COMMONWEALTH OF VIRGINIA
DEPARTMENT OF CONSERVATION
AND ECONOMIC DEVELOPMENT
DIVISION OF MINERAL RESOURCES

GEOLOGY OF THE WOODSTOCK, WOLF GAP, CONICVILLE, AND EDINBURG QUADRANGLES, VIRGINIA

ROBERT S. YOUNG AND
EUGENE K. RADER

REPORT OF INVESTIGATIONS 35

VIRGINIA DIVISION OF MINERAL RESOURCES
James L. Calver
Commissioner of Mineral Resources and State Geologist

CHARLOTTESVILLE, VIRGINIA
1974

COMMONWEALTH OF VIRGINIA
DEPARTMENT OF PURCHASES AND SUPPLY
RICHMOND
1974

Young, R. S., and Rader, E. K., 1974, Geology of the Woodstock, Wolf Gap, Conicville, and Edinburg quadrangles, Virginia: Virginia Division of Mineral Resources Rept. Inv. 35, 69 p.

Raymond Smith Edmundson

RAYMOND SMITH EDMUNDSON

EDUCATOR-GEOLOGIST

It is a great privilege for the writers to dedicate this work to Raymond Smith Edmundson. It may be of interest to the readers of this report that Ray was born in McKeesport, Pennsylvania on February 13, 1908, the only son of Charles Zera and Mary Susan (Smith) Edmundson. The Edmundsons moved to Winchester, Virginia in 1912, and Ray considers Winchester his family home. Completing his elementary and high school education in Winchester, he attended the University of Virginia, where he received a B.A. (Geology) in 1929 and an M.S. (Geology) in 1930. Ray began his Ph.D. studies at Cornell University, Ithaca, New York in 1930. These studies were interrupted during 1931-32 when he taught mathematics at Handley High School, Winchester, Virginia. During this period, Ray married Delia (Dee) Buck Cloud, of Charlottesville, Virginia. Upon completing his Ph.D. studies in 1935, he remained at Cornell as geology instructor until 1937. Ray was a geologist for the Virginia Geological Survey from 1937 until 1946 when he joined the faculty of the University of Virginia, becoming professor of geology in 1956 and serving as departmental chairman from 1959 to 1964. He retired from the University of Virginia in 1968.

Ray is a Fellow in the Geological Society of America and the American Association for the Advancement of Science. Other memberships include the Mineralogical Society of America, National Association of Geology Teachers, American Association of University Professors, Virginia Academy of Science, and Sigma Gamma Epsilon.

Raymond Smith Edmundson has authored more than a dozen publications and a like number of presentations at various professional meetings. His academic and administrative proficiencies are recognized by his colleagues. To an educator the performance of one's students provides the greatest satisfaction. Ray's former students include senior executives in the petroleum and mining industries, professors and administrators in the academic realm, and senior scientists in national and state geological surveys. Beyond all doubt, Ray Edmundson has had an impact on the geologic profession. He currently resides at 1707 Kenwood Lane, Charlottesville, Virginia.

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GEOLOGY OF THE WOODSTOCK, WOLF GAP, CONICVILLE, AND EDINBURG QUADRANGLES, VIRGINIA

By

ROBERT S. YOUNG[1] AND EUGENE K. RADER[2]

ABSTRACT

The Woodstock, Wolf Gap, Conicville, and Edinburg quadrangles are located in the Valley and Ridge physiographic province in the northern part of the Appalachian Valley of Virginia. Bedrock in the area ranges in age from Middle Cambrian to Late Devonian, but consists principally of Cambrian and Ordovician rocks. With the exception of thin metabentonites in the Oranda the rocks are sedimentary and have a total thickness of approximately 18,500 feet.

Early orogenic deformation resulted in northeastward-trending folds. The major ones, from southeast to northwest across the area are Massanutten synclinorium, Mount Jackson anticline, Harmony syncline, Paddy Mountain anticline, Supin Lick syncline, and Anderson Ridge anticline. Shearing forces, contemporaneous with overturning were localized and the following reverse faults developed: Saumsville, Alonzaville, and North Mountain. The normal faults of the area are late and probably represent relaxation of compression forces following folding.

The mineral resources in the mapped area consist of limestone, dolomite, shale, clay, manganese oxides, iron oxides, and zinc sulfide. Limestone and dolomite for use as crushed stone and agricultural stone have been quarried in the area. Numerous potential quarry sites are available. Shale from the Martinsburg, Marcellus, and Hampshire formations has been tested for potential use in the manufacture of brick and ceramic products. Manganese has been produced from the Ridgeley and Keefer formations in the western upland area. Shows of sphalerite and fluorite have been found, but no economic deposits are known.

INTRODUCTION

The original project that lead to the preparation of the geologic maps of the Woodstock (Plate 1), Wolf Gap (Plate 2), Conicville (Plate 3), and Edinburg (Plate 4) 7.5-minute quad-

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[1] North American Exploration, Incorporated, Charlottesville, Virginia 22906.
[2] Staff member.

rangles was the mapping of the Edinburg, Virginia-West Virginia 15-minute quadrangle. The four 7.5-minute quadrangles encompass a combined area of 238 square miles, which is bounded by latitudes 38°45′ N. and 39°00′ N. and longitudes 78°30′ W. and 78°45′ W. (Figure 1). Approximately 85 percent of the

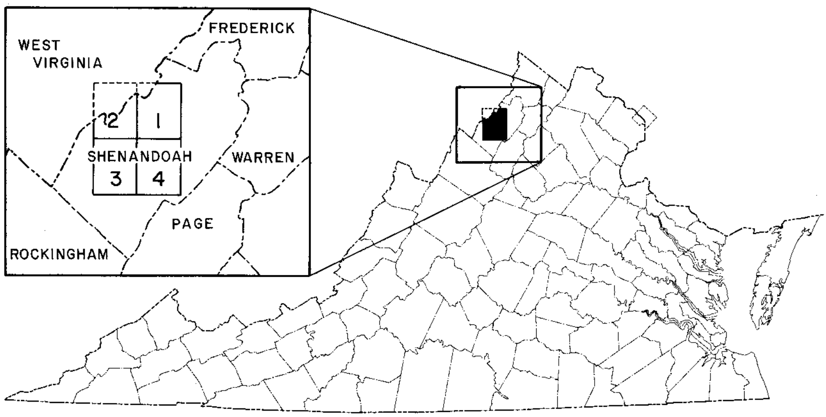

Figure 1. Index map showing location of the Woodstock (Plate 1), Wolf Gap (Plate 2), Conicville (Plate 3), and Edinburg (Plate 4) quadrangles, Shenandoah County, Virginia.

total area is in Shenandoah County, Virginia, and the remainder in Hardy County, West Virginia. In the current program, those portions of the Wolf Gap and Woodstock quadrangles covering West Virginia were not mapped.

Field investigations were done during the summers of 1952 and 1953, the fall of 1971, and the spring of 1972. The base map of the original mapping was at a scale of 1:31,250, which was photostatically enlarged from the topographic map of the Edinburg 15-minute quadrangle at a scale of 1:62,500. The data were transferred from the 1:31,250-scale map to the four 1:24,000-scale maps (7.5-minute series) by utilizing identical grid systems based on the two scales. Formational contacts were adjusted to the topography by aerial-photo inspection and field checked for accuracy in the spring of 1973.

Numerous road junctions and bench marks provided excellent control in the lowland portion of the area. Bench marks and other specific location points were less frequent in the uplands to the west; here, access is primarily along county roads and George Washington National Forest trails.

The Woodstock, Wolf Gap, Conicville, and Edinburg quadrangles lie entirely within the Valley and Ridge physiographic province. The topography of the mapped area is in a mature

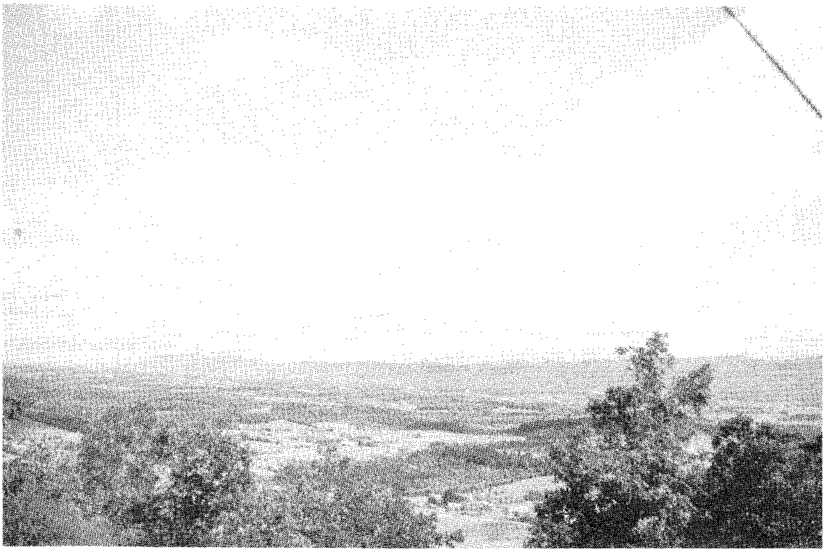

Figure 2. Central lowland on Cambrian and Ordovician rocks with Massanutten Mountain of the eastern upland in the background; looking southeast from Deerhead Lookout Tower (Plate 3).

Figure 3. Western upland of Silurian and Devonian rocks; looking northwest from Deerhead Lookout Tower north of Hudson Crossroads (Plate 3).

stage of dissection. The lowest elevation, slightly less than 720 feet, is found along the North Fork of the Shenandoah River (Plate 4). The highest elevation, 3,293 feet, occurs at the Virginia-West Virginia boundary (Airway Beacon Triangulation Station, Plate 2). The lowland part of the area, underlain primarily by carbonate rocks, forms a rolling surface of low relief in which the streams have cut shallow, but relatively steep-walled, valleys (Figure 2). The more rugged upland areas to the northwest and southeast, underlain for the most part by noncarbonate rocks, has moderate relief and steep slopes (Figure 3). The mapped area is drained by the North Fork of the Shenandoah River and its main tributary, Stony Creek. Drainage west of Great North Mountain in West Virginia is through Lost and Cacapon rivers. The drainage divide follows the state boundary along Great North Mountain. Underground drainage occurs throughout much of the lowland area, and the water-table depth ranges from 100 to 300 feet, depending on rock type (Hall, 1928). Drainage in the western upland sector is controlled by major structures; in the lowland sector, usually no such relation exists.

The two most interesting geomorphological features in the area are the multiple terraces and the meander belt of the North Fork of the Shenandoah River. The terraces are discussed in the section on Quaternary stratigraphy. The North Fork meander belt was the subject of specific research (Hack and Young, 1959) and the reader is referred to that publication for further information.

Previous geologic studies in the region include a description of the structural and stratigraphic features of the Appalachian Valley of Virginia as early as 1835 by Rogers (1884). Spencer (1897) included the southeastern portion of the Edinburg 7.5-minute quadrangle (Plate 4) in a geologic study of Massanutten Mountain. The geologic map and geology of the Appalachian Valley in Virginia were published by Butts (1933, 1940-41). A description of the northeastern part of the Woodstock quadrangle was included in Monroe (1942). "Industrial limestones and dolomites in Virginia: northern and central parts of Shenandoah Valley" (Edmundson, 1945) was an invaluable guide during the initial mapping program. A significant stratigraphic contribution was made by Cooper and Cooper (1946) in a study of the lower Middle Ordovician stratigraphy of the Shenandoah Valley. Gooch (1949) described the structure and stratigraphy of the Saumsville area in an unpublished M.S. thesis. Young (1954) studied the present area for an unpublished Ph.D. thesis, which included the initial mapping for the present report. Wood (1962) described the Stonehenge Formation in the area. The geomorphology of the area has been discussed by Hack (1965).

The initial mapping program was made possible by the financial support, transportation, and equipment provided by the Virginia Geological Survey, W. M. McGill, State Geologist. The transfer of map data and preparation of this report were authorized by James L. Calver, Commissioner and State Geologist, Virginia Division of Mineral Resources.

The writers wish to acknowledge the counsel and assistance of W. B. Brent, M. A. Cameron, R. S. Edmundson, C. M. Nevin, J. C. Parsons II, W. E. Scherffius, and C. P. Thornton in the field work and preparation of the geologic maps.

Numbers preceded by "R" in parentheses (R-5342) correspond to localities where rock samples were collected (Plates 1, 2, 3, 4). Samples are on file in the repository of the Virginia Division of Mineral Resources.

STRATIGRAPHY

The stratigraphic units of the mapped area, consisting entirely of sedimentary rocks, range from Middle Cambrian through Upper Devonian in age (Table 1) and have a maximum thickness of approximately 18,500 feet. Thin beds of Ordovician metabentonite are the only record of igneous activity in this general region.

Table 1.—Geologic formations in the Woodstock, Wolf Gap, Conicville, and Edinburg quadrangles.

Age	Name	Character	Approximate thickness in feet
Quaternary	Alluvium	Varicolored unconsolidated sand, clay, and gravel.	
	Terrace deposits	Varicolored unconsolidated sand, clay, and gravel.	

Age	Name	Character	Approximate thickness in feet
Devonian	Hampshire Formation	Red shale and thin-bedded, cross-bedded sandstone.	550+
	Chemung Formation	Interbedded brown and red shale and sandstone and thin quartzitic conglomerate; sparsely fossiliferous.	1900-2000
	Brallier Formation	Fissile, olive to brown micaceous shale with interbedded greenish-brown, fine-grained sandstone.	1500-1700
	Mahantango Formation	Upper member: massive to thick-bedded, argillaceous siltstone. Middle member: grayish-green shale and thin-bedded, green siltstone. Lower member: thin-bedded, pale-green silty shale with lesser amounts of siltstone. Fossiliferous.	800-850
	Marcellus Shale	Fissile, thin-bedded, gray and black shale, sparsely fossiliferous.	450-550
	Needmore Formation	Thin-bedded, olive to buff and yellow to brown shale; lower beds sandy; fossiliferous.	125
	Ridgeley Sandstone	Medium- to thick-bedded, white to brown calcareous sandstone and sandy conglomerate; fossiliferous.	10-125
	New Scotland limestone	Dark-gray, medium-grained limestone with beds of massive, white chert; abundantly fossiliferous.	100

Age	Name	Character	Approximate thickness in feet
Devonian	New Creek Limestone	Gray, coarse-grained crinoidal limestone.	6-8
	Keyser Formation	Medium-bedded, gray, fine- to medium-grained limestone; fossiliferous; weathers dark gray to white.	150
Silurian	Tonoloway Formation	Finely laminated, gray and yellow argillaceous limestone; sparsely fossiliferous.	200-250
	Wills Creek Formation	Thin-bedded, blocky- to cobbly-weathering, yellow shale; fossiliferous; sandy near middle; calcareous in unweathered western sections.	130-175
	Bloomsburg Formation	Red and green mottled mudstone; minor red shale and shaly sandstone and thin- to medium-bedded, red sandstone; white sandstone near middle in Massanutten Mountain area.	0-300
	McKenzie Formation	Yellow calcareous shale; fossiliferous.	0-75±
	Keefer Sandstone	Gray, cross-bedded orthoquartzite with subordinate green and purple shale.	0-70
	Rose Hill Formation	Yellow sandy shale and white, brown, and red, fine- to medium-grained sandstone, abundantly fossiliferous locally.	0-650
	Tuscarora Formation	Thick-bedded, white orthoquartzite with a basal conglomerate; minor red, green, and purple shale common locally.	50-250

Age	Name	Character	Approximate thickness in feet
Silurian	Massanutten Sandstone	Massive, white to gray conglomeratic quartzite and orthoquartzite; minor thin-bedded, green shale.	840
Ordovician	Juniata Formation	Thin-bedded, red sandstone, shale, siltstone, and graywacke; grayish-brown sandstone.	0-200
	Oswego Formation	Brown-weathering, gray, fine-grained sandstone, locally conglomeratic; thin, red shale and reddish-brown sandstone.	0-375
	Martinsburg Formation	Thick-bedded, gray silty shale with sporadic thin, fine-grained sandstone; calcareous siltstone at base; black shale near base; locally thick, brown, fine-grained sandstone at top; fossiliferous.	3000±
	Oranda Formation	Calcareous siltstone with intercalated argillaceous limestone and metabentonite, abundantly fossiliferous.	40±
	Edinburg Formation	St. Luke Member: dove-gray, fine-grained limestone. Liberty Hall: medium-bedded, dark-gray to black limestone. Lantz Mills: dark-gray, nodular-weathering limestone. All units fossiliferous.	425-600
	Lincolnshire Formation	Medium- to thick-bedded, dark-gray, medium-grained limestone with black chert; lenses of light gray, coarse-grained limestone; fossiliferous.	90-110

Age	Name	Character	Approximate thickness in feet
Ordovician	New Market Limestone	Upper part: massive, dove-gray sublithographic limestone. Lower part: thin-bedded, buff limestone and carbonate conglomerate.	75-250
	Beekmantown Formation	Massive to thick-bedded, gray to brown dolomite with white chert; minor bluish-gray limestone and dove-gray sublithographic limestone.	2000-2500
	Stonehenge Formation	Thick-bedded, bluish-gray, fine- to medium-grained limestone; sparsely fossiliferous.	500±
Cambrian	Conococheague Formation	Laminated, bluish-gray limestone; massive, gray, medium-grained dolomite; gray, fine- to medium-grained sandstone; algal "reefs" locally.	2500±
	Elbrook Formation	Thick-bedded, nonlaminated, bluish-gray limestone and shaly dolomite.	500±

Both marine and continental rocks are well represented. From the Cambrian Elbrook Formation through the Ordovician Martinsburg Formation, the rocks are marine, predominantly limestone and dolomite. The Oswego Formation and overlying Juniata Formation are continental rocks of younger Ordovician age. The Tuscarora Formation, part of the Rose Hill and Keefer formations, and the Bloomsburg Formation are littoral and continental phases of the Silurian. The Upper Silurian and Lower and Middle Devonian are represented by marine rocks. The Upper Devonian contains the youngest lithified continental beds in the area; red beds occur in the Chemung Formation and predominate in the succeeding Hampshire Formation. In general, the marine strata crop out in the northeastward-trending, central lowland belt, whereas the littoral and continental deposits crop out in the uplands to the southeast and northwest.

One major and several minor disconformities are present in the stratigraphic section. The major break, which occurs at the top of the Beekmantown Formation, is widespread throughout the Shenandoah Valley. Faunal and lithologic evidence indicates the absence of the thick Mocassin Formation of southwestern Virginia (Cooper and Cooper, 1946). Paleontologic data are sufficient only to place this hiatus between the Edinburg and Oranda formations of the Middle Ordovician. Positive areas in Late Ordovician and Early Silurian times account for local absences of nearshore and continental rocks. The magnitude of these unconformities varies considerably within short lateral distance. A minor hiatus occurs between the Ridgeley Sandstone and Needmore Formation (Rader, 1962).

The stratigraphy of the Massanutten Mountain area differs considerably from that of the remainder of the mapped area. In the Massanutten Mountain area, distinct Oswego and Juniata formations are absent; the Rose Hill and Keefer cannot be separated from the Tuscarora; the Bloomsburg red beds are greatly thickened; and the Helderberg limestones are very thin. These stratigraphic anomalies are more fully discussed where they occur in the section.

CAMBRIAN SYSTEM

ELBROOK FORMATION

The Elbrook Formation is composed primarily of thick-bedded, nonlaminated, bluish-gray limestone (R-5300, R-5301) and shaly dolomite. The shaly dolomite characteristically weathers dark yellow. Locally, thin, red shale and light-colored dolomite are present (R-5337). The upper contact is placed above the youngest yellow-weathering shale and blue algal limestone and below the oldest crinkly weathering quartzose limestone. Typical Elbrook lithologies crop out along State Highway 42, 0.1 mile north of its junction with State Highway 263 (Plate 3).

The lack of a bottom contact and faulted relations prevent accurate thickness determination of the Elbrook. Butts and Edmundson (1939) report an average thickness of 2,000 feet in northern Shenandoah County, but probably no more than 500 feet is exposed in the Saumsville area.

No fossils were found in this formation in the Edinburg area, and the Middle Cambrian age is based on the occurrence elsewhere of a limited *Glossopleura* (trilobite) fauna. *Cryptozoon undulatum,* an algae, is locally well developed south of this area.

CONOCOCHEAGUE FORMATION

The Conococheague Formation is the most heterogeneous unit in the stratigraphic section, and it includes limestones, dolomites, sandstones, and silty shales (R-5303, R-5304, R-5336). The limestones are rudely laminated and bluish-gray; many are arenaceous. Where silty, they have a characteristic, projecting, crinkly, weathered surface (Figure 4). The dolomites are mas-

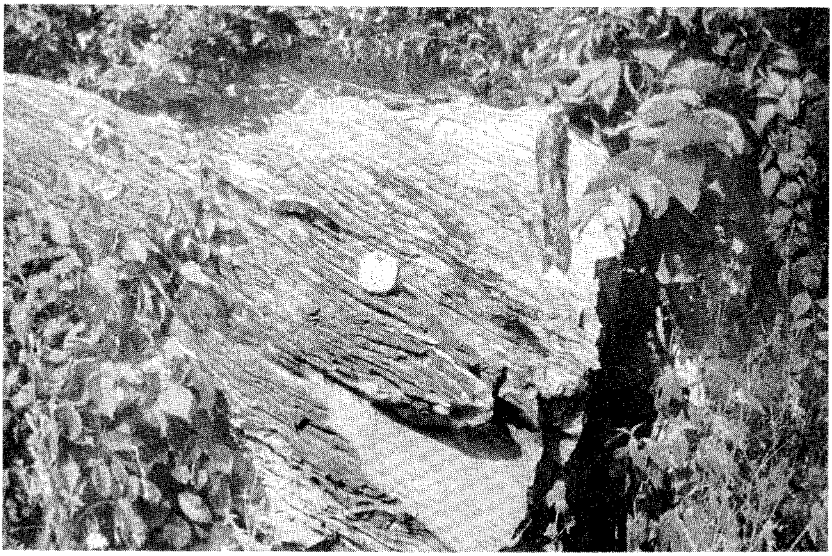

Figure 4. Silicious laminae brought out by weathering of Conococheague limestone west of Woodstock (Plate 1).

sive, gray, and medium grained. Gray, fine- to medium-grained sandstones, as minor ridge makers, are excellent structure markers, but are without correlative value as they are local. Wilson (1952) states that in Frederick County these sandstone lenses occupy a basal position with respect to the remainder of the Conococheague and has termed this interval the Big Springs Station Member. This is not true, however, for the area of the present report where sandstones are distributed throughout the unit. The silty shales are also local, and are important in that they may carry a well-preserved trilobite fauna. Thin, oolitic limestones and edgewise conglomerates are distributed sporadically throughout the middle and upper portions of the Conococheague. The criteria used to locate the base of the Conococheague is discussed in the section on the Elbrook Formation. The upper contact is mapped above the youngest thick dolomite and below the oldest chalky weathering limestone of the Stonehenge Formation. A good section of Conococheague is exposed along Narrow Passage Creek west of State Road 605 (Plate 4). On the southeast side of the North Mountain fault, there seems to be a full section where the Conococheague is approximately 2,500 feet thick.

The Conococheague formation is sparsely fossiliferous. "Reefs" of *Cryptozoon proliferum* and *C. undulatum* are locally well formed. One such "reef" is exposed in the valley southeast of the junction of State Roads 681 and 652, which is about 1 mile southwest of Saumsville (Plate 1). Elsewhere, in Winchester, Virginia, upper Conococheague silty shales contain abundant *Tellerina wardi* and other trilobites; a few specimens of the brachiopod *Lingulepis walcotti* were found in the vicinity of Verona, Virginia.

ORDOVICIAN SYSTEM

STONEHENGE FORMATION

The Stonehenge Formation was named by Stose (1908) and emended by Sando (1958, p. 839-841). The Stonehenge of this report is equivalent to the Chepultepec Formation of Brent (1960) and Rader (1967, 1969) and the Stonehenge Formation of Edmundson and Nunan (1973). In the mapped area, the Stonehenge is a uniformly thick-bedded, bluish-gray, fine- to medium-grained limestone (R-5306, R-5307, R-5312). It is characteristically nonlaminated in contrast with the underlying Conococheague Formation, and it is essentially nondolomitic in contrast with the overlying Beekmantown Formation. Good exposures occur 0.3 mile northwest of the end of State Road 676 (Plate 1) and along Narrow Passage Creek 0.5 mile northwest of where State Road 686 crosses the creek (Plate 4). The Stonehenge is consistently about 500 feet thick.

Although sparse, the Stonehenge fauna is widely distributed and characteristic. A cephalopod assemblage predominates, of which several species of *Dakeoceras* and *Levisoceras* are most abundant. The gastropod *Helicotoma uniangulata* is locally abundant in certain layers. The fossils, because of silicification, often stand in relief on weathered limestone surfaces. Silicified specimens have been collected at the previously mentioned Narrow Passage Creek locality. Brachiopod and cephalopod assemblages in the Stonehenge have been described by Young (1956), Unklesbay and Young (1956), and Wood (1962).

BEEKMANTOWN FORMATION

As used in this report, the Beekmantown Formation refers to the strata overlying the distinctive, cephalopod-bearing Stonehenge Formation and underlying the sublithographic New Market Limestone. Thus restricted, the Beekmantown includes two faunal zones, a lower *Lecanospira* and an upper *Ceratopea* zone.

The Beekmantown consists of massive to thick-bedded, gray to brown dolomite and variable amounts of white "cauliflower" chert (R-5305, R-5317, R-5331, R-5334, R-5335). Where chert zones are well developed, they are topographically expressed as rounded hills, conspicuous on the ordinarily level valley floor. Basal intraformational breccias of light dolomite in dark dolomite are not uncommon. Exceptions to the usual dolomites of

Figure 5. Irregular dolomitization contact between white-weathering sublithographic limestone and brown-weathering dolomite of the Beekmantown Formation 0.5 mile east of Edinburg (Plate 4).

the Beekmantown include bluish-gray limestone near the middle of the unit and local intercalations of sublithographic limestones in the uppermost 75 feet. The contact between the coarse, brown dolomite and the dove-gray sublithographic limestone is gradational (Figure 5). The absence of sublithographic limestones in most outcropping sections may be attributed to either the uneven character of the unconformity at the top of the Beekmantown or complete dolomitization of the limestones. A faulted sequence southwest of Alonzaville (Plate 1) is the least dolomitized Beekmantown section. At this locality the middle one-third consists of relatively pure, massive, gray limestones; dark-gray, laminated limestones; lesser amounts of brown dolomites; and a local, thin, black shale. Some of the purer limestones carry the high-spired gastropod *Hormatoma* sp.

An excellent section of Beekmantown is exposed along Narrow Passage Creek from north of State Road 686 southeastward to U. S. Highway 11 near Willow Grove (Plate 4). A partial section is exposed along State Road 263 at Mt. Clifton (Plate 3). A sedimentary breccia crops out west of State Road 716, 0.4 mile north of its junction with State Road 263 (Plate 3). The thickness of the Beekmantown ranges from 2,000 to 2,500 feet.

Fossils in the Beekmantown are commonest and best preserved in the chert zones, but are also found in the discontinuous limestones in the middle of the unit. Eleven genera from three phyla were identified by Dutton (1953) from the mapped area. The gastropods *Lecanospira* sp., *Ophileta* sp., and *Hormatoma* sp. are the most abundant forms; the gastropods *Roubidouxia* sp. and *Ceratopea* sp., and brachiopods and trilobite fragments occur less frequently. The lower *Lecanospira* zone (Nittany division of Butts, 1942) is characterized by *Lecanospira* sp., *Roubidouxia* sp., and *Hormatoma* sp. The upper *Ceratopea* zone (Bellefonte division of Butts, 1942) is usually identified by the gastropods *Ceratopea* sp. and *Lophonema* sp. Species of *Ophileta* occur in both zones.

Unconformity: One of the most extensive unconformities within the Paleozoic section of Virginia occurs at the top of the Beekmantown Formation. Its presence is marked by (1) dolomite pebble conglomerates at the base of the New Market Limestone; (2) local thickness variations in, or the absence of, the New Market Limestone, and (3) absence of typical Chazyan fossils in the succeeding strata (Cooper and Cooper, 1946). Butts (1940) states that deposition was possibly continuous where the Beekmantown is succeeded by "the St. Clair facies" of the "Murfreesboro limestone," but that a hiatus is present where the Beekmantown is overlain by "Mosheim limestone" (New Market Limestone). The magnitude of the Beekmantown-New Market break is not as great as suggested by Butts, as it has been shown that the New Market is the equivalent of the upper "Blackford facies of the Murfreesboro" in southwestern Virginia. Outside the mapped area, the Beekmantown is directly overlain by the Lincolnshire Limestone, indicating a stratigraphic break of at least 500 feet, and probably 800 feet. In the mapped area, the Beekmantown is overlain by 70-250 feet of New Market Limestone.

NEW MARKET LIMESTONE

In most places west of the Massanutten synclinorium (Plate 4), the New Market is divisible into two units: (1) a lower series of thin-bedded, shaly and dolomitic, buff limestones and carbonate pebble conglomerates (R-5313, R-5332); and (2) an upper series of massive, dove-gray sublithographic limestones (R-5314, R-5328, R-5333). The basal conglomerate of the New Market may contain dolomite pebbles, derived from the Beekmantown, in a calcilutite matrix. The upper division is the "quarry limestone" of the Shenandoah Valley and often contains 98 percent calcium carbonate. The massive, purer limestone characteristically weathers white and in many outcrops has a rillenstein surface.

The New Market is well exposed in an abandoned quarry 0.8 mile southeast of Rinkerton (Plate 3). A maximum thickness of 250 feet is found about 4 miles west of Edinburg (Plate 3). The normal range in thickness, however, is from 75 to 150 feet.

Tetradium syringoporoides, a coral, is the most important fossil in the New Market, occurring in great abundance at many places. Locally, rhynchonellid brachiopods, probably *Rostricellula pristina,* have been found (Cooper and Cooper, 1946).

LINCOLNSHIRE FORMATION

The Lincolnshire is a medium- to thick-bedded, dark-gray, medium-grained limestone. Normally, it contains nodules of characteristic black chert (R-5330). Locally, lenses of light-gray, coarse-grained limestone may be present (Murat limestone of Campbell, 1905). These lenses are not restricted in stratigraphic position. Near the upper contact, the Lincolnshire is distinctly nodular and, therefore, difficult to separate from the Lantz Mills of Cooper and Cooper (1946), which is in the Edinburg Formation. In the absence of fossils, the most reliable criterion is pink iron stains on clay partings between Lincolnshire nodules. Good exposures of Lincolnshire occur along and to the north of Swover Creek about 0.5 mile west of the junction of State Roads 694 and 691 (Plate 3). The thickness ranges from 90 to 110 feet.

Fossils most useful for identification of the Lincolnshire include *Maclurites magnus*, a gastropod, *Dinorthis atavoides*, and several species of *Sowerbyella*, brachiopods.

EDINBURG FORMATION

Cooper and Cooper (1946) named the Edinburg Formation from exposures northeast of Edinburg, Shenandoah County, Virginia; the type locality is 1.5 miles northeast of Edinburg along the north bank of the North Fork of the Shenandoah River (Plate 4). The formation of this area comprises the Lantz Mills and Liberty Hall, and the St. Luke Member. The Lantz Mills is more extensive than the Liberty Hall in the mapped area. The Lantz Mills type locality is located 2.4 miles west of Lantz Mills along Swover Creek (Cooper and Cooper, 1946) (Plate 3). The Lantz Mills is a relatively thin-bedded, medium-grained, dark-gray limestone which characteristically weathers to cobbles and nodules (R-5315, R-5329). Bedding is difficult to distinguish, and at many places is marked only by a slight color difference. The Liberty Hall in its type area (Lexington, Virginia) consists of black, thin-bedded shale and dense, black, medium-bedded limestone. In the mapped area, however, the black shale is absent, and the Liberty Hall consists of medium-bedded, dark-gray to black limestone (R-5316). The St. Luke Member, 90 feet thick, is found only at the top of the Edinburg, and is not known to have interfingering relations with either Lantz Mills or Liberty Hall. The type locality is one mile S.60°E. of St. Luke (Plate 1) but its best outcrops are along Swover Creek west of Lantz Mills (Cooper and Cooper, 1946). The St. Luke is a pure, dove-gray, fine-grained limestone, closely resembling the New Market, except for local coarse calcarenites and cross-bedded coquinites (R-5350). Metabentonites have been found in various beds of the Edinburg, but none have been observed in the St. Luke.

The Edinburg is assigned a thickness of 455 feet at the type locality. Other sections in the western belts range from 425 to 600 feet.

The Lantz Mills is abundantly fossiliferous, the Liberty Hall less so, and the St. Luke sparsely fossiliferous. The forms most useful for identification of the Edinburg are *Echinosphaerites aurantium* (cystoid), *Mastopora pyriformis* (algae), and species of *Resserella*, *Christiania*, and *Dinorthis* (brachiopods).

ORANDA FORMATION

The Oranda Formation is the most distinctive unit of the Ordovician System in the northern Shenandoah Valley. In the mapped area, it is predominantly a calcareous siltstone (R-5349) with intercalated argillaceous limestones; two of the metabentonites that are present in the type section at Strasburg, Virginia, have been observed. The siltstones resist weathering, giving distinct topographic expression, and low Oranda ridges are excellent to delineate structure. Good exposures of the Oranda occur at Zion Church at the junction of State Roads 693 and 707 (Plate 3).

The Oranda Formation is 56 feet thick at the type locality in northern Shenandoah County, but thicknesses of 40 feet are more common in the mapped area. Because of mapping scale and few exposures, it was not feasible to delineate the Oranda as a separate unit; it has been mapped with the Edinburg Formation.

This unit is extremely fossiliferous and the forms are generally well preserved. The brachiopods *Reuschella edsoni*, *Christiania trentonensis*, and species of *Sowerbyella* and *Strophomena* are most dependable for recognition of the Oranda. The hitherto unreported occurrence of the trilobite *Bronteopsis gregaria* Raymond in the Oranda extends the known range of this form from basal Edinburg through Oranda, rather than to the base of the St. Luke Member as reported by Cooper and Cooper (1946) and Cooper (1953).

Metabentonites: Occurrences of metabentonite in the Ordovician of the Shenandoah Valley have been known for some time (Nelson, 1926). Since their discovery, they have been used extensively throughout the Appalachians as key beds. As such, they are thought by many to closely parallel time planes.

Rosenkrans (1933) and Kay (1935) have previously described the known metabentonites of the Shenandoah Valley in northern Virginia. The only previous mention of altered volcanic material within the mapped area is that by Rosenkrans (1933). He correlated two thin metabentonites that he found along the stream just east of Woodstock with two similar beds in the basal Salona of Pennsylvania. Rosenkrans erred in referring these beds to the Martinsburg. Actually, they are 20 feet below the top of the Oranda (at that time included in the Chambersburg).

The metabentonites of the lower Edinburg, in the classic Tumbling Run section near Strasburg, have not been recognized in the mapped area. Because of their relative thickness at Tumbling Run, some of these metabentonites are almost certain to occur in the lowland areas of the present report. However, the metabentonites weather very rapidly, and their apparent absence is attributed to lack of fresh exposures.

Two 3-inch-thick metabentonite beds are exposed at several places in the folded sequence of Oranda on the southwest end of the Harmony syncline. These two beds are found only in fresh roadcuts, where they soon display a noticeable white bloom. As with the two beds east of Woodstock, these metabentonites are 20 to 25 feet below the top of the Oranda.

Samples of each of the above-described metabentonites were run in a powder-type x-ray diffraction unit. Each of the samples is composed primarily of montmorillonite and illite, with lesser amounts of unidentified material of clay size. These results correspond very closely with those obtained by Weaver (1953), in a more comprehensive study of the metabentonites of Pennsylvania.

MARTINSBURG FORMATION

The Martinsburg Formation is a rather homogeneous sequence of thick-bedded, peg-weathering, gray, silty shales (R-5295, R-5302, R-5311). Thin, fine-grained sandstones are distributed sporadically throughout the entire section, and thin, black shales are found near the base in most sections. The base of the Martinsburg is marked by a thin zone of nodular, calcareous siltstones which are difficult to distinguish from the Oranda, except by fossils. The unit terminates upward in a medium-grained, brown sandstone, which may be very fossiliferous ("*Orthorhynchula* zone"). In Massanutten Mountain, 40 to 50 feet of thick, brown, fine-grained sandstone is found above Martinsburg shales and below the Massanutten Sandstone. This sandstone is either a nonfossiliferous phase of the "*Orthorhynchula* zone" or an Oswego sandstone equivalent. It is mapped as part of the Martinsburg. From Edinburg Gap northwestward along State Road 675 for approximately 1.5 miles fossiliferous Martinsburg beds are well exposed (Plate 4).

Reliable thickness determinations of the Martinsburg are prevented by lack of complete sections. West of Edinburg Gap, it is estimated to be about 3,000 feet thick.

The Martinsburg is moderately fossiliferous. The presence of the trilobite *Cryptolithus* is sufficient to determine undifferentiated Martinsburg. The brachiopod *Orthorhynchula linneyi* and gastropod *Sinuites cancellatus* zones, at the top and base respectively, are present in most outcrops and are reliable guide fossils. In addition to these continuous zones, the Martinsburg contains many thin, but erratic, fossil zones. With respect to the upper boundary, Butts (1940, p. 208) states that "the large brachiopod, *O. linneyi*, universally present and abundant in these beds from central Pennsylvania to the south end of Clinch Mountain east of Morristown, Tennessee . . . the *Orthorhynchula* bed is probably the best horizon marker in the entire Appalachian Valley."

OSWEGO FORMATION

Complete sections of the Oswego Formation are rare in the northern Shenandoah Valley because of proximity to the ridge-forming Tuscarora Formation and resulting heavy talus. Along Little North Mountain and Great North Mountain, the Oswego is predominantly a fine-grained, brown-weathering, gray sandstone. It is characteristically flecked with limonite grains. The individual sandstone beds range from medium to thick, and at many places are separated by thin shales. In some areas a characteristic conglomerate is present (R-5320) (Figure 6). The pebbles, up to two inches in diameter, are composed of white quartz and gray chert. Some thin, red shales and reddish-brown sandstones are present in the upper Oswego. The contact with the overlying Juniata appears to be gradational and is mapped at the base of the oldest flaggy, red or brown sandstones

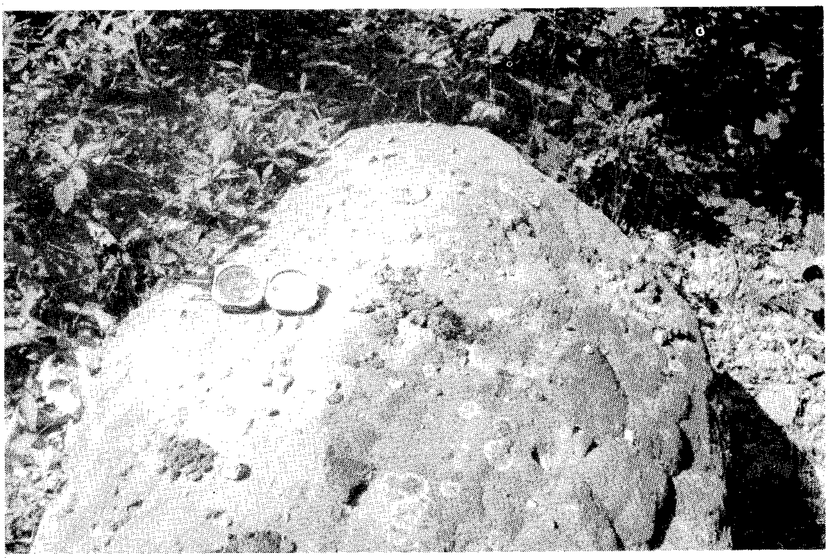

Figure 6. Conglomerate of the middle Oswego Formation north of Middle Mountain along State Road 691 (Plate 2).

characteristic of Juniata. The Oswego Formation is well exposed along State Road 691 north of Middle Mountain (Plate 2) and along State Road 600 southwest of Fetzer Gap (Plate 1).

As well as can be determined, the thickness of the Oswego on North Mountain is 375 feet. It is apparently absent in the Massanutten Mountain area, although it may be partially represented by the 40 to 50 feet of brown sandstone that is mapped as part of the Martinsburg Formation.

JUNIATA FORMATION

The Juniata Formation is the first major thickness of red beds in the mapped area. Thin-bedded red sandstones are the dominant constituent lithology (R-5319), though red shales, red siltstones, red graywackes, and grayish-brown sandstones are also present. The thicker sandstones are usually well cross-bedded. Toward the top of the Juniata, the shale percentage increases and a conspicuous rhythmic alternation of sandstone and shale is present (Figure 7). The formation is well exposed along State Road 691 southwest of Tibbet Knob (Plate 2) and along State Road 600 southwest of Fetzer Gap (Plate 1).

The thickness of the Juniata varies considerably, ranging

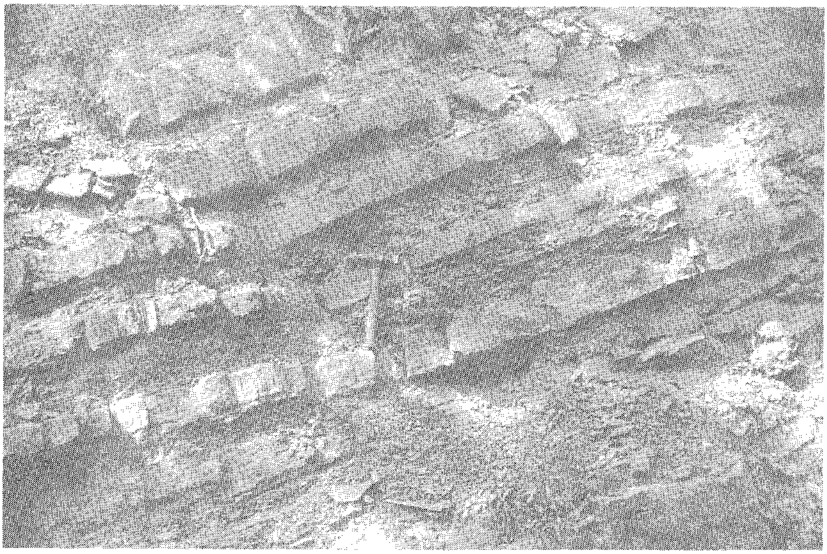

Figure 7. Alternating red shales and sandstones of the upper Juniata at the south end of Long Mountain along State Road 691 (Plate 2).

between 0 and 200 feet. In the western belts, the thickness averages 150 feet. There are no red beds in the Upper Ordovician of the Massanutten Mountain area and the Juniata is presumed to be absent. The formation is devoid of fossils.

SILURIAN SYSTEM

TUSCARORA FORMATION

The lithology of the Tuscarora Formation is remarkably uniform throughout the mapped area. Almost all sections have a basal conglomeratic phase (R-5324), 10 to 15 feet thick, which grades upward into the thick-bedded orthoquartzitic phase. The quartzites are composed of rounded, white quartz grains cemented by white silica (R-5298, R-5325). Bedding ranges between moderate and thick. Minor intercalations of red, green, and purple shales are common locally. These shales appear at several stratigraphic horizons and are limited laterally. The Tuscarora is extremely resistant to weathering; thus, it crops out on or near the mountain summits in the western portion of the area (Plates 1, 2). The formation is well exposed along Great North Mountain at Wolf Gap, Big Schloss, and Tibbet Knob (Plate 2) and along Little North Mountain at Fetzer Gap and Stultz Gap (Plate 1).

The thickness of the Tuscarora ranges between 50 and 250 feet. Windgaps, common in Little North Mountain, usually correspond to local thinning. Thinning of the easternmost outcrop belt is progressive from northeast to southwest, along the trend of Little North Mountain.

The Tuscarora is continental and the only fossils are two problematic worm trails, *Arthrophycus alleghaniensis* and *Scolithus verticalis*. Where found, *A. alleghaniensis* is often abundant, forming a mat of crossing, annulated trails on bedding surfaces.

MASSANUTTEN SANDSTONE

Geiger and Keith (1891) named the Massanutten Sandstone for exposures in Massanutten Mountain, Virginia. The name *Massanutten* is used here to designate the thick sequence of massive, white to gray conglomeratic quartzites (R-5309), orthoquartzites, and minor thin-bedded, green shales overlying the Martinsburg Formation and underlying red beds of the Bloomsburg Formation in the Massanutten Mountain area. Thus restricted, it conforms with the original definition and to that of Spencer (1897). The lithology is identical with that of the Tuscarora, except that no red or purple shales have been observed in the Massanutten.

The formation is confined to the Massanutten Mountain area where it crops out in subsidiary anticlines and synclines on Powell, Short, and Bowman mountains and Mertins Rock (Plate 4). It is well exposed along State Road 675 in Edinburg Gap, where it is 840 feet thick. As in the Tuscarora, the only Massanutten fossils so far found are poor specimens of *Arthrophycus alleghaniensis* and *Scolithus verticalis*.

On the basis of lithology, position, and problematic worm trails, the lower part of the Massanutten is correlated with the Tuscarora. The excessive thickness of the Massanutten, as compared with the Tuscarora, and the absence of typical rocks of the Rose Hill and Keefer formations in the Massanutten section indicate that the upper part of the Massanutten may be equivalent in age to part of the Rose Hill and Keefer. The use of the name Massanutten as a stratigraphic term should be restricted to the Massanutten Mountain area of the northern Shenandoah Valley.

ROSE HILL FORMATION

The Rose Hill Formation consists almost entirely of sandy shales and thin- to medium-bedded sandstones (R-5326, R-5327). The shales are brittle and yellow; the sandstones are fine to medium grained and white to brown. Medium-bedded, red sandstones are not uncommon near the top of the unit. The shales may contain limonite lenses, but the Cacapon hematitic beds are absent. Good exposures occur along State Road 675 south of Wolf Gap near spot elevation 1908 (Plate 2). The thickness of the Rose Hill on the east side of Great North Mountain is 650 feet. The formation cannot be recognized, as such, in the Massanutten Mountain area.

Certain strata of the Rose Hill are abundantly fossiliferous, though in general, it is sparsely fossiliferous. Fossils are most abundant in the thin, fine-grained, brown sandstones. Ostracods, especially species of *Zygobolba,* are numerically most important, but the brachiopod *Coelospira nitens* (*"Anoplotheca hemispherica"*) and the trilobite *Liocalymene clintoni* are the most distinctive Rose Hill forms.

KEEFER SANDSTONE

The Keefer Sandstone consists of gray, cross-bedded orthoquartzite (R-5321) with subordinate green and purple shales. The shales are restricted to the basal portion. The Keefer is a very resistant unit, forming flatirons along Great North Mountain. The formation cannot be recognized, as such, in the Massanutten Mountain area. One of the best Keefer exposures is on State Road 675, 0.5 mile south of Wolf Gap (Plate 2). The formation is 60 to 70 feet thick where it is exposed.

The Keefer of Virginia is sparsely fossiliferous. Butts (1940) and Woodward (1941) report the presence of rare *Scolithus* tubes. "Worm trails," identical with *Arthrophycus alleghaniensis,* occur in the Keefer at two localities (Figure 8) on the east side of Tibbet Knob (Plate 2). *Arthrophycus alleghaniensis* in Virginia and West Virginia was previously thought to be confined to the Tuscarora, Clinch, and Massanutten formations (Butts, 1940). The writers concur with Woodward (1941) that *Arthrophycus alleghaniensis* is a facies fossil restricted to the clean sandstones of the Lower and Middle Silurian.

There are three possibilities concerning the Rose Hill and Keefer in the Massanutten Mountain area: (1) it is not repre-

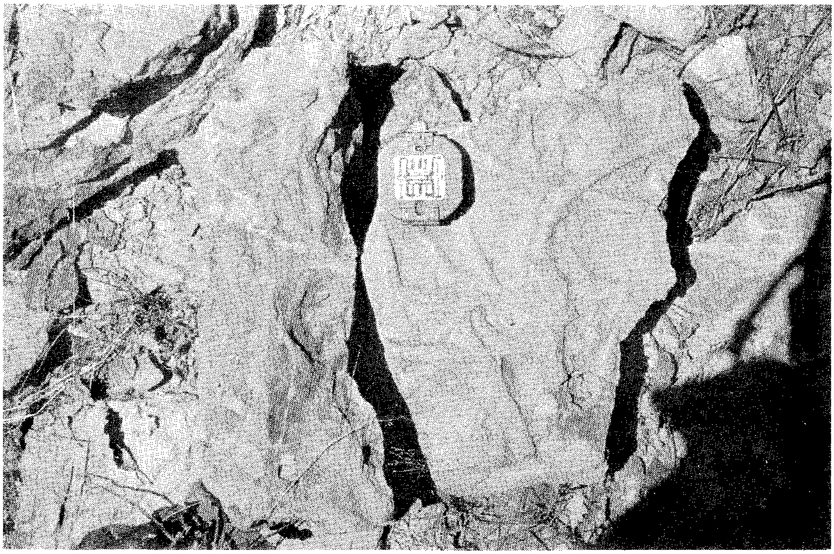

Figure 8. *Arthrophycus alleghaniensis* from the lower Keefer Sandstone from the east side of Tibbets Knob (Plate 2).

sented in the section, (2) it is present as the upper portion of the 800 feet of orthoquartzites (Massanutten Sandstone), or (3) it is present as the lower portion of Bloomsburg red beds overlying the orthoquartzites. Swartz (1938) follows the last interpretation. However, because of the absence of Rose Hill and Keefer lithology and fossils, the presence of typical Bloomsburg lithology, and the nearly homogeneous nature of the Massanutten quartzites, it is here assumed that the basal Silurian sandstones thicken rapidly from the Great North Mountain area toward the east and that the Rose Hill and Keefer, in their typical developments, are absent in Massanutten Mountain. This is not to infer that Rose Hill and Keefer time-equivalent rocks are absent, for the thick beach deposits of the Massanutten must transgress time planes (Figure 9). It is, therefore, suggested that the Rose Hill and Keefer equivalent is represented by the upper 300 to 500 feet of the Massanutten Sandstone (Young, 1955).

McKENZIE FORMATION

The McKenzie Formation is composed of yellow, calcareous shale. The one known exposure of the formation is on the east side of Great North Mountain, along State Road 675 about 1.0

Figure 8. *Arthrophycus alleghaniensis* from the lower Keefer Sandstone from the east side of Tibbets Knob (Plate 2).

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Road 600 northeast of Tea Mountain Hollow a folded section of the formation is exposed (Plate 1).

The Bloomsburg is 300 feet thick at Edinburg Gap (Plate 4), and ranges from 0 to 250 feet thick in the western upland. The Bloomsburg is unfossiliferous.

WILLS CREEK FORMATION

The Wills Creek Formation is a series of thin-bedded, blocky- to cobbly-weathering, yellow shales at its best exposure about 0.4 mile east of Edinburg Gap along State Road 675 (Plate 4). The shales are sandy near the middle part. Thin red shales are intercalated in the yellow shales near the base of the unit. In the western sections, the unweathered yellow shales are calcareous and more resistant to weathering than the overlying Tonoloway and Keyser limestones. Structures involving these units may show topographic expression.

The thickness of the Wills Creek at Edinburg Gap is 175 feet. From discontinuous outcrops in Cedar Creek valley, in the western belt, the thickness is estimated at 130 feet. The fauna of the Wills Creek is varied, but few species are abundant. Ostracods predominate over all other forms, literally covering square feet of bedding. However, for field identification, *"Spirifer" vanuxemi*, a brachiopod, is the most useful fossil.

TONOLOWAY FORMATION

The Tonoloway Formation is composed of finely laminated, alternating gray and yellow, argillaceous limestones (R-5318). The laminae weather differentially; thus, many outcrops present a distinctive, coarsely banded appearance. The top of the Tonoloway is extremely difficult to determine where it is overlain by the Keyser Formation. Thin layers of dark-gray, granular limestone, characteristic of the Keyser, are interstratified with the laminated beds. The percentage of the granular limestone increases rapidly upward in the column to the nearly complete exclusion of the laminated limestones. In the Cedar Creek section, typical Tonoloway-like lithology has been noted in the Keyser within 100 feet of the Ridgeley Sandstone. In complete sections, the sequence is apparently gradational lithologically, and the boundary can be accurately placed only where there is faunal evidence. The upper boundary is more distinct at Edinburg Gap where the Helderberg is present in abbreviated form (mapped as part of the unit, Lower Devonian and Upper Silurian rocks, on Plate 4). The Tonoloway is best exposed in Cedar Creek valley (Plate 1), where it is 250 feet thick; it is approximately 200 feet thick at Edinburg Gap.

Tonoloway fossils are sparsely distributed; however, ostracods may be locally abundant. *Leperditia alta* (ostracod) and *Camarotoechia litchfieldensis* (brachiopod) are the best indices, although neither is confined to the Tonoloway.

KEYSER FORMATION

The Keyser Formation consists of medium-bedded, gray, fine- to medium-grained limestone. The lower beds are characteristically coarser grained than the upper beds. The lower beds weather dark gray with an irregular surface, whereas the upper beds weather white with a smooth surface. The lower Keyser boundary is difficult to determine in the field because of intercalations of Tonoloway-like lithology in the Keyser. These intercalations have been observed as much as 100 feet above the first appearance of the brachiopod *Eccentricosta* sp. The Keyser cannot be treated as a distinct unit in the Upper Silurian-Lower Devonian limestone belt of the Massanutten Mountain area. The best outcrops of the Keyser are in Cedar Creek valley (Plate 1). The formation is about 150 feet thick.

Keyser fossils, in Cedar Creek valley, are scarce and usually fragmentary. The two faunal zones of the Keyser elsewhere (Bowen, 1967), the lower *Eccentricosta jerseyensis* zone and the upper *Meristella praenuntia* zone, cannot be separated. However, the coral *Favosites helderbergiae* is one of the more abundant forms in the mapped area. Other fossils useful in determining the Keyser are the brachiopod *Camarotoechia litchfieldensis* and the coral *Cladopora rectilineata.* The lower part of the Keyser is Upper Silurian and the upper part is Lower Devonian (Swartz, 1929; Bowen, 1967).

HELDERBERG LIMESTONES

The limestones and cherts of the New Creek Limestone and New Scotland limestone, which compose the Helderberg in the mapped area, are shown as a single unit on the geologic maps (Plates 1, 2, 3). In the Massanutten Mountain area the Helderberg forms part of the upper portion of the unit, Lower Devonian and Upper Silurian rocks (Plate 4).

New Creek Limestone

The New Creek Limestone is equivalent to the Coeymans Limestone of earlier reports in Virginia. In Cedar Creek valley (Plate 1) 6 to 8 feet of gray, coarse-grained, crinoidal limestone is sparsely exposed. Although the brachiopod *Gypidula coeymanensis* was not observed, the position and distinctive nature of this limestone suggest that it probably occupies the New Creek interval.

New Scotland Limestone

The New Creek is succeeded by approximately 100 feet of dark-gray, medium-grained New Scotland limestone which contains massive, white chert layers (R-5296), especially in the upper 25 feet. These chert layers and the overlying Ridgeley Sandstone form linear hills which are excellent delineators of structure (Plates 1, 2). The New Scotland is abundantly fossiliferous. Many of the fossils are silicified and may be etched out. The brachiopods *Eospirifer macropleurus* and *Delthyris perlamellosus* are considered to be indices of this formation.

RIDGELEY SANDSTONE

In western Shenandoah County, the Ridgeley Sandstone is a series of medium- to thick-bedded, white to brown, calcareous sandstones and sandy conglomerates (R-5294). The constituent quartz grains and small pebbles are well rounded and usually frosted. Calcareous cement may compose up to 30 percent of the rock. Replacement lenses and fracture fillings of limonite and manganese dioxide are common, especially in Cedar Creek valley. Although it generally weathers rapidly on exposure, the Ridgeley forms a distinct topographic high. Where it is cemented with quartz and has steep dips, the Ridgeley forms towering walls (Woodstock Reservoir, Plate 2). Good exposures of Ridgeley occur 0.6 mile south-southwest of Cedar Creek Church along State Road 600 and at the spring west of Van Buren Furnace along State Road 713 (Plate 1). The thickness of the formation varies considerably, ranging from 10 to 125 feet.

The Ridgeley is moderately to abundantly fossiliferous. In the closely folded sections bedding is usually determined only through fossil zones. The two faunal zones cited by Woodward (1943) for the Ridgeley of West Virginia can usually be found in Virginia. These are the lower *"Spirifer" murchisoni-Platyceras* sp. zone and the upper *"Spirifer" arenosus* zone. *Hipparionyx proximus* is conspicuously absent. Worm trails, of a variety previously unreported for the Ridgeley of Virginia and West Virginia, were collected by the writers from the west side of Fetzer Gap. Butts (1940) states that the 10 to 15 feet of sandstone at or near the top of the "Helderberg Group" as mapped by him in the Massanutten Mountain area is Ridgeley. Swartz (1938) thinks that "the Ridgeley sandstone reported from the Massanutten Mountain area is in part, if not wholly, Keyser in age," a conclusion based on fossil evidence. In this report the opinion of Butts (1940) is adopted.

DEVONIAN SYSTEM

NEEDMORE FORMATION

The Needmore Formation is composed of thin-bedded, olive (basal) (R-5293) to buff (upper) (R-5348) shales. The basal beds contain sandy material, probably reworked Ridgeley Sandstone. The Needmore consists of thin-bedded, yellow to brown shale in the southeastern part of the Edinburg quadrangle (Plate 4). Thin intercalations of dark, grayish-black shales in the upper Needmore indicate a transition into the Marcellus shale. The top of the youngest buff shale was picked as the top, where exposures were available. Exposures of Needmore are uncommon, because of the proximity of the ridge-forming Ridgeley Sandstone. The most completely exposed section is along State Road 600 at Tea Mountain Hollow (Plate 1) adjacent to Cove Run. The maximum thickness of the formation is 125 feet.

The lower half of the Needmore is generally very fossiliferous. The brachiopod *Anoplotheca acutiplicata* and the trilobite *Odontopleura callicera* are dependable guides to this horizon. A hiatus of small magnitude in the vicinity of Fetzer Gap is indicated by the absence of the ostracod zone *Ranapeltis trilateralis* (Rader, 1962). The magnitude of this hiatus increases to the southwest in Virginia where, near Marion, Smyth County, the Needmore equivalent overlies the *Orthorhynchula* zone of the Martinsburg Formation (Ordovician). For a regional correlation of the Needmore the reader should refer to Dennison (1961).

MARCELLUS SHALE

Hall (1839) named the Marcellus Shale from exposures at Marcellus, New York. Soft to fissile, thin-bedded, gray and black shales (R-5322) overlie the Needmore in the mapped area, and, thus, occupy the interval of the Marcellus in New York. The black shales oxidize to a dull, silver gray, and are in places indistinguishable from lower Mahantango shales. An exposure along State Road 675 just east of crossing of Yellow Spring Run shows the lithologic aspects of the formation and the relationship between the bedrock and terrace gravels (Plate 2). A maximum thickness of 450 to 550 feet is estimated from exposures northwest of Jerome.

Because the upper Marcellus of the Massanutten Mountain area cannot be separated from the lower Mahantango, the two formations in this area are mapped as a single unit. In outcrop belts in Cedar Creek valley (Plate 1) and west of Three-mile Mountain (Plate 2), the Marcellus-Mahantango boundary can be mapped with reasonable accuracy. The youngest black shale is mapped as the top of the Marcellus. Discontinuous outcrops are present along the northwest side of the North Mountain fault southwest of Columbia Furnace. The shales here are bleached and highly shattered.

The fauna of the Marcellus is a typical black shale fauna, small, partially pyritized, and apparently thin shelled. Although sparse and generally poorly preserved, the Marcellus fauna is distinctly related to the overlying very fossiliferous Mahantango. Species of *Tornoceras* and *Michelinoceras,* cephalopods, and *Buchiola* and *Pterochaenia,* bivalves, are fairly numerous. *Leiorhynchus limitare,* a brachiopod, is an index to this horizon and is abundant.

MAHANTANGO FORMATION

The Mahantango Formation in the mapped area has three distinct, though gradational, units. Because of lack of regional stratigraphic control, these units are here informally referred to as the lower, middle, and upper members of the Mahantango. The lower member is gradational with the underlying Marcellus and is composed of thin-bedded, pale-green, silty shales with lesser amounts of siltstone. The shales weather dull silver to buff and silty concretions are common. Typical Mahantango fossils are scarce, but are locally abundant in the siltstone. The middle member consists of nearly equal proportions of grayish-green shales (R-5347) and thin-bedded, green siltstones in rhythmic sequence. Fossils are very scarce in both lithologies of the middle member. The upper member apparently corresponds to the "persistent massively bedded greenish sandstone" of Butts (1940) and Butts and Edmundson (1966) in Frederick County. These strata may be more accurately described as massive to thick-bedded, argillaceous siltstones (R-5323, R-5346). Spheroidal weathering is well developed because of the physical homogeneity of these rocks. The upper member is the typical "fossiliferous Hamilton" of the Appalachian Valley. It is the writers' opinion that further paleontologic investigation will provide grounds for zonation of the Mahantango in Virginia as Ellison (1965) has done in Pennsylvania. In the Massanutten Mountain area (southeast corner of Plate 4), the formation consists of grayish-brown, silty shale and siltstone and is mapped with the older Marcellus Shale as a single unit.

The Mahantango Formation is well exposed along State Road 675 for 0.6 mile northwest of the junction with State Road 717 (Plate 2). There is no section in the mapped area from which accurate thickness determination can be made for the formation. Its thickness is estimated at 800 to 850 feet in the vicinity of Liberty Furnace (Plate 2).

The faunal list for the Mahantango is too long to cite here. For details, Butts (1940, p. 314-315) and Woodward (1943, p. 351-353) may be consulted. For purposes of identification of the Mahantango the brachiopods *Spinocyrtia granulosa, Mucrospirifer mucronatus, Megastrophia concava,* and *Modiomorpha concentrica* are considered diagnostic.

BRALLIER FORMATION

The Brallier Formation is a thick assemblage of fissile, olive to brown, micaceous shales (R-5345) with interbedded thin, greenish-brown, fine-grained sandstones. The sandstones do not occupy a definite stratigraphic level and are limited laterally. The base of the Brallier is mapped at the top of the massive sandstone of the Mahantango. The top of the formation is mapped as the base of the oldest 3-foot-thick sandstone of Chemung-type lithology. The Brallier is well exposed along State Road 717, 0.5 mile southwest of its junction with State Road 675 (Plate 2). The Brallier is exposed on both limbs of the Supin Lick syncline, where it has a thickness of 1,500 to 1,700 feet. The only fossils collected from the Brallier were fragments of *Pteridichnites biseriatus,* a trace fossil.

CHEMUNG FORMATION

In the mapped area the Chemung Formation is undoubtedly a transitional facies between a nonmarine (red bed?) sequence, once present in the east, and the completely marine Greenland Gap Group (Dennison, 1970) of West Virginia. Lithologically, the formation consists of brown and red shales, thin quartzitic conglomerates (R-5343), and brown and red sandstones (R-5342, R-5344). The red and brown shales are stiff, micaceous, and unfossiliferous. The thin conglomerates, which have pebbles of 0.25 inch diameter, are very tough and, being concentrated in the lower Chemung, form distinctive ridges (Supin Lick Ridge and Snider Hill, Plate 3). The brown sandstones contain characteristic Chemung fossils, but good specimens are rare because of rapid weathering of the sandstones. The red sandstones near the top of the Chemung are distinguishable from the overlying unfossiliferous Hampshire Formation through the occurrence of crinoid columnals on almost every outcrop. Many of the Chemung red beds are cross-bedded and ripple marked. The lower contact of the Chemung was mapped on any one of three criteria: (1) the first appearance of the thin quartzitic conglomerates, (2) the first red shale in the section, or (3) the first appearance of large spiriferoid brachiopods. It is certain, therefore, that this boundary, as mapped, varies somewhat from place to place. Good exposures of the Chemung occur along State Road 720 for 0.5 mile east of the junction with State Road 611 on Supin Lick Ridge (Plate 3). The Chemung is 1,900 to 2,000 feet thick in the Supin Lick syncline, the only outcrop belt in the mapped area (Plates 2, 3).

The Chemung of the Supin Lick syncline is more sparsely fossiliferous than usual. The brachiopod *Platyrachella mesastrialis* is abundant in a few layers, but nearly always in fragmental form. The brachiopod *Cyrtospirifer disjunctus* could not be definitely identified, although it is probably present.

HAMPSHIRE FORMATION

The Hampshire Formation is entirely nonmarine and is approximately 95 percent red beds. Thin-bedded, usually cross-bedded, sandstones ("flags") (R-5340) predominate just above the Chemung, whereas peg-weathering red shales (R-5341) make up the upper 300 feet of the exposed section. The best exposures are east and west of Riles Run where State Roads 703 and 720 cross the stream (Plate 3). About 550 feet of Hampshire is exposed in an incomplete section along the axis of the Supin Lick syncline. The Hampshire is apparently devoid of fossils.

QUATERNARY SYSTEM

Alluvium, in the strict definition, covers both types of deposits described herein as *Terrace Deposits* and *Alluvium.* However, the alluvial flood-plain deposits are usually so readily distinguishable from the alluvial terrace deposits that separate descriptions and map units appear warranted.

TERRACE DEPOSITS

For convenience, the terrace deposits are classified as (a) highest, (b) intermediate, and (c) lowest. As is generally the case, the age of the terraces increases with elevation, and the highest terrace is the oldest.

This highest terrace is extensive and lies at an elevation of more than 1,000 feet in the area south and east of Columbia Furnace, between Swover (Plate 1) and Narrow Passage (Plates 3, 4) creeks (Figure 11). The upper surface maintains

Figure 11. Highest terrace looking southeast from Wesley Chapel toward Edinburg Gap (Plate 4).

remarkable regularity over considerable distances. Occasionally, as along Stony Creek southeast of Readus (Plate 4), the highest terrace has two levels, with a total thickness of not less than 160 feet. The upper level has a slightly more restricted distribution and contains larger boulders. Both levels of this highest terrace are composed exclusively of silica-rich pebbles, cobbles, and boulders in a sandy clay matrix. The larger-than-sand-size fraction is dominated by quartzite (Tuscarora) and white sandstone (Ridgeley), with minor red sandstone (Rose Hill?) and siliceous oolites (Conococheague). The larger detritus shows a high degree of rounding and a complete lack of post-depositional weathering. Depth and degree of development of the soil horizon is not known, but there are local, well-formed, limonitic hardpans.

The lateral extent of the highest terrace indicates that the ancestral North Fork of the Shenandoah River determined the level of deposition, although the river now flows 2 miles to the southeast. At that time, the North Fork was flowing at a level somewhat higher than 1,000 feet of present elevation, or over 200 feet above its present bed. The presence of Ridgeley and probable Rose Hill detritus makes the mountainous area to the northwest the only possible source.

Figure 12. Intermediate terrace above lower terrace northeast of Mt. Jackson (Plate 3).

The intermediate terrace is closely related to the present North Fork and is best developed on the west side between Mount Jackson and Hawkinstown (Plates 3, 4). This terrace occupies a much more restricted distribution than the highest terrace. Near Mount Jackson, it is 30 to 50 feet above the lowest terrace (Figure 12). It is also recognizable on the inside of a poorly formed meander at Palmyra Church (Plate 4) and on the two southwesternmost Seven Bends of the North Fork (Plate 4). Also, it extends, with limited lateral distribution, up the valley of Stony Creek to Lantz Mills (Plate 4). The upper surface of the intermediate level has an elevation of approximately 900 feet.

The detritus of the intermediate terrace deposits is silica-rich and the particles are rarely larger than pebbles. The matrix is brown sandy clay with local, creamy-white clay streaks, and composes about 50 percent of the bulk. The pebbles appear to be reworked fanglomerate material from the western slopes of Massanutten Mountain (Figure 13).

Best expression of the lowest level is seen on the east side of the North Fork on State Road 698, near Walkers Chapel (Figure 14, Plate 4). Here the terrace rises 15 to 18 feet above the present flood plain, and consists of 2 to 3 feet of fine-grained alluvium on a pinnacled limestone surface. The terrace level

Figure 13. Intermediate terrace gravel near Lantz Mills (Plate 4).

Figure 14. Lowest terrace 0.5 mile southwest of Walkers Chapel (Plate 4).

varies between 820 and 840 feet in elevation. The terrace material is dominantly brown to buff sand, with no particles larger than coarse sand. This is in contrast with the dominantly loamy present flood plain.

The highest terrace was formed of alluvium transported and deposited by the ancestral North Fork and its tributaries during the Pleistocene. The transition from the Pleistocene to the present regime was not continuous, and during a very minor reversal, the alluvium that composes the lowest level of the highest terrace was deposited. Analogous conditions have led King (1949) to assign a Pleistocene age to gravel-capped benches of the Elkton, Virginia, area. Climatic conditions during deposition, development of hardpan, and depth of present river level below the highest terrace indicate that this terrace is no younger than late Pleistocene.

The close relations of the intermediate and lowest terraces to the present river course indicate that they were formed by the North Fork during climatic hesitations in the normal post-Pleistocene erosion cycle. The pauses in each of these cycles were of relatively short duration, but not as short as that responsible for the lower level of the highest terrace.

ALLUVIUM

Practically every stream in the four quadrangles have alluvial flood plains at someplace in their reaches. Because of the generally less steep gradients, flood plains are most extensive and thickest in the valleys of the larger streams in the lowland sector of the general area, especially along the North Fork of the Shenandoah River.

Although quite variable in specific composition, the flood plain deposits are predominantly clay and silt, and are notable in the absence of cobbles and boulders. The deposits are moderately high in organic content, giving rise to the dark grayish-brown color. The flood plains are quite fertile and support some of the best farms in the area.

STRUCTURE

The rocks of the stratigraphic column (Table 1), if divided into three roughly equal parts, show differing degrees of competency to structural deformation. The lower, carbonate and shale section that is exposed in the lowlands, though relatively competent, is more closely folded than the thick sandstones of the middle division. Thus, the broad folds of the eastern and western uplands reflect this sandstone section. All of the above factors, together with westward decrease in intensity of deformation, make possible the suggested threefold division: (1) Massanutten Mountain or eastern upland, (2) central lowland, and (3) western upland.

MASSANUTTEN MOUNTAIN AREA

The Massanutten Mountain area consists of a series of folds, ranging from close to relatively open, expressed at the surface in rocks from Upper Ordovician through Upper Devonian. Only small, unmappable faults were observed. The southeasternmost folds, involving Devonian shales, are close and the beds have high-angle dips, some being almost vertical. Martinsburg shale, forming the northwest boundary, has numerous small and open flexures.

Folds in the Massanutten Sandstone are much more open, and with one exception, have one limb considerably steeper than the other. The herein-named Short Mountain and Powell Mountain synclines have a steeper eastern flank, thus conforming with most Appalachian synclines. The syncline paralleling Bowman Mountain and Mertins Rock is an exception; its western flank is steeper, and the axial plane is overturned to the southeast in part of the mapped area. This anomaly is probably related to the rapid eastward thickening of the Massanutten Sandstone. The thick sandstone may have been sufficiently massive and homogeneous to act as a local strut, transmitting forces laterally. The combination of relatively weak forces transmitted through the strut, strong vertical component of the forces carried by basement rocks, and an area of rapid thickness variation within the strut apparently caused local underfolding.

CENTRAL LOWLAND AREA

Surface structures in the central lowland area occur chiefly in carbonate rocks and shales, ranging from Middle Cambrian to Middle Ordovician. Four major folds and two major faults were mapped.

FOLDS

The Mt. Jackson anticline (Plates 1, 2, 3) is overturned to the northwest. The eastern flank is faulted at Edinburg and north of Saumsville. This anticline is the major fold of the lowland belt. Its generally uniform structure is complicated by minor folds.

The herein-named Lantz Mills syncline (Plates 3, 4) is made up of a series of minor flexures of gross synclinal nature. The constituent folds are generally overturned northwestward, although in some places, as northwest of Bowmans Crossing, the entire sequence of folds across the synclinal complex is upright. In the area northwest of Bowmans Crossing (Plate 4) and northeast of Hamburg (Plate 3), doming has given an abnormally wide outcrop belt of New Market and Lincolnshire formations. This doming has locally deflected the usual trends of the minor folds.

The herein-named Rinkerton anticline (Plates 3, 4) forms the hanging wall of the Saumsville fault southwest of Readus. This fold, like the Lantz Mills syncline, is complex. The axial planes vary between overturned, near Rinkerton, and upright, near Hamburg. Strata along the western flank, bordering the Saumsville fault, are generally overturned or steep. The anticline is terminated to the northeast by the Saumsville fault.

The herein-named Harmony syncline (Plates 1, 4) is the most complex of the major folds. It generally forms the footwall of the Saumsville fault. The syncline is terminated northeastward by the Alonzaville fault. Although there are from seven to thirteen recognizable minor fold axes across the syncline, only those immediately adjacent to the Saumsville fault are overturned. It is likely, however, that most of these minor folds were formed by movements along the fault.

FAULTS

The lowland belt is bounded on the northwest by the North Mountain and herein-named Alonzaville faults. The major shear zone, the North Mountain fault (Plates 1, 2, 3), is approximately 170 miles long (Giles, 1942), and dips of 25 to 35° are estimated for the mapped area portion. Throughout most of its extent, the North Mountain fault is actually a fault zone with stratigraphic displacement distributed across several faults. The stratigraphic throw varies greatly because of the folded character of the area prior to faulting, and changes in the strike of the fault zone. Near Conicville (Plate 3), the stratigraphic displacement is about 15,000 feet, and 6 miles to the northeast it is less than 9,000 feet.

Where carbonate rocks are present, the fault is at many places marked by a 100- to 200-foot-thick shattered zone. In places, the shattering is so intense that precise stratigraphic determination is impossible. There is some evidence of minor, sympathetic faulting in the footwall. Many small slivers of Tuscarora are found along the fault zone, and six are large enough to be mapped.

Although the major relative displacement was northwestward, there was probably some northeastward movement. This is indicated by (a) minor asymmetrical folds in the hanging wall which trend roughly perpendicular to the strike of the fault, (b) distribution of drag slivers of Tuscarora and Ridgeley along the fault, (c) large drag folds on the southwest end of Threemile Mountain, and (d) drag folds in the footwall. Estimates of dip of the fault are based on (a) topographic relations of the fault trace in the valley northwest of Columbia Furnace, (b) attitude of the footwall drag folds, (c) fracture cleavage in the fault zone, and (d) dip of the beds on both sides of the fault.

The small faults underlying Threemile Mountain and small hills to the southwest probably have low-angle dips. The trace of the fault plane on the west side of Threemile Mountain indicates a dip of about 15°. These small fault plates formed along the axis of the Little North Mountain upwarp in the footwall of the major North Mountain fault. The fault traces on the western sides of these hills are probably continuous at depth. Footwall drag folds, exposed at the southwest end of Deerhead Lookout Tower, show that the dominant fault movements were northwestward.

The short Alonzaville fault (Plate 1) is similar in all characteristics but size to the North Mountain fault, and these two faults are thought to be contemporaneous and genetically related. For reasons not apparent, the North Mountain fault, by splitting and rejoining in this local area, forms the Alonzaville fault. An additional fault sliver, northwest of St. Luke, is probably a low-angle fault plate, initiated and "pushed" along by the overriding block.

The Saumsville fault has a general trend to the northeast, locally veering north. The fault dies out southwestward of the mapped area in a synclinal fold, and is truncated northeastward by the Alonzaville fault. Stratigraphic displacement in most places does not exceed 800 feet. The relationship of the Saumsville fault to the Rinkerton anticline and the Harmony syncline indicates that the fault probably originated in the limb common to these two folds. The faulting produced moderate, close folds on the truncated nose of the Rinkerton anticline, but minor drag folds are rare in both fault blocks. The dip of 60 to 65° is based on fault zone fracture cleavage exposed along Crooked Run and near Pleasant View Church (Plate 3). Two fault slivers, southwest of Patmos Church (Plate 1) and southwest of Saumsville, are interpreted as low-angle fracture plates caused by the reverse faulting. Truncation of the Saumsville fault by the Alonzaville fault shows that the Saumsville shear zone developed first. The nature of the original vertical extent of the Saumsville fault cannot be precisely determined from the characteristics of that portion now exposed. It may or may not have extended through the cover, which was probably of the order of 4 to 5 miles. Small stratigraphic displacement, lack of visible offset extension northward beyond or within the Alonzaville and North Mountain fault slices, and absence of associated minor structures indicate that this fault probably passed upward into an anticline.

The herein-named Edinburg fault is poorly exposed and its total extent is not know, but is at least 2 miles long. This shear zone, exposed at two places within the city limits of Edinburg, is essentially vertical. Present distribution of stratigraphic units shows that there was strong horizontal movement along the fault; therefore, it is considered dominantly a strike-slip fault. As indicated on the geologic maps, this shear zone may extend northeastward as far as Woodstock.

WESTERN UPLAND AREA

Dominant structural features of the western upland are broad, open folds with numerous, minor flank and nose folds. Four major folds are mapped. Normal faults are common, and one minor, probably strike-slip, fault is present. The surface rocks in this structural unit are Upper Ordovician through Upper Devonian.

FOLDS

The Mt. Pleasant syncline (Plate 1) and the herein-named Paddy Mountain anticline (Plates 1, 2) are much more closely folded than the Supin Lick syncline (Plates 2, 3) or Anderson Ridge anticline (Plate 2). The Mt. Pleasant syncline has six strong, minor folds superimposed on it. The east limb of this syncline is faulted and overturned, partly because of the North Mountain fault; and the west limb is vertical or nearly so. The secondary folds are generally upright, and are complicated by smaller flank folds, which at many places are strongly overturned. Even smaller drag folds are at many places well developed on the flanks of the secondary and tertiary folds. In this area, the smallest drag folds may give data on the plunge of secondary folds. The southwest end of the Mt. Pleasant syncline is covered by heavy float and has been deeply weathered.

The Paddy Mountain anticline is tightly folded, but not overturned. The crest, near the southwest terminus, has been eroded deeply enough so that a small area of Martinsburg shale is exposed. The syncline between this anticline and the Anderson Ridge anticline is mapped as a continuation of the Supin Lick syncline.

The Supin Lick syncline and Anderson Ridge anticline are the largest folds in the mapped area, and both extend for many miles outside this area. The Supin Lick syncline is broad and simple in outline along the axis. The eastern limb is vertical or overturned, because of the North Mountain fault, and gentle dips prevail on the western limb near the axis. Further northwestward, the west limb is complexly folded, and in one place is faulted. These complex minor folds, although very tight, are usually symmetrical, indicating that forces rotational in the vertical plane were negligible.

The Anderson Ridge anticline is also simple in overall outline, though complex on the southwestern nose. This anticline has been deeply breached, exposing a wide outcrop area of Martinsburg shale, rimmed by Ordovician and Silurian sandstones. The sandstones are folded in several places on the southeast flank. As well as can be determined from sparse outcrops, the Martinsburg shale seems to be closely folded.

FAULTS

The normal fault along Tea Mountain Hollow (Plate 1) is probably the most extensive fault in the western upland. The fault has a dip of 84°SE., and at the point of maximum displacement the stratigraphic throw is 1,000 to 1,100 feet. Slickensides show dominantly downdip southeastward movement of the hanging wall, with a slight southerly, oblique component. If the small footwall anticline is considered as the next to last fold in the Cedar Creek valley series, then only the axial portion of the southeastern syncline is cut out by this fault.

Another normal fault, about 1 mile long, is exposed near the nose of the Supin Lick syncline (Plate 2), about 3 miles west-northwest of Columbia Furnace. It is essentially confined to the Mahantango Formation. The fault has a dip of 85°SE. and is marked by (a) rapid dip changes in the strata on both sides of the fault, (b) a zone of drag folding, and (c) a 2- to 3-inch-thick zone of fault gouge. A series of very minor, normal faults are exposed in the footwall block. These faults all have a dip of about 40°NW. and displacement ranges from a few inches to a few feet, in each case increasing the width of the Mahantango Formation. Friction was sufficient to cause slight drag of the beds adjacent to the faults. All of the normal faults are thought to be late in the structural history of the area, and probably represent relaxation of compressive forces which caused the major deformation.

Immediately northeast of Liberty Furnace, the Ridgeley and adjacent beds are offset by a minor fault (Plate 2), along which the movement appears to have been largely strike-slip. This fault originated along an anticlinal axis, and may have been fairly early in the structural sequence.

The structure of that portion of Little North Mountain at Sheffer Gap (Plate 1) and southwest for 5 miles may be interpreted in more than one way. Outcrops of all units except the Tuscarora are very sparse because of heavy sandstone float and dense vegetation. However, the following observations can be made: (a) the Tuscarora does not extend through Sheffer Gap, (b) the Tuscarora thins progressively southwest of Sheffer Gap, (c) the Oswego and Juniata south of Sheffer Gap are very thin, and (d) in the section at Stultz Gap (Plate 1), the Oswego and Juniata are absent, and the Rose Hill and Keefer are very thin. This portion of Little North Mountain is similar stratigraphically to that of the Threemile Mountain section 1.5 miles to the southwest.

Based on the above data, two interpretations are: (a) this part of Little North Mountain could be bounded on the northwest by a low-angle reverse fault, similar to the major North Mountain fault zone to the southeast. It would trend in a generally northeasterly arcuate curve, and have a displacement of no more than a few hundred feet. At either end it would be terminated by the North Mountain fault. (b) Minor faults occur at both ends of this section of Little North Mountain. The fault through Sheffer Gap may be a normal or strike-slip fault, but in either case the displacement is small and the extent is limited. The fault near Stultz Gap is probably a reverse fault and definitely minor in stratigraphic throw. Therefore, the writers have mapped this section of Little North Mountain as unfaulted, except at the extremities.

ECONOMIC GEOLOGY

The mineral resources of the study area are largely potential and include carbonate rocks, silica sands, shales, gravel, manganese, iron, and zinc. Carbonate rocks, iron, and maganese have been exploited in the past, but restricted transportation facilities, limited reserves, and market conditions, plus other factors have retarded further development. The mining of a sphalerite orebody near Timberville southwest of the mapped area (Hayes, 1960) from 1957 to 1962 focused attention during recent years on the distribution of zinc sulfide in the Shenandoah Valley. A number of occurrences of sphalerite are now known in the Beekmantown of the lowland belt.

CARBONATE ROCKS

Carbonate rocks, limestone and dolomite, appear to represent the greatest potential economic resources, both in terms of value and quantity. There are no known sections of dolomite of requisite thickness, chemical quality, and homogeneity to be considered chemical or glass grade. Consequently, future demand for this rock type is most likely to be crushed rock for road construction. Dolomites of the Conococheague Formation were produced for road metal from a small, abandoned quarry just east of the junction of State Roads 42 and 263 west of Mt. Clifton (Plate 3, abandoned quarry number 3). This rock type is so widely distributed in the lowland belt that potential quarry sites are literally numberless.

The limestones of this area may be classified as either high calcium or impure. The chief source of chemical-grade limestone in the northern Shenandoah Valley is the high-calcium phase of the New Market ("Mosheim") Limestone. It has been used as fluxing stone in the steel industry, in the manufacture of glass, in the production of hydrated lime, as agricultural lime, and as a road-base stabilizing agent. The New Market crops out in three belts in the lowlands of the mapped area. In general, each belt may be divided into a pure, upper unit and lower, argillaceous beds. The work of Edmundson (1945) demonstrates that there are significant deposits in the middle and western belts of New Market Limestone, but sums up the production potential in the statement that ". . . since the area is remote from railroads no large-scale commercial development appears likely in the near future." The following section of the New Market, which is exposed along Swover Creek 2.5 miles west of Lantz Mills, is one of the better (Edmundson, 1945):

New Market Limestone (218 feet, dip 20°SE.)

2. Upper limestone, dove-gray, compact, thick-bedded; SiO_2, 0.14; Fe_2O_3, 0.04; Al_2O_3, 0.52; $CaCO_3$, 98.56; $MgCO_3$, 0.82; total, 100.08 ....116 feet

1. Lower limestone, dove-gray, compact, clayey partings; SiO_2, 1.20; Fe_2O_3, 0.08; Al_2O_3, 0.78; $CaCO_3$, 95.22; $MgCO_3$, 2.65; total, 99.93 ....102 feet

Numerous small quarries have been intermittently operated in the past by farmers to obtain agricultural lime and crushed stone. The only commercial limestone operation in the New Market was about 1 mile northwest of Mount Jackson on State Highway 263 (Plate 3, abandoned quarry number 2). Because of its proximity to a railroad and the local synclinal structure, this site may be best adapted for future development; however, the chemical quality of the limestone has not been determined.

Limestone has been quarried commercially from the Stonehenge Formation at the northern city limit of Edinburg (Plate 4) and from the Edinburg Formation 0.9 mile northwest of Interchange 69, Interstate Highway 81 on State Road 703 (Plate 3, abandoned quarry number 1). Potential road-metal quarry sites are too numerous to describe individually; however, because of thickness and general homogeneity, Beekmantown dolomite and Stonehenge limestone are especially well suited for use as road metal.

CLAY, SAND, AND GRAVEL

There are reports of the manufacture of bricks at Woodstock (Watson, 1913; Ries and Somers, 1920) over a half-century ago from clays or saprolite that are developed on Martinsburg shales. Watson (1911) also notes a sand and gravel operation at Edinburg, undoubtedly from the intermediate terrace which is well developed in the western environs of Edinburg. There is no available record of when these operations ceased, but it is assumed that they were relatively short-lived. More recently, data have been published on the potential for brick clay and materials for lightweight aggregate (Calver, Hamlin, and Wood, 1961, R-659, R-660, R-661, R-675) and silica sand (Harris, 1972, R-4515) in this general area.

MANGANESE

Concentrations of manganese-bearing minerals are scattered along the eastern boundary of the western uplands. The seemingly better occurrences are in the Ridgeley Sandstone, with a lesser one in the Keefer Sandstone. These are residual concentrations, and occur both as fracture fillings and small replacement lenses, with neither type exceeding more than a few feet in greatest dimension. Most of the manganese-bearing minerals have been concentrated by ground water along bedding rather than cross-cutting fractures.

Because manganese oxides and manganiferous iron oxides-hydroxides are found in both the Ridgeley and underlying New Scotland limestone, the term "Oriskany ore" is a misnomer. The principal manganese ore minerals, in order of importance, are pyrolusite, wad (an earthy mixture of manganese minerals), psilomelane, and manganite. The chief impurities are silica and phosphorus, the latter in the mineral wavellite.

The main deposits of manganese are concentrated in Cedar Creek valley, with fewer deposits west of Columbia Furnace. Stose and Miser (1922) and Monroe (1942) mapped and described the mines, prospects, and mineralized outcrops in this area. The Capola Mountain mine, in Cedar Creek valley, was the chief producer. Here, the ore-bearing horizon is repeated by close synclinal folding, permitting mining of both walls simultaneously.

One potentially significant concentration of manganese, not previously described, occurs in the Keefer Sandstone, 0.25 mile north-northwest of Stultz Gap. Psilomelane is the dominant manganese mineral, and is associated with limonite in a steep overturned series of beds. At one exposure, the limonite-psilomelane bed is 7 feet thick, and it correlates with a shale bed of other Keefer sections. Minor amounts of psilomelane were also found in adjacent sandstone, near a minor fault zone. Because of cover, the lateral (strike) extent of this zone is not known.

IRON

Until about 1900, three iron furnaces operated in the mapped area. These were the Columbia, Liberty, and Van Buren furnaces. The ore supplying these furnaces was derived mainly from the Ridgeley Sandstone and Rose Hill Formation. The Beekmantown Formation is locally iron-bearing, but has not been mined. These iron deposits, like those of manganese, are residual concentrations, and generally occur as small, irregular replacement bodies, more or less elongate parallel to bedding. Fracture fillings are subordinate.

The highest grade and largest concentrations of Ridgeley ("Oriskany") iron-bearing minerals are in Cedar Creek valley, with less important deposits along the west limb of the Supin Lick syncline west of Columbia Furnace. The ore mineral is limonite, and is almost always manganiferous.

Iron ore that was mined from the Rose Hill Formation occurred as lenticular replacements of shale. No fracture fillings were noted. The iron minerals are not confined to a definite stratigraphic level within the Rose Hill. The Rose Hill was worked and prospected at many places in this general area, but the Threemile Mountain mineralized zone apparently produced the greatest tonnage of iron ore.

One replacement body of limonite occurs in Beekmantown chert, one mile northeast of Alonzaville. The iron-bearing zone is massive and apparently high grade. This mineralized zone appears to be less than 1,500 feet long. It has been prospected, but not mined.

ZINC

The Bowers-Campbell sphalerite orebody near Timberville southwest of Conicville was mined by the Tri-State Zinc Company from 1957-62. Although quite small, approximately 1.5 million tons, the ore was relatively high-grade (6 to 7 percent Zn) for a Valley-type zinc deposit. As would be anticipated, the proving of this orebody, and its subsequent mining, was preceded, accompanied by, and followed by considerable regional prospecting. In recent years, the zinc district has been extended to the latitude of Staunton to the southwest (Good and Allen, 1972) and to Middletown on the northeast (Young, 1967; Scherffius, 1969), with a few occurrences of sphalerite now known in the mapped area. The locations of these sphalerite "shows" are noted on the geologic maps of the Conicville and Edinburg 7.5-minute quadrangles.

In the mapped area, the sphalerite is confined to Beekmantown dolomite, with the apparently more significant concentrations occurring in the lower part of the formation. In most instances the principal ore mineral, sphalerite, has been converted, in surface exposures, to its secondary equivalent, smithsonite. In the chemical breakdown of sphalerite, especially the dark phases, greenockite is also usually formed. Of the six sphalerite occurrences that are located, those on Buck Hill

(Plate 3) and east of Mt. Jackson appear to be the more significant in terms of potential size and grade, both being associated with breccias.

FLUORITE

Minor amounts of fluorite were found in Cambrian dolomites (Elbrook and Conococheague formations) near the leading edge of the North Mountain fault. Purple fluorite is found in thin veinlets and smears on fractures. All occurrences known are minor and without apparent economic significance. Examples of these occurrences may be seen in prominent outcrops of Elbrook just north of the intersection of State Roads 42 and 263 (Plate 3), and in the abandoned quarry in the Conococheague, 0.6 mile east of that same intersection, south of State Road 263.

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APPENDIX

ROAD LOG

The following road log is a guide to important geologic features that can be seen along or near highways in the Woodstock, Wolf Gap, Conicville, and Edinburg 7.5-minute quadrangles. Distances between points of interest, as well as cumulative mileage, are shown, and the stops are places where features such as formational contacts, structures, fossils, and interesting rock types or minerals may be observed.

Cumulative mileage	*Distance*	*Explanation*
0.00	0.00	Begin road log at the intersection of U. S. Highway 11 and State Highway 263 in Mt. Jackson in the New Market quadrangle, adjoining the Conicville quadrangle on the south. Proceed northwest on State Highway 263.
0.55	0.55	Pass under Interstate Highway 81 bridge.
0.95	0.40	Note New Market Limestone exposed in abandoned quarry to the north (right).
1.80	0.85	Junction of State Highway 263 and State Road 614. Continue northwest (straight) on State Highway 263.
2.05	0.25	*STOP 1.* Grace Church. New Market sublithographic limestone exposed in road cut and in stream west of church (R-5328). Overturned Beekmantown-New Market contact is exposed in field to north of road. Continue on State Highway 263.
3.50	1.45	*STOP 2.* Beekmantown, New Market, and Lincolnshire formations exposed in double roadcut. Beekmantown—thin-bedded, yellow-weathering, gray, fine-grained limestone (R-5331). New Market—basal impure, dark limestone (R-5332); upper dove-gray micrite (R-5333). Lincolnshire—black, blocky chert (R-5330).

Cumulative mileage	Distance	Explanation
3.70	0.20	Junction of State Highway 263 and State Road 720. Turn right on 720.
4.60	0.90	Junction of State Roads 720 and 716. Continue northwest (straight) on State Road 720.
5.00	0.40	Note Conococheague limestone at north end of bridge over Crooked Run.
5.15	0.15	Note Conococheague sandstone on north side of road.
6.45	1.30	Junction of State Road 720 and State Highway 42 at Hudson Crossroads. Continue on west (straight) on State Road 720.
6.90	0.45	Note Chemung sandstone and shale exposed to south of road.
7.15	0.25	Junction of State Roads 720 and 721. Bear right and continue north on State Road 720.
7.35	0.20	Junction of State Roads 720 and 721. Turn left and continue northwest on State Road 720.
8.05	0.70	*STOP 3.* Hampshire Formation exposed along road from curve to near creek (Riles Run). Red flaggy sandstones (R-5340), shales, and mudstones (R-5341); brown shales and sandstones; green shales. Continue west (straight) on State Road 720.
9.05	1.00	Junction of State Roads 720 and 611. Turn right and proceed northeast on State Road 611. Note conglomerate float from the Chemung along road to next junction.
11.50	2.45	*STOP 4.* Chemung Formation exposed at junction of State Roads 611 and 703 with brown and red sandstones and shale. Turn right on State Road 703 and proceed east.
12.25	0.75	Note Hampshire red flaggy sandstone and peg-weathering shale exposures.

Cumulative mileage	Distance	Explanation
12.40	0.15	Note excellent exposures of Hampshire Formation near axis of Supin Lick syncline.
13.00	0.60	Junction of State Roads 703 and 705. Continue southeast on State Road 703.
13.60	0.60	Note Elbrook dolomite to north of road. These exposures are just east of the North Mountain fault.
14.25	0.65	Junction of State Road 703 and State Highway 42. Turn right on State Highway 42. Road is on sandstone ridge of Conococheague Formation.
14.55	0.30	Junction of State Highway 42 and State Road 703 in Conicville. Turn left on State Road 703 and proceed east.
15.05	0.50	Junction of State Roads 703 and 694. Turn left on State Road 694 and proceed east.
16.65	1.60	Junction of State Roads 694 and 709. Continue east on State Road 694.
17.25	0.60	Note road is on upper terrace level. View to east—the middle terrace level is ahead and New Market Gap is on the skyline.
17.45	0.20	Junction of State Roads 694 and 707. Proceed straight (east) on State Road 707.
17.80	0.35	*STOP 5.* Zion Church. Junction of State Roads 707 and 693. Oranda and Edinburg (St. Luke and Lantz Mills) formations exposed around church and in field to south of State Road 693. Behind church almost entire section of Oranda calcareous siltstone (R-5349) and upper St. Luke limestone (R-5350) are exposed. Turn around and return to State Road 694 via State Road 707.
18.15	0.35	Junction of State Roads 707 and 694. Turn right (north) on State Road 694.

Cumulative mileage	*Distance*	*Explanation*
18.65	0.50	*OPTIONAL STOP 5A.* Junction of State Roads 694 and 691. Beginning north of the intersection east of State Road 694 and proceeding west along Swover Creek the following section is exposed:

	Thickness feet
Oranda Formation	not measured
Reuschella "edsoni" zone	
Edinburg Formation (413 feet)	
St. Luke Member (96 feet)	
Calcilutite with *Cryptophragmus antiquatus*	20
Calcarenite with *Foerstephyllum "halli", Doleroides, Zygospira, Oligorhynchia,* and *Rhinidictya*	76
Lantz Mills (308 feet)	
Limestone, nodular with *Mastopora pyriformis, Lambeophyllum, Cryptophragmus antiquatus, Homotelus, Echinosphaerites,* and *Resserella*	308
Lincolnshire Formation (111 feet)	
Limestone, dark-gray, sparse chert	38
Limestone, cherty, with *Sowerbyella, Multicostella, Girvanella*	73
New Market Limestone (250 feet)	
Calcilutite, dove-gray	250
Beekmantown Formation	not measured

(see Cooper and Cooper, 1946, p. 82 and Edmundson, 1945, p. 58-59 for more detailed section).

Turn right on State Road 691.

Cumulative mileage	Distance	Explanation
18.90	0.25	Junction of State Road 691 and 682. Note Martinsburg Formation exposed to the north. Continue to the right on State Road 691.
19.35	0.45	Note St. Luke Member of Edinburg Formation exposed to the north.
19.45	0.10	Note Oranda Formation exposures to north of road.
19.75	0.30	Note Beekmantown exposures to north of road.
20.00	0.25	Note New Market and Lincolnshire exposures to north of road.
20.65	0.65	Junction of State Roads 691 and 675. Turn right on State Road 675.
22.65	2.00	Interstate Highway 81 bridge.
23.55	0.90	Junction of State Road 675 and U. S. Highway 11 at Edinburg. Turn left on U. S. Highway 11.
24.10	0.55	Junction of U. S. Highway 11 and State Road 675. Turn right on State Road 675.
24.65	0.55	Note Beekmantown Formation exposure overlain by terrace gravels at west end of Shenandoah River bridge.
25.45	0.80	Note alluvial fan. Road is parallel to long axis of fan for 0.85 mile.
26.85	1.40	*STOP 6.* Martinsburg Formation is exposed for 300 yards downslope along State Road 675. Shale and lithic sandstone, graded bedding, fossiliferous shale, minor folding, and cleavage-bedding relations may be observed at this stop. Continue on State Road 675.

Cumulative mileage	*Distance*	*Explanation*
28.75	1.90	*STOP 7.* Park at spring. Massanutten Sandstone is well exposed for about 200 yards to the west along road (R-5309). At the spring and to the east Bloomsburg red beds (R-5308) and white standstone (R-5310) are exposed. Turn around and return to U. S. Highway 11 via State Road 675.
33.40	4.65	Junction of State Road 675 and U. S. Highway 11. Turn right on U. S. Highway 11.
34.60	1.20	Junction of U. S. Highway 11 and State Road 673.
34.80	0.20	*OPTIONAL STOP 7A.* Turn right on State Road 673 and proceed 0.2 mile to farm road on right. Park and take 10-minute walk along road to North Fork of Shenandoah River. Type locality is in exposures along road and in adjacent fields of Edinburg Formation (see measured section in Cooper and Cooper, 1946, p. 81 and Edmundson, 1945, p. 50 and 62). Edinburg — black, argillaceous limestone and shale. Lincolnshire—dark-gray, cherty, fossiliferous limestone. New Market — dove-gray micrite. Return to U. S. Highway 11 via State Road 673.
35.00	0.20	Junction of U. S. Highway 11 and State Road 673. Proceed north on U. S. Highway 11.
36.75	1.75	Junction of U. S. Highway 11 and State Road 605. Turn left (northwest) on State Road 605.
37.25	0.50	Interstate Highway 81 bridge. Note intermediate terrace level to south.
38.15	0.90	Junction of State Roads 605 and 683. Turn left (southwest) and continue on State Road 605.

Cumulative mileage	*Distance*	*Explanation*
38.30	0.15	Note Conococheague limestone with silty laminae on right side of road.
38.45	0.15	*OPTIONAL STOP 7B.* At intersection State Road 605 and Narrow Passage Creek; Conococheague, Stonehenge, and Beekmantown formations are well exposed downstream from the road. Continue on State Road 605.
38.85	0.40	Note Conococheague limestone with silty laminae on right side of road.
39.65	0.80	Junction of State Road 605 and State Highway 42. Turn left on State Highway 42.
40.55	0.90	Junction of State Highway 42 and State Road 682. Continue on State Highway 42. Note terrace level to east.
41.40	0.85	Note Martinsburg shale in field to north of road.
43.75	2.35	Note terrace gravel in roadcut.
44.05	0.30	Junction of State Highway 42 and State Road 675 at Columbia Furnace. Turn right on State Road 675.
44.20	0.15	Junction of State Roads 675 and 623. Turn left on State Road 675. Note Beekmantown Formation cliffs east of bridge and flood plain along Stony Creek.
44.95	0.75	*STOP 8.* Marcellus Shale (R-5322) and terrace gravel exposed in cut. Continue northwest on State Road 675.
45.50	0.55	Junction State Roads 675 and 749. Bear left and continue on State Road 675.
46.15	0.65	*STOP 9.* Mahantango Formation, middle member, is well exposed in roadcut to north of road. Fossiliferous sandstone and shale are exposed (R-5323). Continue on State Road 675.

Cumulative mileage	*Distance*	*Explanation*
46.20	0.05	Junction of State Roads 675 and 717. Turn left on State Road 717.
46.75	0.55	*STOP 10.* Mahantango and Brallier formations well exposed in large road cut. At east end of cut a normal fault in the Brallier is exposed. Turn around and return to State Road 675 via State Road 717.
47.30	0.55	Junction State Roads 717 and 675. Turn left on State Road 675.
47.60	0.30	Note Mahantango Formation exposures in roadcuts to south.
48.25	0.65	Note Marcellus Shale exposures in roadcuts to south.
48.80	0.55	Note Ridgeley Sandstone exposure to north. (See Harris, 1972, p. 21-23.)
48.90	0.10	Junction of State Roads 675 and 789. Continue on State Road 675.
49.70	0.80	*STOP 11.* Keefer Sandstone containing *Arthrophycus alleghaniensis* exposed along road. Continue on State Road 675.
49.90	0.20	*STOP 12.* Rose Hill Formation well exposed in roadcut. Formation is mostly sandstone with minor shale and few fossils (R-5326, R-5327). Continue on State Road 675.
50.45	0.55	*STOP 13.* Tuscarora Formation well exposed in roadcut, low dip to east. Continue on State Road 675.
50.70	0.25	Wolf Gap. Turn around and return to Columbia Furnace via State Road 675.
57.20	6.50	Junction of State Roads 675 and 623. Turn left on State Road 623.
57.40	0.20	Junction of State Roads 623 and 768 at Union Church. Continue on State Road 623.
58.10	0.70	Note upper terrace level. Big Schloss visible to west on skyline.

Cumulative mileage	Distance	Explanation
60.60	2.50	Junction of State Roads 623 and 605 at St. Luke. Continue northeast on State Road 623.
61.60	1.00	Note New Market Limestone to north of road. (See measured section of Edmundson, 1945, p. 57.)
63.20	1.60	Junction of State Roads 623 and 604. Continue on State Road 623.
65.50	2.30	Junction of State Roads 623 and 600. Turn left on State Road 600.
66.30	0.80	Note Martinsburg Formation outcrops on left.
67.20	0.90	*STOP 14.* Oswego Formation sandstone and conglomerate exposed in roadcut. Continue on State Road 600.
67.90	0.70	*STOP 15.* Tuscarora Formation exposed on west side of road. Overlook to east permits a good overview of the Shenandoah Valley; Massanutten Mountain is on the skyline. Continue on State Road 600.
69.10	1.20	*STOP 16.* Ridgeley, Needmore, and Bloomsburg formations exposed in roadcut. A normal fault is present between the Needmore and Bloomsburg. Ridgeley—coarse-grained, conglomeratic sandstone (R-5294). Needmore — olive-green, buff-weathering shale (R-5293). Bloomsburg — red sandstone and shale (R-5297). Continue on State Road 600.
70.00	0.90	Junction of State Roads 600 and 603. Turn right on State Road 600.
70.75	0.75	*STOP 17.* Ridgeley sandstone and conglomerate exposed in roadcut and on hill at trout farm. End of road log in Cedar Creek valley of Woodstock quadrangle.

GENERAL INDEX

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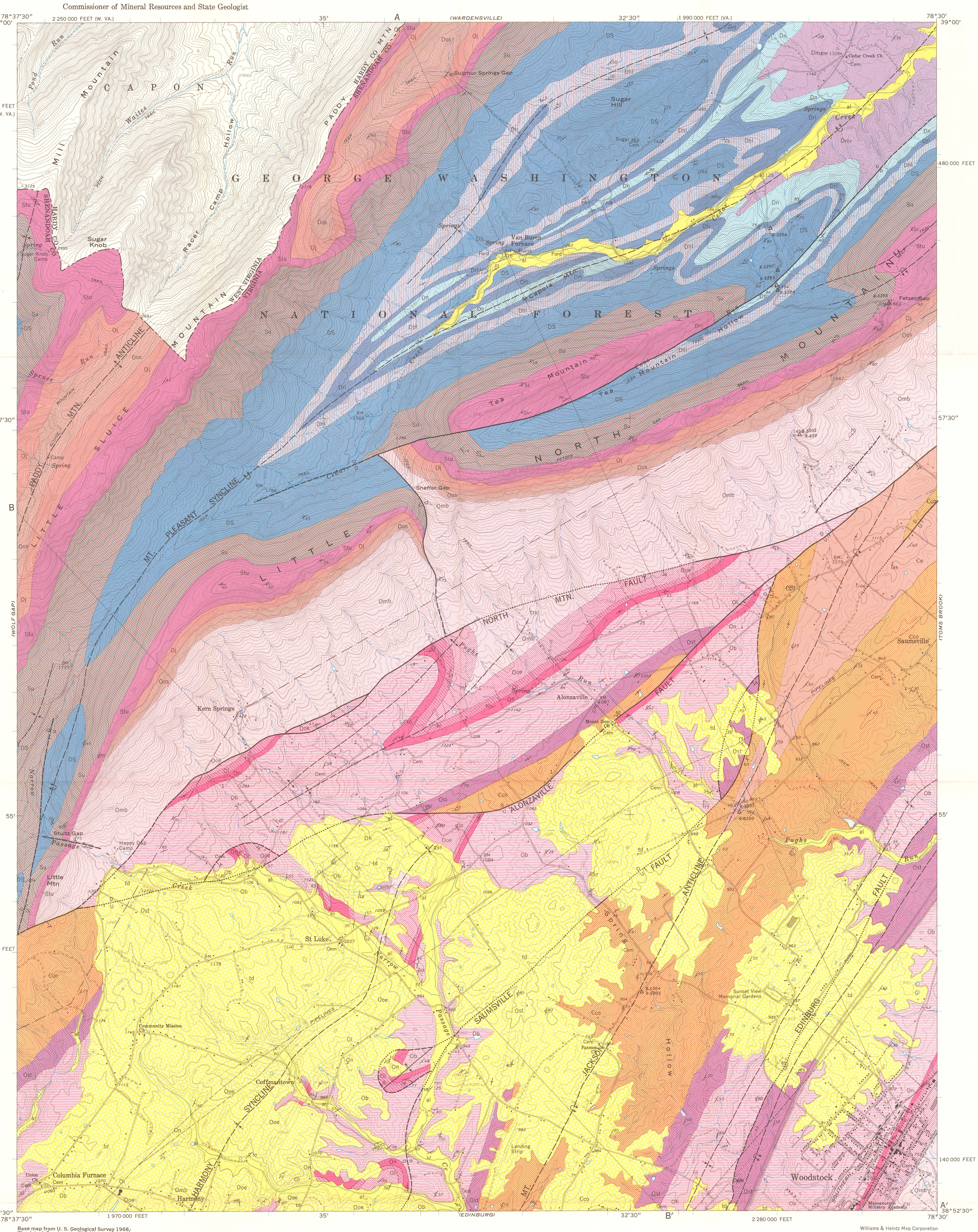
COMMONWEALTH OF VIRGINIA
DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT
DIVISION OF MINERAL RESOURCES
James L. Calver
Commissioner of Mineral Resources and State Geologist



Base map from U. S. Geological Survey 1966, Woodstock Quadrangle, 7½-Minute Series

Williams & Heintz Map Corporation

GEOLOGIC MAP OF THE WOODSTOCK QUADRANGLE, VIRGINIA

Geology by Robert S. Young and Eugene K. Rader

MN GN 5½° 98 MILS 1°32' 27 MILS

UTM GRID AND 1966 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:24000

1 ½ 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 .5 0 1 KILOMETER

CONTOUR INTERVAL 20 FEET

1974

VIRGINIA
QUADRANGLE LOCATION

EXPLANATION

CENOZOIC — QUATERNARY

al Alluvium
Varicolored unconsolidated sand, clay, and gravel.

td Terrace deposits*
Varicolored unconsolidated sand, clay, and gravel.

PALEOZOIC — DEVONIAN

Dmr Marcellus Shale
Fissile, gray to black shale.

Dn Needmore Formation
Thin-bedded, olive to buff shale; sandy near base.

Dri Ridgeley Sandstone
Medium- to thick-bedded, white to brown, calcareous sandstone and sandy conglomerate.

Dhl Helderberg limestones
New Scotland limestone: dark-gray, medium-grained, cherty limestone. New Creek Limestone: gray, coarse-grained, crinoidal limestone.

DS Lower Devonian and Upper Silurian rocks
Keyser Formation: gray, medium-grained limestone; weathers dark gray to white. Tonoloway Formation: finely laminated, gray and yellow, argillaceous limestone. Wills Creek Formation: yellow, calcareous shale. Bloomsburg Formation: red sandstone and red- and green-mottled mudstone.

SILURIAN

Su Silurian rocks, undivided
McKenzie Formation: yellow, calcareous shale. Keefer Sandstone: gray, cross-bedded orthoquartzite; minor green and purple shale. Rose Hill Formation: yellow, sandy shale and white to brown, fine- to medium-grained sandstone.

Stu Tuscarora Formation
White orthoquartzite with a basal conglomerate; shale common locally.

ORDOVICIAN

Oj Juniata Formation
Red sandstone, shale, siltstone, and graywacke; grayish-brown sandstone.

Oos Oswego Formation
Fine-grained, brown-weathering, gray sandstone.

Omb Martinsburg Formation
Gray, silty shale; calcareous siltstone; thin, fine-grained sandstone.

Ooe Oranda Formation and Edinburg Formation
Oranda: calcareous siltstone and argillaceous limestone. Edinburg: dove-gray, fine-grained limestone (St. Luke Member); medium-bedded, dark-gray to black limestone (Liberty Hall); dark-gray, nodular-weathering limestone (Lantz Mills).

Ol Lincolnshire Formation
Dark-gray, medium-grained, cherty limestone.

On New Market Limestone
Dove-gray, sublithographic limestone; buff limestone; and carbonate pebble conglomerate.

Ob Beekmantown Formation
Massive, gray to brown dolomite with white chert; minor bluish-gray limestone and dove-gray, sublithographic limestone.

Ost Stonehenge Formation
Thick-bedded, bluish-gray, fine- to medium-grained limestone.

CAMBRIAN

Єco Conococheague Formation
Laminated, bluish-gray limestone; gray, medium-grained dolomite; gray, fine- to medium-grained sandstone.

Єe Elbrook Formation
Thick-bedded, nonlaminated, bluish-gray limestone and shaly dolomite.

CONTACTS

Solid where exposed, dashed where approximate, dotted where covered or inferred

FOLDS

Anticline—trace of fold

Syncline—trace of fold

Overturned anticline—trace of fold

Overturned syncline—trace of fold

FAULTS

U D

Solid where exposed, dashed where approximate, dotted 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

In cross section

T/A Horizontal movement:

T—relative movement toward observer

A—relative movement away from observer

ATTITUDE OF ROCKS

45 Strike and dip of beds

60 Strike and dip of overturned beds

Strike of vertical beds

MINE

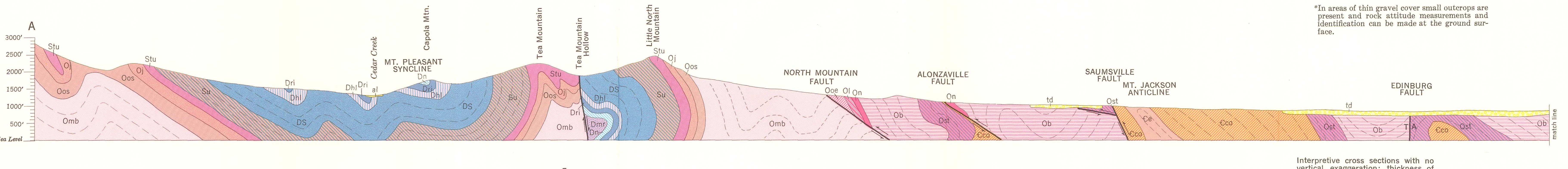
Abandoned mine

Capola Mountain mine (manganese ore)

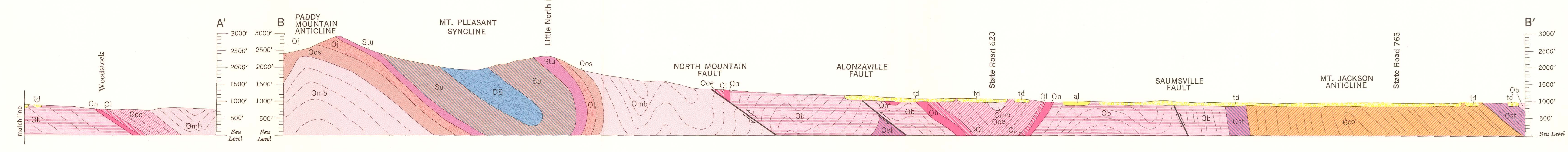
SAMPLE LOCATIONS

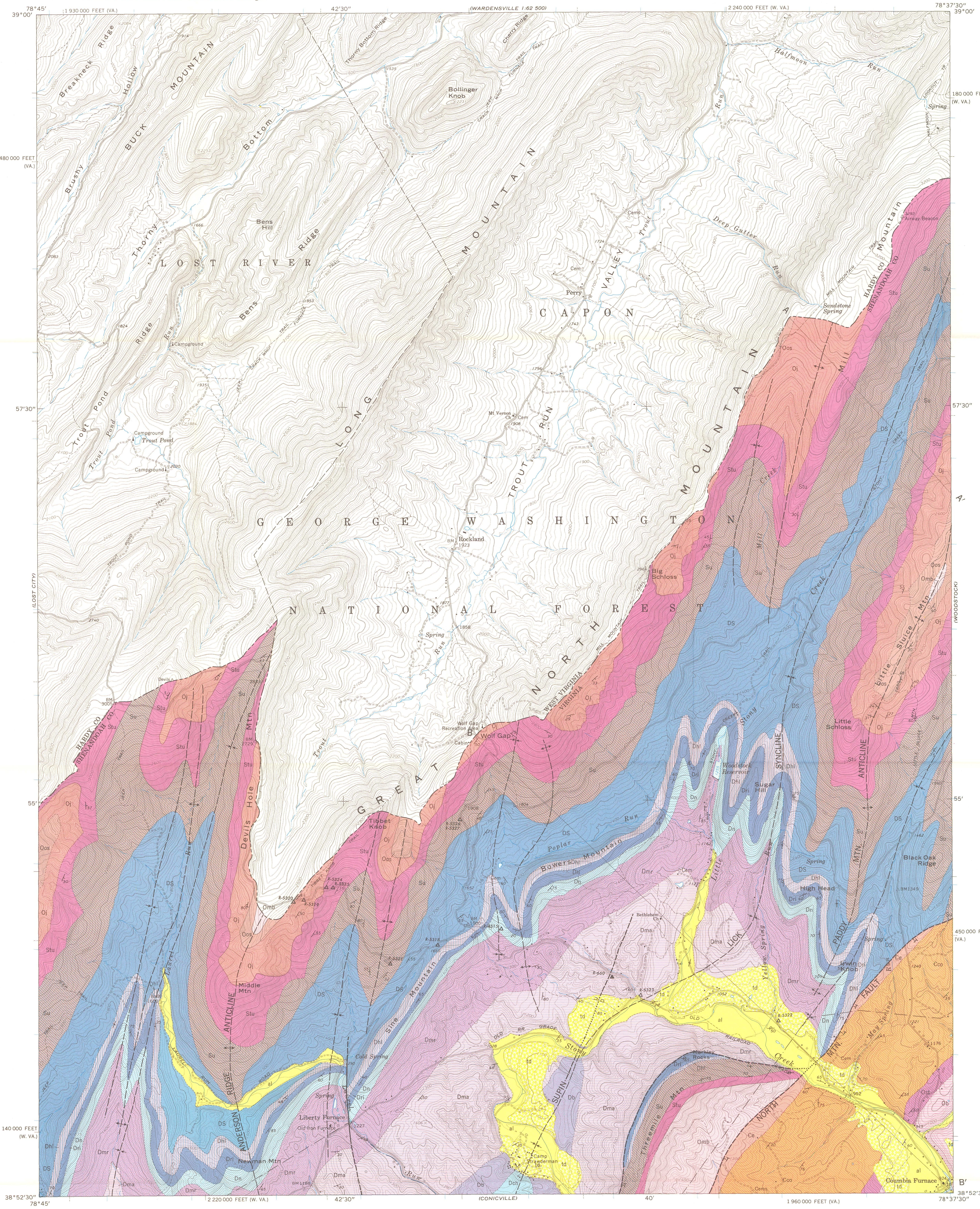
R-5301 Location and repository number of sampled lithology

*In areas of thin gravel cover small outcrops are present and rock attitude measurements and identification can be made at the ground surface.



Interpretive cross sections with no vertical exaggeration; thickness of alluvium and terrace deposits diagramatic.





Base map from U. S. Geological Survey 1966, Wolf Gap Quadrangle, 7½-Minute Series

UTM GRID AND 1966 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

Williams & Heintz Map Corporation

GEOLOGIC MAP OF THE WOLF GAP QUADRANGLE, VIRGINIA

Geology by Robert S. Young and Eugene K. Rader

SCALE 1:24 000

CONTOUR INTERVAL 20 FEET

1974

QUADRANGLE LOCATION

EXPLANATION

CENOZOIC — QUATERNARY

al — Alluvium
Varicolored unconsolidated sand, clay, and gravel.

td — Terrace deposits
Varicolored unconsolidated sand, clay, and gravel.

PALEOZOIC — DEVONIAN

Dch — Chemung Formation
Interbedded brown and red shale and sandstone; thin quartzitic conglomerate.

Db — Brallier Formation
Interbedded olive to brown, micaceous shale and greenish-brown, fine-grained sandstone.

Dma — Mahantango Formation
Upper member: argillaceous siltstone. Middle member: grayish-green shale and green siltstone. Lower member: pale-green silty shale with lesser amounts of siltstone.

Dmr — Marcellus Shale
Fissile, gray to black shale.

Dn — Needmore Formation
Thin-bedded, olive to buff shale; sandy near base.

Dri — Ridgeley Sandstone
Medium- to thick-bedded, white to brown, calcareous sandstone and sandy conglomerate.

Dhl — Helderberg limestones
New Scotland limestone: dark-gray, medium-grained, cherty limestone. New Creek limestone: gray, coarse-grained, crinoidal limestone.

DS — Lower Devonian and Upper Silurian rocks
Keyser Formation: gray, medium-grained limestone; weathers dark gray to white. Tonoloway Formation: finely laminated, gray and yellow, argillaceous limestone. Wills Creek Formation: yellow, calcareous shale. Bloomsburg Formation: red sandstone and red- and green-mottled mudstone.

SILURIAN

Su — Silurian rocks, undivided
McKenzie Formation: yellow, calcareous shale. Keefer Sandstone: gray, cross-bedded orthoquartzite; minor green and purple shale. Rose Hill Formation: yellow, sandy shale with white to brown, fine- to medium-grained sandstone.

Stu — Tuscarora Formation
White orthoquartzite with a basal conglomerate; shale common locally.

ORDOVICIAN

Oj — Juniata Formation
Red sandstone, shale, siltstone, and graywacke; grayish-brown sandstone.

Oos — Oswego Formation
Fine-grained, brown-weathering, gray sandstone.

Omb — Martinsburg Formation
Gray, silty shale; calcareous siltstone; thin, fine-grained sandstone.

Ob — Beekmantown Formation
Massive, gray to brown dolomite with white chert; minor bluish-gray limestone and dove-gray, sublithographic limestone.

Ost — Stonehenge Formation
Thick-bedded, bluish-gray, fine- to medium-grained limestone.

CAMBRIAN

Cco — Conococheague Formation
Laminated, bluish-gray limestone; gray, medium-grained dolomite; gray, fine- to medium-grained sandstone.

Ce — Elbrook Formation
Thick-bedded, nonlaminated, bluish-gray limestone and shaly dolomite.

CONTACTS

Solid where exposed, dashed where approximate, dotted where covered or inferred

FOLDS

Anticline—trace of fold
Syncline—trace of fold
Overturned anticline—trace of fold
Overturned syncline—trace of fold

FAULTS

Solid where exposed, dashed where approximate, dotted 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

ATTITUDE OF ROCKS

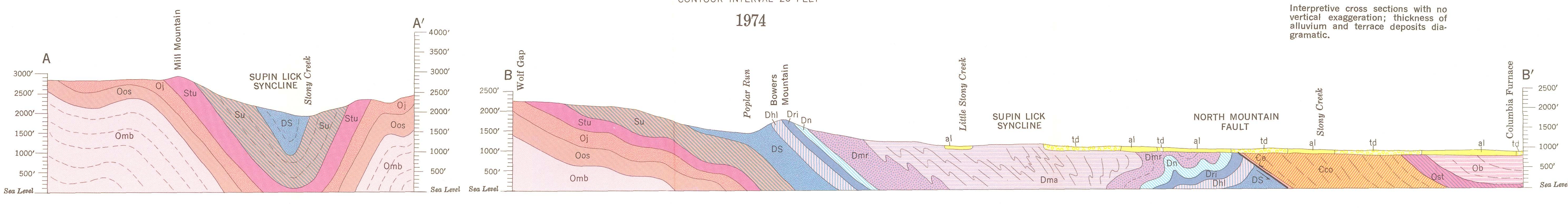
Strike and dip of beds
Strike and dip of overturned beds
Strike of vertical beds

SAMPLE LOCATIONS

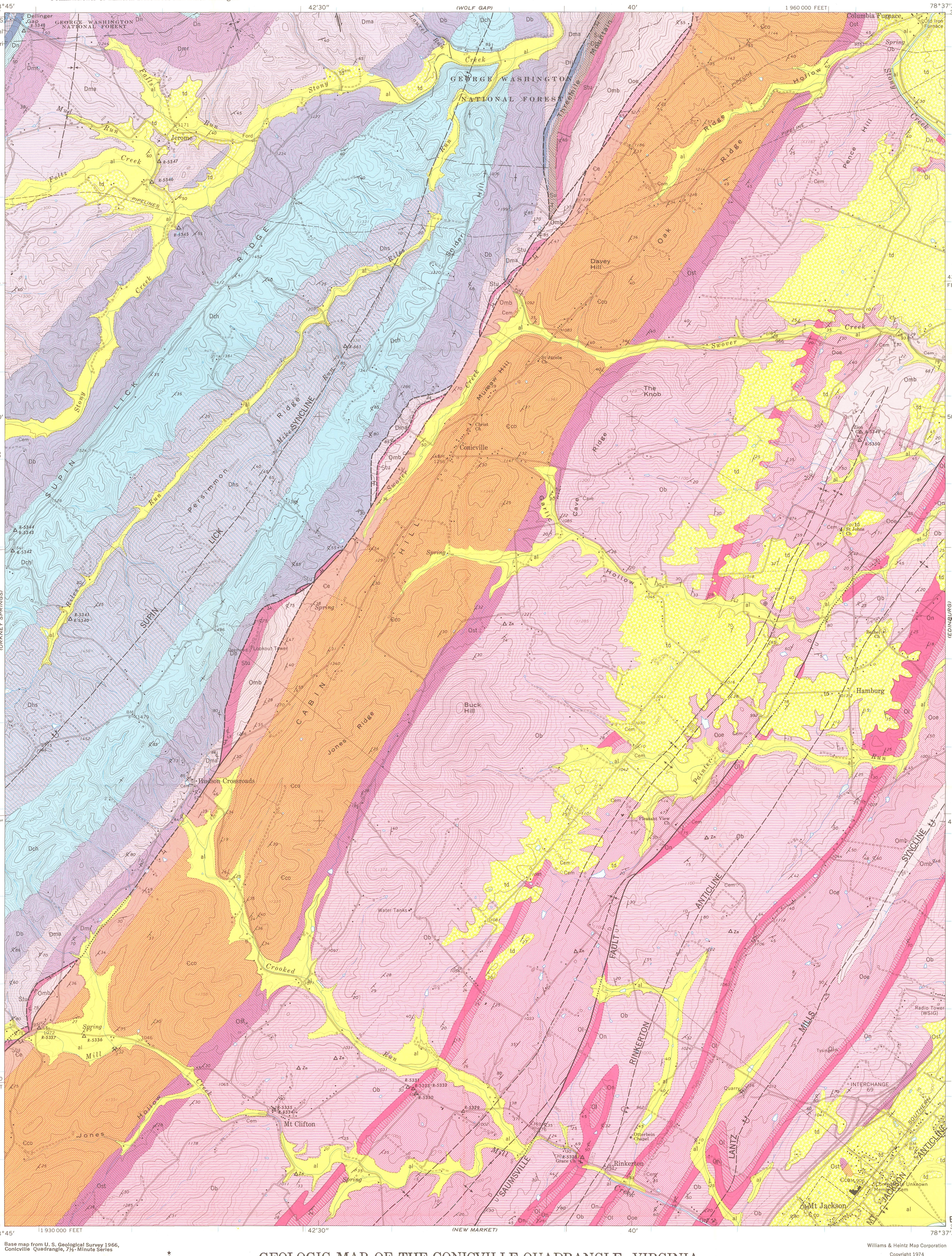
Location and repository number of sampled lithology

Sample of raw material having potential commercial use: R, repository number

Interpretive cross sections with no vertical exaggeration; thickness of alluvium and terrace deposits diagramatic.



COMMONWEALTH OF VIRGINIA
DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT
DIVISION OF MINERAL RESOURCES
James L. Calver
Commissioner of Mineral Resources and State Geologist



Base map from U. S. Geological Survey 1966, Conicville Quadrangle, 7½-Minute Series

GEOLOGIC MAP OF THE CONICVILLE QUADRANGLE, VIRGINIA

Geology by Robert S. Young and Eugene K. Rader

UTM GRID AND 1966 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

MN GN 5½° 98 MILS 1°27′ 26 MILS

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

1974

Williams & Heintz Map Corporation

QUADRANGLE LOCATION

SAMPLE LOCATIONS

△ R-5337 Location and repository number of sampled lithology

△ Zn Sphalerite

EXPLANATION

CENOZOIC — QUATERNARY

al — Alluvium
Varicolored unconsolidated sand, clay, and gravel.

td — Terrace deposits
Varicolored unconsolidated sand, clay, and gravel.

PALEOZOIC — DEVONIAN

Dhs — Hampshire Formation
Thin-bedded, red sandstone and red shale.

Dch — Chemung Formation
Interbedded brown and red shale and sandstone; thin quartzitic conglomerate.

Db — Brallier Formation
Interbedded olive to brown, micaceous shale and greenish-brown, fine-grained sandstone.

Dma — Mahantango Formation
Upper member: argillaceous siltstone. Middle member: grayish-green shale and green siltstone. Lower member: pale-green silty shale with lesser amounts of siltstone.

Dmr — Marcellus Shale
Fissile, gray to black shale.

Dn — Needmore Formation
Thin-bedded, olive to buff shale; sandy near base.

Dri — Ridgeley Sandstone
Medium- to thick-bedded, white to brown, calcareous sandstone and sandy conglomerate.

Dhl — Helderberg limestones
New Scotland limestone: dark-gray, medium-grained, cherty limestone. New Creek Limestone: gray, coarse-grained, crinoidal limestone.

DS — Lower Devonian and Upper Silurian rocks
Keyser Formation: gray, medium-grained limestone; weathers dark gray to white. Tonoloway Formation: finely laminated, gray and yellow, argillaceous limestone. Wills Creek Formation: yellow, calcareous shale. Bloomsburg Formation: red sandstone and red- and green-mottled mudstone.

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Stu — Tuscarora Formation
White orthoquartzite with a basal conglomerate; shale common locally.

ORDOVICIAN

Omb — Martinsburg Formation
Gray, silty shale; calcareous siltstone; thin, fine-grained sandstone.

Ooe — Oranda Formation and Edinburg Formation
Oranda: calcareous siltstone and argillaceous limestone. Edinburg: dove-gray, fine-grained limestone (St. Luke Member); medium-bedded, dark-gray to black limestone (Liberty Hall); dark-gray, nodular-weathering limestone (Lantz Mills).

Ol — Lincolnshire Formation
Dark-gray, medium-grained, cherty limestone.

On — New Market Limestone
Dove-gray, sublithographic limestone; buff limestone; and carbonate pebble conglomerate.

Ob — Beekmantown Formation
Massive, gray to brown dolomite with white chert; minor bluish-gray limestone and dove-gray, sublithographic limestone.

Ost — Stonehenge Formation
Thick-bedded, bluish-gray, fine- to medium-grained limestone.

CAMBRIAN

Єco — Conococheague Formation
Laminated, bluish-gray limestone; gray, medium-grained dolomite; gray, fine- to medium-grained sandstone.

Єe — Elbrook Formation
Thick-bedded, nonlaminated, bluish-gray limestone and shaly dolomite.

CONTACTS

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FOLDS

Anticline—trace of fold

Syncline—trace of fold

Overturned anticline—trace of fold

Overturned syncline—trace of fold

FAULTS

D U T

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ATTITUDE OF ROCKS

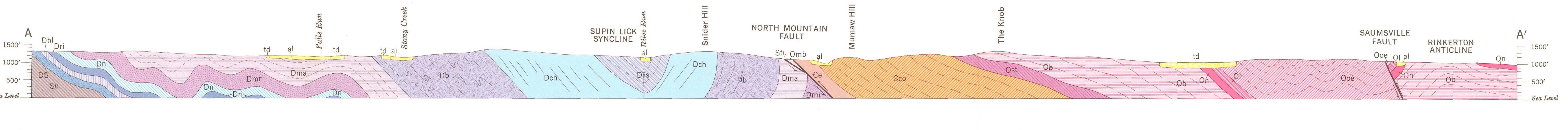
45 Strike and dip of beds

60 Strike and dip of overturned beds

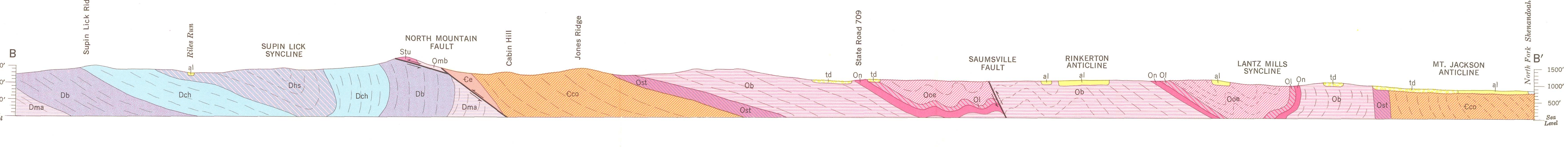
Strike of vertical beds

QUARRIES

Abandoned quarry
1. Crushed stone (limestone)
2. High-calcium limestone
3. Crushed stone (dolomite and limestone)



Interpretive cross sections with no vertical exaggeration; thickness of alluvium and terrace deposits diagramatic.



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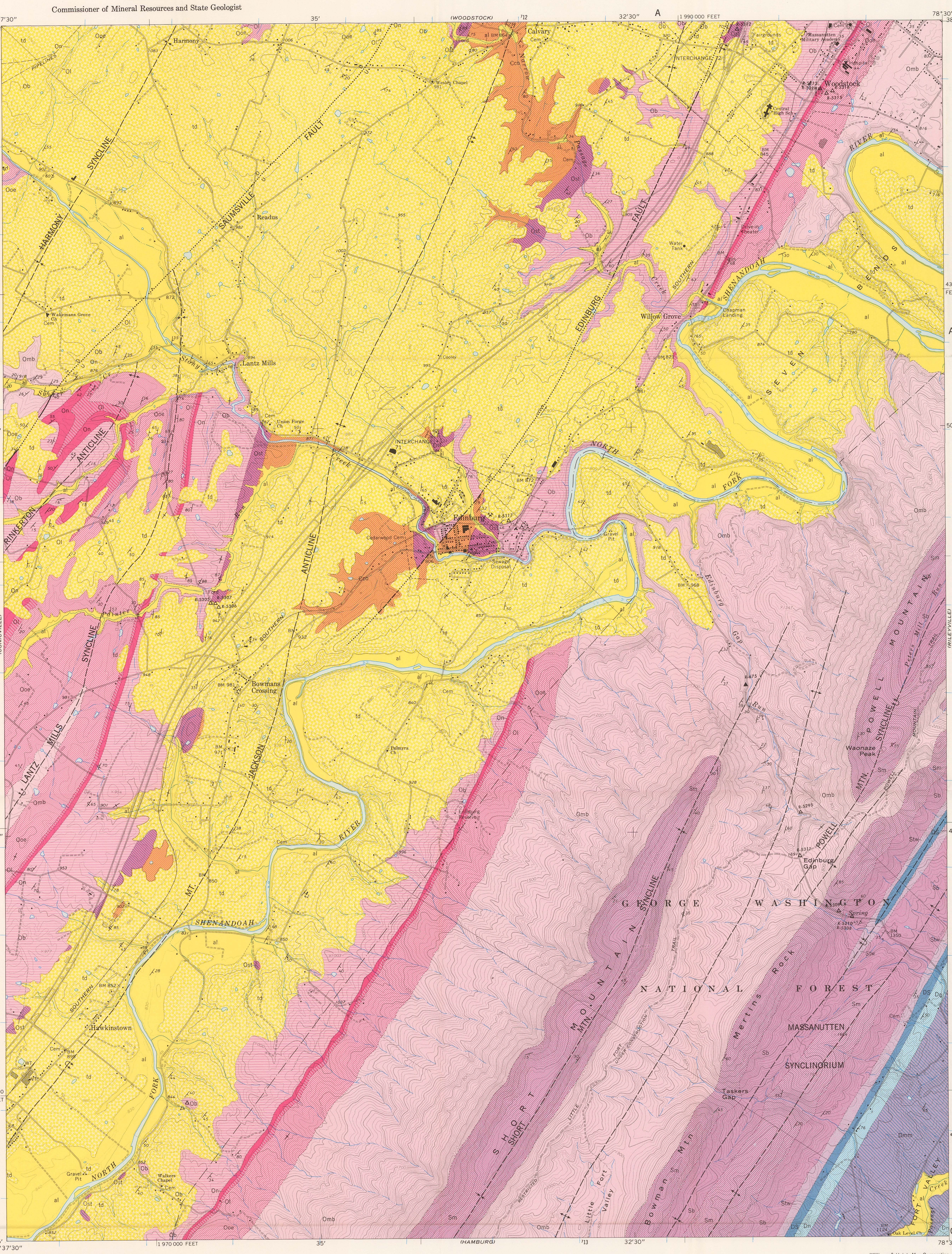

Base map from U. S. Geological Survey 1966, Edinburg Quadrangle, 7½-Minute Series

UTM GRID AND 1966 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

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GEOLOGIC MAP OF THE EDINBURG QUADRANGLE, VIRGINIA

Geology by Robert S. Young and Eugene K. Rader

SCALE 1:24 000

1 ½ 0 1 MILE

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1 .5 0 1 KILOMETER

CONTOUR INTERVAL 20 FEET

1974

VIRGINIA
QUADRANGLE LOCATION

EXPLANATION

CENOZOIC — QUATERNARY

al — Alluvium
Varicolored unconsolidated sand, clay, and gravel.

td — Terrace deposits*
Varicolored unconsolidated sand, clay, and gravel.

PALEOZOIC — DEVONIAN

Dmm — Mahantango Formation and Marcellus Shale
Mahantango: grayish-brown, silty shale and siltstone. Marcellus: thin-bedded, black and gray shale.

Dn — Needmore Formation
Thin-bedded, yellow to brown shale.

DS — Lower Devonian and Upper Silurian rocks
Thin-bedded, argrillaceous limestone with sandstone in uppermost part.

SILURIAN

Stw — Tonoloway Formation and Wills Creek Formation
Tonoloway: yellow, shaly limestone. Wills Creek: yellow shale, sandy near middle.

Sb — Bloomsburg Formation
Red- and green-mottled mudstone; red shale and shaly sandstone; white sandstone.

Sm — Massanutten Sandstone
Massive, white to gray orthoquartzite; conglomeratic at base; minor thin-bedded, green shale.

ORDOVICIAN

Omb — Martinsburg Formation
Gray, silty shale; calcareous siltstone; brown, fine-grained sandstone at top.

Ooe — Oranda Formation and Edinburg Formation
Oranda: calcareous siltstone and argillaceous limestone. Edinburg: dove-gray, fine-grained limestone (St. Luke Member); medium-bedded, dark-gray to black limestone (Liberty Hall); dark-gray, nodular-weathering limestone (Lantz Mills).

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U D

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In cross section

T/A Horizontal movement:

T—relative movement toward observer

A—relative movement away from observer

ATTITUDE OF ROCKS

45 Strike and dip of beds

60 Strike and dip of overturned beds

Strike of vertical beds

QUARRY

Abandoned quarry

Crushed stone (limestone)

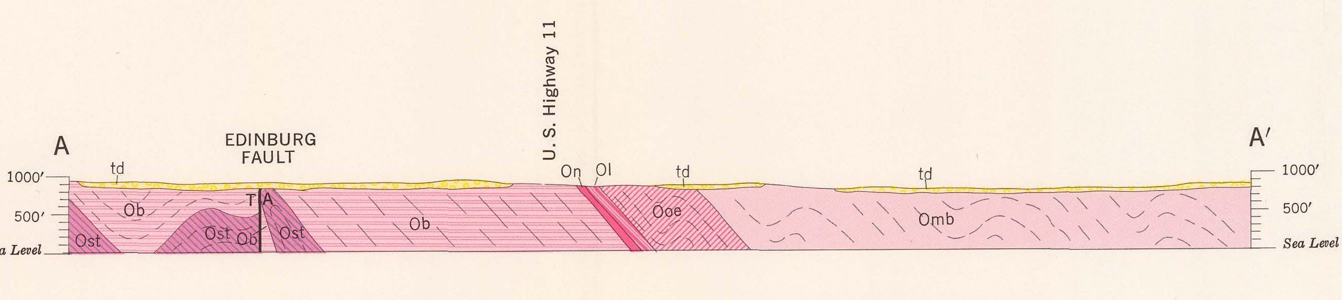
SAMPLE LOCATIONS

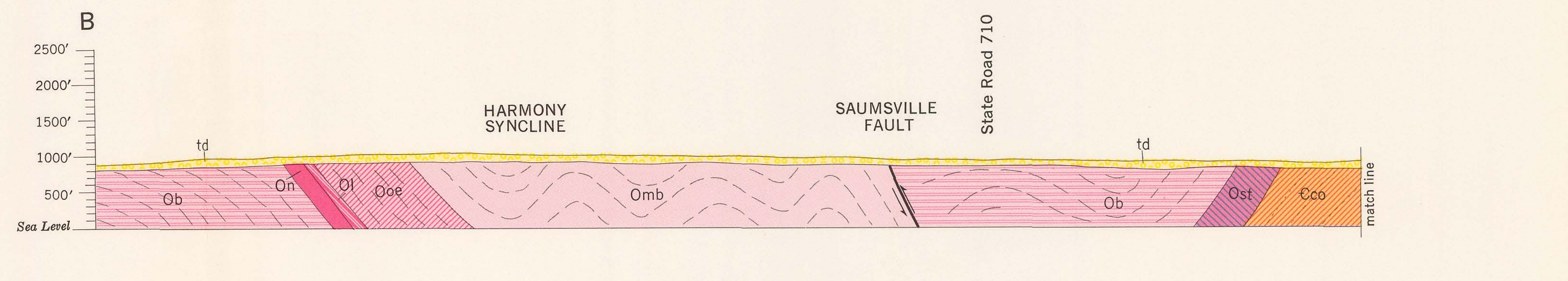
R-5313 Location and repository number of sampled lithology

R-675 Sample of raw material having potential commercial use; R, repository number

Zn Sphalerite

*In areas of thin gravel cover small outcrops are present and rock attitude measurements and identification can be made at the ground surface.





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