

GEOLOGY OF THE NEW CASTLE AREA,
CRAIG COUNTY, VIRGINIA

by

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INTRODUCTION

Location of Area

The New Castle area is located in the northeastern half of Craig County, Virginia, in the Valley and Ridge Province. The northwestern corner of the area is 4.5 miles from the Virginia-West Virginia border (fig. 1). The map area is rectangular and encompasses approximately 45 square miles. It is bounded by latitudes $37^{\circ} 25' 50''$ N. and $37^{\circ} 31' 30''$ N., and longitudes $80^{\circ} 05' 00''$ W. and $80^{\circ} 12' 30''$ W.

Purpose of the Investigation

The investigation included:

- 1) Preparation of a geologic map and cross-sections;
- 2) The study and descriptions of the rock formations, with detailed measurements of several stratigraphic sections;
- 3) An analysis of the geologic structure, and;
- 4) An interpretation of the geologic history of the area.

Accessibility of the Area

Most parts of the map area are readily accessible by way of primary, secondary, and private roads as well as numerous mountain trails maintained by the United States

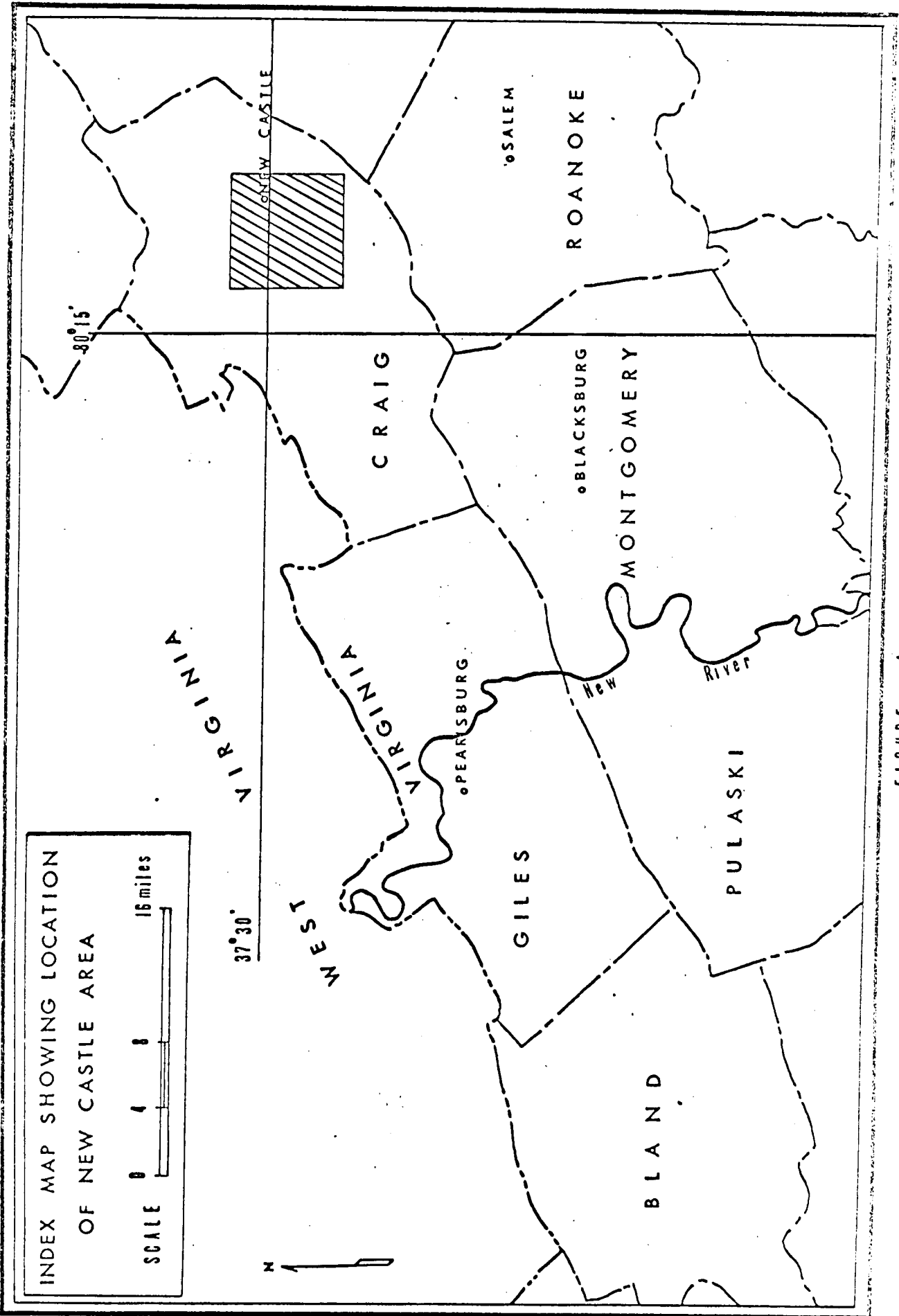


FIGURE I

Forest Service.

The area is nearly bisected by Virginia Route 42 which extends from the southwestern edge of the map to New Castle in the northeastern part of the area. Virginia Route 311 crosses the map area from the southern boundary to New Castle and then continues northwestward. Virginia Route 615 extends from New Castle to the northeastern extremity of the area. County roads provide additional accessibility. Much of the remainder of the map area can be reached by private farm roads, National Forest mountain trails and electric power line forest cuts. Private roads furnish access to the bases of Sinking Creek, Johns Creek, Nutters and Little Mountains, as well as Aps Knob, and Peters Hill. These private roads generally extend only one quarter of the way up the mountain slopes, but the mountain summits may be reached by trails.

Methods of Study

Geologic mapping of the area on a scale of 1:24,000 was carried out from June 1966 to April 1967. The field data were recorded on a composite map of portions of the Catawba, Virginia and Looney, Virginia, 7½-minute quadrangles and southern sections of the 15-minute New Castle, Virginia quadrangle advance sheets. The northern portion of the area, recorded on the advance New Castle sheets, has a contour interval of 40 feet whereas the southern portion, recorded on

the Catawba and Looney quadrangles, has a contour interval of 20 feet. As much use as possible was made of United States Geological Survey aerial photographs at scales of 1:27,120. Owing to the lack of distinctive lithologic horizons the structure of the Middle Devonian shales was not mapped in detail.

Previous Work

Prior to the writer's study, the geology of the New Castle area had not been mapped in detail. Woodward's (1932) map of the geology of the Roanoke area, Virginia, included the southern portion of the area under study, but his scale did not allow for detail. Butts (1933) mapped the geology on a reconnaissance basis as part of his geologic map of the Appalachian Valley of Virginia. Tillman (1963) described in some detail some of the formations found along Virginia Route 311, and Tillman and Lowry (1963) described the formations found in Johns Creek Gorge and along Virginia Route 42 on Aps Knob.

Acknowledgments

The writer wishes to thank Mr. Robert E. Francis who, while working on his own thesis, "Gravity and Magnetic Surveys of the New Castle Area, Craig County, Virginia" accompanied the writer on many traverses and discussed some of the problems involved in mapping the area.

The writer would also like to thank the members of his advisory committee; Dr. C. G. Tillman, who supervised the mapping and made numerous helpful suggestions concerning the stratigraphic and paleontological aspects of the work; Dr. W. D. Lowry, for his critical and very helpful suggestions especially on problems concerning the structural geology of the area; and Dr. B. N. Cooper, Head of the Department of Geological Sciences, Virginia Polytechnic Institute, who helped the author differentiate the Middle Ordovician stratigraphy.

The writer also wishes to thank Dr. C. E. Sears who made many helpful suggestions concerning the field work. The writer would also like to thank the topographic branch of the United States Geological Survey, Arlington, Virginia, for preparing the base map used in the study.

TOPOGRAPHY, RELIEF AND DRAINAGE

The New Castle area has a maximum elevation of 3670 feet on Sinking Creek Mountain in the the southwest corner of the area, and a minimum elevation of 1241 feet on Craigs Creek in the northeast corner of the area; thus the total relief in the area is 2429 feet.

Three types of topography are represented in the area. Lands within the valley between Johns Creek and Sinking Creek Mountains are characterized by large, rounded, gently sloping hills and numerous sinkholes. Maximum elevations of these hills are generally between 2580 and 2740 feet. This part of the area is underlain by Ordovician limestones and dolomites and has well developed karst topography and underground drainage. All underground streams in this area eventually drain into Meadow Creek. This area is mostly farm and pasture land interspersed with some wooded areas.

The second type of topography is represented by Sinking Creek Mountain, Johns Creek Mountain, Nutters Mountain, Little Mountain, and Aps Knob. Sinking Creek and Johns Creek Mountains are long, steep-sided, narrow crested and very thickly-forested ridges. These ridges are formed by the two flanks of the breached Sinking Creek Anticline. Nutters Mountain and Little Mountain slope off gently in all directions and have broader summits. They are somewhat unusual because they are the topographic representation of small anticlines.

The upper slopes are too steep for farming, though the lower, more gentle slopes of Johns Creek and Sinking Creek Mountains have been used for grazing. Pine forests of the Jefferson National Forest cover the slopes of all of the mountains. Crests on these topographic features within the map area are between 2000 feet and 3670 feet.

The valleys east of Sinking Creek Mountain and north of Johns Creek Mountain are examples of the third type of topography. Both valleys are synclinal in nature and have low hills with maximum relief about 300 feet. These areas are underlain by thin, fissile, folded Devonian shales. The many small streams which flow between the low hills characteristic of this topography form a trellis drainage pattern. The hills are steep and rolling, and elongate in a northeast direction.

The major stream in the area is Craigs Creek which nearly parallels Virginia Route 311, flowing from the southern border of the area towards New Castle. At New Castle, Johns Creek and Meadow Creek, the major tributaries in the area, flow into Craigs Creek and it flows in a northeasterly direction from this point until it joins the James River near Buchanan, Virginia.

STRATIGRAPHY

General Statement

All of the rocks exposed in the New Castle area are sedimentary. The formations range in age from Early Ordovician to Middle Devonian (Erian Series). The thickness of sedimentary rock exposed within the area is at least 5,200 feet.

The oldest Early Ordovician unit in the area is the Upper Knox Dolomite. This part of the Knox Dolomite attains a thickness of at least 200 feet in the New Castle area. At the top of the Knox Dolomite is a major disconformity. The surface of the disconformity is highly irregular and, at one location, its outcrop trace shows 20 feet of relief. The overlying Middle Ordovician Series is represented by various gray limestone units totaling 558 feet in thickness. These limestones are overlain by 42 feet of buff-yellow Eggleston shale, argillaceous limestone and bentonite. This formation is succeeded by approximately 1,340 feet of calcareous shale and limestone of the Martinsburg Formation. The overlying Juniata Formation consists of 215 feet of maroon shale and sandstone, and is the uppermost Ordovician formation.

The major part of the Silurian System is represented by a series of clastic formations. The Tuscarora Sandstone

is the lowermost Silurian formation and is represented by 51 feet of gray-white orthoquartzite. Overlying the Tuscarora is the purplish-red sandstone and shale of the Rose Hill Formation. The Rose Hill attains a thickness of approximately 110 feet in the New Castle area. Succeeding this formation is about 243 feet of the "Keefer-Wills Creek" sandstone and quartzite. This unit is overlain by approximately 200 feet of Tonoloway Limestone. The uppermost Silurian unit is the friable, coarse-grained sands of the Clifton Forge Sandstone which is 158 feet thick in the area.

The Devonian System is represented by the dark gray, fossiliferous Licking Creek Limestone; the iron-rich Ridgeley Sandstone; and a thick section of very thin-bedded Middle Devonian shale. The Licking Creek Limestone has a maximum thickness of 23 feet in the area. The Ridgeley Sandstone crops out at only one locality in the area and attains a thickness of 60 feet. The Middle Devonian shale rests, from place to place, on the Clifton Forge Sandstone, the Licking Creek Limestone or the Ridgeley Sandstone. The Devonian shale has a minimum thickness in the area of 2,000 feet, but the true thickness may be as much as twice that.

ORDOVICIAN SYSTEM

LOWER ORDOVICIAN SERIES

Knox Dolomite

Name - The Knox Dolomite was named by Safford (1869, p.151, 158, 159, 203-226) for dolomite in Knox County, Tennessee. In the New Castle area only the upper portion of the Knox Dolomite is exposed and this was mapped as a single unit. This dolomite lies unconformably below the cherty, dolomitic limestone of the Blackford Formation.

Distribution - The Knox Dolomite crops out in the axial portion of the Sinking Creek Anticline (see map). It is exposed at many points along Virginia Route 42, from 600 feet east of the east junction with County Road 622 to the western border of the area. It can be seen in scattered outcrops along County Road 623 and on the surrounding farms. The uppermost units are exposed on the F. J. Sizur farm, southeast of the eastern intersection of Virginia Route 42 and County Road 622, where the Knox Dolomite is disconformably overlain by the Blackford Formation. The Knox is also exposed in an overturned sequence on either side of the Saltville Fault, along County Road 624 near the western edge of the area. No detailed measurement of the Knox Dolomite was made in the New Castle area. A minimum thickness of 200 feet was calculated from exposure in a group of hills near the western edge of the map area.

Lithology - The Knox Dolomite is medium-gray, fine-grained, thick-bedded, cherty dolomite for the most part. The beds are thinner upward toward the contact with the Blackford Formation. The dolomite also becomes much more cherty near the top of the formation. In some cases the chert makes up 40 per cent of the thin upper beds and can be seen weathered to a thin fretwork. Some of the highest beds just below the contact contain cavities filled with crystalline dolomite. These filled cavities can be seen on the F. J. Sizur farm alongside County Road 622. The thin upper beds which are free of the chert are argillaceous, and weather to a platy appearance and a buff color. The upper beds of dolomite are fossiliferous and contain cephalopods and some algal limestone. Sando (1956, p.935) reported massive algal limestone in the Lower Ordovician Beekmantown Formation of Maryland. The upper part of the Knox Dolomite, equivalent to the Beekmantown of Maryland, is Lower Ordovician in age (Twenhofel, et al., 1954).

Major Disconformity

A conspicuous stratigraphic break in the Paleozoic rocks of the New Castle area occurs at the top of the Knox Dolomite. Local irregularities of the contact surface, produced by erosion, cause the thickness of the formation to vary as much as 20 feet in the New Castle area. Pinnacles of dolomite

can be seen projecting into the overlying Blackford Formation as much as 20 feet above the Knox-Blackford contact on the F. J. Sizur farm along County Road 622 near the eastern intersection with Virginia Route 42. Cooper (1944, p.33) reports variations in the thickness of the Beekmantown Formation of as much as 400 feet. The overlying Blackford Formation contains rounded clasts of dolomite and chert derived from the eroded Knox Dolomite. Some of the clasts are four inches along their longest axis.

MIDDLE ORDOVICIAN SERIES

Blackford Formation

Name - Butts (1940, p.126-127) proposed the name "Blackford facies" for the red beds, chert conglomerates, gray shale and chert beds overlying the Beekmantown Formation (Upper Knox Dolomite) at Blackford, Russell County, Virginia. B. N. Cooper (1945, p.42) separated the blocky chert beds from Butts' original grouping and named them the Elway Limestone. In the New Castle area the name Blackford is limited to those beds directly above the post-Knox unconformity and below the first calcilutite beds of the Elway Limestone.

Distribution - The Blackford Formation was mapped together with the overlying Elway Limestone, Lincolnshire Limestone, and Chatham Hill Limestone (see map). The Blackford Formation overlies the erosional unconformity at the top of the Knox Dolomite. The Blackford Formation can be seen in scattered outcrops, in contact with the Knox Dolomite, along the northwest base of Sinking Creek Mountain and the southeast base of Johns Creek Mountain. Good exposures can be seen on the F. J. Sizur farm, just southeast of the eastern intersection of Virginia Route 42 and County Road 622. At this location pinnacles of the Knox Dolomite extend up into the Blackford Formation producing a highly irregular contact

(see map). Maximum thickness of the Blackford at this location is 22 feet.

Lithology - In the New Castle area the Blackford Formation is composed of gray, fine-to medium-grained, limestone and dolomitic limestone containing chert and dolomite pebble clasts. The Blackford weathers to an irregular surface due to the clasts of chert and dolomite, which were derived from the underlying Knox Dolomite. According to G. A. Cooper (1956, Chart 1) the Middle Ordovician Blackford Formation is in the Marmor Stage.

Elway Limestone

Name - B. N. Cooper (1945, p.212) proposed the name Elway Limestone for the part of the "Blackford facies" of Butts (1940, p.126-127) that yields blocky chert on weathering. The name came from Elway on U. S. Highway 19 near Lebanon, Russell County, Virginia, but the type section is near Blackford, Russell County, Virginia. In the New Castle area the Elway Limestone includes the beds from the top of the Blackford Formation to the base of the Lincolnshire Limestone.

Distribution - The Elway Limestone was mapped together with the Blackford Formation, the Lincolnshire Limestone and the Chatham Hill Limestone (see map). Excellent exposures of the Elway Limestone can be found along Virginia Route 42,

just west of the U. S. Fish Hatchery. Excellent exposures can also be seen on the F. J. Sizur farm, just east of the eastern intersection of Virginia Route 42 and County Road 622. Good exposures can also be seen along County Road 624. The Elway Limestone is 155 feet thick in the New Castle area.

Lithology- The Elway Limestone is primarily a medium- to very dark-gray calcilutite. The unit contains blocky black chert which weathers white and projects from the smooth, dove-gray weathered surface. This black chert occurs throughout the section of Elway. On the Sizur farm, burgundy-colored chert occurs about 22 feet from the lower contact with the Blackford Formation and is sparsely distributed through the following 37 feet of section. According to G. A. Cooper (1956, Chart 1) the Elway Formation is in the Ashby Stage of the Middle Ordovician.

Lincolnshire Limestone

Name- The Lincolnshire Limestone was named by Cooper and Prouty (1943, p.863) for a limestone partially exposed in a quarry northwest of Five Oaks, Tazewell County, Virginia. The formation was named for Lincolnshire Branch which runs along the quarry. In the New Castle area the Lincolnshire Limestone is those beds between the uppermost calcilutite of the underlying Elway Limestone and the lowermost fossiliferous, nodular beds of the overlying Chatham Hill Limestone.

Distribution - The Lincolnshire Limestone occurs along the base of the northwest flank of Sinking Creek Mountain and at the base of the southeast flank of Johns Creek Mountain. Good exposures of the upper 60 feet of the Lincolnshire can be seen in contact with the overlying Chatham Hill Limestone on the F. J. Sizur farm. This exposure is at the northwest base of Sinking Creek Mountain in a gully approximately 0.5 mile southwest of the U. S. Fish Hatchery. Nowhere in the area is the Lincolnshire fully exposed. It was mapped together with the Blackford Formation, the Elway Limestone and the Chatham Hill Limestone (see map). The Lincolnshire Limestone is approximately 190 feet thick in the New Castle area.

Lithology - In all sections the Lincolnshire Limestone consists of a medium- to dark-gray, medium- to coarse-grained thick-bedded to massive fossiliferous limestone. It weathers to a medium-gray, smooth surface, containing some white-weathering, black chert layers. The lowermost units are coarse-grained and contain thin layers of chert. According to G. A. Cooper (1956, Chart 1) the Lincolnshire Limestone is in the Ashby Stage of the Middle Ordovician.

Chatham Hill Limestone

Name - The Chatham Hill Limestone was named by B. N. Cooper and G. A. Cooper (Cooper, G. A., 1956, p.53) for

exposures near Virginia Route 16 along the northwest slope of Walker Mountain near Chatham Hill, Virginia. In the New Castle area the Chatham Hill Limestone lies between the underlying Lincolnshire Limestone and the overlying Witten Limestone.

Distribution - The Chatham Hill Limestone, which was mapped together with the underlying Middle Ordovician limestones, is well exposed in places on the F. J. Sizur farm, east of County Road 622 (see map). It is also exposed along the northwest flank of Sinking Creek Mountain. No exposures of the Chatham Hill were seen along Johns Creek Mountain though both the overlying and underlying units are exposed. Good exposures of the upper part of the Chatham Hill can be seen in contact with the overlying Witten Limestone in a quarry, across Virginia Highway 42 from the U. S. Fish Hatchery, about 1.8 miles southwest of New Castle. The Chatham Hill Limestone has a maximum thickness of 191 feet on the Sizur farm.

Lithology - The Chatham Hill Limestone is a dark-gray, very thin-bedded, nodular weathering fine-grained limestone. It has a distinctive brownish color on the fresh fractured surface but weathers to a light gray. The Chatham Hill is highly fossiliferous and contains sponges, brachiopods, trilobites and the cystoid Echinosphaerites. The upper 40

feet of the unit contains nodular chert. Forty feet above the base of the formation is a unit about 10 feet thick which is massive dark-gray, fine-grained limestone. This unit thins out in a northeasterly direction and is absent at the nose of the Sinking Creek Anticline. According to G. A. Cooper (1956, Chart 1) the Chatham Hill Limestone is in the Porterfield Stage of the Middle Ordovician.

Witten Limestone

Name - Cooper and Prouty (1943, p.872-873) proposed the name Witten Limestone for exposures along Virginia Highway 16 about 0.25 mile north of County Road 604, Tazewell County, Virginia. The name was derived from Witten Valley Church. In the New Castle area the Witten overlies the Chatham Hill Formation and underlies the Eggleston Formation.

Distribution - In the New Castle area the Witten Limestone and Eggleston Formation were mapped as one unit (see map). The Witten can be found at the base of the northwest flank of Sinking Creek Mountain and to the north of the Saltville Fault along the base of the southwest flank of Johns Creek Mountain. The Witten Limestone makes up a low line of hills at the above mentioned places. The Witten Limestone is well exposed on the F. J. Sizur farm, east of County Road 622. A complete section of Witten Limestone can also be seen in a quarry along Virginia Route 42, across from the U. S.

Fish Hatchery, about 1.8 miles west of New Castle. The Witten Limestone is 60 feet thick in the New Castle area.

Lithology - The Witten Limestone is essentially a light- to medium-gray, fine- to medium-grained limestone, having cuneiform fracture and weathering light-gray. The lower portion of the formation contains some thin layers of dolomite interbedded with the limestone which can easily be seen on the weathered surface. According to G. A. Cooper (1956, Chart 1) the Witten Limestone is in the Wilderness Stage of the Ordovician.

Eggleston Formation

Name - A. A. L. Matthews (1932, p.11) proposed the name Eggleston Formation for exposures along County Road 605 near Eggleston and Narrows, Giles County, Virginia. In the New Castle area the Eggleston is limited to the beds between the top of the massive limestones of the Witten Limestone and the yellowish-green shales of the Martinsburg Formation. In the area the Eggleston was mapped with the Witten Limestone.

Distribution - The Eggleston Formation and the Witten Limestone are well exposed along the northwest flank of Sinking Creek Mountain and along the southeast flank of Johns Creek Mountain (see map) where these units stand out as a line of low hills more resistant to erosion than the overlying Martinsburg Formation. The contact between the Martinsburg

and the Eggleston Formations can be traced along the entire length of Sinking Creek Mountain on the basis of topographic expression. The best section of Eggleston is exposed along a gully on the F. J. Sizur farm, just east of County Road 622, near its eastern junction with Virginia Route 42. Other good exposures can be found at the southeast base of Johns Creek Mountain along County Road 624. The Eggleston Formation is 42 feet thick in the New Castle area.

Lithology - The Eggleston consists of buff to yellow shales and greenish-gray limestones. A medium-grained, cross-bedded sandstone is at the base of the Eggleston Formation. A thin bed of greenish-yellow bentonite marks the top of the Eggleston. According to G. A. Cooper (1956, Chart 1) the Eggleston Formation is in the Wilderness Stage of the Ordovician.

MIDDLE AND UPPER ORDOVICIAN SERIES

Martinsburg Formation

Name - Geiger and Keith (1891, p.156-163) proposed the name Martinsburg Formation for outcrops at Martinsburg, West Virginia. In the New Castle area the Martinsburg Formation includes those beds from the top of the bentonite of the Eggleston Formation to the lowest red beds of the overlying Juniata Formation. Recognition of the upper contact is further aided by the presence of Orthorhynchula stevensoni in the upper beds of the Martinsburg Formation.

Distribution - The Martinsburg Formation occurs near the base of the southeast flank of Johns Creek Mountain and similarly near the base of the northwest flank of Sinking Creek Mountain. The Martinsburg Formation is poorly exposed throughout the area and nowhere in the area can a complete section be found. It erodes easily, and the greenish-yellow shale chips found in the soil are the main evidence used in mapping the formation. Scattered outcrops are exposed on the mountain slopes and some partial sections are visible where gullies have cut back towards the ridges. Martinsburg outcrops can be seen along County Road 624 about 1.8 miles west of its intersection with Virginia Route 42 near the U. S. Fish Hatchery. Many outcrops of the Martinsburg can be found on farms located on the slopes already mentioned. Owing to

the lack of a completely exposed section of Martinsburg the thickness of the interval between the top of the Eggleston and the base of the Juniata Formations was calculated trigonometrically. Estimates made in this way at three different localities yield a thickness of 1340 feet. Specifically, along Virginia Route 42 it was calculated to be 1322 feet thick, and at the northeastern and southeastern ends of Sinking Creek Mountain the thickness was calculated to be 1322 and 1350 feet respectively.

Lithology - The Martinsburg grades from gray, calcareous, thin- to medium-bedded, buff to greenish-yellow weathering shale at its base to interbedded fine-grained limestone, thin-bedded calcareous sandstone and shale at the top. Most outcrops of the Martinsburg are fossiliferous and contain various species of brachiopods and some crinoids. The upper 11 feet along Virginia Route 42 (see map) contains the distinctive Martinsburg brachiopod Orthorhynchula stvensoni. The Martinsburg is in conformable contact with both the underlying Eggleston and overlying Juniata Formations. According to Twenhofel et al. (1954, Chart 2) the Martinsburg Formation is in the Trenton, Eden and Maysville stages of the Middle and Upper Ordovician.

Juniata Formation

Name - Darton (1896, p.2) named the Juniata Formation

for exposures along the Juniata River in Pennsylvania. In the New Castle area the Juniata Formation includes those beds overlying the Orthorhynchula stevensoni zone in the uppermost part of the Martinsburg Formation and underlying the first grayish-white sandstones of the Tuscarora Sandstone.

Distribution - The Juniata Formation occurs along the northwest flank of Sinking Creek mountain and the southeast flank of Johns Creek Mountain. The upper cross-bedded, light orange-white sandstone member is completely exposed on Aps Knob where it is in contact with the Tuscarora quartzite. For the most part the formation is poorly exposed on the flanks of Johns Creek and Sinking Creek mountains. The lack of exposure of the formation reflects its poor resistance to erosion. Red and maroon shale chips and sand in the soil are the main criteria for recognition during mapping. A few scattered outcrops occur on the slopes as a result of gullying. The Juniata is approximately 215 feet thick.

Lithology - The lower 140 feet of the Juniata Formation consists of maroon to olive-gray and red interbedded thin shale and sandstone. The maroon shale in places contains mottled greenish-gray and light-green splotches of clay or mudstone. The upper 75 feet is composed of a light orange-white, medium-grained, well-sorted sandstone. According to Twenhofel et al. (1954, Chart 2) the Juniata Formation is in the Richmond Stage of the Ordovician.

SILURIAN SYSTEM

Tuscarora Sandstone

Name - Darton and Taff (1896, p.2) named the Tuscarora Quartzite for exposures of white and gray massive quartzite along Tuscarora Mountain in Pennsylvania. Clark (1897, p.172-188) proposed the name Tuscarora Formation and later authors (i.e., C. K. Swartz et al., 1942, Chart 3) have used the term Tuscarora Sandstone. In the New Castle area the lower boundary of the Tuscarora Sandstone is marked by the first appearance of white to light-gray massive sandstones overlying the last of the cross-bedded, light orange-white beds of the Juniata Formation. The upper boundary is marked by the first purplish-red beds of the overlying Rose Hill Formation.

Distribution - The Tuscarora Sandstone occurs along the crest of Sinking Creek and Johns Creek Mountains. It is the ridge-maker responsible for the topographic expression of these mountains. Though the Tuscarora is a thin unit it provides approximately 400 feet breadth of outcrop on the southeastern side of Sinking Creek Mountain near the southwest corner of the area (see map) where it is exposed on the dip slope. On Johns Creek Mountain the Tuscarora Sandstone is vertical to slightly overturned. The Tuscarora Sandstone also forms the crest of Aps Knob where the contact with the cross-bedded Juniata is well exposed in a cliff 20

to 30 feet high. The Tuscarora Sandstone is about 51 feet thick in the New Castle area.

Lithology - At its base the Tuscarora Sandstone is composed of a white- to light-gray, fine- to medium-grained sandstone which grades to white, medium-grained orthoquartzite at the top. The orthoquartzite is relatively free of impurities and is extremely durable. The weathered surface near the upper contact attains a light brown to orange-white color. The weathered blocks on the ridge crests weather to gray. According to C. K. Swartz et al. (1942, Chart 3) the Tuscarora Sandstone was deposited during the Early Ordovician.

Rose Hill Formation

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Name - C. K. Swartz (1923, p.27-28) proposed the name Rose Hill Formation for exposures on Rose Hill, Cumberland, Maryland. In the New Castle area the Rose Hill includes those purple and red sandstones and shales lying between the Tuscarora Sandstone and the overlying coarse-grained, reddish-white sandstone and quartzite of the "Keefer-Wills Creek" Sandstone.

Distribution - The Rose Hill Formation is well exposed on Aps Knob along Virginia Route 42, and good exposures can also be found on the eastern side of Aps Knob. Excellent exposures of the Rose Hill can be seen in a power-line cut on the southeast side of Sinking Creek Mountain near the southwest corner of the area. The purplish-red sandstones can be

found as large blocks of float on the lower slopes of Sinking Creek and Johns Creek mountains, on their southeast and northwest flanks respectively, and on the eastern slopes of Aps Knob. Purplish-red sandstone and shale chips in the soil were the main criteria for mapping on the northwest flank of Johns Creek Mountain as no exposures of bedrock were found. The Rose Hill formation is 110 feet thick as measured along Virginia Route 42, on Aps Knob.

Lithology - The Rose Hill Formation has a greater variation in lithology than any other unit in the area. On Aps Knob it is composed of purplish-red, iron-rich, thin- to medium-bedded sandstone and shale. Some of the shale contains green clay splotches. On Sinking Creek Mountain the unit is predominantly a hematite-cemented sandstone. There it is composed of very-fine to very-coarse quartz grains set in a matrix of very-fine-grained hematite. At the Sinking Creek Mountain exposures, blood-red fragments of weathered Rose Hill Sandstone were also found. On Sinking Creek Mountain this unit is very resistant to erosion where the sandstones are thick-bedded and relatively little shale is present. On Aps Knob where the unit is for the most part shale with thinner beds of sandstone it underlies a topographic low between the more resistant Tuscarora Sandstone below and "Keefer" Sandstone above. According to C. K. Swartz et al. (1942, Chart 3) the Rose Hill Formation is in

The Niagaran Series of the Silurian.

"Keefer-Wills Creek" Sandstone

Name - Stose and Swartz (1912, p.41-46) named the Keefer Sandstone member of the McKenzie Formation for exposures on Keefer Mountain in Maryland. C. K. Swartz (1923, p.22) included the Keefer Sandstone as a member of the Rochester Formation. Butts (1940, p.245) included the Keefer Sandstone as a member of the Clinton Formation. The Wills Creek shale was named by Uhler (1905, p.19-26) for exposures along Wills Creek, near Cumberland, Maryland. In the New Castle area the interval containing both the Keefer and the Wills Creek formations was mapped as one unit. This interval is defined to include those beds lying between the top of the Rose Hill Formation and the base of the Tonoloway Limestone.

Distribution - Excellent exposures of the lower 150 feet of the "Keefer-Wills Creek" Sandstone can be seen on Aps Knob, along Virginia Route 42. An almost complete section of the sandstone and quartzite of the "Keefer-Wills Creek" Sandstone can be found in Johns Creek Gorge, near the eastern entrance to the gorge, just west of New Castle. The basal quartzites of the "Keefer-Wills Creek" Sandstone make up secondary ridges on the southeast flank of Sinking Creek Mountain and the northwest flank of Johns Creek Mountain. Outcrops of this unit make up the exposed core of Nutters

Mountain, Little Mountain and Peters Hill. A good exposure of the Wills Creek equivalent or upper part of the unit can be seen where Virginia Route 311 crosses the southern nose of Peters Hill, about three miles west of New Castle; excellent exposures of this unit occur in a power line cut on the southeast flank of Sinking Creek Mountain, near the southwest corner of the map. The maximum thickness of the "Keefer-Wills Creek" Sandstone in the New Castle area is 243 feet, measured in Johns Creek Gorge.

Lithology - The "Keefer-Wills Creek" Sandstone is composed of a basal, reddish-white orthoquartzite grading to a coarse-grained, reddish-white, hard sandstone near the top.

The unit contains a few beds of hematite-rich sandstone about 60 feet above the base. The uppermost units are fossiliferous containing ostracodes and upon weathering become friable. Some of the quartzites of the "Keefer-Wills Creek" Sandstone resemble the quartzite of the Tuscarora Sandstone but they are generally more reddish in color and finer-grained. In Maryland, C. K. Swartz (1923, p.32-35) included the Keefer with the Rochester Shale in the Niagaran Series of the Silurian System. C. K. Swartz et al., (1942, Chart 3) places the Wills Creek in the Cayugan Series of the Upper Silurian.

Tonoloway Limestone

Name - Ulrich (1911, Pl. 28) used the name Tonoloway Limestone in a stratigraphic column, but did not describe it. Stose (Stose and Swartz, 1912, p.7) formally proposed the name for exposures on the east flank of Tonoloway Ridge, near Rock Ford, Morgan County, West Virginia. In the New Castle area the Tonoloway Limestone includes those beds between the top of the "Keefer-Wills Creek" Sandstone and the lowermost sandstone unit of the Clifton Forge Sandstone.

Distribution - The Tonoloway Limestone is well exposed along the north side of Johns Creek where the Creek forms a deep gorge through the northern extension of Peters Hill. A few beds of limestone and sandstone probably representing the upper part of the Tonoloway can also be seen along Virginia Route 311 on Peters Hill approximately 2.7 miles west of New Castle. On County Road 615, along the eastern side of Pine Top, exposures of black chert and limestone occur at road level. This limestone may represent the upper part of the Tonoloway. The chert and limestone are overlain by Clifton Forge Sandstone at this location. Throughout the rest of the area the Tonoloway is expressed as a topographically low covered interval. For this reason the Tonoloway Limestone was mapped with the overlying Lower Devonian formations. The Tonoloway is 202 feet thick, as measured in Johns Creek Gorge.

Lithology - The lower portion of the Tonoloway Limestone is an olive-gray to gray, fine- to medium-grained, thin-bedded, impure, sandy limestone. This unit is fossiliferous and contains the brachiopod Camarotoecchia and the ostracode Leperditia. The highest portion is more dolomitic and massive with no evident fossils and some thin beds of black chert. C. K. Swartz et al. (1942, Chart 3) places the Tonoloway Limestone in the Cayugan Series of the Upper Silurian.

UPPER SILURIAN-LOWER DEVONIAN SERIES

Clifton Forge Sandstone

Name - F. M. Swartz (1929, p.29) proposed the name Clifton Forge Sandstone for exposures at Clifton Forge, Virginia. Lesure (1957, p.45) referred to this unit as the lower member of the Keyser Formation overlying the Tonoloway Limestone. In the New Castle area the Clifton Forge Sandstone includes those beds between the top of the Tonoloway Limestone and the base of either the Licking Creek Limestone, the Oriskany Sandstone, or the base of the Middle Devonian shale, depending on locality.

Distribution - The Clifton Forge Sandstone was mapped with the Tonoloway Limestone and overlying beds beneath the Middle Devonian shales. The Clifton Forge Sandstone is exposed on Pine Top, and on the flanks of Little Mountain, Nutters Mountain and along Virginia Route 311 on Peter Hill approximately three miles west of New Castle. The exposures on Pine Top occur stratigraphically below a fossiliferous limestone, which has been identified by its fossil content to be the Licking Creek Limestone, an equivalent of the Becraft Limestone. The sandstone overlies the black chert and limestone of the Tonoloway Limestone. Though no fossils were found the sandstone is similar both lithologically and stratigraphically to the Clifton Forge Sandstone of Lesure (1957, p.42-45) in the Clifton Forge Iron District, Virginia.

Along the northwest flank of Johns Creek Mountain and the southeast flank of Sinking Creek Mountain the interval containing the Clifton Forge Sandstone is expressed by a low area containing very sandy soil with a few scattered outcrops of punky, gray, coarse-grained sandstone. The Clifton Forge Sandstone is also exposed at the New Castle overlook on Virginia Route 42, 0.8 mile southwest of the town. A coarse-grained, punky sandstone which may be the upper 40 feet of the Clifton Forge Sandstone is also exposed in contact with the overlying Licking Creek Limestone along Craig Creek below the New Castle quarry 0.9 mile south of New Castle. Excellent exposures of reddish-brown-weathering Clifton Forge Sandstone can be seen on Pine Top where the Castle Sands Company is quarrying the unit for construction sand. The maximum thickness of the Clifton Forge Sandstone in the New Castle area is 158 feet, measured in Johns Creek Gorge.

Lithology - For the most part the Clifton Forge Sandstone is a light- to medium-gray, medium- to coarse-grained, friable sandstone. The upper 60 feet is extremely friable, and porous. The gray sandstone weathers to reddish-brown and the weathered surface where exposed develops a crust-like covering which is more resistant to weathering than is the fresh surface. It contains some bryozoans, crinoids and a few brachiopods which may be seen on the east side of Johns Creek

Gorge and at the overlook on Virginia Route 42 southwest of New Castle. According to F. M. Swartz (1939, p.44-45) the Clifton Forge Sandstone member of the Keyser Formation is placed in the Cayugan Series of the Upper Silurian. Butts (1940, p.269) places the Clifton Forge Sandstone of the Keyser in the Helderberg Series of the Devonian.

DEVONIAN SYSTEM

Licking Creek Limestone

Name - F. M. Swartz (1939, p.69) named the Licking Creek Limestone after exposures along Licking Creek near Warren Point, Franklin County, Pennsylvania. He extended the name to the south into Virginia to take the place of the term Becraft Limestone which he had used in 1930 (Swartz, F. M., 1930, p.42). In the New Castle area the Licking Creek Limestone includes those beds between the top of the Clifton Forge Sandstone and the base of the Middle Devonian shales.

Distribution - The Licking Creek Limestone is exposed at only two locations in the New Castle area. In the New Castle Quarry, approximately 0.9 mile south of New Castle, the total thickness of 23 feet of Licking Creek Limestone is exposed. The second outcrop occurs along the east flank of Pine Top, on County Road 615, just opposite the Whitlow farm, about 0.5 mile northeast of New Castle. Mr. Whitlow dumped some of this limestone along Craig Creek on his farm when County Road 615 was built. The Licking Creek Limestone may also have been deposited in other parts of the area but are absent now probably due to leaching by solution.

Lithology - The Licking Creek Limestone is primarily a dark-gray, fine- to medium-grained, highly fossiliferous

sandy limestone. The unit contains many brachiopods as well as bryozoans, corals and trilobites. The brachiopods include Megastrophia and Howellella concinnus (Hall). According to Woodward (1932, p.59) the Licking Creek Limestone in the New Castle area is in the Helderberg Group of the Lower Devonian. According to F. M. Swartz (1930, p.42) the Licking Creek Limestone is an equivalent of the Becraft Limestone. This age presents a problem. If the age is correct the Licking Creek Limestone may overlies an unconformity where New Scotland and Coeymans age beds are missing, or the upper part of the underlying "Clifton Forge Sandstone?" may actually be the equivalent of New Scotland and/or Coeymans beds.

Ridgeley Sandstone

Name - Schuchert et al. (1913, p.92) proposed the name Ridgeley Sandstone for exposures near Ridgeley, West Virginia. In the New Castle area, the Ridgeley Sandstone overlies the Clifton Forge Sandstone and underlies the Middle Devonian shale.

Distribution - The only exposure of Ridgeley Sandstone occurs on the western flank of Peters Hill along Virginia Route 311 about 3.5 miles west of New Castle. The Ridgeley Sandstone is 60 feet thick at this location.

Lithology - The Ridgeley Sandstone is a medium- to coarse-grained, iron-rich, friable sandstone. It weathers reddish-

orange. Iron-oxide composes approximately 25 to 40 per cent of the rock and weathers out to a thin, dark reddish-black irregular pattern. This unit is distinguished by means of the change in lithology from the underlying Clifton Forge Sandstone. The high iron-oxide content of the Ridgeley Sandstone is the major difference between the two sandstones. No fossils were found at this locality. The Ridgeley is in contact with an orange-white, medium-grained, friable sandstone. If this underlying sandstone is the Clifton Forge Sandstone then the Licking Creek Limestone is missing at this locality. No evidence of Licking Creek Limestone was found there, indicating a probable positive area at this locality during Licking Creek time. G. A. Cooper et al. (1942, Chart 4) places the Ridgeley Sandstone in the Deerpark Stage of the Lower Devonian.

Major Disconformity

A stratigraphic break in the Paleozoic rocks of the New Castle area occurs at the base of the Middle Devonian shales. These shales overlies different formations at different localities in the area. At the New Castle quarry, 0.9 mile south of New Castle the shales overlies the Licking Creek Limestone. Along County Road 615, northeast of New Castle, the shales overlies the Clifton Forge Sandstone. On the western side of Peters Hill, on Virginia Route 311, west

of New Castle, the shales overlie the Ridgeley Sandstone.

The variation of the stratigraphic sequence in the area, below the shale, indicates a significant period of erosion affecting these different localities with varying intensity.

Undifferentiated Middle Devonian Shales

Name - The thin black shales of the New Castle area are probably the equivalent of the Needmore and Millboro shales of the Clifton Forge district (Lesure, 1957, p.52-53), just northeast of the New Castle area. The Needmore Shale was named by Willard (1939, p.149) for exposures between Needmore and Warfordsburg in southern Fulton County, Pennsylvania. The Millboro shale was named by Butts (1940, p.300) for exposures at Millboro Springs, Bath County, Virginia. In the New Castle area the Middle Devonian shale from place to place overlies either the Clifton Forge Sandstone, the Licking Creek Limestone or the Ridgeley Sandstone.

Distribution - The Middle Devonian shales occur in two broad synclinal structures east and northwest of the Sinking Creek anticline, hereafter called the Craigs Creek syncline and Johns Creek syncline respectively. Shale exposures can be seen on Virginia Route 42 just southwest of the New Castle town limits. The Devonian shale can be readily seen along

most of Virginia Route 311 south of New Castle. At the New Castle Quarry, 0.9 mile south of New Castle, the Licking Creek Limestone is overlain by a thin bed of black blocky chert (14 inches thick) which in turn is overlain by the Devonian shales. Along County Road 615 northwest of New Castle the Devonian shale is seen to be in contact with both remnants of weathered Licking Creek Limestone and the red friable sands of the Clifton Forge Sandstone. On the west side of Peters Hill the Devonian shales are in contact with the Ridgeley Sandstone. The Devonian shales were not measured, but at least 2,000 feet of shale is estimated for the area.

Lithology - The Middle Devonian shales are mostly black, brown, reddish-brown or dark green in color. Some of the lower shale beds contain some brown, clay concretions. Higher in the section round, cherty, black concretions are also scattered through the shale. At the New Castle Quarry section the shale contains a 14-inch, basal chert layer which may be equivalent to the Huntersville Chert (Tillman, 1963, p.66). Some of the shale higher in the unit grades from black to dark gray and is slightly calcareous. The shale is extremely thin-bedded and crenulated for the major portion of its exposures, though some of the units are slightly more thickly-bedded.

The Needmore Shale is correlated by Butts (1940, p.303-305) with the Onondaga of New York. G. A. Cooper (1942, p.1736, 1738) states that the Millboro may represent the entire Hamilton Shale. This places the undifferentiated shale in the Upper Onesquethaw, the Cazenovia, Tioughnioga and Taghanic Stages of the Devonian (G. A. Cooper, 1942, Chart 4).

Unconsolidated Deposits

The colluvium and alluvium deposits that cover much of the mountain slopes in the area were not mapped. As approximately 70 per cent of the map area is covered by these surficial deposits many of the contacts are inferred.

STRUCTURAL GEOLOGY

General Statement

The New Castle area lies at the junction of the southern and central Appalachians as defined by Rodgers (1949, p.1644-1645). The Sinking Creek anticline is one of the northernmost features of the southern Appalachians and is the dominant structural feature in the area. The anticline is asymmetric with its northern limb slightly overturned. The anticline plunges northeast to apparent extinction southwest of New Castle. The Saltville fault passes through the central portion of the Sinking Creek anticline; its trace extends roughly parallel to the strike of the anticline. The fault breaches the nose of the Sinking Creek anticline and apparently dies out in the Devonian shale underlying New Castle. The Saltville fault is a reverse fault and has a maximum stratigraphic displacement of only 200 feet in the area.

Four small anticlines, Nutters Mountain anticline, Peters Hill anticline, Little Mountain anticline and Pine Top anticline, all strike generally N. 30° E. and plunge southwest to extinction north and west of New Castle (see map). These four northern anticlines have Silurian sandstones in their cores. In this area they represent the southernmost features of the Central Appalachians.

The Johns Creek syncline is northwest of the Sinking

Creek anticline, and the Devonian shales which lie within its boundaries show severe folding and crumpling. The Craigs Creek syncline occurs to the east of the Sinking Creek anticline and underlies the town of New Castle. Here, too, Devonian shales show an extreme degree of folding and crumpling.

A small dome occurs 0.9 mile south of New Castle, at the base of Sinking Creek Mountain. The New Castle quarry was developed in the Licking Creek Limestone on this structure.

Sinking Creek Anticline

The Sinking Creek anticline, an imposing structure south of New Castle, covers approximately two-thirds of the map area. Johns Creek Mountain is the topographic expression of the northwestern limb and Sinking Creek Mountain is the topographic expression of the southeastern limb. The Tuscarora Sandstone crops out along the crest of the two ridges. Near the northeastern extremity of the northwestern limb the Tuscarora is overturned and dips range from 58° to 84° southeast. The exposed core of the anticline is composed of Knox Dolomite. Beds on Sinking Creek Mountain and Aps Knob are in normal sequence and dip from 20° to 42° southeast and 31° to 39° east, respectively. The gap which occurs between Aps Knob and Johns Creek Mountain is probably the

topographic expression of a fracture created by the stress resulting from the overturning of the beds of Johns Creek Mountain. The change in direction of dip of the beds on either side of the gap support this hypothesis (see map).

Minor Anticlines

As already stated, the four smaller anticlines to the north and west of New Castle, Nutters Mountain anticline, Peters Hill anticline, Little Mountain anticline and Pine Top anticline, all have a general strike of N. 30° E. The Nutters Mountain and Peters Hill anticlines are slightly asymmetric with steeper northwestern flanks. The Little Mountain and Pine Top anticlines are both structurally and topographically lower than the other two anticlines and no major asymmetry of structure was observed. John Creek flows through the structural depression between the Nutters Mountain anticline and the Peters Hill anticline. The stream breaches the anticline and the Peters Hill anticline near its northeast limit. The stream exposes Rose Hill Sandstone, at water level, at two places in the gorge.

The flanks of the four anticlines are composed of those units lying stratigraphically between the Rose Hill Sandstone and the Devonian shale. "Keefer-Wills Creek" quartzites form the crest of Nutters Mountain, Little Mountain and Peters Hill. The Nutters Mountain anticline has dips of 20° to 30° northwest, on the northwestern flank and 13° to 20° southeast, on the southeastern flank. The four anti-

clines are surrounded by Devonian shale.

Johns Creek and Craigs Creek Synclines

The two broad synclines that lie northwest and east of the Sinking Creek anticline are occupied by Devonian shale and form the valleys of Johns Creek and Craig Creek, respectively. Strikes in the syncline are generally north-eastward in both the Johns Creek syncline and the Craigs Creek syncline. Both synclines contain abundant small folds, too small for mapping in the scale used. The Devonian shales are complexly folded. The age of deformation cannot be accurately determined in the New Castle area because the youngest Paleozoic rocks preserved within the area are Middle Devonian in age. In the Millers Cove area to the southwest of New Castle (Bauerlein, 1967) Mississippian rocks were also included in the deformation. The structure of the New Castle area is part of the regional Appalachian structure and is probably a result of the Appalachian orogeny which is of late Paleozoic age (King, 1951, p.125) occurring after the deposition of Mississippian units in surrounding areas.

Saltville Fault

The Saltville fault has long been recognized as one of the principal thrusts in the Appalachian region (Butts,

1940, p.457; Cooper, B. N., 1944, p.191). It is known to extend from New Castle southwestward to the southern border of Tennessee where it continues southward as the Rome fault. In the New Castle area, the fault parallels the strike of the Sinking Creek anticline and crops out at the southeastern base of Johns Creek Mountain just north of the anticlinal axis. The trace of the fault underlies the stream valley of Meadow Creek for a large portion of its extent in the area. In the Aps Knob area it is primarily a reverse fault with offset becoming increasingly less in a northeasterly direction. Actual measurement of the attitude of the fault plane was impossible as the only outcrops of the trace were represented by a brecciated zone at least 10 feet thick. The trace is quite sinuous in the area owing primarily to the effect of erosion on the fault plane.

A stratigraphic displacement of 120 feet occurs at the nose of the Sinking Creek anticline, about two miles southwest of New Castle on Virginia Route 42 where the Tuscarora Sandstone is seen in fault contact with the red shales and sandstones of the Juniata Formation. In the southwestern portion of the area along County Road 624 near the intersection with County Road 625, the maximum displacement of approximately 200 feet occurs where upper Chatham Hill Limestone beds are in contact with the lower portion of the

Martinsburg Formation. The dip of the fault plane was determined by the asymmetry of the folded beds on both the hangingwall and footwall of the fault.

The Saltville fault has a scissors character in the area (see map, sections A-A', B-B'). The southeastern block appears to have been moved slightly over the northwestern block with the pivot point near the southwestern side of Aps Knob. Beds of the Tuscarora Sandstone of the hangingwall block northeast of the Aps Knob pivot point occur to the west of their counterparts on the footwall. Normally eastward dipping beds of the hangingwall of a reverse fault would be expected to migrate, due to erosion, farther east than similar beds on the footwall. Near the Appalachian Power Dam on Virginia Route 42 about 2 miles southwest of New Castle, the Tuscarora of the hangingwall block, though dipping to the east, is 120 feet west of its counterpart of the northern footwall block, which also dips east though not as steeply. A scissors motion of the fault would explain this apparent anomaly. An alternate interpretation is that the Saltville fault, at least in the New Castle area, is primarily an oblique-slip rather than a dip-slip fault. Farther southwest, as near Saltville, the fault is known to be a thrust of low dip and great stratigraphic displacement.

Syntectonic Deposition and Basement Structure

The Paleozoic formations within the New Castle area, when compared with equivalent units in other nearby, structural settings are relatively thin. For the interval from the top of the Knox Dolomite through the Tuscarora Sandstone, larger thicknesses have been reported in other areas than in the New Castle area. Bauerlein (1967, p.19-24) reported a thickness of 2530 feet for this interval in the Millers Cove area, Virginia. Lesure (1957, p.22-33) reported 2554 feet for the same interval in the Clifton Forge area, Virginia. Moon (1961, p.13-31) reported a thickness of sediments of 2540 feet in the Poplar Hill area, Virginia and Ovenshine (1961, p.23-49) reported a thickness of 3399 feet for this interval in the Spruce Run Mountain area, Virginia. In the New Castle area the interval from the top of the Knox Dolomite through the Tuscarora Sandstone is 2300 feet thick.

The "Keefer-Wills Creek" Sandstone, measured on the nose of the Sinking Creek anticline is 150 feet thick and the same unit measured in Johns Creek Gorge is 248 feet thick. The thinness of the Paleozoic sediments on the Sinking Creek Anticline may be interpreted to mean that the area now occupied by the anticline was one of less subsidence than

the surrounding areas during that extent of the Paleozoic era represented in the area.

R. E. Francis (1967), who worked on the "Gravity and Magnetics of the New Castle Area, Craig County, Virginia," shows that the Sinking Creek anticline is expressed in the basement underlying the New Castle area (see Francis, R. E., 1967, Plate 2 and 3). This indicates that the basement was involved in the upwarping of the Sinking Creek anticline. His maps do not, however, indicate that the minor anticlines to the north of the Sinking Creek anticline are expressed on the basement. They may be nothing more than surface wrinkles in a large syncline which includes both the Johns Creek syncline and the Craigs Creek syncline.

ECONOMIC GEOLOGY

Within the New Castle area Clifton Forge Sandstone is being actively quarried by the Castle Sands Company, Inc., for use as construction sand and sand for the manufacture of Portland cement. The sandstone is so friable that drilling equipment has not yet been used in the quarrying process. Most of the quarry work has been accomplished by bulldozers and little cleaning of the worked sand is necessary. The quarry is located on Pine Top, but Castle Sands plans to purchase the eastern flank of Little Mountain in hopes of extending their operations.

The Virginia State Highway Department has used both the Licking Creek Limestone and the Witten Limestone of the New Castle area for crushed stone. Opposite the U.S. Fish Hatchery on Virginia Route 42 about 1.5 miles southwest of New Castle and Witten Limestone was quarried for road base; and about 0.9 mile south of New Castle along Virginia Route 311, at the New Castle Quarry, Licking Creek Limestone was quarried for same purpose.

GEOLOGIC HISTORY

The geologic history of the Appalachian Valley and Ridge Province has been discussed by Butts (1940), Eardley, King (1959) and others. The New Castle area lies within the boundaries of the Appalachian miogeosyncline. The geologic history of the New Castle area is summarized briefly below.

All the rocks exposed in the New Castle area are sedimentary. The range in age, of the exposed formations within the area, is from Early Ordovician to Middle Devonian.

In the New Castle area the Knox Dolomite of Early Ordovician age contains algal limestone which indicates that the water in which it formed was shallow.

Following the deposition of the Knox Dolomite, the sea retreated and the resulting coastal plain was subjected to intense erosion. The surface of the Knox Dolomite is highly irregular. Scour channels and pinnacles of dolomite are evidence of this period of erosion. Similar evidence of post-Knox erosion have been cited in other parts of the United States, and the withdrawal of the Early Ordovician Sea from the New Castle area is believed to have been part of a regional emergence. At the beginning of Chazyan time the sea again advanced over the area. Material derived from

the high areas washed down into topographic lows and the clastic sediment of the Blackford Formation was deposited on the erosional surface of the Knox Dolomite. After deposition of the Blackford formation the Elway Limestone, a calcilutite, probably was formed as a chemical precipitate of fine-grained calcium carbonates. Deposition of limestone persisted during much of the Middle Ordovician and is also represented by the Lincolnshire Limestone, the Chatham Hill Formation and the Witten Limestone.

After deposition of the Witten Limestone, at the beginning of the depositional period of the Eggleston Formation the source area probably began to rise as all the succeeding deposits, broadly viewed, are dominantly detrital and increasingly coarse-grained. The advent of this period of uplifting is marked by a thin sandstone unit at the base of the Eggleston shales. Thin-bedded, buff shales, coarse-grained limestones and bentonites are included in the Eggleston Formation. The shales may indicate a closer proximity to the source area, than that of the underlying limestone. The bentonites probably resulted from the decomposition of volcanic ash. The bentonites indicate volcanic activity was taking place near the end of Eggleston time.

During the Middle and Late Ordovician, the Martinsburg Formation was deposited above the Eggleston Formation. The Martinsburg is primarily a silty calcareous shale with some thin beds of limestone. The great thickness of Martinsburg indicates a period of gradual subsidence.

The Martinsburg Formation was succeeded by the sandstones and shales of the Juniata Formation. The upper, light orange, cross-bedded sandstones were probably deposited in shallow, near-shore conditions. The Juniata deposits are generally considered to be derived from an eastern landmass (Eardley, 1951, p.82-83), as are the overlying Silurian sandstones.

The Silurian period began with the deposition of medium- to coarse-grained sand during Tuscarora time. This sand or fine-grained gravel was fairly free of impurities and was almost entirely composed of quartz sand and pebble.

The beds of the overlying Rose Hill Formation are composed of finer-grained sediments. Muds, silts and sands were deposited and affected by currents as is indicated by ripple marks, but no gravel was found within this formation.

Deposition of fine-grained sands continued through "Kefer-Wills Creek" time. Cross-bedding in the iron-bearing quartzites of the "Kefer-Wills Creek" Sandstone indicate

that some turbulent conditions still affected the deposited material. The upper sandstone beds contain some ostracodes indicating the return of favorable conditions for marine life. Conditions from the end of Martinsburg time through the Lower Silurian were generally unfavorable, in the New Castle area, for marine life.

Overlying the "Keefer-Wills Creek" Sandstone is the Tonoloway Limestone. The Tonoloway contains many coarse-ribbed brachiopods and it is a medium- to coarse-grained, sandy limestone.

The coarse-grained, iron-bearing Clifton Forge Sandstone overlies the Tonoloway Limestone. In nearby areas this sandstone is carbonate-cemented.

After the deposition of the Clifton Forge Sandstone the eastern part of the area may have been more deeply submerged than the western side. Licking Creek Limestone was deposited under shallow water conditions. No Licking Creek Limestone was found in the western portion of the area indicating either none had been deposited or that the western portion of the map area was uplifted higher than the eastern portion; and any deposits of Licking Creek Limestone, which may have accumulated were eroded away, or that the limestone has been dissolved by weathering agents.

The local exposure of Ridgeley Sandstone found in the western portion of the area, in contact with Clifton Forge Sandstone, is a coarse-grained sandstone, probably deposited under conditions very similar to those affecting the Clifton Forge Sandstone.

After deposition of the Ridgeley Sandstone, the area was once more subjected to a period of emergence and erosion. The erosion surface exposed Clifton Forge Sandstone, Licking Creek Limestone and Ridgeley Sandstone. This may be interpreted to mean that the surface contained high and low areas during the period of erosion.

On this erosion surface was deposited a great thickness of mud, silt and sand, upon the resubmergence of the area. These deposits were lithified into the thin-bedded Middle Devonian shales.

Deformation of the Paleozoic rocks occurred after the deposition of the Middle Devonian shale. In the nearby Millers Cove area (Bauerlein, 1967) Mississippian rocks were also included in the deformation.

From the time of deformation to the present, erosion, developed by either gradual uplift of the land or eustatic adjustment of sea level, has altered the area to its present form.

GEOLOGIC SECTIONS

Geologic Section 1. - Middle Ordovician limestones on F. J. Sizur Farm, near eastern intersection of County Road 622 and Virginia Route 42.

	THICKNESS	
	Feet	Inches
Martinsburg Formation (not measured)		
Eggleston Formation (42 feet)		
38. Bentonite; dark greenish-yellow, cuneiform weathering.....	2	
37. Shale; buff to yellow, thin-bedded, highly fissile.....	1	
36. Limestone; dark-green, medium-grained, argillaceous; weathers brownish-green		6
35. Shale; buff to yellow, thin-bedded, highly fissile.....	1	
34. Limestone interbedded with shale; limestone, gray, medium-grained, argillaceous; shale, green to buff, thin-bedded.....	2	
33. Covered interval; dark-brown soil, some shale chips.....	8	4
32. Limestone; medium-gray, medium-grained, massive, cuneiform-jointed; weathers		

	THICKNESS	
	Feet	Inches
buff.....	2	
31. Covered interval; reddish-brown soil.	5	8
30. Shale; greenish-gray; weathers buff..	4	6
29. Covered interval.....	10	
28. Limestone; greenish-gray, medium-grained; weathers brownish-green.....	1	
27. Sandstone; light reddish-brown, medium-grained, cross-bedded.....	4	
Witten Limestone (60 feet)		
26. Limestone; medium-gray, fine- to medium-grained, massive, cuneiform fracture; weathers light-gray and nodular.....	19	
25. Limestone; medium-gray, medium-grained, with thin interbeds of dolomite.....	13	9
24. Calcilutite; light-gray with thin interbeds of dolomite; calcilutite weathers smooth and dove-gray.....	3	6
23. Limestone; gray, fine- to medium-grained, dolomitic, nodular weathering, cuneiform fracture.....	23	9
Chatham Hill Limestone (191 feet)		
22. Limestone; dark-gray, fine-grained, thin-bedded, cherty, fossiliferous		

THICKNESS

Feet Inches

(brachiopods, sponges and cystoids),
weathers to cobbly rubble; edges of
fractured, fresh surface are brownish-
gray..... 24

21. Covered interval..... 56

20. Limestone; dark-gray, fine-grained,
thin-bedded, nodular-weathering,
fossiliferous..... 33

19. Covered interval..... 18

18. Limestone; dark-gray, thin-bedded,
fossiliferous, some very thin beds
containing flint..... 60

Lincolnshire Limestone (190 feet)

17. Limestone; medium- to dark-gray,
medium- to coarse-grained, fossil-
iferous, cherty; weathers to a medium-
gray, smooth-surface, black chert
layers weather white..... 60

16. Covered interval; scattered outcrops
of cherty calcarenite (approximate
thickness)..... 125

15. Calcarenite; medium-gray, contains
thin layers of black chert, chert
weathers white and blocky..... 5

	THICKNESS	
	Feet	Inches
Elway Limestone (155 feet)		
14. Calcilutite; dark-gray, cherty; weathers dove-gray, chert is black and weathers white.....	12	
13. Covered interval (approximate thickness).....	80	
12. Calcilutite; dark-gray, massive; weathers smooth and dove-gray.....	1	6
11. Interbedded limestone and dolomite; limestone, light-gray, fine-grained, thin-bedded; dolomite, tan and thin-bedded.....	2	
10. Calcilutite; dark-gray, highest occurrence of burgundy chert.....	7	
9. Limestone; dark-gray, fine-grained, thin-bedded with thin dolomitic interbeds.....	8	
8. Calcilutite; light-gray, with scattered occurrences of black and burgundy chert.....	15	
7. Limestone; alternating dark- and light-gray limestone, fine-grained, contains small calcite rhombs.....	3	
6. Limestone; gray, fine-grained, thick-		

	THICKNESS	
	Feet	Inches
bedded, nodular, contains lowest occurrence of burgundy chert.....	4	
5. Limestone; gray, fine-grained, thick-bedded, nodular.....	3	
4. Calcilutite; light-gray, thin-bedded, contains black chert.....	9	
3. Limestone; alternating dark- and light-gray beds, fine-grained, thin-bedded.	3	
2. Calcilutite; dark-gray; weathers dove-gray.....	7	6
Blackford Formation (22 feet)		
1. Limestone; gray, fine- to medium-grained, dolomitic, contains dolomite and chert pebble clasts.....	22	
Knox Dolomite (not measured)		

Geologic Section 2. - Upper Ordovician and Lower Silurian
formations on the south side of Abs
Knob, along Virginia Route 42,
southwest of New Castle.

THICKNESS

Feet Inches

Covered

"Keefer-Wills Creek" Sandstone (lower 150 feet)

- 42. Sandstone; light-gray, medium-grained,
very hard, conchoidal fracture;
weathers brown..... 12
- 41. Sandstone; light-reddish-orange to
white, medium-grained, highly friable 8
- 40. Orthoquartzite; light-gray to purplish-
gray, medium-grained, massive, conchoid-
ally fractured..... 20
- 39. Sandstone; light-red to white, medium-
to coarse-grained, friable..... 39
- 38. Sandstone; reddish-white to light-gray,
medium- to coarse-grained, silica-
cemented, ridge-former..... 80

Rose Hill Formation (110 feet)

- 37. Covered interval; orange-red and
green shaly float..... 12
- 36. Shale; purplish-red, thin-bedded,
sandy..... 2

	THICKNESS	
	Feet	Inches
35. Sandstone; greenish-gray to gray, medium-grained, shaly, weathers reddish-purple.....	6	
34. Covered interval; light-red and green shaly float.....	15	
33. Shale; purplish-red, thin-bedded, sandy with green clay galls.....	12	
32. Covered interval; red and green shaly float.....	9	
31. Shale; dark-purplish-red, thick-bedded, ripple marks present.....	6	
30. Sandstone; very dark-purplish-red, fine-grained, very hard.....	6	
29. Covered interval; purplish-red shale float.....	42	
Tuscarora Sandstone (51 feet)		
28. Covered interval; white, sandy float.	6	
27. Sandstone; white to light-gray and light-orange-red, fine- to medium-grained, at base; grades to white, medium-grained quartzite at top.....	45	
Juniata Sandstone (215 feet, 10 inches)		
26. Sandstone; light-gray and reddish-orange, medium-grained, thick-bedded,		

	THICKNESS	
	Feet	Inches
cross-bedded.....	39	
25. Shale; olive-gray, thin-bedded.....	1	
24. Sandstone; bright-reddish-orange, fine- to medium-grained.....	35	
23. Interbedded sandstone and shale; olive and maroon, fine-grained sandstone, thin, fissile shale with green clay splotches.....	20	5
22. Interbedded shale and sandstone; maroon shale, dark-gray to maroon, fine- to medium-grained sandstone....	21	
21. Sandstone; maroon to purplish-red, fine-grained.....	1	
20. Interbedded sandstone and shale; sand- stone, maroon, fine-grained; shale, maroon and green, thin-bedded.....	12	
19. Covered interval; sand and shale float	10	6
18. Sandstone; reddish-tan to light-gray, medium-grained, massive, ripple marks present.....	16	
17. Sandstone; olive-gray, medium-grained, interbedded with light-red, iron-rich sandstone and thin maroon shale.....	9	6
16. Shale; maroon, thin-bedded.....	9	3

	THICKNESS	
	Feet	Inches
15. Sandstone; dark-gray, medium-grained, thin-bedded, with thin beds of purplish-gray shale.....	2	5
14. Sandstone; light-gray, medium-grained, weathers light-red, slightly friable, with a few interbeds of thin, maroon shale.....	1	11
13. Interbedded sandstone and shale; sandstone, maroon, gray and olive, fine-grained; shale, maroon, thin, highly fissile.....	10	
12. Sandstone; reddish-gray, medium-grained		8
11. Interbedded shale and sandstone; shale, maroon, thin-bedded; sandstone, maroon and olive-gray, fine-grained, thin-bedded, slightly calcareous.....	4	5
10. Sandstone; tan to olive, medium-grained, cross-bedded.....	1	
9. Interbedded sandstone and shale; sandstone, maroon, olive and gray, fine-grained, cross-bedded, fossiliferous; shale, maroon and thin-bedded.....	2	
8. Interbedded shale and sandstone; shale, purplish-red to maroon, thin-bedded;		

	THICKNESS	
	Feet	Inches
sandstone, dark-red, fine-grained....	1	11
7. Shale; olive to light-gray with thin beds of red.....	1	8
6. Interbedded sandstone and shale; sandstone, olive to red, fine-grained; shale, red, thin-bedded.....	6	7
5. Sandstone; gray to olive, fine-grained, calcareous.....	3	
4. Interbedded shale and sandstone; sandstone, reddish-gray, thin-bedded, calcareous; shale, reddish-olive-gray, thin-bedded.....	5	5
3. Shale; olive to red, thin-bedded.....		2
Martinsburg Formation (uppermost 17 feet)		
2. Sandstone; dark-gray, fine-grained, massive, calcareous, fossiliferous (upper portion contains <u>Orthorhynchula stevensoni</u>).....	11	
1. Shale; greenish-gray, nodular in places, fossiliferous; weathers buff to greenish-tan.....	6	
Covered		

Geologic Section 3. - Upper Silurian and Lower Devonian
formations on the north side of Johns
Creek, along the eastern end of Johns
Creek Gorge.

THICKNESS

Feet Inches

Devonian Shale (not measured)

Clifton Forge Sandstone (158 feet)

- | | |
|---|----|
| 35. Sandstone; light- to medium-gray,
coarse-grained, finely cross-bedded,
highly friable, porous; weathers brown | 42 |
| 34. Covered interval; sandy soil..... | 38 |
| 33. Sandstone; light- to medium-gray,
medium-grained, calcareous, fossil-
iferous (contains same fossils as unit
32)..... | 24 |
| 32. Sandstone; grayish-white, medium- to
coarse-grained, irregularly-bedded,
some cross-bedding evident, fossil-
iferous including crinoids, bryozoans
and some brachiopod fragments; forms a
small cliff..... | 30 |
| 31. Covered interval; soil composed of buff
siltstone and some gray sandstone..... | 22 |
| 30. Sandstone; grayish-white, medium-
grained, thin-bedded; weathers reddish- | |

	THICKNESS	
	Feet	Inches
brown.....	2	
Tonoloway Limestone (202 feet)		
29. Covered interval; shaly limestone fragments in dark brown soil.....	32	
28. Limestone; gray, fine-grained, massive, dolomitic, cliff-former; dolomite weathers buff and forms a fretwork within the limestone.....	40	
27. Covered interval; light-brown soil...	10	
26. Limestone; gray, fine-grained, massive, dolomitic, cliff-former.....	30	
25. Covered interval; brown soil, shaly limestone float.....	27	
24. Limestone; gray, fine-grained, thin- bedded, some cross-bedding present, fossiliferous (<u>Camarotoechia</u> and <u>Leperditia</u>):.....	22	
23. Limestone; dark-gray, medium- to coarse-grained, thin-bedded, sandy, fossiliferous (<u>Camarotoechia</u>).....	19	
22. Covered interval; brown soil.....	20	
21. Limestone; dark-gray, medium-grained, thin-bedded, sandy; weathers dark, reddish-gray, fossiliferous.....	2	

	THICKNESS	
	Feet	Inches
"Keefer-Wills Creek" Sandstone (243 feet)		
20. Covered interval; sandy soil, scattered small outcrops of sandstone (approximate thickness).....	50	
19. Sandstone; orange-white, coarse-grained, medium- to thick-bedded; weathers orange to reddish-white.....	16	
18. Sandstone; reddish-gray, medium-grained, medium-bedded, cross-bedded, some shaly portions.....	8	
17. Sandstone; reddish-white, fine-grained, thick-bedded, cross-bedded.....	12	
16. Sandstone; tan, medium-grained, thin-bedded.....	2	
15. Sandstone; grayish-white, medium-grained, thick-bedded.....	5	
14. Sandstone; gray, fine- to medium-grained, platy to thin-bedded.....	2	6
13. Sandstone; gray, fine- to medium-grained, medium-bedded.....	4	
12. Sandstone; tan, fine-grained, thin-bedded, shaly.....	4	
11. Orthoquartzite; gray, fine-grained, medium-bedded.....	10	

	THICKNESS	
	Feet	Inches
10. Covered interval.....	30	
9. Orthoquartzite; red, glassy, thick-bedded, cross-bedded, very hard, some ripple marks present between beds....	25	
8. Orthoquartzite; light-gray, fine-grained, cross-bedded.....	3	
7. Sandstone; purplish-red, fine-grained, massive.....	7	
6. Sandstone; red, fine-grained, thin- to medium-bedded, hematitic.....	6	
5. Sandstone; red, very thin bed of hematitic sandstone.....		1
4. Sandstone; red, fine-grained, thin-bedded, hematitic.....	5	6
3. Sandstone; reddish-gray, fine-grained, medium-bedded, cross-bedded.....	17	
2. Orthoquartzite; gray, very fine-grained.....	2	
1. Orthoquartzite; reddish-gray, massive to thick-bedded, extremely hard.....	34	
Rose Hill Formation (at water level)		

Geologic Section 4. - Licking Creek Limestone exposed in New Castle Quarry, 0.9 mile south of New Castle, along Virginia Route 311.

	THICKNESS	
	Feet	Inches
Devonian Shale (not measured)		
4. Shale; black and green, thin, crenulated.		
3. Chert; black, thin-bedded, blocky....	1	2
Licking Creek Limestone (23 feet)		
2. Limestone; dark-gray, fine-grained, massive to thick-bedded, fossiliferous (<u>Megastrophia</u> and <u>Howellella concinnus</u>)	23	
Clifton Forge Sandstone ? (upper 40 feet)		
1. Sandstone; gray to brown, coarse-grained, calcareous, friable, cross-bedded.....	40	
Covered.		

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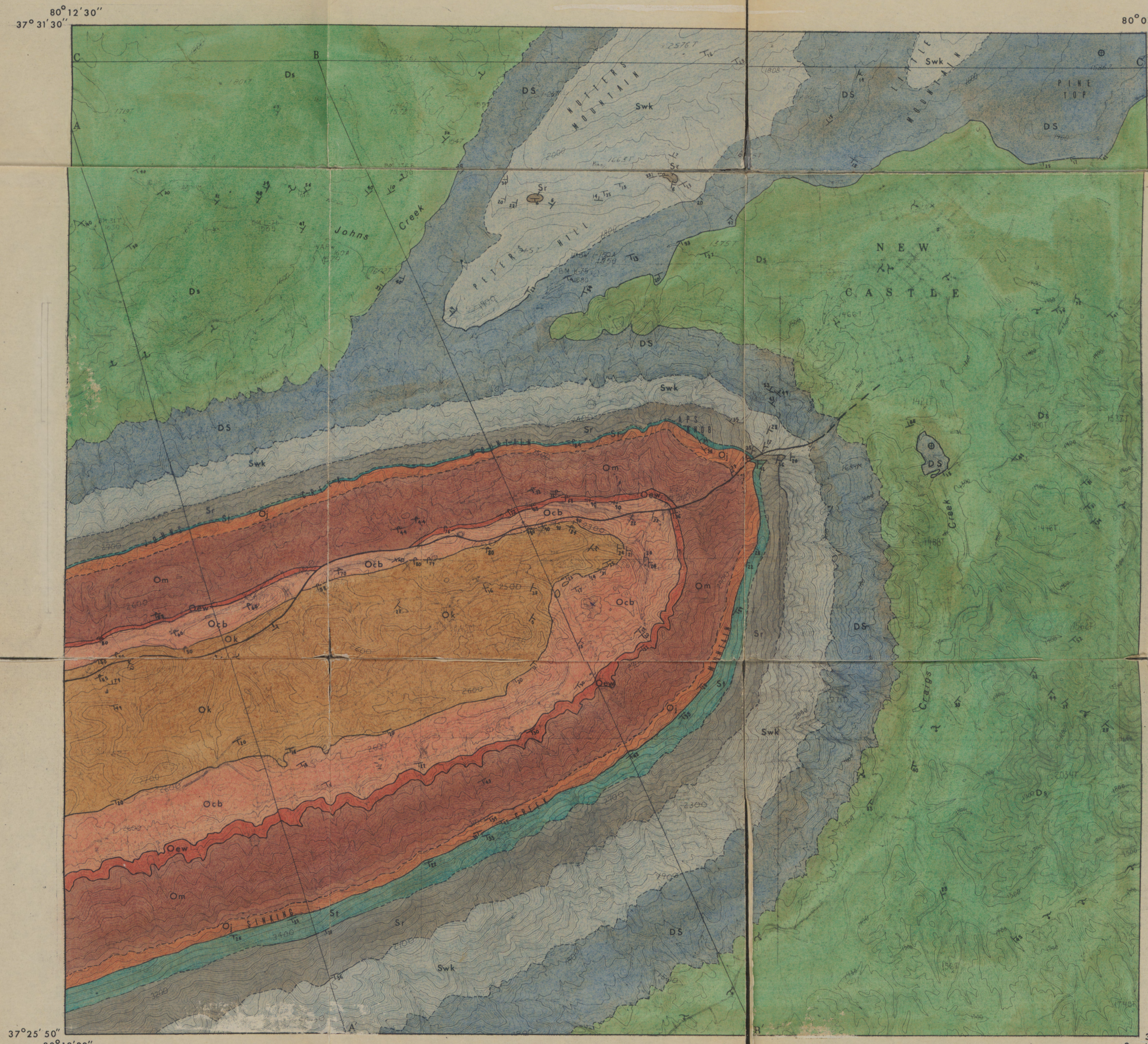
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Geology of the New Castle area, Craig County, Virginia

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GEOLOGIC MAP AND SECTIONS OF THE NEW CASTLE AREA, CRAIG COUNTY, VIRGINIA

BY
MARTIN L. BREGMAN
1966-1967



EXPLANATION

Ds
Devonian Shale
Millboro Shale and
Needmore Shale

DS
Devonian and Silurian Formations
Ridgeley Sandstone, Licking Creek
Limestone, Clifton Forge Sandstone,
and Tonoloway Limestone

Swk
"Keefer-Wills Creek"
Sandstone

Sr
Rose Hill Formation

St
Tuscarora Sandstone

Oj
Juniata Formation

Om
Martinsburg Formation

Oew
Middle Ordovician Limestones
Eggleston Formation and Witten
Limestone

Ocb
Middle Ordovician Limestones
Chatham Hill Limestone, Lincolnshire
Limestone, Elway Limestone, Duckett
Formation

Ok
(Upper) Knox Dolomite

Saltville Fault
Reverse fault, Ton upper plate

Contact
Dashed where inferred or approx-
imately located

Strike and dip of beds

Strike and dip of overturned beds

Strike of vertical beds

Horizontal beds

Generalized strike of contorted beds

DEVONIAN

SILURIAN

ORDOVICIAN

Scale 1:24,000
0 1 2 miles

Contour Interval
20 and 40 feet

3%
MAGNETIC NORTH
TRUE NORTH
approximate mea-
surement 1945

