along State 670 just southeast of the intersection of that road and State Road 674, northwest side of Denton Valley.	Athens	180 feet (54.9 m) composite	Lightweight aggregate; brick	Abrupt vitrification (2100°-2200° F); short firing range.
R-6207A[2]	Along the Norfolk and Western Railway on the southeast side of the River Knobs, just southwest of the Middle Fork Holston River.	Athens	200 feet (61 m)	Lightweight aggregate	Abrupt vitrification (2100°-2200° F); may be calcareous
R-6207B[2]	Same as R-6207A	Athens	30 feet (12.2 m) composite at base of unit	Brick; lightweight aggregate; quarry tile	Abrupt vitrification (2200°-2300° F) short firing range.
R-6209[2]	On the northwest side of the Great Knobs, 0.1 mile southeast of State Road 670 and 0.15 mile southwest of Wolf Creek.	Athens	90 feet (27.5 m) composite	Brick	Abrupt vitrification (2200°-2300° F) short firing range.
R-6210A[3]	On the northeast side of U.S. Highway 19-58 approximately 0.4 mile southeast of Greendale.	Nolichucky	40 feet (12.2 m) composite	Not suitable for use as lightweight aggregate	May be calcareous
R-6201B[3]	Same as R-6210A	Nolichucky	50 feet (15.3 m) composite at base of unit	Not suitable for use as lightweight aggregate	May be calcareous
R-6211[3]	Along Town Creek just southwest of the Norfolk and Western Railway crossing of Greenspring Road, Abingdon	Chepultepec residuum	Grab sample	Structural clay products	Abrupt vitrification at 1200° C; may be calcareous

[1]Johnson, Denny, and Le Van, (1966)
[2]Sweet, (1976)
[3]Data from the Tuscaloosa Metallurgy Research Laboratory, U.S. Bureau of Mines and on open-file at the Virginia Division of Mineral Resources.
*Samples on file with the Virginia Division of Mineral Resources.

There may be subsurface commercial mineral deposits of gypsum, anhydrite, and salt adjacent to the Saltville fault (Withington, 1965, p. 13-31). These minerals are mined near the fault about ten miles (16 km) northeast of Greendale at Plasterco and Saltville. Unusually high concentrations of sulfate in springs and other surface waters could help locate potential sites. The maroon Fido Sandstone was used locally as a decorative stone and as grave stones. The sandstone is very hard when fresh but crumbles after prolonged exposure to weather due to the dissolution of the calcareous matrix. The maroon, crinoidal limestone at the top of the Ste. Genevieve has potential use as a decorative stone.

Travertine, a porous precipitate of calcium carbonate, is found along several streams. When dried and crushed, travertine forms an excellent agricultural lime. Extensive deposits (Plate 1, R-6364) along Wolf Creek south of Abingdon were mined in the early 1900's for local use.

There are prospect pits (Plate 1, prospect number 19) in low-grade iron mineralizations of the Unicoi Formation along the Holston Mountain fault. The mineralization is principally hematite occuring as solid chunks and as cement between angular quartzite fragments (R-6351). There were two iron mines in the Knox Group, upper part with magnetite (hematite) and iron carbonate, with some limonite, as the ore (Watson, 1907, p. 461-462). One of these, the Holston, or Riverside mine, (abandoned mine no. 17, Reference Locality 7, Plate 1) was on the south bank of the South Fork Holston River about two miles from Alvarado; magnetite and iron carbonates were mined at the site by the Ivanhoe Furnace Company. About 1000 tons of ore per month were shipped in 1907 (Watson, 1907). A narrow gauge railway, the road bed of which is still evident along the south bank of the South Holston Lake, connected the mine site with the main railroad at Browns Siding (Alvarado). The Ivanhoe Furnace Company reported 62 percent metallic iron in the magnetite ore and 35 percent in the iron carbonate ore. The other mine, the Golleher, was five miles southeast of Abingdon (Watson, 1907). An analysis of this ore in 1884 (Watson, 1907, p. 461-462) showed 56.05 percent metallic iron. This mine was not located during mapping. The iron mineralization may have resulted from deposition of marcasite from waters covering the irregular surface of the Knox unconformity (Cooper and Diggs, 1953, p. 265-266).

Table 6.-Summary of soil types[1]

Soil Type	General Characteristics	General Location	Slope
Alleghany	Deep, well-drained loam, formed in old alluvial material	Terraces, footslopes and alluvial fans	0-20 percent
Atkins	Deep, poorly drained silt loam to silty clay loam, formed in alluvial material	Flood plains	0-3 percent
Braddock	Deep, well-drained loam to clay loam, formed in colluvial material or old alluvium; often very stony loam surface layer	Footslopes, fans, and terraces	0-30 percent
Clarksville	Deep, very cherty, somewhat excessively drained silt loam to silty clay loam	Steep side slopes and narrow ridge tops; most areas in timber, pasture, or hay	2-60 percent
Dandridge	Shallow, excessively drained silty clay loam to silty clay with abundant shale chips	Uplands underlain by calcareous shale	10-50 percent
Frederick	Deep, well-drained silt loam to silt clay, formed in residuum	Uplands underlain by dolomitic limestone	2-60 percent
Greendale	Deep well-drained silt loam	Narrow strips along drainage ways, on bottomlands, and in depressions	0-6 percent
Hagerstown	Deep well-drained silt loam to clay; limestone outcrops common with sinkholes in places	Uplands underlain by fairly pure limestone	0-45 percent Usually 15 percent
Jefferson	Deep well-drained gravelly loam, formed in colluvial material	Uplands	2-65 percent
Ramsey	Shallow, somewhat excessively drained loam	Hills and mountains	10-70 percent
Tellico	Shallow to deep, well-drained very fine sandy loam with distinctive reddish brown color	Ridge slopes	10-60 percent
Westmoreland	Shallow to deep, well-drained silt loam to very stony silt loam to shaly silt loam	Uplands underlain by shale, siltstone, sandstone, limestone	0-50 percent
Wheeling	Deep, well-drained silt loam to very gravelly sandy loam, formed in loamy alluvial material overlying gravelly material	Terraces	0-30 percent

[1]Compiled from data supplied by U.S. Soil Conservation Service

ENVIRONMENTAL GEOLOGY

In this section data on slopes, soils, physical and chemical properties of bedrock, fault zones, karst areas, alluvial and colluvial deposits, and disturbed lands are analyzed to aid in land-use planning.[1] Slopes are defined as follows: *nearly level,* grades less than 3 percent; *gently sloping,* grades 3 to 7 percent; *sloping,* grades 7 to 15 percent; *moderately sloping,* grades 15 to 25 percent; *steep,* grades 25 to 35 percent; and *very steep,* grades of more than 35 percent. Thicknesses of soils (defined as the lower limit of root penetration) and residuum (the weathered material between the soil and bedrock) are based on observations made in the field and from Soil Conservation Service data. General terms for soil depths and depth limits are: *shallow,* less than 20 inches; *moderately deep,* 20 to 40 inches; *deep,* greater than 40 inches. The general characteristics of the soil types of the area are summarized in Table 6. Additional information concerning the soils and interpretations for specific uses can be obtained from the local U.S. Soil Conservation Service office.

Environmental units 1 through 10 were established on the bases of geology and topography. Unit 11 is land disturbed by man. While data presented here should be of value to planners and developers, *suitability of individual sites should be evaluated by professional geologists.*

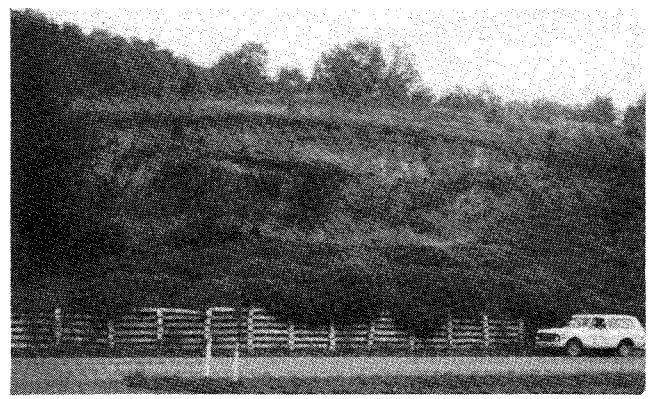
UNIT 1

This generalized unit is underlain chiefly by dolomitic rocks of the Honaker and Copper Ridge formations, and the Knox Group, upper part (Plates 1 and 2). The Lenoir-Mosheim limestones are included in unit 1 because they are stratigraphically near the other formations and because they are thin; for similar reasons, the thin Chepultepec limestone on Walker Mountain is included with unit 1. There are chert interbeds in the dolomites and chert float is common in the soil formed on the unit and on the formation surfaces. The area underlain by the Copper Ridge, which is confined to the southeast slope of Walker Mountain, has large amounts of sandstone fragments in the soil and on the surface.

Most of the Walker Mountain portion of this unit is covered by Frederick and Clarksville soils. These are cherty silt loams that possess moderate to rather high natural fertility, but steep slopes, poor drainage, or abundant chert and sandstone debris often restrict the use of these soils to pasture or forestry.

South of Walker Mountain, unit 1 is underlain by a higher percentage of limestone and the topography is more gently rolling than to the north. The broad, well-drained valleys are covered primarily by deep Frederick and Clarksville soils. These soils are well drained, yet their physical properties enable them to retain sufficient moisture for plant growth. Where slope does not exceed 15 percent, these soils form the most productive croplands in the area; corn is the most abundant product. On moderate to steep slopes, both the Frederick and Clarksville soils are well suited for pasturage and forest.

All of the soils in unit 1 vary in thickness because of pinnacle weathering of the dolomite and limestone bedrock and they are generally thinner on steeper slopes. The presence of chert fragments in the subsoil, especially in the Clarksville, increases the internal porosity. Where chert fragments are not abundant, water percolation rates may be low. The loams exhibit moderate to high shrink-swell and form a slippery, adhesive mud when wet. Bedrock outcrops are sparse over much of the area. Small sinkholes are common in unit 1, especially in the Lenoir-Mosheim, but generally do not impair agricultural use; however, waste disposal and industrial sites must be carefully studied and engineered to avoid problems (see karst unit and unit 11). Building sites are abundant but moderate to high shrink-swell potentials of the subsoil should be considered when planning for basements. Moderate creep rates should be expected after excavations on steep slopes, such as along U.S. Highway 19-58A north of Butts (Figure 16). Mass wasting at this site was augmented by a combination of conditions including a steep slope, a deeply weathered zone of carbonate rocks, and a zone of little-permeable shales underlying the carbonates.



16. Large recurring slump in soils over the dolomite bedrock of the Copper Ridge Formation seen on the east side of U.S. Highway 19-58A about 0.7 mile (1.1 km) south of Greendale (Plate 2).

UNIT 2

This unit consists of Nolichucky, Conococheague and Chepultepec limestones (Plates 1 and 2). Minor sandstone lenses occur in the Conococheague and chert, as individual

[1]Additional data concerning soils, water, regional planning, and forestry may be obtained from the following agencies: (1) Soil Conservation Service, U.S. Department of Agriculture, P.O. Box 10026, Richmond, VA 23240; (2) State Water Control Board, Abingdon, VA 23230; (3) Mount Rogers Planning District, 1021 Terrace Drive, Marion, VA 24254; (4) Virginia Division of Forestry, P.O. Box 3758, Charlottesville, VA 22903.

ENVIRONMENTAL GEOLOGY

In this section data on slopes, soils, physical and chemical properties of bedrock, fault zones, karst areas, alluvial and colluvial deposits, and disturbed lands are analyzed to aid in land-use planning.[1] Slopes are defined as follows: *nearly level,* grades less than 3 percent; *gently sloping,* grades 3 to 7 percent; *sloping,* grades 7 to 15 percent; *moderately sloping,* grades 15 to 25 percent; *steep,* grades 25 to 35 percent; and *very steep,* grades of more than 35 percent. Thicknesses of soils (defined as the lower limit of root penetration) and residuum (the weathered material between the soil and bedrock) are based on observations made in the field and from Soil Conservation Service data. General terms for soil depths and depth limits are: *shallow,* less than 20 inches; *moderately deep,* 20 to 40 inches; *deep,* greater than 40 inches. The general characteristics of the soil types of the area are summarized in Table 6. Additional information concerning the soils and interpretations for specific uses can be obtained from the local U.S. Soil Conservation Service office.

Environmental units 1 through 10 were established on the bases of geology and topography. Unit 11 is land disturbed by man. While data presented here should be of value to planners and developers, *suitability of individual sites should be evaluated by professional geologists.*

UNIT 1

This generalized unit is underlain chiefly by dolomitic rocks of the Honaker and Copper Ridge formations, and the Knox Group, upper part (Plates 1 and 2). The Lenoir-Mosheim limestones are included in unit 1 because they are stratigraphically near the other formations and because they are thin; for similar reasons, the thin Chepultepec limestone on Walker Mountain is included with unit 1. There are chert interbeds in the dolomites and chert float is common in the soil formed on the unit and on the formation surfaces. The area underlain by the Copper Ridge, which is confined to the southeast slope of Walker Mountain, has large amounts of sandstone fragments in the soil and on the surface.

Most of the Walker Mountain portion of this unit is covered by Frederick and Clarksville soils. These are cherty silt loams that possess moderate to rather high natural fertility, but steep slopes, poor drainage, or abundant chert and sandstone debris often restrict the use of these soils to pasture or forestry.

South of Walker Mountain, unit 1 is underlain by a higher percentage of limestone and the topography is more gently rolling than to the north. The broad, well-drained valleys are covered primarily by deep Frederick and Clarksville soils. These soils are well drained, yet their physical properties enable them to retain sufficient moisture for plant growth. Where slope does not exceed 15 percent, these soils form the most productive croplands in the area; corn is the most abundant product. On moderate to steep slopes, both the Frederick and Clarksville soils are well suited for pasturage and forest.

All of the soils in unit 1 vary in thickness because of pinnacle weathering of the dolomite and limestone bedrock and they are generally thinner on steeper slopes. The presence of chert fragments in the subsoil, especially in the Clarksville, increases the internal porosity. Where chert fragments are not abundant, water percolation rates may be low. The loams exhibit moderate to high shrink-swell and form a slippery, adhesive mud when wet. Bedrock outcrops are sparse over much of the area. Small sinkholes are common in unit 1, especially in the Lenoir-Mosheim, but generally do not impair agricultural use; however, waste disposal and industrial sites must be carefully studied and engineered to avoid problems (see karst unit and unit 11). Building sites are abundant but moderate to high shrink-swell potentials of the subsoil should be considered when planning for basements. Moderate creep rates should be expected after excavations on steep slopes, such as along U.S. Highway 19-58A north of Butts (Figure 16). Mass wasting at this site was augmented by a combination of conditions including a steep slope, a deeply weathered zone of carbonate rocks, and a zone of little-permeable shales underlying the carbonates.

16. Large recurring slump in soils over the dolomite bedrock of the Copper Ridge Formation seen on the east side of U.S. Highway 19-58A about 0.7 mile (1.1 km) south of Greendale (Plate 2).

UNIT 2

This unit consists of Nolichucky, Conococheague and Chepultepec limestones (Plates 1 and 2). Minor sandstone lenses occur in the Conococheague and chert, as individual

[1]Additional data concerning soils, water, regional planning, and forestry may be obtained from the following agencies: (1) Soil Conservation Service, U.S. Department of Agriculture, P.O. Box 10026, Richmond, VA 23240; (2) State Water Control Board, Abingdon, VA 23230; (3) Mount Rogers Planning District, 1021 Terrace Drive, Marion, VA 24254; (4) Virginia Division of Forestry, P.O. Box 3758, Charlottesville, VA 22903.

nodules, is common in the Conococheague and Chepultepec. The bedrock-residuum-soil interfaces are irregular over short distances due to pinnacle weathering of the bedrock; surface outcrops are common, generally as extensive ledges. Tests for depth to bedrock must be closely spaced to make accurate determinations.

Most of unit 2 is covered by the Frederick and Hagerstown soils. These are very fertile and well-drained soils and provide rich farmlands. Much of the topography is nearly level to gently rolling and it is ideal for cultivation, except at rock outcrops or deep sinkholes. Unit 2 has the majority of deep sinkholes mapped (see karst unit), and where these occur in abundance, land is used as pasture. High shrink-swell clay and sticky mud are undesirable features of these soils. Because of steep slopes and numerous rock fragments, some areas underlain by the Conococheague are used as pastures, orchards or woodlands.

UNIT 3

The range of rugged knobs southeast of Rich Valley, near Countiss Ridge, and in outcrop belts locally bordering the Pulaski fault trace are underlain by shales, calcareous shales, and platy limestones of the Nolichucky, which constitute Unit 3 (Plate 2). The soil is very shallow and is composed primarily of Westmoreland silt loam, a well-drained soil containing abundant small fragments of shale. Slopes are steep to very steep and, because the land is subject to severe erosion on unprotected slopes, the area is best suited for forests. The most gentle slopes are suitable for pastures.

UNIT 4

The series of rugged low ridges south of U.S. Highway 58 (Plates 1, 2) are underlain by shales, siltstones, and sandstones of the Athens Formation and are perhaps the most striking topographic feature in the area. These ridges, the Great Knobs, the River Knobs-McConnell Ridge, and the Knobs at South Holston Lake, trend northeast-southwest. These areas, together with other, smaller ones underlain by the Athens, make up unit 4. The dominant soil is the Dandridge silt loam, which is clayey, very shallow, and contains a high percentage of shale fragments. Slopes are generally steep to very steep and erosion is severe where the soils are unprotected. Minor sliding and sloughing are common where dip parallels slope; artificial cuts must be properly engineered to avoid rapid mass wasting. While the shale has potential value as fill material, the unit is probably best suited for woodland. Properly prepared building sites on gentle slopes may be used for individual homes, but the shallowness of the soil imposes limitations in waste disposal.

UNIT 5

The Mississippian Cove Creek, Fido, Gasper, and Ste. Genevieve formations (Plate 2) compose the bedrock underlying this unit. The Fido is a maroon, calcareous sandstone, while the other formations are predominantly argillaceous limestones. The Fido is covered mainly by a soil equivalent to the Tellico, a very fine sandy loam, which is well drained and easily cultivated and has a distinctive reddish-brown color. Steep slopes and thin soil limit the Fido to pastureland, but gentler slopes are used for field crops. The three limestone formations of this unit are covered by the Dandridge, Ramsey, and Westmoreland soils. These are typically shallow with mostly steep slopes, making pasture or woodland the most suitable use. Where slopes are gentle, field crops are produced. Erosion is severe on unprotected slopes. Dandridge soils are clay-rich and subject to slump. The Gasper limestone has several karst areas (see karst unit). Building sites are generally stable but karst areas should be avoided. Only areas of Fido Sandstone are suitable for waste disposal and this is conditionally based on adequate soil depth.

UNIT 6

The interbedded calcareous shales, siltstones, sandstones and minor argillaceous limestones of the Pennington Formation (Plate 2) underlie unit 6. These rocks form shallow to very shallow soils which erode easily if unprotected. Dandridge silt loams are the dominant soils, and many shale and small sandstone fragments are scattered in the subsoil. Slopes are steep to very steep and tend to slide when disturbed. The steepness of the terrain limits use mostly to forestry.

UNIT 7

The zones of possible weakness along fault traces and associated brecciated beds (indicated as "b" on Plates 1 and 2) making up this unit present a unique set of environmental characteristics. These zones cross more than one geologic (as well as environmental) unit and include a wide variety of environmental properties. On-site investigations should be made to determine soil characteristics.

Structures and excavations in incompetent shales and siltstones should be carefully engineered to avoid slump or slide caused by the release of compressional stress associated with faulting.

Carbonate bedrock is generally much more brittle than shale and tends to break, shatter, and fracture. Some breaks may be recemented by minerals deposited from groundwater making them more resistant to weathering than the original bedrock. Where the fractured bedrock is not recemented, it may undergo further dissolution, resulting in karst features. Lake reservoirs located on fault zones may

not hold water because the fractures in the bedrock afford easy escape of the surface waters into the groundwater system. Springs are very common along fault zones due to fractures in the bedrock.

Load-bearing strengths are frequently reduced in rocks affected by fault activity and large projects may require special engineering to avoid foundation failure caused by settling. Strong earthquakes may produce new motion along faults.

UNIT 8

Unit 8 consists of areas mapped as colluvium and also those areas which border the colluvium. These border areas are not totally covered by colluvial material and often have bedrock exposed. This environmental unit cuts sharply across formational boundaries and is shown as a dashed line on Plate 1. The colluvium thickness ranges from greater than 25 feet (8 m) near the foot of the mountains to one boulder thick farther away from them. The rock content of the colluvium is in the range from approximately 5 to 90 percent and consists of angular to subrounded, sandstone and quartzite cobbles and boulders. Most of the bedrock covered by the colluvium is carbonate. Slopes range from gently rolling to steep; soil types include the Jefferson and the Frederick.

The colluvial material is pervious, but clay soil developed on the underlying carbonate bedrock may inhibit downward, and increase lateral, water movement. Thus excavation on moderate to steep slopes is likely to produce slump. Under normal conditions the materials may be expected to slowly creep downslope.

Areas of thick colluvium are best suited for woodland; areas with moderate thickness could be used for pasture. Slopes of less than 15 percent are suited for farm crops.

UNIT 9

Terrace deposits (Unit 9) along the South Fork and Middle Fork of the Holston River are generally less than 10 feet (3 m) thick and consist of sand, silt, and clay, and waterworn fragments of sandstone and quartzite. The dominant soils are the Braddock clay and the Allegheny and Wheeling loams. All are deep, easy to cultivate, and well drained. Much of the terrace land has a gently sloping to sloping character and is very valuable for field crops; the steeper areas are in pasture. Rounded gravels and boulders are scattered on the surface and in the soil. Along the shore of South Holston Lake, the matrix soil material has been removed, leaving free-standing sandstone boulders which could be of minor value as construction material. Building sites, especially along the lake, are generally good and stand above the common flood levels. The terraces are not suitable for solid and liquid waste disposal facilities because rapid flow through the coarse deposits would cause pollution of the South Holston Lake reservoir.

UNIT 10

Low-level floodplain deposits (alluvium) have been mapped as this unit along the South Fork and Middle Fork Holston River as well as along many of the other streams, but only the most extensive areas were mapped. Floodplains may be swampy, and the certainty of periodic flooding makes them unfit for building or waste disposal sites. Along the South Fork and Middle Fork of the Holston River, loam is the most common soil. Because the soil is well drained, almost level, and easy to work, it makes important cropland.

The primary soil types on the floodplains along small streams in valleys underlain by carbonates are the Greendale, Allegheny and Atkins silt loams which were formed from deposits of fine soil material washed from nearby slopes. The smaller streams and also those which head in unit 4 have floodplains covered mostly with Atkins silty clay loam. Because of an almost impervious subsoil, the Atkins is poorly drained and probably best suited for pasture. Many of the larger streams have floodplains covered by Greendale soils. The Greendale and Allegheny are very fertile and well drained and produce high crop yield. Soil is generally less than five feet (1.5 m) deep and is largely free of gravels, except along Rockhouse Run and Cox Mill Creek. These creeks are partially filled with sandstone gravels and boulders washed from adjacent, colluvium-covered slopes.

UNIT 11

This unit includes disturbed land, those portions of the landscape which have been significantly altered by the activities of man. Landfill sites, earthen dams and associated lakes, quarries, fills, and large industrial parks are the primary examples of disturbed land. But it must be pointed out that urban areas with their residential developments, shopping centers, and main business districts and major roads show the greatest effects of man's use of the land. Major problems and expense may result from restricting groundwater flow and recharge, activating slide-prone areas, and increasing the risk of pollution. Foundation cracking or collapse can result from inadequate consideration of natural or man-generated hazards.

UNIT 12

Karst topography, sinkholes, sinking creeks, and caves are common in units 1 and 2, and less common in unit 5; small sinkholes also occur along the fracture zones of unit 7. Many of the larger solution features, located in the field and on aerial photographs, have been delineated on Plates 1 and 2. Such areas have underground solution networks resulting

in great potential for groundwater pollution. These networks do not filter out pollutants, and hence areas with carbonate bedrock and shallow soil may undergo severe groundwater contamination. Sources of contamination are septic tank fields and other waste disposal sites. Areas with underground solution networks should only be used for low-density land development and waste disposal should be by sewer lines instead of septic tanks (Washington County Planning Commission, 1974, p. 4, 5).

Even small sinkholes are indicative of subsurface solution and potential settling or collapse of the surface. For this reason, areas with known sinkholes are severely limited as sites for buildings or structures requiring high load-bearing strength of bedrock. Sinkholes provide a primary conduit for groundwater recharge and serve as openings to natural storm sewers in areas underlain by carbonate bedrock. Any activity which interfers with recharge, such as a large paved parking lot, could cause a change in the water table and could cause local flooding during heavy rains.

Caves and sinking creeks (Figure 13) accompany considerable subsurface solution activity and commonly occur in sinkholes. Caves and caverns may benefit a community by providing underground storage facilities, potential sources of revenue through commercial or recreational development, and civil defense shelters (see Douglas, 1964 and Holsinger, 1975). Springs are common and constitute an important source of water in the mapped area; individual farms, industries, and the town of Abingdon obtain water from natural springs.

Stream divides are useful in delineating watersheds for planning water and sewer systems and flood control projects. Some interesting geologic features are indicated from a study of these drainage divides. For example, divides may lie at the crest of anticlines even though these crests may be in broad valleys, as in Watauga Valley. Thus, original structural control is reflected by the divides.

EXAMPLES OF FAILED PROJECTS

Geologic factors must be considered in modifying natural lands. Otherwise, projects may fail to function as designed. Beaver Creek Lake in the Wyndale quadrangle (Plate 2) was built to control flooding in the Beaver Creek drainage basin as well as to provide a public recreation facility. The dam site and reservoir were located on limestone. The clay topsoil, which could have sealed the reservoir bed, was used to build the earthen dam. Following construction, dammed waters escaped via the jointed limestone bedrock. Another example of a construction problem is the Abingdon sewage lagoon located just west of Wolf Creek on the northwest flank of the Great Knobs (Plate 1). The bedrock is Knox Group, upper part, a well-jointed, predominantly carbonate rock unit. Construction was similar to that at Beaver Creek and the project failed.

REFERENCES

Averitt, Paul, 1941, The Early Grove gas field, Scott and Washington counties, Virginia: Virginia Geol. Survey Bull. 56, 50 p.

Bartlett, C. S., Jr. and Webb, H. W., 1971, Geology of the Bristol and Wallace quadrangles, Virginia: Virginia Division of Mineral Resources, Rept. of Inv. 25, 93 p.

Berryhill, H. L., Jr. 1949, Stratigraphy and structure of Wyndale quadrangle, Washington County, Virginia: Unpublished M.S. thesis, University of North Carolina, 62 p.

Billings, M. P., 1972, Structural geology: Englewood Cliffs, New Jersey, Prentice-Hall, Inc., 606 p.

Butts, Charles, 1933, Geologic map of the Appalachian Valley in Virginia: Virginia Geol. Survey Bull. 42, 56 p.

_____, 1940-41, Geology of the Appalachian Valley in Virginia: Virginia Geol. Survey Bull. 52, pt. 1 (geologic text), 568 p.; pt. 2 (fossil plates), 271 p.

Campbell, M. R., 1899, Description of the Bristol quadrangle (Virginia-Tennessee): U.S. Geol. Survey Geol. Atlas, Folio 59, 8 p.

Cooper, B. N., and Diggs, W. E., 1953, Geology of the iron deposits at the Riverside mine near Alvarado, Washington County, Virginia (abs.): Virginia Jour. Science, vol. 4, no. 4, p. 265-266.

Douglas, H. H., 1964, Caves of Virginia: Falls Church, Virginia, Virginia Cave Survey, 761 p.

Edmundson, R. S., 1945, Industrial limestones and dolomites in Virginia; northern and central part of the Shenandoah Valley: Virginia Geol. Survey Bull. 65, 195 p.

Harris, L. D., 1960, Drowned valley topography at beginning of Middle Ordovician deposition in Southwest Virginia and northern Tennessee: U.S. Geol. Survey Prof. Paper 400-B, p. B186-B189.

Holsinger, J. R., 1975, Description of Virginia caves: Virginia Division of Mineral Resources, Bull. 85, 450 p.

Johnson, S. S., Denny, M. V. and Le Van, D. C., 1966, Analysis of clay, shale and related minerals-southwestern counties: Virginia Division of Mineral Resources, Mineral Resources Rept. 6, 186 p.

Kellberg, J. M. and Grant, L. F., 1956, Coarse conglomerates of the Middle Ordovician in the southern Appalachian Valley: Geol. Soc. of America Bull., vol. 67, no. 6, p. 697-716.

King, P. B. and Ferguson, H. W., 1960, Geology of northeasternmost Tennessee: U.S. Geol. Survey, Prof. Paper 311, 136 p.

Leible, K. A., 1973, Paleotectonic significance of the Middle Ordovician polymictic conglomerates at Avens Ford, Virginia and South Holston Dam, Tennessee (abs): Geol. Soc. of America Abs., vol. 5, no. 5, p. 412.

Napps, K. B., 1972, Traditional pottery in Washington County, Virginia and Sullivan County, Tennessee, *in* Publications: The Historical Society of Washington County, Virginia, series II, no. 10, p. 3-16.

Nicholas, R. L., 1956, Petrology of the arenaceous beds in the Conococheague Formation (late Cambrian) in the northern Appalachian Valley of Virginia: Jour. Sed. Petrology, vol. 26, no. 1, p. 3-14.

O'Neill, B. J., Jr., 1964, Atlas of Pennsylvania's mineral resources — pt. 1, Limestones and dolomites of Pennsylvania: Pennsyvlania Geol. Survey, 4th Ser., Bull. M50, 40 p.

Parrott, W. T., 1954, Physical test results of the Virginia highway statewide aggregate survey: Virginia Department of Highways, 68 p.

Rodgers, John, 1953, Geologic map of East Tennessee with explanatory text: Tennessee Division of Geology Bull. 58, pt 2., 168 p.

Shimer, H. W. and Shrock, R. R., 1944, Index fossils of North America: New York, John Wiley and Sons, 837 p.

Sweet, P. C., 1976, Clay-material resources in Virginia: Virginia Division of Mineral Resources, Mineral Resources Rept. 13, 56 p.

Tennessee Division of Geology, 1966, Geologic map of Tennessee.

Tyler, J. H., 1960, Geology and mineral resources of the Abingdon area Washington County, Virginia: Unpublished M.S. Thesis, Virginia Polytech. Inst., 120 p.

Virginia Division of Mineral Resources, 1963, Geologic map of Virginia.

Washington County Planning Commission, 1974, Comprehensive land use plan Washington County, Virginia: unpublished draft copy.

Watson, T. L., 1907, The mineral resources of Virginia: Lynchburg, Virginia, J. P. Bell Co., 618 p.

Withington, C. F., 1965, Suggestions for prospecting for evaporate deposits in southwestern Virginia: U.S. Geol. Survey Prof. Paper 525-B, p. B29-B33.

APPENDIX

STRATIGRAPHIC SECTIONS

Section A; Plate 2: Garrett Creek

Measured in and adjacent to Garrett Creek from 100 yards (91.5 meters) northeast of intersection of State roads 611 and 700 through Black Hollow to about 500 feet (152.5 meters) south of intersection of State roads 611 and 633; strike averages N60°E, dips range 26° to 32° southeast.

	Thickness in feet	*(meters)*
Lenoir Limestone (52 ft.) (15.9 m)		
78 Limestone, argillaceous, medium-gray, fine-grained numerous calcite-filled fractures, contains small crinoids, brachiopods, and rarely gastropods	52.0	(15.9)
Knox Group, upper part (1255.2 ft.) (382.8 m)		
77 Covered, possibly Knox dolomite	121.0	(36.9)
76 Dolomite, light-gray to medium-light-gray, micrograined, medium-bedded, contains some white dolomite crystal clusters	82.5	(25.2)
75 Covered	451.2	(137.6)
74 Dolomite, very light-gray, very fine-grained, weathers yellow-gray. Interbedded with medium-light-gray, medium-coarse-grained dolomite, specks of chert	16.5	(5.0)
73 Limestone, medium-light-gray, micrograined crinkly laminations, fossiliferous, *?Ceratopea,* crinoids; some dolomite interbeds medium-light-gray, coarse-grained	35.0	(10.7)
72 Dolomite, medium-light-gray, micrograined in part, weathers to very light-gray with some coarse-grained dolomite in upper part; chert, blocky, medium-bluish-gray to light-gray, some with rhomb-shaped voids	38.5	(11.7)
71 Covered	22.0	(6.7)
70 Dolomite, light-gray, micrograined to very fine-grained; 33 feet (10 meters) above base 5 feet (1.5 meters) of dolomite very light-gray, medium- to coarse-grained; white massive chert with rhomb-shaped voids just below top of unit, partly covered	71.5	(21.8)
69 Covered	11.0	(3.4)
68 Dolomite, medium- to light-gray, very fine- to medium-grained, finer grained dolomite weathers to very light-gray, contains some white chert with rhomb-shaped voids and iron stain in fractures	38.5	(11.7)
67 Covered, abundant chert with rhomb-shaped voids and with iron staining	148.5	(45.3)
66 Interbedded limestone, medium-gray, micrograined, laminated, conchoidal fracture, questionable gastropods and worm borings, and dolomite, light-gray, fine-grained; much chert float	38.5	(11.7)
65 Dolomite, medium-light-gray to light-gray, very fine- to medium-grained, laminated; some chert layers, light-gray, blocky	44.0	(13.4)
64 Interbedded limestone, medium-dark-gray, micro to very fine-grained, conchoidal fracture, irregular laminations, some pebbly conglomerate and worm trails; and calcareous dolomite, medium-light-gray, micro to very fine-grained, clusters of white dolomite crystals, generally thin-bedded. Limestone pebble conglomerate at top	65.0	(19.8)
63 Covered	71.5	(21.8)
Chepultepec limestone (77 ft.) (23.5 m)		
62 Limestone, medium-dark-gray to medium-gray, micro to very fine-grained, some white calcite crystal clusters, worm-tracks, fossil "hash", gastropods, flat-pebble conglomerate. Two feet (0.6 meter) of dolomite, medium-gray, very fine-grained, about 15 feet (4.6 meters) above base. Base composed of one foot (0.3 meter) of sandy dolomite	77.0	(23.5)
Copper Ridge Formation (1323.4 ft.) (403.6 m)		
61 Three feet (0.9 meter) of sandstone at top, light-gray when fresh, weathers yellowish-gray, fine- to medium-grained, subrounded, dense, slightly		

	Thickness in feet (meters)	
calcareous. Interbedded limestones, medium-light-gray, micrograined, conchoidal fracture, very thin clay and silty laminations, rare fossil fragments of brachiopods and gastropods; and dolomite, medium-gray to medium-light-gray, very fine-grained, partly sandy, some dolomite crystal clusters	38.5	(11.7)
60 Dolomite, medium-light-gray to light-gray with some pinkish tint, very fine- to coarse-grained, some with floating sand grains; chert nodules, light-gray, blocky in upper part	52.0	(15.9)
59 Dolomite, light-gray to very light-gray, medium- to coarse-grained	44.0	(13.4)
58 Dolomite, medium-gray to very light-gray micro to very fine-grained, streaks with floating sand grains, and two layers of dolomitic sandstone, light-gray, fine- to medium-grained, subrounded; 3 inches (7.6 cm) sandstone 46 feet (14 meters) above base, and 5 inches (12.7 cm) dolomitic sandstone 71 feet (21.7 meters) above base	99.0	(30.2)
57 Covered	4.0	(1.2)
56 Sandstone, light-gray, weathers grayish-orange, fine- to coarse-grained, poorly-sorted, subrounded, dense when fresh, friable when weathered	1.5	(0.5)
55 Dolomite, medium-light-gray, very fine- to medium-grained, coarser grained in upper part	36.0	(11.0)
54 Covered	4.5	(1.4)
53 Limestone, medium-light-gray to medium-dark-gray, micro to very fine-grained, some with very small calcite bird's-eyes, fossil fragments of brachiopods and ostracodes, stylolites and pelletoidal layers	16.5	(5.0)
52 Covered	19.0	(5.7)
51 Limestone, medium-light-gray to dark-gray, micrograined, conchoidal fracture, rare fossil fragments, crinkly clay laminations; some dolomite, medium-dark-gray, very fine-grained	16.5	(5.0)
50 Dolomite, light- to medium-gray, micro to coarse-grained; some chert, medium-dark gray	38.5	(11.7)
49 Covered	11.0	(3.4)
48 Limestone, medium-gray, very fine- to fine-grained, thin pebble conglomerate near the base	6.0	(1.8)
47 Covered	11.0	(3.4)
46 Limestone, medium-dark-gray, micrograined, some pebble conglomerate	0.5	(0.2)
45 Covered	6.0	(1.8)
44 Limestone, medium-gray, micro to very fine-grained, some sand and some oolites, thin-bedded with chert nodules; 1 foot (0.3 meter) bed of dolomite, light-gray, very fine-grained, located 2 feet (0.6 meter) below the top of unit	23.0	(7.0)
43 Dolomite, medium-light-gray to medium-gray; 6 inches (15.2 cm) calcareous dolomite at base, dark-gray, fine-grained, laminated	3.0	(0.9)
42 Two feet (0.6 meter) of sandy limestone at base, medium-light-gray, medium- to coarse-grained, subrounded quartz grains, tabular crossbeds; three feet (0.9 meter) of oolitic limestone, medium-light-gray, well-rounded, coarse- to very coarse-ooids; five inches (12.7 cm) oolitic chert, medium-dark-gray, medium- to coarse- ooids. Some limestone pebble conglomerate, flattened, rounded pebbles to 18 mm	5.5	(1.7)
41 Limestone, medium-gray, very fine- to medium-grained, pelletoidal, stylolitic	4.0	(1.2)
40 (At Old Mill Dam): Limestone, light-gray, fine-grained, pelletoidal, thick-bedded	5.0	(1.5)
39 Sandstone, medium-gray, weathers grayish-orange, fine- to coarse-grained, subrounded, fair sorting, crossbedded, friable with some dolomite clasts near top	3.0	(0.9)
38 Dolomite, medium-light-gray, micro to fine-grained, streaks of floating sand grains, laminated, with butcher-block weathering. 6 inch (15.2 cm) layer of chert, light-gray, vuggy with white dolomite crystals. 6 inches (15.2 cm) of limestone, medium-light-gray, micrograined, with conchoidal fracture	47.0	(15.3)

	Thickness in feet (meters)	
37 Covered	38.5	(11.7)
36 Interbedded limestone, medium-dark-gray, micro to very fine-grained, gastropod fossils(?), pelletoidal, with chert nodules; limestone-pebble conglomerate with elongated pebbles up to 9 inches (22.9 cm) long, pebble limestone dark-gray, micrograined; and dolomite, medium-light-gray, very fine-grained	16.5	(5.0)
35 Dolomite, medium-light-gray, very fine-grained, 3 inch (7.6 cm) dolomite-pebble conglomerate (calcareous in part), pebbles weather to very light-gray, located 61.3 feet (18.7 meters) above the base; white chert nodules scattered through the unit	77.2	(23.5)
34 Limestone, medium-light-gray, micrograined, conchoidal fracture, weathers blue-gray, some white calcite crystal clusters	2.0	(0.6)
33 Dolomite, light-gray, medium-grained, some white dolomite crystal clusters	28.0	(8.5)
32 Covered	26.3	(8.5)
31 Dolomite, light-gray, to medium-light-gray, very fine- to medium-grained, some white dolomite crystal clusters	39.4	(12.0)
30 Covered	164.7	(50.2)
29 Dolomite, yellow-gray, coarse-grained, partly exposed in creek and along road	131.4	(40.1)
28 Covered	56.9	(17.4)
27 Dolomite, light-gray, micro to very fine-grained, and medium-gray, fine- to medium-grained	43.8	(13.4)
26 Covered, dolomite partially exposed in creek	81.0	(24.7)
25 Dolomite, medium-light-gray, micrograined, argillaceous, partly covered	65.7	(20.0)
24 Dolomite, sandy, light-gray, micrograined with streaks and scattered fine-grained rounded quartz, two 1 foot (0.3 meters) layers of sandstone, very pale orange, well-sorted, fine- to medium-grained, subrounded in part	8.0	(2.4)
23 Dolomite, light- to medium-gray, micrograined; slightly calcareous, lighter gray in upper part	49.0	(14.9)

	Thickness in feet (meters)	
Maynardville Limestone (71.96 ft.) (21.9 m)		
22 Limestone, medium-dark-gray to medium-gray, micrograined, dense, conchoidal fracture, crinkly silty laminations; 6 inch (15.2 cm) pebble conglomerate with rounded, medium-gray micrograined pebbles, some flattened in coarse-grained matrix	70.96	(21.6)
21 Sandstone, yellowish-gray, very fine-grained, argillaceous, subangular, very thin-bedded, with worm-like borings	1.0	(0.3)
Nolichucky Formation (451.45 ft.) (137.7 m)		
20 Limestone, medium-gray, micro to very fine-grained, with silty partings which weather grayish-orange, trilobites and ostracodes abundant in some layers; shale partings calcareous, light-olive-gray	63.95	(19.5)
19 Shale, light-olive-gray, fissile, cystoid plates, trilobites, including *Maryvillia* sp.; inarticulate brachiopods, including *Dicellomus appalachia,* abundant in thin layers; upper 1/3 of unit, shale, medium-gray silty, subfissile; two thin layers light-olive-gray, argillaceous, glauconitic, fossiliferous, trilobite fragments; glauconite grains are dark-greenish-gray, very fine- to very coarse-grained, rounded	86.3	(26.3)
18 Limestone, medium-gray, micrograined to medium-grained, some layers with oolites which weather light-brown and are coarse- to very coarse-grained, trilobite fragments; at least four, one foot (0.3 meter) layers of limestone, flat-pebble conglomerate, pebbles are micrograined, in oolite and fine-grained matrix	42.2	(12.9)
17 Shale, light-olive-gray, fissile, interbedded with limestone medium-light-gray, very fine-grained, thin-bedded, flat-pebble conglomerate present	14.1	(4.3)
16 Covered	29.1	(8.9)
15 Limestone, medium-light-gray, very fine- to coarse-grained, some bright-		

	Thickness in feet (meters)	
green glauconite, oolitic in part. Trilobite fossil fragments	23.5	(7.2)
14 Covered	18.3	(5.6)
13 Limestone, medium-gray and medium-light-gray, micrograined to fine-grained, irregular brown laminations, thick to medium beds, mostly thin-bedded in upper part; (partly covered)	174.0	(53.1)
Honaker Formation (926.6 ft.) (282.6 meters) (incomplete section)		
12 Dolomite, calcareous, medium-light-gray, very fine-grained, very thin-bedded	10.0	(3.1)
11 Dolomite, light-gray to medium-light-gray, micro to fine-grained thick- to medium-bedded, some vugs with dolomite crystals	61.0	(18.6)
10 Dolomite, light-gray, micro to fine-grained, medium- to thick-bedded, some layers vuggy	171.2	(52.2)
9 Covered	158.2	(48.3)
8 Dolomite, medium-light-gray, micro to fine-grained, some layers vuggy, streaks that are calcareous	56.8	(17.3)
7 Covered	46.9	(14.3)
6 Dolomite, medium-gray to medium-light-gray, very fine-grained crystalline, (partly covered)	130.9	(39.9)
5 Covered	55.0	(16.8)
4 Dolomite, medium-light-gray, micrograined, bedding thin to medium	33.0	(10.1)
3 Covered (across State Road 700)	66.0	(20.1)
2 Dolomite, medium-gray, very fine-grained, in part calcareous, medium-bedded	137.5	(41.9)
1 Covered, Saltville fault zone	34.2	(10.4)
Cove Creek Limestone	Not measured	

Section B; Plate 2: Tributary of Garrett Creek

Along west hill slope of Garrett Creek 1/2 mile (0.8 km) southeast of intersection of State Roads 611-633. Strike N60°E, dip 30° to 42° southeast.

	Thickness in feet (meters)	
3 Covered, probably fault zone		
Lenoir Limestone (159.5 ft.) (48.6 m)		
2 Limestone, medium-dark-gray, micrograined, partly argillaceous, wavy silty laminations, fossiliferous in some layers containing mainly small crinoids with some brachiopods, ostracodes, gastropods(?); calcite fracture filling	159.5	(48.6)
Knox Group, upper part (16.5 ft.) (5.0 m) (upper unit only)		
1 Dolomite, medium-light-gray, micrograined	16.5	(5.0)

Section C; Plate 2: Spring Creek

From beneath the high-tension power line crossing State Road 611 about 100 yards (9.15 meters) north of State Road 645 and measured along Spring Creek southward to the entrance ramp at Exit 6 of Interstate Highway 81. Dip of beds varies from near vertical to almost horizontal; generally the dip is SE and strike is N35°E.

	Thickness in feet (meters)	
Chepultepec limestone (745.2 ft.) (227.3 m) (top not exposed, partial thickness)		
68 Limestone, dark-gray, micrograined, some fossils embedded, mainly low-spired gastropods; interbedded with dolomite, calcareous, medium-gray, very fine-grained, medium-bedded; poorly exposed in Spring Creek between Interstate Highway 81 and U.S. 11 and behind service station	85.0	(25.9)
67 Covered (across U.S. Highway 11)	67.0	(20.4)
66 Limestone, medium-dark-gray, micrograined, thick-bedded, thin-laminated, at 32 to 35 feet (9.8 to 10.7 meters) above base is one bed of dolomite, medium-gray	63.5	(19.4)
65 Covered	21.1	(6.4)
64 Limestone, dark-gray, partly weathers very light-gray, micrograined, thick-bedded, partly thin-laminated; dolomite, medium-light-gray, at 29 to 31 feet (8.8 to 9.5 meters) above base and top 22 feet (6.7meters)	87.5	(26.7)
63 Chert, medium-dark-gray, algal banded spheres to 1.0 foot (0.3 meter) diameter	2.8	(0.9)

	Thickness in feet	(meters)
62 Dolomite, medium-dark-gray, micrograined, medium-bedded; with some limestone in middle part, medium-dark-gray, thin-laminated	5.7	(1.7)
61 Covered	25.6	(7.8)
60 Limestone, medium-dark-gray, micrograined, wavy argillaceous laminations, thick-bedded	5.7	(1.7)
59 Covered	5.5	(1.7)
58 Limestone, medium-dark-gray, micrograined, and medium-gray, very fine-grained, thin-laminated, thick-bedded	104.5	(31.9)
57 Covered	19.2	(5.9)
56 Limestone as unit 58	24.7	(7.5)
55 Limestone, medium-dark-gray, micrograined, lumpy, wavy bands in basal 3 feet (0.9 meter); at 3-5 feet (0.9-1.5 meters) above base is limestone, flat-pebble conglomerate in cross-bedded sandy limestone matrix, quarts grains medium- to coarse-grained, well-rounded; at 5-7 feet (1.5-2.1 meters) above base are two layers of dark-gray chert nodules, flattened, rounded and in irregular stringers	7.0	(2.1)
54 Dolomite, medium-gray, very fine-grained, dense, base transitional from unit 53 limestone	2.8	(1.0)
53 Limestone, medium-dark-gray, micrograined, medium-bedded, some streaks are sandy with scattered medium grains, well-rounded; some scattered chert nodules, dark-gray, at 10 feet (3.1 meters) above base is irregular lumpy layer of very porous siliceous material, very light-gray	12.0	(3.7)
52 Covered	4.0	(1.2)
51 Limestone, medium-gray and medium-dark-gray, micrograined, with raised bands, medium-bedded; some dark-gray chert nodules	10.0	(3.1)
50 Covered, abundant dark-gray chert float	4.5	(1.4)
49 Limestone, medium-dark-gray, micrograined, with sandy streaks and raised argillaceous bands; one thin layer of limestone-pebble conglomerate in sandy limestone matrix	11.0	(3.4)
48 Covered	5.5	(1.7)
47 Limestone, medium-dark-gray, micrograined, mostly with raised laminations; some dark-gray chert nodules	66.0	(20.1)
46 Covered	13.7	(4.2)
45 Limestone, medium-dark-gray, weathers to light-gray, micrograined, very thick- to medium-bedded, partly with raised laminations, partly thin-laminated, some dark-gray chert nodules, rare streaks of sandy limestone	52.2	(15.9)
44 Sandstone, medium-light-gray, weathers to pale-yellowish-brown, rounded grains, medium to very coarse; calcareous on fresh surface	0.2	(.06)
43 Limestone as unit 45, rare small algal-banded structures, worm borings, possible gastropods	38.5	(11.7)

	Thickness in feet	(meters)
Conococheague Formation (1697.7 ft.) (517.8 m)		
42 Covered	16.5	(5.0)
41 Limestone, medium-gray and medium-dark-gray, micrograined and very fine-grained, pelletoidal with coarse rounded-grains partly raised laminations; some sandstone float	60.5	(18.5)
40 Covered	16.5	(5.0)
39 Limestone, medium-dark-gray, micrograined, very thick-bedded, with raised bands, some small dark-gray chert nodules, algal mound structures, worm borings and trails	27.5	(8.4)
38 Covered, abundant sandstone float	195.5	(59.6)
37 Limestone, medium-dark-gray, micrograined, and medium- to medium-light-gray, very fine-grained, slightly argillaceous, partly laminated, partly with conchoidal break, some stylolites, some with sulfur odor on fresh break, trace of dark-gray chert nodules; several layers of limestone-pebble conglomerate; near top are some small fossil shell fragments of brachiopods and gastropods	159.5	(48.6)
36 Sandstone, weathered to grayish-orange fine- to medium-grained, low angle cross-bedding	3.0	(9.9)

	Thickness in feet	(meters)
35 Limestone, medium-gray, micrograined, raised laminations, thick-bedded	41.2	(12.6)
34 Sandstone, light-gray, weathers to grayish-orange, slightly calcareous, fine- to medium-grained	2.0	(0.6)
33 Limestone, as unit 33; few thin beds of dolomite, medium-light-gray, very fine-grained; rare chert nodules, medium-light-gray, granular	143.0	(43.6)
32 Covered	35.7	(10.9)
31 Limestone, medium-dark-gray, micrograined, with raised laminations; and limestone medium-light-gray, fine-grained, with some minor interbeds of dolomite, medium-light-gray and medium-bedded	92.5	(28.2)
30 Dolomite, medium-gray and medium-light-gray, very fine-grained, medium-bedded	78.0	(28.8)
29 Interbedded limestone and dolomite, medium- to thick-bedded. Limestone, medium-dark-gray, micrograined, partly with raised laminations and some medium-gray chert nodules; dolomite, medium-light-gray, very fine-grained	56.5	(17.2)
28 Dolomite, medium-light-gray, very fine-grained, medium-bedded	9.0	(2.7)
27 Covered	52.5	(16.0)
26 Dolomite, medium-light-gray, very fine- to fine-grained, laminated, medium-bedded	20.0	(6.1)
25 Covered, reddish-orange soil with much chert, yellowish-gray and light-gray, porous	132.4	(40.4)
24 Limestone, medium-gray, micrograined, partly with micrograined limestone pebbles in micrograined matrix, raised laminations, thick-bedded (at junction of State roads 611 and 886)	33.9	(10.3)
23 Covered	61.0	(18.6)
22 Limestone, medium-gray, micrograined, raised laminations and dolomite bands; some dolomite, medium-light-gray, very fine-grained, medium-bedded	42.6	(13.0)
21 Limestone, medium-gray, micrograined, worm trails, thick-bedded, minor dolomite, medium-light-gray, fine-grained	17.7	(5.4)
20 Covered	60.3	(18.4)
19 Limestone, medium-gray micrograined, thin-laminated, medium-bedded	5.0	(1.5)
18 Covered	99.7	(30.4)
17 Dolomite, medium-gray, micrograined and light-gray, very fine-grained, medium-bedded, weathers with "butcher-block" appearance; thin band of limestone 5 feet (1.5 meters) below top same as unit 19; and 1.0-foot- (0.3 meter)-thick bed of white chert at 1.5 feet (0.5 meter) below top of unit	33.4	(10.2)
16 Partly covered, some weathered sandstone, medium- to coarse-grained and shale, light-olive-gray	6.8	(2.1)
15 Dolomite, medium-light-gray, micrograined; and 1.0 foot (0.3 meter) bed of sandstone at top, weathered grayish-orange fine- to coarse-grained, rounded	4.0	(1.2)
14 Covered	15.0	(4.6)
13 Sandstone, weathered grayish-orange, fine- to medium-grained, thin-bedded	0.7	(0.2)
12 Dolomite, medium-dark-gray, very fine-grained	10.2	(3.1)
11 Sandstone as unit 13, medium-bedded	7.5	(2.9)
10 Interbedded limestone and dolomite, mostly dolomite in upper half. Limestone, medium-dark-gray, micrograined, some "bird's eye" crystal clusters, thick-bedded; dolomite, medium-gray and medium-light-gray, very fine-grained, partly sandy	19.1	(5.8)
9 Sandstone, medium-light-gray, weathers to dark-yellowish-brown, calcareous on fresh surface, medium- to coarse-grained	2.1	(0.6)
8 Limestone, medium-dark-gray, very fine-grained	8.9	(2.7)
7 Covered, sandstone float present	128.0	(39.0)
Nolichucky Formation (150 ft.) (45.6 m)		
6 Covered, in fields and along Norfolk and Western Railway. Thickness estimated from sections to the east and west in same strike belts	150.0	(45.6)
Honaker Formation (482.4 ft.) (147.1 m) (partial thickness)		
5 Covered, between the railroad and		

	Thickness in feet (meters)	
State Road 645 and by the road) ...	74.3	(22.7)
4 Dolomite, light-gray and very light-gray, very fine- to medium-grained, medium-bedded. Partly covered ...	40.0	(12.2)
3 Covered	132.4	(40.4)
2 Dolomite, medium-gray, fine-grained	7.5	(2.9)
1 Weathered clay, reddish-brown and orange; at 165 feet (50.3 meters) above base is 2 feet (.6 meter) thick bed of dolomite, medium-light-gray, micrograined	228.2	(69.6)

Measured Section D; Plate 2: Hickey Gap Road

In the first draw south of Hickey Gap Road (State Road 663), beginning about 0.15 miles (0.25 km) south of intersection with State Road 647. Strike N55°E, dip 10°SE to vertical.

	Thickness in feet (meters)	
Lenoir Limestone (105 ft. 32.1 m)		
23 Limestone, medium-dark-gray, some medium-gray, micrograined, conchoidal fracture, argillaceous, calcite crystalline clusters bird's-eyes, probable fossil fragments, some calcite fracture fillings	70.0	(21.4)
22 Limestone, medium-gray, micrograined, very argillaceous, weathers shaly, contains fragments of inarticulate brachiopods	35.0	(10.7)
Knox group, upper part (700.9 ft.) (214.5 m)		
21 Dolomite, medium- to medium-light-gray, micrograined	104.0	(31.7)
20 Covered	13.0	(4.0)
19 Interbedded limestone, medium-gray to light-gray to medium-light-gray, micrograined, weathers very light-gray; silty, wavy laminae; splotchy with fine-grained limestone interspersed; scattered specks of black material (asphalt?)	43.5	(13.3)
18 Limestone, light-gray to medium-gray, micro to very fine-grained, silty wavy laminae; interbedded, interfingered dolomite, light-gray, fine- to medium-grained	32.0	(9.8)
17 Dolomite, light-gray, fine- to coarse-grained with intergranular black specks (asphalt?), white calcite vug fillings; calcareous dolomite, medium-gray, very fine- to fine-grained; light-gray chert, conchoidal fracture; limestone, medium-light-gray, coarse-grained	22.0	(6.7)
16 Dolomite, medium-light-gray, medium- to coarse-grained; calcite-filled vugs, some very fine-grained, few intergranular black specks (asphalt?); also dolomite, light-gray, micrograined	49.5	(15.1)
15 Limestone, medium-gray, micrograined, scattered white bird's eyes, in part slightly argillaceous	7.5	(2.9)
14 Dolomite, medium-light-gray, very fine- to medium-grained; limestone, medium-light-gray, coarse-grained pebbles in micrite matrix, splotchy .	29.3	(8.9)
13 Covered	62.0	(18.9)
12 Dolomite, light-gray, micro- to very fine- to coarse-grained; mineralization: iron oxide, pyrite(?) (weathered; sparse fine specks)	6.0	(1.8)
11 Covered	40.0	(12.2)
10 Dolomite, light-gray, very fine- to coarse-grained	7.0	(2.1)
9 Covered	42.8	(13.1)
8 Dolomite, very sandy, light-gray, very fine-grained; quartz grains, clear, fine- to medium-grained, well-rounded	2.5	(0.8)
7 Covered	61.0	(18.6)
6 Dolomite, light-gray, fine- to medium-grained, mineralization (weathered iron oxide)	1.2	(0.4)
5 Dolomite, light-gray, micro to very coarse-grained, rare occurrences of floating fine- to medium-grained, rounded sand grains; chert medium-dark-gray, dolomite molds scattered; white crystalline calcite layers	9.9	(28.0)
4 Covered	82.2	(25.1)
3 Dolomite, medium-gray, fine-grained, white calcite fracture filling	2.5	(0.8)
2 Covered	1.0	(0.3)
Chepultepec limestone (incomplete)		
1 Limestone, medium-dark-gray, very fine- to micrograined	9.4	(2.9)

Section E; Plate 1: Crooked Branch

Section from approximately 1000 feet (305 meters) south of State Road 706 at a small borrow pit in shale on the east side of Crooked Branch northward on slopes adjacent to this creek to a point 800 feet (244 meters) north of State Road 705 at the axial trace of the anticline in Watauga Valley. Dip of beds varies from 80 degrees at the top of the section to 12 degrees near the anticlinal axis. Dip direction is southeast and the strike average is N55°E.

	Thickness in feet	(meters)
Athens Formation (Partial thickness 230 ft.) (70.15 m)		
31 Shale, olive-gray, very thin-bedded, partly calcareous, slightly silty; pencil shale has silt-size muscovite; streaks of silty sandstones, yellowish-brown, very fine-grained, subangular, feldspathic, fair porosity	60.0	(18.3)
30 Shale, medium-dark-gray to dark-gray which weathers to light purplish-gray, slightly silty; graptolites *Nemagraptus* sp. and *Climacograptus* sp. abundant	170.0	(51.9)
Lenoir Formation (18.8 ft.) (5.7 m)		
29 Limestone, medium-gray to medium-dark-gray, very fine-grained, argillaceous; bedding thick but weathers thin or lumpy; scattered calcite crystal fragments of echinoderms and other fossil fragments	8.8	(5.7)
Mosheim Formation (18.1 ft.) (5.5 m)		
28 Limestone, medium-gray to medium-light-gray, very fine- to medium-grained, thick-bedded, with calcite crystal bird's-eyes, partly micrite with conchoidal fracture; abundant fossil fragments; scattered dolomite clasts up to 15 inches (38.1 cm) long, 4 inches (10.2 cm) wide in lower part .	18.1	(5.5)
(Note: The unconformity at the Mosheim-Knox Group, upper part boundary is also shown by the lateral thinning of the Lenoir-Mosheim).		
Knox Group, upper part (652.6 ft.) (199.0 m)		
27 Interbedded limestone and dolomite: Dolomite, light-gray, very fine- to medium-grained, mostly calcareous, thick-bedded with butcher-block weathering on bedding surfaces; occasional bedded or nodular chert, medium-light-gray to medium-gray, chalcedonic with conchoidal fracture; limestone, medium-light-gray, micrite, with crinkly silt laminations and conchoidal fracture	162.5	(49.6)
26 Limestone, medium-light-gray, micrite, conchoidal fracture, with crinkly silt laminations disrupted by worm borings, abundant fossil shell fragments; occasional thin beds of dolomite, light-gray, medium-grained, calcareous	72.9	(22.2)
25 Dolomite, medium-light-to very light-gray, micro to coarse-grained, part with silty laminae, coarser layers slightly calcareous; chert nodules, medium-light-gray and pale-orange, partly oolitic, medium-grained, well-rounded, and part with abundant rhombic molds	370.1	(112.9)
24 Dolomite, medium-gray, fine- to coarse-grained, partly with very fine laminae, partly calcareous, occasionally with calcite-filled vugs	47.1	(14.4)
Chepultepec limestone (855.1 ft.) (260.8 m)		
23 Limestone, medium-dark-gray, very fine-grained, laminated with silt, slightly dolomitic with scattered rhombic molds	2.9	(0.9)
22 Covered, across State Road 706 ...	13.1	(4.0)
21 Limestone, medium- to medium-dark-gray, micrite to very fine-grained, with fine-grained dolomite in irregular wavy laminations; abundant fossil fragments in basal ten feet ...	153.1	(46.7)
20 Dolomite, medium-light-gray, very fine-grained, calcareous medium-bedded with very thin laminations ..	2.8	(0.9)
19 Limestone, medium-dark-gray, micrite, mostly thick-bedded with paper-thin silt laminations; streaks of pelletoidal limestone, with scattered calcite crystals; chert nodules, gray-black	227.8	(69.5)
18 Dolomite light- to medium-light-gray, very fine-grained, very thin laminations; beds transitional top and bottom to dolomitic limestone	2.7	(0.8)

	Thickness in feet	(meters)
17 (First 157.3 feet, 48.0 meters, on the southwest side of Crooked Branch; the last 165.4 feet, 50.4 meters, on the northeast.) Limestone, medium-gray to medium-dark-gray, micrite with some very fine-grained, thinly laminated in upper part; chert, white chalcedonic and dark-gray with conchoidal fracture. (Poorly exposed on north side)	322.7	(98.4)
16 Dolomite, medium-gray, very fine-grained, butcher-block-weathered bedding surface; interbedded thin beds of limestone, medium-dark-gray, micrite	14.3	(4.4)
15 Limestone, medium-gray, micrite to very fine-grained, thick-bedded	64.5	(19.7)
14 Limestone, medium-gray, micrite, with conchoidal fracture, and occasional beds very fine-grained; two feet (0.6 meters) light-gray, very fine-grained dolomite at top	51.2	(15.6)
Conococheague Formation (1377.5 ft.) (420.1 m) (partial thickness)		
13 Limestone, medium-dark-gray, micrite, with scattered medium-grained streaks; interbedded with medium-dark-gray micrite, slightly argillaceous, and scattered beds of limestone, medium-light-gray, very sandy, 6 inches to 2 feet (0.2 to 0.6 meters) thick, weathers to mottled-orange and red sandstone, fine- to medium-grained, subrounded, very porous, cross-bedded	163.4	(49.8)
12 Limestone, dark- to medium-dark-gray, very fine-grained, slightly argillaceous; occasional thin interbeds dolomite, light-gray, very fine-grained, with very thin laminations and scattered sandstone as in Unit 13	160.2	(48.9)
11 Limestone, medium-dark-gray, micrite, with probable fossil shell fragments (mostly covered)	63.1	(19.2)
10 Limestone, medium- to medium-light-gray, very fine-grained, laminated with silt; with occasional thin beds of light-gray, fine-grained, calcareous dolomite; chert nodules, dark-gray with white calcite in vugs; ripple-marked layer of limestone at 130 feet (39.7 meters) on north side of small abandoned quarry	245.3	(74.8)
9 Dolomite, medium-light-gray, very fine-grained, medium- to thick-bedded, transitional with occasional beds of limestone, medium-gray, very fine-grained	42.3	(12.4)
8 Limestone, medium- to medium-light-gray, very fine-grained, medium- to thick-bedded, laminated with silt or siliceous dolomite	167.3	(51.0)
7 Interbedded dolomite, light-gray, very fine-grained, laminated with silt, and limestone, medium-light-gray, micrite; abundant chert float; mostly covered	82.0	(25.0)
6 Dolomite, light-gray, very fine-grained, with minor amounts of limestone, medium-gray, micrite, pelletoidal, and argillaceous limestone, medium-dark-gray, very fine-grained; chert, white, granular, mostly as float (Pelletoidal micrite rarely visible unless acid etched)	85.2	(26.0)
5 Limestone, medium-gray, micrite; occasional dolomite, medium-light-gray, very fine-grained; also occasional beds of limestone, flat-pebble conglomerate, medium-dark-gray micrite pebbles in medium-gray micrite matrix	149.8	(45.7)
4 Interbedded limestone, medium-dark-gray, micrite, and dolomite, medium-light-gray, very fine-grained. (Mostly covered, including at State Road 705)	77.0	(23.5)
3 Limestone, medium- to medium-light-gray, micrite, worm-bored, partly pelletoidal, with rare ostracode fossils; interbedded dolomite, medium-light-gray, very fine-grained; algal chert and sandstone float	81.3	(24.8)
2 Covered	43.5	(13.3)
1 Interbedded dolomite, light-gray, very fine-grained, and limestone medium-dark-gray, micrite with white calcite-filled vugs (unit poorly exposed)	17.1	(5.2)

Section F; Plate 1: Wolf Creek

Measured along Wolf Creek from about 300 yards (274.5 m) south of State Road 670 bridge along a dirt road on the east side of the creek, thence northward across the hillslopes north of the Town Creek and Wolf Creek junction. Strike is N60°E., dip is 70° to 87° north (beds overturned).

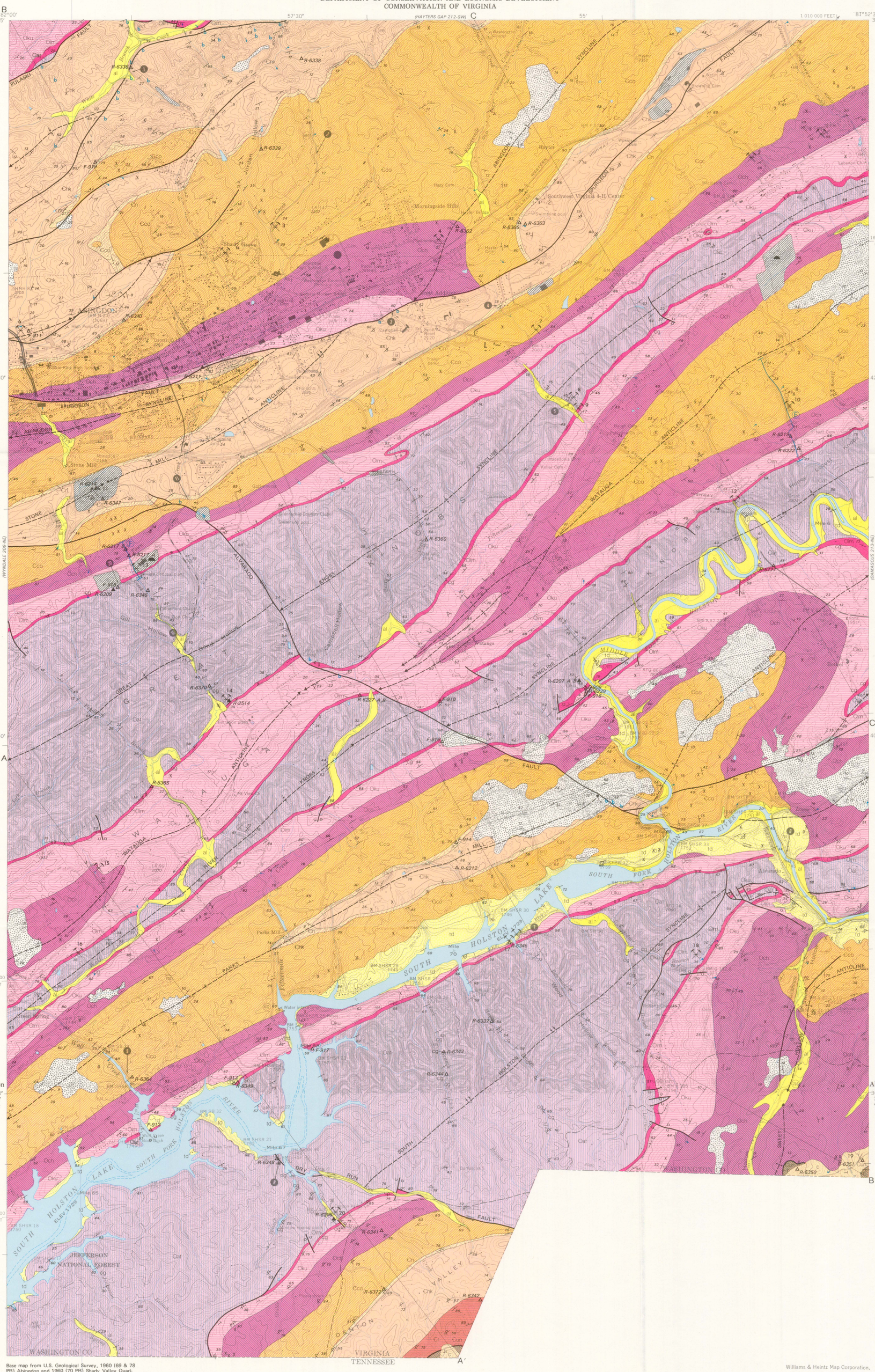
	Thickness in feet	*(meters)*
Athens Formation (lower part, 145 feet) (44.2 m)		
25 Sandstone, light-gray, very fine-grained with some occasional rounded fine- to medium-grained, argillaceous, calcareous, dense	10.0	(3.0)
24 Shale, light-gray, silty, calcareous, foliated; dip 87°N (overturned)	40	(12.2)
23 Covered, probably basal Athens dark-gray shale	95	(29.0)
Lenoir Limestone (15 feet) 4.6 m)		
22 Limestone, gray, coarse- to micrograined, fossiliferous with brachiopods and bryozoans. Base of unit covered	15	(4.6)
Knox Group, upper part (742 feet, 226 m)		
21 Dolomite, cherty, light-gray, fine-grained; some flint nodules and calcareous dolomite, micrograined, medium-bedded, dense; also contains five thin layers of 1.0 foot (0.3 m) of laminated, fine-grained limestone, fossilferous, and some micrite pebbles.	44	(13.4)
20 Limestone, dolomitic, limestone-pebble conglomerate and limestone, light-gray, partly with floating medium- to coarse-grained, rounded, frosted quartz grains; fossiliferous, including gastropod *Coelocaulus* sp., (slickensides indicate some vertical movement)	12	(3.7)
19 Dolomite, light-gray, fine-grained and some laminated calcareous dolomite, weathers light-brown	88	(26.8)
18 Limestone, gray, micrograined, laminated with argillaceous bands and sandy streaks containing scattered fine-grained, rounded, quartz grains. Dip 79°N. (overturned)	46	(14.0)
17 Limestone, light-gray, with wavy argillaceous laminae	33	(10.0)
16 Chert, thin-bedded, dark-gray, dense containing medium-grained euhedral dolomite crystal molds	5	(1.5)
15 Dolomite, light-gray to gray, medium- to very coarse-grained, some porosity	27	(8.2)
14 Chert, light-gray, blocky	2	(0.6)
13 Dolomite, light-gray, medium- to very fine-grained; cherty layers, some calcite veinlets	165	(50.3)
12 Dolomite, light-gray, medium- to very fine-grained, some streaks with scattered medium well-rounded quartz grains. Partly covered	320	(97.6)
Chepultepec limestone (828 feet, 252.5 m)		
11 Limestone, light-gray to medium-dark-gray, micrograined, part thinly laminated, rare fossil fragments and silty worm-burrow markings, medium-bedded	79	(24.1)
10 Dolomite, medium-gray, very fine-grained	2	(0.6)
9 Limestone, medium-dark-gray, partly with thin argillaceous bands, medium- to thick-bedded	36	(11.0)
8 Limestone, sandy, medium-gray, fine-grained, rounded quartz with some low-angle cross-bedding in middle of unit	3	(0.9)
7 Limestone, medium-dark-gray, part thinly laminated and some silty worm-boring marks, medium-bedded	26	(7.9)
6 Dolomite, medium-gray, fine-grained	1	(0.3)
5 Limestone, medium-dark-gray, silty bands and worm markings common, medium- to thick-bedded; rare dark-gray and very light-gray chert nodules. Fossil gastropods noted between 70-95 feet (21.4-29.0 m) and 332-333 feet (101.3-101.6 m) below top. Dip 78° overturned to N.; karst topography	425	(129.6)
4 Dolomite, cherty, medium-gray, fractured; numerous large, rounded, medium-gray chert nodules	3	(0.9)
3 Limestone, medium- to medium-dark-gray, top 3 feet (0.9 m) laminated; some chert nodules, thick-bedded	15	(4.6)

		Thickness in feet (meters)
2	Covered	98 (29.9)
1	Scattered outcrops of limestone, medium-dark-gray with some chert nodules	140 (42.7)

INDEX

Abingdon 10, 11, 13-16, 22, 26
Abingdon syncline 7, 9, 14-16
Alluvium 13
Alvarado 15, 17, 18, 22
Alvarado fault 13, 15-17
Alvarado transverse and thrust fault 15, 16
Anhydrite 18, 22
Athens Formation 2, 10, 11, 14-18, 20, 24
Barnes Chapel 8
Beaver Creek 26
Beaver Creek Lake 26
Berry Creek 16
Bethel 16, 17
Blastoid(s) 11, 12
Blue Ridge mountains 2
Blue Ridge province 18
Brachipod(s) 6, 7, 9-12
Browns Siding (Alvarado) 22
Bryozoans 11, 12
Butts 23
Cephalopod(s) 7, 8, 10
Clay, shale and related materials 20, 21
Clear Creek Lake 15
Clear Creek Lake Dam 2
Chepultepec limestone 7, 8, 18-21, 23, 24
Coelenterates 10
Colluvium 2, 13, 25
Colonial Heights 16
Complexly thrust-faulted belt 13, 14-16
Conococheague Formation 6, 7, 14-16, 18-20, 23, 24
Copper Ridge Formation 2, 6-8, 23
Corals 11
Countiss Ridge 6, 14, 24
Cove Creek Limestone 11-13, 24
Cox Mill Creek 6, 18, 25
Crinoid(s) 10-12
Crooked Branch 7-9, 19
Crushed and broken stone 20
Cummings Heights 14, 15
Cummings Heights syncline 14, 15
Cystoid(s) 6, 7
Damascus quadrangle 16, 17
Denton Valley 2, 5-8, 13, 17, 18
Dry Run 18
Dry Run fault 13, 17, 18
Echinoderm(s) 10
Fido Sandstone 11, 13, 22, 24
Fifteenmile Creek 5, 6, 17
Frontal Blue Ridge belt 13, 17, 18
Garrett Creek 5-9, 13
Gas 18, 21
Gasper limestone 11, 13, 20, 24
Gastropod(s) 7-10
Golleher mine 22
Graptolites 10
Greendale 5, 11
Greendale syncline 11-14
Greenwood Church 18
Great Knobs 8-11, 14, 16, 24, 26
Great Knobs syncline 11, 13-17
Gypsum 18, 22
Halls Bottom 15
Hayter 15
Hematite 9, 22
High Point Church 15
Hilander Park 16
Holston (Riverside) mine 22
Holston Mountain fault 2, 13, 17, 18, 22
Honaker Formation 2, 5, 6, 12-17, 19, 20, 23
Honey Locust Branch 16
Industrial limestone and dolomite 18, 19
Iron carbonate 22
Ivanhoe Furnace Company 22
Jordan Hollow 14
King Ridge 7
Knox Group, upper part 8-10, 15-19, 22, 23, 26
Larimer Branch 17, 18
Lenoir and Mosheim limestones 2, 9, 10, 16-20, 23
Little Mountain 1
Louse Creek 17
Magnetite 22
Maynardville Formation 2, 7
McConnell Ridge 24
Middle Fork Holston River 1, 2, 5, 10, 13, 16, 25
Mobley Hollow 15
Mollusk 11, 12
Negro Hollow 16
Nolichucky Formation 5-7, 14-17, 20, 23
North Fork Holston River 1
Oil 18, 21
Oncolites 10
Ostracodes 6, 7, 10
Parks Mill 6, 9, 17
Parks Mill anticline 5, 6, 13, 16, 17
Pennington Formation 12, 13, 20, 24
Plasterco 22
Possum Hollow 12
Preston Hills 16
Preston Spring 15
Pulaski fault 5-7, 13-15
Rich Valley 1, 2, 11-14, 20, 24
River Knobs 1, 9, 11, 13, 15, 24
River Knobs syncline 16, 17
Rockhouse Run 18, 25

Rome Formation 2, 14, 18
Rosedale Church 16
Rust Hollow 15
Ste. Genevieve limestone 11-13, 22, 24
Salt 18, 22
Saltville 22
Saltville fault 2, 5-7, 11-14, 21, 22
Sinking Creek 5, 15
Slopes (defined) 23
Smith Creek 1
South Fork Holston River 1, 2, 13, 16, 17, 22, 25
South Holston Lake 1, 7, 10, 11, 13, 17, 22, 24, 25
South Holston syncline 10, 11, 13, 17
Southern fold belt 13, 16
Spring Creek 7-9, 17
Spring Creek Church 15, 16
Sponges 9, 10
Spurgeon fault 5, 6, 13, 15, 20
Stone Mill 15
Stone Mill anticline 9, 14-16
Sweet Hollow 2, 13, 17, 18
Sweet Hollow anticline 9, 13, 17, 18
Tellico sandstone 10
Terrace deposits 13, 25
Toole Creek 14, 15
Town Creek 15
Travertine 13, 18, 22
Trilobite(s) 6, 7, 9
Unicoi Formation 2, 10, 18, 22
Valley and Ridge physiographic province 1
Wallace quadrangle 14
Walker Mountain 1, 7-9, 20, 23
Washington County 1
Washington County Planning Commission 26
Watauga 9, 16, 17
Watauga anticline 13, 16
Watauga Valley 9, 16
White Branch 15
Wolf Creek 9, 13, 17, 22, 26



Base map from U.S. Geological Survey, 1960 (69 & 78 PR) Abingdon and 1960 (70 PR) Shady Valley Quadrangles, 7½ Minute Series.

GEOLOGY OF THE ABINGDON AND SHADY VALLEY QUADRANGLES, VIRGINIA

By Charles S. Bartlett, Jr. and Thomas H. Biggs

Williams & Heintz Map Corporation,
Washington, D.C. 20027

Copyright 1979
Commonwealth of Virginia

MN GN 3½° 62 MILS 0°34′ 10 MILS
UTM GRID AND 1978 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:24 000
1 ½ 0 1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 .5 0 1 KILOMETER
CONTOUR INTERVAL 20 FEET

VIRGINIA
QUADRANGLE LOCATION

1979

EXPLANATION

CENOZOIC

QUATERNARY

al — Alluvium

Floodplain deposits, varicolored unconsolidated sand, clay, and gravel.

td — Terrace deposits

Unconsolidated sand, clay, rounded gravels and boulders.

c — Colluvium

Unconsolidated, angular fragments and boulders with very little matrix material.

PALEOZOIC

ORDOVICIAN

Oat, cg — Athens Formation (of Butts, 1933)

Oat, *gray, fissile shale with minor gray, thin-bedded argillaceous siltstones (lower part). Buff-brown shales, siltstones, fine-to coarse-grained sandstones and polymictic conglomerates; some siltstones and sandstones are calcareous (upper part).* cg, *polymictic conglomerate locations.*

Olm, cg — Lenoir and Mosheim limestones

Olm, *Lenoir Limestone: gray to dark-gray, fine-grained, medium-bedded argillaceous limestone. Mosheim Limestone: light-gray, very fine-grained, conchoidal fracture, medium-bedded limestone with numerous calcite crystal clusters.* cg, *irregular erosional conglomerates at the base.*

Oku, cg — Knox Group, upper part

Oku, *light-gray, fine- to coarse-grained, cherty dolomite with minor interbeds of blue-gray limestone.* cg, *zones of erosional breccia in upper part.*

Och — Chepultepec limestone

Dark blue-gray, thick-bedded, partly cherty limestone with minor gray dolomite.

CAMBRIAN

Cco — Conococheague Formation

Ccr — Copper Ridge Formation

Conococheague: dark-gray to blue-gray, fine-grained, medium-bedded, partly cherty limestone, with some light-gray, dense dolomite interbeds and numerous thin beds of gray to brown medium-grained calcareous sandstone. Copper Ridge: in cross-section only.

Cn — Nolichucky limestone

Medium-gray, medium-to thin-bedded limestone with distinctive silty laminations which weather in relief.

Chk — Honaker Formation

Gray to light-gray, medium-bedded, partly cherty dolomite; interbeds of medium-gray limestone increase to the southeast; distinctive dark-gray, coarse-grained dolomite at top.

Cr — Rome Formation

Interbedded pale red, gray-green clay shale; pale maroon siltstone; light-gray, very fine-grained dolomite. Algal-banded gray chert float.

Cun — Unicoi Formation

White to light-brown, coarse-grained quartz sandstone and quartzite; iron and manganese stain or cement common.

CONTACTS

Exposed or approximate

Environmental unit boundary

FOLDS

Anticline — trace of fold and direction of plunge

Syncline — trace of fold and direction of plunge

Overturned anticline — trace of fold

Overturned syncline — trace of fold

FAULTS

Black line where exposed or approximate; gray line where covered or inferred; tick mark indicates direction of dip; U, upthrown side; D, downthrown side; T, upper sheet; arrows indicate direction of relative movement.

A | T — Relative horizontal movement (in cross section). A, away from observer; T, toward observer.

BRECCIA

b — Brecciated beds

ATTITUDE OF ROCKS

Strike and dip of beds

Strike and dip of overturned beds

Strike of vertical beds

QUARRIES AND PROSPECTS

Active quarry

11. Acme Stone, Inc. quarry (dolomite)

Abandoned quarries and mines

1. Crushed stone (limestone)
2. Crushed stone (limestone)
3. Crushed stone (limestone & dolomite)
4. Crushed stone (limestone)
5. Crushed stone (limestone)
6. Crushed stone (dolomite)
7. Crushed stone (limestone & dolomite)
8. Shale quarry
9. Crushed stone (limestone)
10. Crushed stone (limestone & dolomite)
12. Shale quarry
13. Crushed stone (limestone)
14. Shale quarry
15. Crushed stone (limestone)
16. Crushed stone (limestone)
17. Riverside, or Holston iron mines
18. Shale quarry
20. Shale quarry

Prospect

19. Iron prospect

SAMPLE LOCATIONS

R-6214 — R, repository number of rock sample on file at the Virginia Division of Mineral Resources.

R-6209 — Sample of raw material having potential commercial use; R, repository number of sample on file at the Virginia Division of Mineral Resources.

F-918 — F, repository number of fossil sample on file at the Virginia Division of Mineral Resources.

(E) — Location of measured stratigraphic section described in text.

11 — Reference locality described in text.

LAND MODIFICATION FACTORS

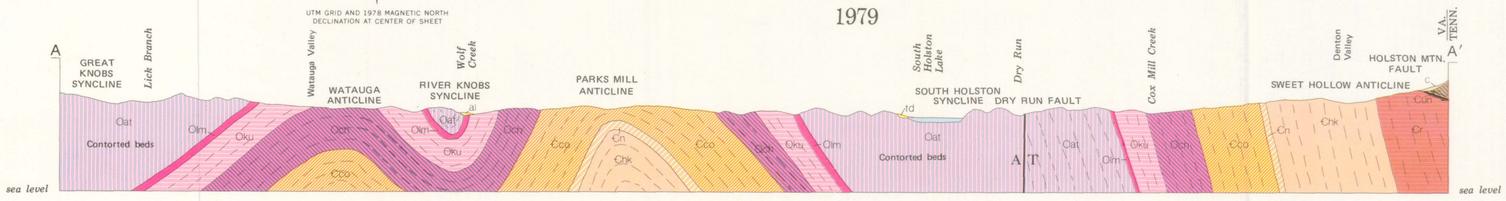
Modified Land: Extensive cut or fill due to grading.

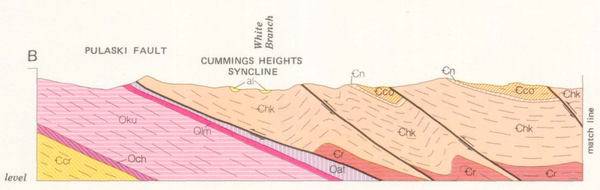
Modified Land: Landfill

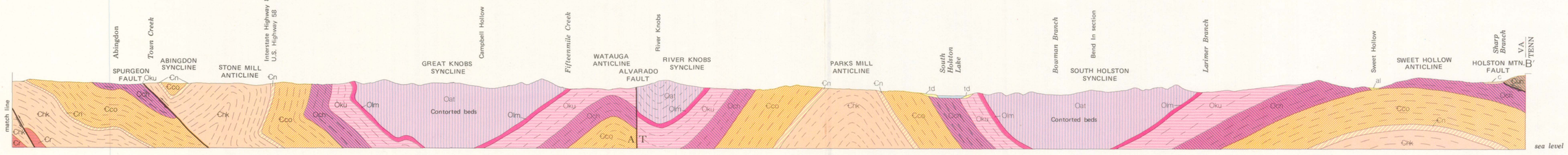
Karst Land: areas of known or potential sinkhole development, subsidence and cave openings.

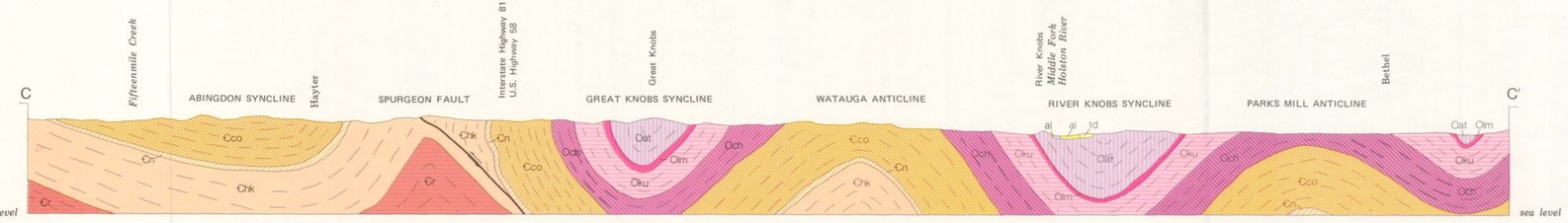
Sinkhole

Spring

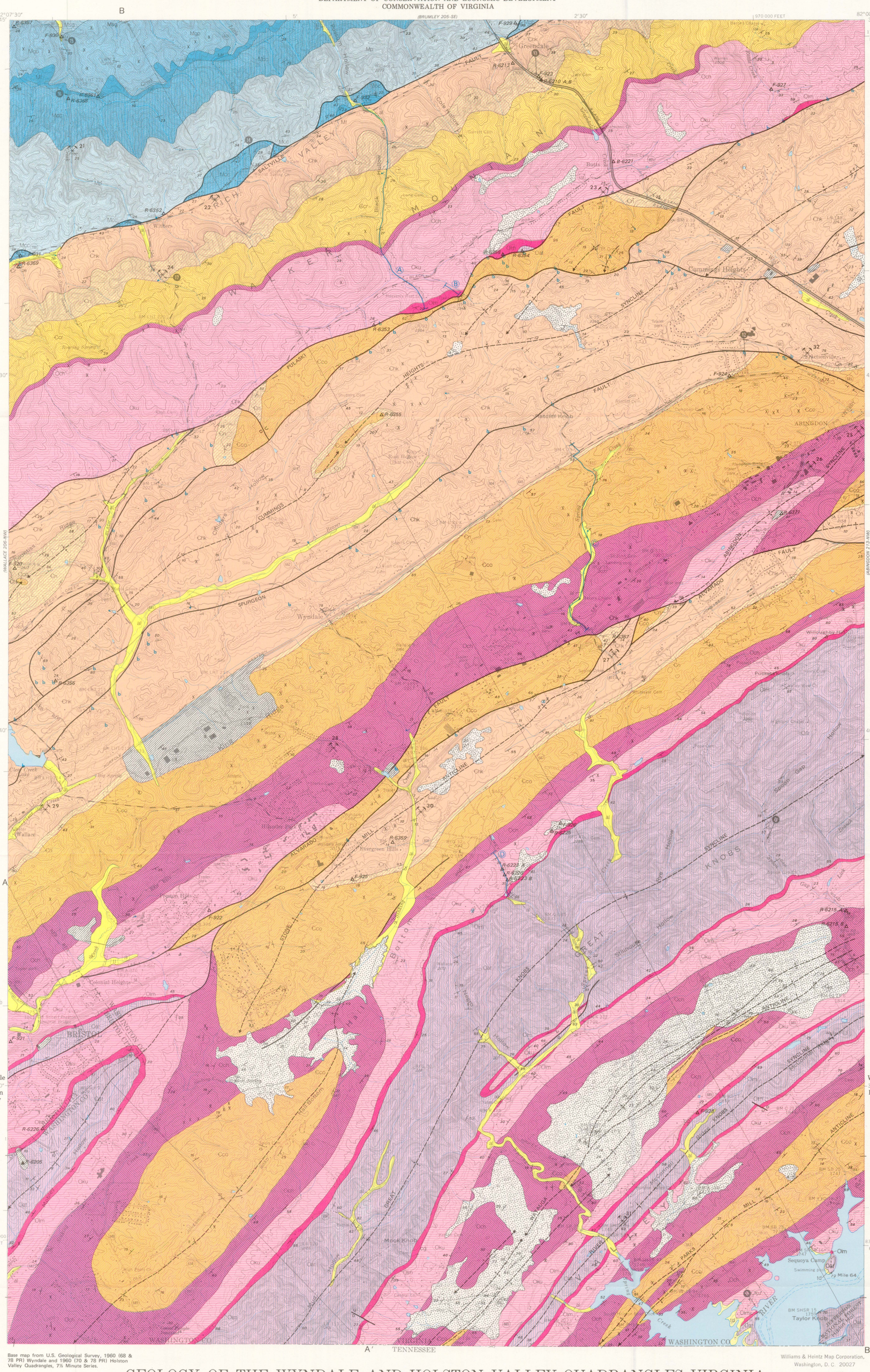








Interpretive cross sections with no vertical exaggeration.



Base map from U.S. Geological Survey, 1960 (68 & 78 PR) Wyndale and 1960 (70 & 78 PR) Holston Valley Quadrangles, 7½ Minute Series.

Williams & Heintz Map Corporation, Washington, D. C. 20027

Copyright 1979
Commonwealth of Virginia

GEOLOGY OF THE WYNDALE AND HOLSTON VALLEY QUADRANGLES, VIRGINIA

By Charles S. Bartlett, Jr. and Thomas H. Biggs

SCALE 1:24 000

CONTOUR INTERVAL 20 FEET

1979

EXPLANATION

CENOZOIC — QUATERNARY

al — Alluvium

Floodplain deposits, varicolored unconsolidated sand, clay, and gravel.

td — Terrace deposits

Unconsolidated sand, clay, rounded gravels and boulders.

MISSISSIPPIAN

Mp — Pennington Formation

Interbedded gray siltstone, shaly sandstone, argillaceous limestone, and silty shale; mostly maroon and greenish-gray in upper portion.

Mcc — Cove Creek Limestone

Gray, argillaceous limestone, most of which is thinly laminated; weathers to pale gray.

Mf — Fido Sandstone

Maroon to brown, cross-bedded, thick-bedded, calcareous sandstone; partly crinoidal.

Mgp — Gasper limestone

Gray to light-gray, argillaceous, thin-to thick-bedded limestone; weathers shaly; partly crinoidal.

Msg — Ste. Genevieve limestone

Gray, argillaceous, medium-bedded limestone; uppermost beds are maroon, crinoidal, sandy limestone (only upper 200 feet exposed).

Mhd — Hillsdale Limestone: in cross-section only

Mlv — Little Valley Formation: in cross-section only

PALEOZOIC — ORDOVICIAN

Oat, cg — Athens Formation (of Butts, 1933)

Oat, *gray, fissile shale with minor gray, thin-bedded argillaceous siltstones (lower part). Buff-brown shales, siltstones, fine-to coarse-grained sandstones and polymictic conglomerates; some siltstones and sandstones are calcareous (upper part).* cg, *polymictic conglomerate locations.*

Olm, cg — Lenoir and Mosheim limestones

Olm, *Lenoir Limestone: gray to dark-gray, fine-grained, medium-bedded argillaceous limestone. Mosheim Limestone: light gray, very fine-grained, conchoidal fracture, medium-bedded limestone with numerous calcite crystal clusters.* cg, *irregular erosional conglomerates at the base.*

Oku, cg — Knox Group, upper part

Oku, *light-gray, fine- to coarse-grained, cherty dolomite with minor interbeds of blue-gray limestone.* cg, *zones of erosional breccia in upper part.*

Och — Chepultepec limestone

Dark blue-gray, thick-bedded, partly cherty limestone with minor gray dolomite.

CAMBRIAN

Cco — Conococheague Formation

Ccr — Copper Ridge Formation

Conococheague: dark-gray to blue-gray, fine-grained, medium-bedded, partly cherty limestone, with some light-gray, dense dolomite interbeds and numerous thin beds of gray to brown medium-grained calcareous sandstone. Copper Ridge: gray to light-gray, medium-bedded dolomite, with a few dark-gray, cherty limestone interbeds and numerous thin beds of gray to brown medium-grained calcareous sandstone. Bottom portion includes Maynardville Formation that consists of medium-dark-gray straticulate limestone.

Cn — Nolichucky Formation

North of Spurgeon fault: gray-green, silty, calcareous, fissile shale and blue-gray, argillaceous, very thin-to medium-bedded limestone. South of Spurgeon fault: medium-gray, medium- to thin-bedded limestone with distinctive silty laminations which weather in relief.

Chk — Honaker Formation

Gray to light-gray, medium-bedded, partly cherty dolomite; interbeds of medium-gray limestone increase to the southeast; distinctive dark-gray, coarse-grained dolomite at top.

Cr — Rome Formation

Interbedded pale red and gray-green clay shale.

CONTACTS

Exposed or approximate

FOLDS

Anticline — trace of fold and direction of plunge

Syncline — trace of fold and direction of plunge

FAULTS

Black line where exposed or approximate; gray line where covered or inferred; tick mark indicates direction of dip; U, upthrown side; D, downthrown side; T, upper sheet; arrows indicate direction of relative movement.

BRECCIA

Brecciated beds

ATTITUDE OF ROCKS

Strike and dip of beds

Strike and dip of overturned beds

Strike of vertical beds

QUARRIES

Abandoned quarries

21. Shale quarry
22. Virginia Department of Highways (crushed stone- dolomite)
23. Crushed stone (dolomite)
24. Shale quarry
25. Crushed stone (limestone)
26. Crushed stone (limestone)
27. Crushed stone (limestone & dolomite)
28. Crushed stone (limestone)
29. Crushed stone (dolomite)
30. Crushed stone (limestone and dolomite)
31. Shale quarry
32. Crushed stone (dolomite)

SAMPLE LOCATIONS

R-6371 — R, repository number of rock sample on file at the Virginia Division of Mineral Resources.

R-6205 — Sample of raw material having potential commercial use; R, repository number of sample on file at the Virginia Division of Mineral Resources.

F-921 — F, repository number of fossil sample on file at the Virginia Division of Mineral Resources.

Location of measured stratigraphic section described in text.

Reference locality described in text.

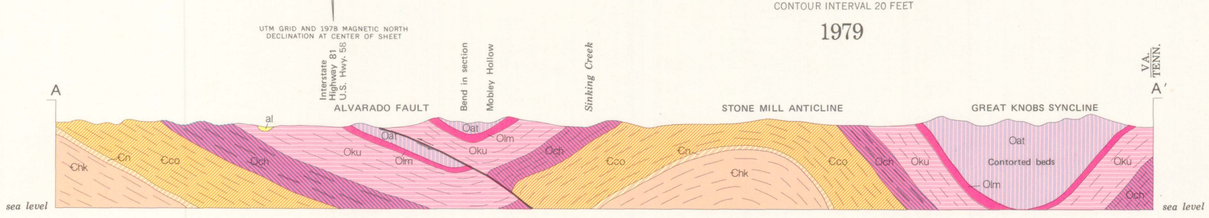
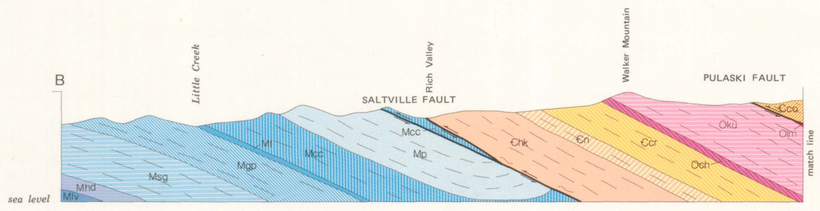
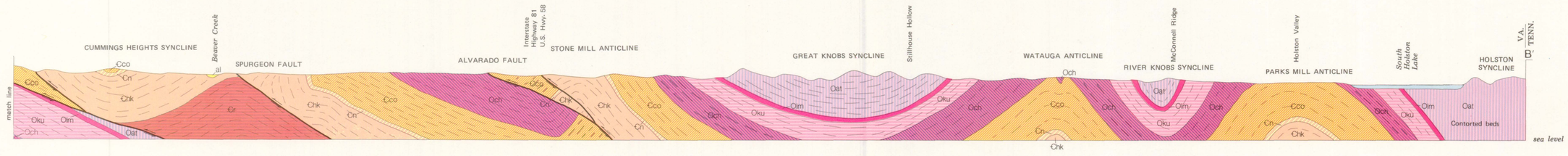
LAND MODIFICATION FACTORS

Modified Land: Extensive cut or fill due to grading.

Karst Land: areas of known or potential sinkhole development, subsidence and cave openings.

Sinkhole

Spring



Interpretive cross sections with no vertical exaggeration.