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# FIELD GUIDE TO SELECTED PALEOZOIC ROCKS, VALLEY—RIDGE PROVINCE, VIRGINIA

## PART I: ROANOKE, CLIFTON FORGE, FRONT ROYAL AREAS

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This field trip is designed to show some of the exposed potential reservoir beds of Silurian age, structural style west of the mid-province front, Middle and Upper Ordovician turbidite sequences, and structural style of the Blue Ridge front. The road log (Figure 1) begins at a field stop described in Bartholomew, Milici, and Schultz (1980).

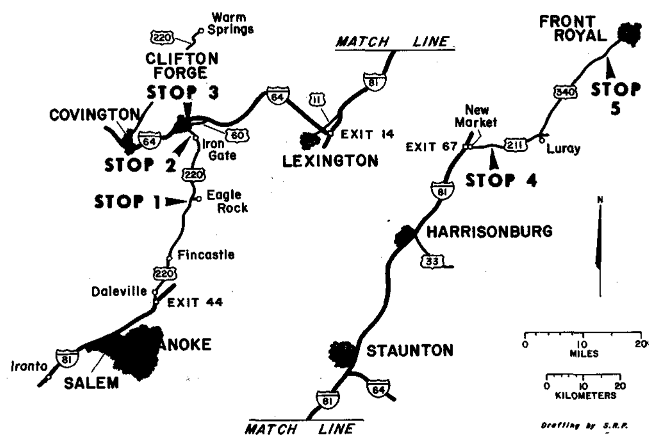


Figure 1. Map of trip route and stop locations.

| CUMULATIVE MILEAGE | INTERVAL MILEAGE | EXPLANATION |
|---|---|---|
| 0.0 | 0.0 | Begin trip one mile south of Ironto exit on Interstate Highway 81. *Proceed northward* on Interstate Highway 81 and enter area of the Salem syncline which contains rocks ranging in age from Middle Cambrian (Elbrook Formation) to Lower Mississippian (Price Formation). High bluffs to the east are formed of brecciated rocks of the Elbrook Formation (Middle Cambrian) in the hanging wall of the Pulaski thrust system. |
| 1.0 | 1.0 | Exit 38 |
| 1.5 | 0.5 | Bluff to west consists of nearly horizontal Upper Devonian Brallier Formation sandstones and shales for next mile. |
| 3.0 | 1.5 | Cross the Pulaski thrust system at crest of ridge and continue on the hanging wall of the thrust for the next seven miles to about exit 40. Mountains to the west are composed of Devonian and Mississippian clastics of the Salem syncline. The distant mountain range to the east contains Chilhowee Group clastics and Precambrian granites and gneisse of the Blue Ridge thrust sheet, which lies north, east and south of Roanoke. The low lands just to the east are Middle and Lower Cambrian carbonate rock units of the Pulaski thrust system (Amato, 1974). |
| 10 | 7 | Exit 40. Leave the Pulaski thrust system and enter the folded and faulted Silurian and Ordovician rocks of the east limb of the Salem syncline (Amato, 1974). Between exits 41 and 43, the low linear |

| CUMULATIVE MILEAGE | INTERVAL MILEAGE | EXPLANATION |
|---|---|---|
| | | ridge to the west (Green Ridge) marks the outcrop of near vertical Silurian sandstones (Tuscarora Formation). |
| 17 | 7 | Exit 43 Tinker Mountain, ahead and to the west, is separated from the main part of the Salem syncline by the Green Ridge thrust which lies along the eastern base of Green Ridge. The prominent mountains to the east (Reed and Coyner mountains) mark the location of the Reed-Coyner mountain window, where Ordovician through Middle Devonian rocks are within a Cambrian carbonate rock terrain comprised of rocks from both the Salem syncline (west) and the Pulaski thrust system. |
| 21 | 4 | Exit 44. *Leave Interstate Highway 81* at Cloverdale exit and *proceed north* on U.S. Highway 220. |
| 22.5 | 1.5 | Daleville, leave Salem syncline and return to Pulaski thrust system. A transverse thrust ramp separating these structures crosses U.S. Highway 220 in the northern outskirts of Daleville. Locally the Lower Cambrian Rome Formation overlies the Middle Cambrian Elbrook Formation. The low distinctive hills along the trip route are formed by the Rome (McGuire, 1976). |
| 27.1 | 4.6 | East of the highway a segment of the Pulaski fault system has brought brecciated Elbrook dolomites over low dipping Conococheague limestones and dolomites in the "Trinity syncline." |
| 28.9 | 1.8 | Fault slice of the Pulaski thrust system containing Elbrook Formation and reentrant of Middle Ordovician limestones and shales is located on outskirts of Fincastle. |
| 29.3 | 0.4 | Elbrook dolomites exposed on hill to the west in the hanging wall of a thrust; highway is on Middle Ordovician limestones. |
| 30.2 | 0.9 | The Fincastle conglomerate (a part of the Edinburg Formation, Middle Ordovician) is exposed in the overturned limb of a syncline on the east side of the highway. The clasts in the Fincastle and associated conglomerates include recognizable rock fragments from Middle Ordovician through Lower Cambrian formations (McGuire, 1970). |
| 30.5 | 0.3 | Second exposure of Fincastle conglomerate in the upright limb of the fold. |
| 31.0 | 0.5 | Exposures of black fissile shale similar to the Paperville Shale (Ordovician) of Southwest Virginia and the lowermost black shales along the east limb of the Massanutten syncline in northern Augusta County and southern Rockingham County. |
| 35.4 | 4.4 | Middle Ordovician limestones and Beekmantown dolomites are exposed on both sides of the road. These rocks are in the trough of a southwest plunging syncline that has reverse asymmetry (steeper limb to east) as compared with typical Appalachian synclines (McGuire, 1970). |
| 40.3 | 4.9 | Abandoned quarry in overturned Middle and Lower Ordovician limestones in the hanging wall of a fault seemingly associated with the Pulaski thrust system. |
| 40.7 | 0.4 | **STOP 1** — Junction of U.S. Highway 220 and State Highway 43 at a magnificent exposure known as "Eagle Rock" in a gorge on the James River. Rocks of the Martinsburg (Upper Ordovician) to the Needmore(?) (Middle Devonian) formations are repeated by faulting in exposures along U.S. Highway 220. The fault is at the location of the Needmore(?) shale about 350 yards north of the U.S. 220 — State 43 intersection. The section south of the fault is the footwall and the northern part is the hanging wall. It is our interpretation that the fault flattened in the incompetent Needmore(?) shale at the top of a thrust ramp prior to the folding and rotation of the sections. The location of the fault appears to be related to the position of the mid-province structural front and rocks similar to those described at the Fetzer Gap section in Shenandoah County (Rader and Biggs, 1976). |

Measured Section: Footwall along U.S. Highway 220 at Eagle Rock exposure beginning at fault about 350 yards north of intersection of U.S. Highway 220 and State Highway 43. Portion below the contorted zone in the Keefer Sandstone modified from Diecchio (1980).

| | | THICKNESS (FEET) |
|---|---|---|
| Fault | | |
| Devonian: | | |
| Needmore shale (3.0′) | | |
| 51 | Shale, olive-green sheared | 3.0± |
| Licking Creek Limestone (5.0′) | | |
| 50 | Limestone, medium-gray, laminated, black chert | 5.0± |
| Silurian: | | |
| Clifton Forge Sandstone (5.0′) | | |
| 49 | Sandstone, light-gray, fine- to medium-grained, cross-bedded | 5.0± |
| Tonoloway Limestone (13.9′) | | |
| 48 | Limestone, medium- to light-gray with dark shale interbeds, mudcracks | 13.9 |
| Wills Creek Sandstone (205.5′) | | |
| 47 | Sandstone, light-gray to white, fine- to medium-grained, rusty brown on weathering, calcareous, with clay nodules; in part scree covered | 10.0 |

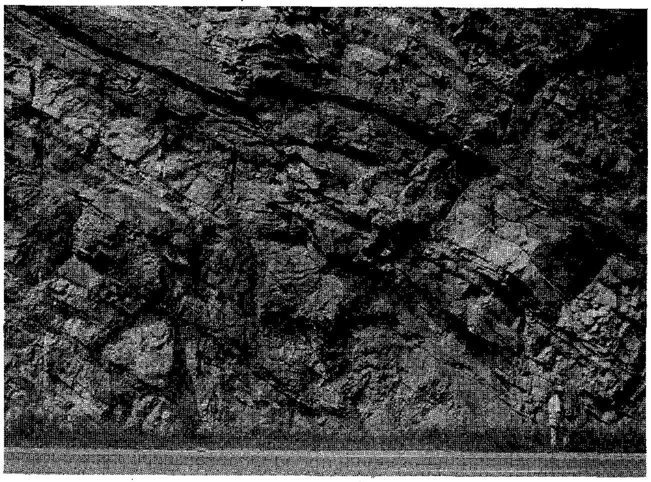

Figure 2. West dipping reverse fault in the Wills Creek Sandstone.

| | | THICKNESS (FEET) |
|---|---|---|
| 46 | Sandstone, fine- to medium-grained, rusty brown on weathering, calcareous in part, bimodal cross-bedding | 55.9 |
| 45 | Sandstone, light-gray to white, fine- to very fine-grained, bedding thin, some low-angle cross-bedding, ripple marks; about 57 feet above base is a small, west dipping reverse fault (Figure 2); about 115 feet above base is a small anticline | 139.6 |
| | "Bloomsburg" Formation (60.1′, Figure 3) | |
| 44 | Sandstone, purple with vertical greenish-gray "burrows"; shale, purple to gray interbedded with white sandstone, 4-inch shale at top of unit | 28.7 |
| 43 | Sandstone, purple to light-gray, fine- to very fine-grained, black cross-beds | 15.7 |
| 42 | Sandstone, purple with green mottles, fine-grained, thin silty shale, vertical greenish-gray "burrows" | 15.7 |
| | Keefer Sandstone (146′ +) | |
| 41 | Sandstone, light-gray, very fine- to fine-grained with gray silty shale interbeds | 72.4 |

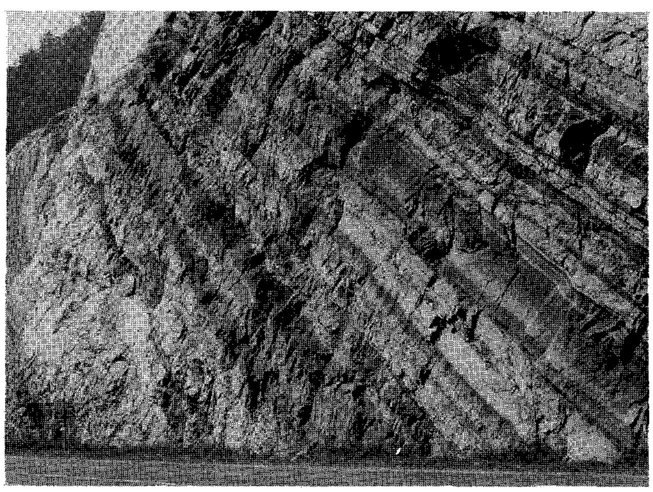

Figure 3. White unit on the left (east) is the Keefer Sandstone. The dark beds are sandstone and shale of the "Bloomsburg" Formation. The light-colored sandstone in the upper right is the Wills Creek Sandstone.

| | | THICKNESS (FEET) |
|---|---|---|
| 40 | Contorted zone. 90′ wide | |
| 39 | Sandstone, light-gray, fine-grained, with carbonaceous partings, trails on bedding planes, *Skolithus* and mudcracks | 74.0 |
| | Rose Hill Formation (82.7′) | |
| 38 | Sandstone and clay shale, medium-light-gray, with some red staining | 21.0 |
| 37 | Sandstone, fine- to very fine-grained, grayish-red-purple, hematitic | 21.0 |
| 36 | Interbedded sandstone and clay shale. Sandstone, as above; clay shale, dark-greenish-gray, fissile, trails on bedding planes | 26.5 |
| 35 | Clay shale to silt shale, dark-greenish-gray, fissile; interbedded medium-light-gray sandstone, very thin-bedded | 7.5 |
| 34 | Sandstone, medium- to coarse-grained, grayish-red-purple, hematitic, upper 3.0 feet pebbly, carbonaceous partings, trails on bedding planes; interbedded fine-grained, medium-light-gray sandstone | 6.7 |
| | Tuscarora Formation (139.8′) | |
| 33 | Conglomerate, rounded to subrounded quartz pebbles, 0.5 cm maximum diameter, medium-dark, black (carbonaceous?) matrix, carbonaceous partings. | 0.3 |
| 32 | Sandstone, medium- to very fine-grained, medium-gray, locally conglomeratic, subrounded quartz pebbles and black siltstone clasts, medium-dark-gray shaly partings | 3.0 |
| 31 | Sandstone, fine- to very fine-grained medium-gray to light-gray, medium- to thick-bedded, *Skolithus* | 7.0 |
| 30 | Sandstone, medium- to fine-grained, light-gray to light-olive-gray, black specks throughout, black cross-beds, interbeds and partings of carbonaceous materials | 6.5 |
| 29 | Sandstone, medium- to fine-grained, medium-dark-gray to light-olive-gray, massive, black stains along joints | 12.5 |
| 28 | Sandstone, medium- to fine-grained, pinkish-gray | 2.0 |
| 27 | Sandstone, fine- to coarse-grained, variegated medium-light-gray, light-gray and light-brown, cross-bedded | 2.5 |
| 26 | Sandstone, fine- to very fine-grained, medium- light-gray, massive | 15.0 |
| 25 | Sandstone, fine- to very fine-grained, very light-gray, massive-bedded | 2.5 |
| 24 | Sandstone, fine- to very fine-grained, medium-light-gray, massive | 5.0 |
| 23 | Sandstone, fine- to very fine-grained, very light-gray, medium-bedded | 2.0 |
| 22 | Sandstone, fine- to very fine-grained, medium-light-gray, massive | 6.0 |
| 21 | Conglomeratic sandstone, medium- to coarse-grained, light-gray, weathers light-brown, quartz pebbles, 1 cm maximum diameter | 3.0 |
| 20 | Carbonaceous silt shale | 1.0 |

| | | THICKNESS (FEET) |
|---|---|---|
| 19 | Sandstone, very fine-grained, grayish-orange, massive | 4.0 |
| 18 | Sandstone, coarse- to fine-grained, light-gray, some medium-dark-gray beds in upper 4 feet, cross-bedded, olive-gray shale clasts | 26.0 |
| 17 | Sandstone, medium- to fine-grained, medium-light-gray, weathers very pale-orange to light-brown, medium- to very thin-bedded, cross-bedded, rare olive-gray shale clasts | 20.0 |
| 16 | Sandstone, fine- to very fine-grained, light-gray, massive-bedded, cross-bedded | 1.5 |
| 15 | Sandstone, medium- to fine-grained, very light-gray, weathers light-brown, medium- to very thin-bedded, cross-bedded | 2.5 |
| 14 | Sandstone, fine- to very fine-grained, medium-light-gray, cross-bedded, black joint surfaces, some yellowish-gray, 2-cm shale beds in upper 2-feet | 7.0 |
| 13 | Sandstone, fine- to very fine-grained, weathers light-brown, medium- to thick-bedded, cross-bedded, interbedded light-olive-gray silt shale in upper 6 feet | 10.5 |
| Ordovician: | | |
| Oswego Sandstone (36′) | | |
| 12 | Siltstone, light-olive-gray, weathers light-brown, good cleavage; 5-cm bed of sandstone, fine-grained, light-gray, at 3 feet above base of interval | 4.5 |
| 11 | Interbedded sandstone and siltstone, sandstone, fine- to very fine-grained, medium-light-gray to light-olive-gray, medium-bedded, cross-bedded; siltstone, light-olive-gray, weathers light-brown | 3.0 |
| 10 | Sandstone, fine- to very fine-grained, light-bluish-gray, weathers light-brown, thick- to very thin-bedded, cross-bedded, occasional clasts and interbeds of light-olive-gray silt shale, 1 cm maximum clast size | 4.0 |
| 9 | Interbedded litharenite and siltstone: Litharenite, fine- to very fine-grained, medium- light-gray, weathers pale-yellow-brown to pale-brown, thick-bedded, micaceous, cross-bedded, some siltstone clasts; siltstone, light-olive-gray; weathers light-brown | 3.0 |
| 8 | Sandstone, fine- to very fine-grained, light-blue-gray, weathers light-brown, very thin- to thick-bedded, cross-bedded, interbeds and clasts of light-olive-gray silt shale, 2 cm maximum clast size, carbonaceous partings, black silt-shale interbedded at 4 feet below top of interval | 11.5 |
| 7 | Siltstone, medium-gray, weathers light-olive-gray, medium-bedded | 1.5 |
| 6 | Litharenite, fine- to very fine-grained, greenish-gray, weathers light-brown, medium- to very thin-bedded; interbeds of medium-gray silty shale, weathers light-olive-gray, channeling | 8.5 |
| Martinsburg Formation (upper 52.5′) | | |
| 5 | Siltstone, medium-gray, weathers light-olive-gray, medium-bedded, slightly micaceous, some medium-light-gray sandstone stringers, 2-cm beds of fossiliferous sandstone at middle of interval *(Lingula)*, channeling | 2.0 |
| 4 | Siltstone, fossiliferous, olive-gray, *Lingula*, gastropods, fossiliferous beds are phosphatic, some beds of *Lingula* coquina, occasional carbonaceous(?) partings; medium-bedded, brownish-gray sandstone at 1.5 and 3 feet above base | 13.0 |
| 3 | Sandstone, very fine-grained, dark-gray to brownish-gray with white specks that weather light-brown, with interbedded olive-gray, medium- to thick-bedded siltstone | 7.5 |
| 2 | Siltstone, fossiliferous, olive-gray, weathers brownish-gray, *Lingula* | 3.0 |
| 1 | Interbedded sandstone and shale, sandstone, fine-grained, medium-gray to medium-dark-gray, rare white specks that weather grayish-orange, very thin- to thick-bedded; silt shale to clay shale, medium-dark-gray, sandstone increases upward | 27.0 |

END OF SECTION

| CUMULATIVE MILEAGE | INTERVAL MILEAGE | EXPLANATION |
|---|---|---|
| 41.8 | 1.1 | The steep, low, wooded hills to the west are characteristic of the geomorphic forms developed on the Brallier Formation. Brallier and Millboro formations (Devonian) are exposed for the next nine miles. |
| 51.5 | 9.7 | At the south (near) end of the bridge over the James River are good exposures of Devonian rocks; the Ridgeley (Oriskany) Sandstone and the uppermost Helderburg limestone (Licking Creek Limestone). |
| 52.9 | 1.4 | Town of Iron Gate. |
| 54.3 | 1.4 | Rainbow arch, northern part of the Rich patch anticline. |
| 55.9 | 1.6 | Junction of U.S. highways 220 and 60 in Clifton Forge. *Turn left* on U.S. 60/220 and proceed westward. |
| 57.0 | 1.1 | Intersection U.S. Highway 60/220 and Interstate Highway 64, *proceed west* on Interstate 64 to Covington. |
| 65.3 | 8.3 | The anticline to the north is in the Licking Creek Limestone; this structure and parallel structures plunge obliquely into the Rich Patch anticline (Figure 4). This junction of stuctures forms a major lineament that separates the Central Appalachian fold trends from the Southern Appalachian fold trends. |

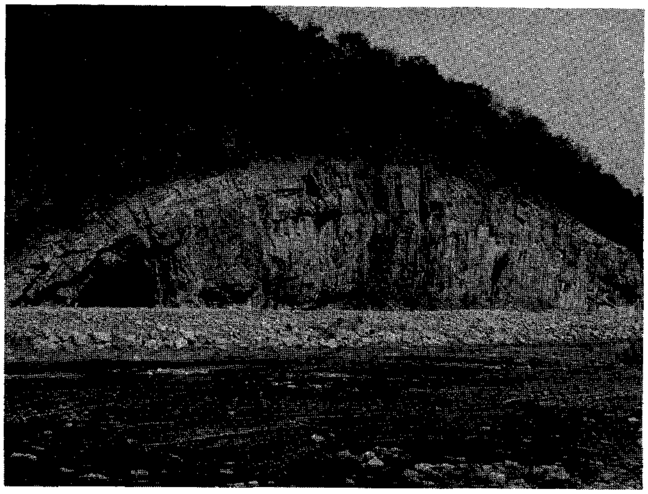

Figure 4. Anticline in the Licking Creek Limestone (Devonian) along the Jackson River, view to the north.

Figure 5. View to south of Rainbow arch from Clifton Forge. Note the west dipping reverse fault cutting ledges of Keefer Sandstone.

| CUMULATIVE MILEAGE | INTERVAL MILEAGE | EXPLANATION |
|---|---|---|
| 68.0 | 2.7 | Exit Interstate Highway 64 west at U.S. Highway 220 and re-enter I-64 headed east. |
| 79.2 | 11.2 | *Proceed eastward* on Interstate Highway 64 to the first Clifton Forge exit. Follow U.S. Highway 60/220 eastward through Clifton Forge to intersection of U.S. highways 60 (east) and 220 (south). |
| 80.3 | 1.1 | *Turn right* (south) on U.S. Highway 220 and proceed to Iron Gate Community and *turn around.* |
| 84.4 | 4.1 | **STOP 2** - *Pull off to right* in Iron Gate (Rainbow) gorge. Exposure of a classic western Virginia anticline. From the center of the arch at water level of the Jackson River, a normal sequence Martinsburg Formation (Upper Ordovician) through the Keefer Formation (Silurian) is well exposed (Figure 5). The lower part of the arch is formed by the Tuscarora Formation (Silurian) and the upper part by the Keefer Formation (Lesure, 1957). (Stratigraphic relationships between Eagle Rock, Iron Gate and Warm Springs are shown in Figure 6). The fold is strongly asymmetric with a well-defined kink fold on the west limb. A northwest dipping reverse fault in the west crest is visible only from the Clifton Forge area. This anticline, as well as most other western Virginia anticlines, was probably generated along a ramp thrust arising from a decollement in the subsurface. A question arises concerning the origin of this anticline: Does the ramp-thrust zone crop out or does it stay in the Upper Ordovician shales (Martinsburg/Reedsville) of the subsurface? If it comes to the surface, the logical horizon for flattening would be the Millboro-Needmore shales at intervals |

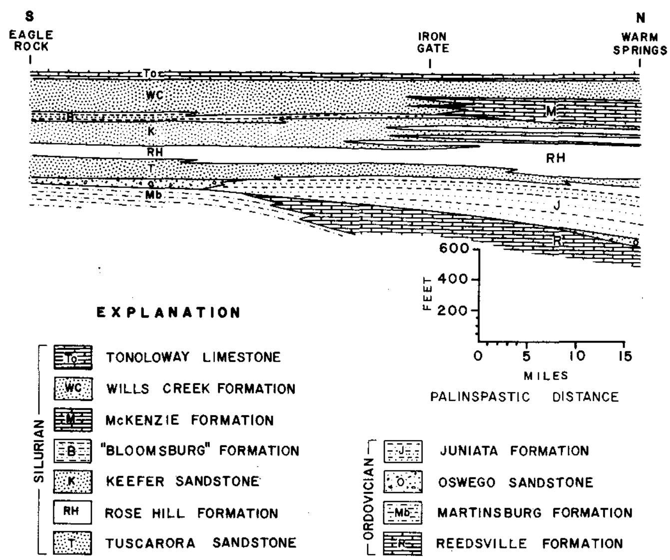


Figure 6. Stratigraphic relationships of sections at Eagle Rock, Iron Gate, and Warm Springs. See Figure 1 for locations. Note the increase in sandstone to the south toward Eagle Rock.

| CUMULATIVE MILEAGE | INTERVAL MILEAGE | EXPLANATION |
|---|---|---|
| | | containing Tioga metabentonite beds, which occur throughout several hundreds of feet of the shales in this area. These formations are at the surface along the west flank of the anticline to be seen at Stop 3 and extend beneath the broad expanses of Upper Devonian clastics in synclines to the north. A decollement beneath the Upper Devonian rocks of Brailler Formation would help to explain the intense folding in the Brailler south of Douthat State Park and along State Highway 42. |

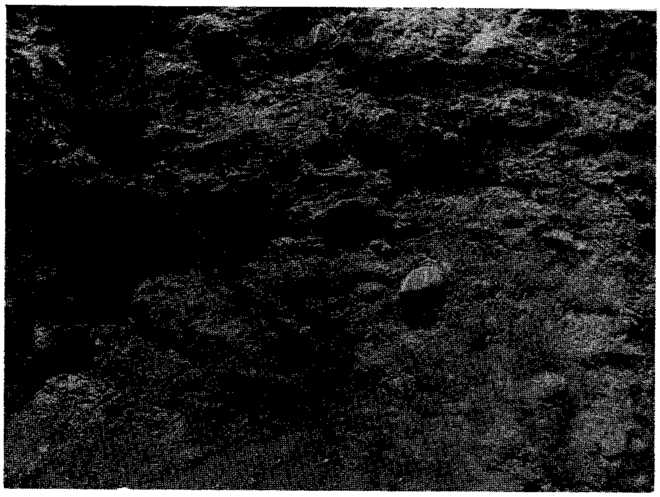

Figure 7. Millboro Shale breccia at Stop 3 containing rotated concretions and light-colored blocks of Needmore shale.

Figure 8. Millboro Shale breccia containing, bedded blocks of Needmore shale.

| CUMULATIVE MILEAGE | INTERVAL MILEAGE | EXPLANATION |
|---|---|---|
| 86.2 | 1.8 | Return to intersection of U.S. Highway 60 and 220 in Clifton Forge. *Turn right* at traffic light onto U.S. Highway 60 east. |
| 86.4 | 0.2 | **STOP 3** - Park on left at Motor Sales Corporation and walk back to west to community park. This exposure of fracture porosity in the Millboro and Needmore shale is at the lowest exposed point in the northwestern part of the Iron Gate anticline. Strongly cleaved to pulverized Millboro Shale and shale breccia surround intensely fractured to brecciated blocks of Needmore(?) shale (Figure 7). Rock type and fabric in these exposures are similar to those in the breccia zones (Max Meadows breccia) associated with the Pulaski decollment to the east and to the fabric developed in the Chattanooga shale beneath the Pine Mountain thrust in Southwest Virginia. *Proceed east* on U.S. Highway 60. |
| 87.9 | 1.5 | Intersection of U.S. Highway 60 and Interstate Highway 64; *proceed eastward* on I-64. |
| 88.4 | 0.5 | On right are exposures of Millboro Shale showing features similar to those seen at last stop (Figure 8). |
| 90.7 | 2.3 | To the west are bluffs composed of the Brallier Formation that display disharmonic and kink-band type folds that are characterisitc of folds in this rock unit west of the Rich Patch anticline and the anticline that conincides with Mill Mountain (ahead and to the left beyond the bluffs). |
| 91.8 | 1.1 | Cowpasture River. |
| 92.6 | 0.8 | Helderburg limestones and Oriskany sandstones exposed on the left in the road cut. |

| CUMULATIVE MILEAGE | INTERVAL MILEAGE | EXPLANATION |
|---|---|---|
| 95.5 | 2.9 | Long Dale furnace; site of early iron ore smelting in the Clifton Forge iron district. |
| 110.5 | 15.0 | Mile post 50, Trace of North Mountain fault; Conococheague rocks thrust over Beekmantown rocks. |
| 113.9 | 3.4 | Maury River. |
| 115.7 | 1.8 | Junction of U.S. Highway 11 and Interstate Highway 64; continue east on Interstate 64. |
| 116.5 | 0.8 | Exit 14, Junction of Interstate highways 64 and 81; proceed north on Interstate Highway 81. The Staunton fault zone parallels the highway to exit 52, where the highway crosses onto the upper plate. |
| 127.2 | 10.7 | Mile post 202, Linear ridge to the west is developed on steeply inclined sandstones of the Conococheague Formation. |
| 131.2 | 4.0 | Mile post 206. Brownish scar at base of mountain to the east is clay in the Cold Spring kaolinite pits located at the west foot of the Blue Ridge Mountains and on the drainage divide between the Shenandoah and James River systems. These residual clay deposits are developed from Lower Cambrian limestones and shales and have been protected from erosion by their position on the drainage divide. |
| 146.5 | 15.3 | Exit 57. Conical wooded hills to the west are developed from massive chert beds in the Beckmantown Formation. |
| 158.9 | 12.4 | Exit 60. Recross the Staunton fault and enter the North Mountain fault block. |
| 164.8 | 5.9 | Mole Hill, the conical-shaped hill to the north-west, is an olivine basalt plug of Eocene age. |

| CUMULATIVE MILEAGE | INTERVAL MILEAGE | EXPLANATION |
|---|---|---|
| 170.9 | 6.1 | Exit 64, Harrisonburg, Note Massanutten Mountain to the east; its southern end is the south western limit of Silurian sandstones in Shenandoah Valley. |
| 181.3 | 10.4 | Exit 66, Mauzy. Ten miles to the west at Brocks Gap an anomalous Upper Ordovician-Lower Silurian sandstone section is exposed. An interpretation of this section is in Rader and Perry (1976). |
| 188.2 | 6.9 | Exit 67, New Market. *Turn right* onto U.S. Highway 211 east. |
| 188.7 | 0.5 | Junction of U.S. highways 211 and 11. *Turn left* and proceed north on U.S. Highway 11/211. |
| 188.9 | 0.2 | Junction of U.S. Highway 211 and 11. *Turn right* and proceed east on U.S. Highway 211. Note the prominent wind gap to the east. This gap, New Market Gap, occurs at a structural high in the plunge of the Massanutten synclinorium, where the Massanutten Sandstone is breached. |
| 192.7 | 3.8 | **STOP 4** - New Market Gap. Exposures east and west of gap. During the late Middle and Late Ordovician the eastern portion of the Appalachian miogeocline was subsiding rapidly and receiving sediments from the east. Some formed turbidites. Typical base - and top-truncated Bouma cycles are preserved in the Martinsburg Formation in the Massanutten synclinorium. The Martinsburg is overlain by the Massanutten Sandstone (Lower and Middle Silurian). The deposition history of the Massanutten Sandstone has been described by Roberts and Kite (1978). Proceed east on U.S. Highway 211 to Luray. |
| 195.7 | 3.0 | Typical Martinsburg turbidites are exposed at places along the highway for three miles. |
| 198.2 | 2.5 | South Fork Shenandoah River. In this area disharmonic, recumbent folds and klippen are in rocks underlying the Martinsburg Formation. |
| 200.9 | 2.7 | Luray Caverns on left in the Lower Ordovician Beekmantown Formation. Continue on U.S. Highway 211 bypass. |
| 202.9 | 2.0 | Junction of U.S. highways 211 bypass and 340. *Turn left* onto U.S. 340 north. Proceed toward Front Royal. From here to Stop 5 the trip route traverses Upper Cambrian and Lower Ordovician carbonate rocks. |
| 210.3 | 7.4 | Rileyville. |
| 212.3 | 2.0 | Compton. |
| 216.6 | 4.3 | Bentonville. |
| 219.3 | 2.7 | Limeton. |
| 221.2 | 1.9 | **STOP 5** - Gooney Creek campground. Pull into campground and park. Along Gooney Run, at the south side of the campground, granodiorite of the Pedlar Formation(?) (Precambrian) is on overturned beds of the Lower Ordovician Beekmantown Group. Contact zone is about 150 yards east of U.S. Highway 340 bridge over Gooney Run. Seismic and deep drilling data (Harris, 1979; Harris and Bayer, 1979a, 1979b; and Cook and others, 1979) provide evidence for a model that explains the relationships between the structural styles of the Valley and Ridge and Blue Ridge. According to Harris (1979) the rootless Blue Ridge anticlinorium was thrust west on a subhorizontal fault which ramped upward from a master decollement. Harris (1979) and Harris and Bayer (1979a) suggest that Valley and Ridge rocks extend beneath the Blue Ridge anticlinorium. |
| | | END OF ROAD LOG |

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# PART II: AREA NORTH OF ABINGDON ALONG U.S. 58A/19

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| CUMULATIVE MILEAGE | INTERVAL MILEAGE | EXPLANATION |
|---|---|---|
| 0.0 | 0.0 | Begin road log at the intersection of U.S. 11 (West Main St., Abingdon) and U.S. 19 about one mile west of the main business district of Abingdon. (Figure 1). |
| 0.2 | 0.2 | Proceed north on U.S. Highway 19. The first rock exposures on the right (east) are interbedded limestones and dolomites of the Conococheague Formation (Upper Cambrian); beds are inclined very steeply to the south or partially overturned to the north. These overturned strata are on the southeast limb of a thrust faulted anticline. Just north are vertical, thin-bedded limestones of the Nolichucky Formation. |
| 0.4 | 0.2 | Intersection at right (east) with U.S. Highway 58 alternate; continue north on U.S. 58 A/19. |
| 0.9 | 0.5 | In right bank are exposures of fractured, gently inclined Honaker dolomite. State Road 848 (Old Cummings Heights Road) intersection from east. |
| 1.3 | 0.4 | Appalachian Power Company substation on right. A small thrust fault was mapped about 100 yards north of this location. |
| 1.7 | 0.4 | Scattered exposures of Honaker Formation limestones and dolomites define the surface axial trace of the Cummings Heights syncline. |
| 2.0 | 0.3 | Outcrops on right are Honaker dolomite beds which dip south into the Cummings Heights syncline. |
| 2.5 | 0.5 | At right are low-dipping, thin-bedded limestone and shale of the Nolichucky. This outcrop is in a fault-bounded slice in the base of the Pulaski thrust fault. |
| 2.8 | 0.3 | Cross area of major offset along Pulaski thrust fault, where the Honaker Formation (Middle Cambrian) is thrust onto upper Knox dolomites (Lower Ordovician) with displacement of about 6000 feet. |
| 3.0 | 0.2 | Upper Knox dolomite dips southward and forms the upper portion of the Saltville thrust plate. |
| 3.4 | 0.4 | Carvosso United Methodist Church on right is on a narrow outcrop belt of the basal Ordovician Chepultepec Formation. Charles Butts was the first to note characteristic cephalopods at this locality. |
| 3.5 | 0.1 | There are good exposures on right of the upper portion of the Copper Ridge Formation (Upper Cambrian) which is dominated by dolomite but contains some limestone, chert and distinctive brownish sandstone interbeds. |

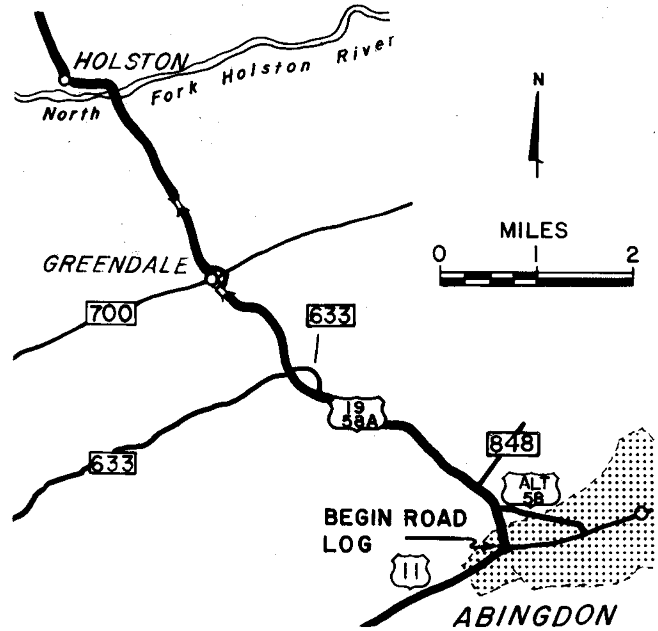


Figure 1. Location Map. Measured section begins 0.1 mile north of Greendale Community.

| CUMULATIVE MILEAGE | INTERVAL MILEAGE | EXPLANATION |
|---|---|---|
| 3.9 | 0.4 | Opposite the Sunoco Service Station a wall built by the highway department restrains portion of weathered carbonates of the lower part of the Copper Ridge Formation in a landslide-prone area. |
| 4.1 | 0.2 | Shales and thin-bedded limestones of the Nolichucky Formation are on the right. The beds contain brachiopods, trilobites and cystoid plates. Shale increases in the Formation to the north and is dominant here. |
| 4.2 | 0.1 | The lower portion of the Nolichucky here contains several interformational limestone-pebble conglomerates (note the exposure adjacent to the "no parking" sign (Figure 2). |
| 4.4 | 0.3 | On left (west) is medium-bedded dolomite of the Honaker Formation. |
| 4.5 | 0.1 | Greendale Community; State Road 700 intersection. |
| 4.6 | 0.1 | Cross surface trace of Saltville thrust fault which here has a displacement of over 15,000 feet. Honaker Formation (Middle Cambrian) is thrust onto the Pennington Formation (Upper Mississippian). Both formations are partly covered. |

Figure 2. Intraformational limestone-pebble conglomerate in lower Nolichucky.

In the following measured section, 5146.9 feet of Mississippian rocks and older rock units are described. Portions of this section were first described by Averitt in 1941. The author sampled and described the section in 1968. The portion of the section herein described for the Maccrady and Price formations was sampled in 1970 and included in the author's dissertation on Lower Mississippian stratigraphy (Bartlett, 1974, p. 232-236.) Slagle (1978) recently studied the Hillsdale Limestone paleontology and paleoecology at exposures in the section. Schmidt (1973) sampled the Price Formation on this outcrop in his regional study. Near Benhams (about 10 miles to the southwest) 7080 feet of Mississippian rocks, possibly representing the thickest accumulation of Mississippian age deposits in North America, were traversed in an exploratory well drilled in early 1981 by Highlander Resources. The well was spudded in the Pennington Formation. Mileage from Abingdon on left side of column.

| Mileage | UNIT NO. | Description | THICKNESS (FEET) |
|---|---|---|---|
| | | Mississippian: | |
| | | Pennington Formation (854+ feet) | |
| | | First (southernmost) 150 yards of exposure forms a small anticlinal fold which is a repeat of units 191-188. | |
| | | Normal fault, displacement approximately 180 feet, lies in gully on left side of highway. | |
| | 191 | Shale, brownish-gray, and siltstone, dense, medium-to thin bedded, with occasional fossils | 106 |
| | 190 | Shale, greenish-gray and reddish-brown, fissile, and siltstone, medium-bedded | 38 |
| | 189 | Shale, gray, with some gray, argillaceous thin-bedded fossiliferous limestone, and some siltstone with rounded shapes suggesting slumping contemporaneous with deposition | 12 |
| | 188 | Sandstone and siltstone, gray, weathers to brown, calcareous, medium-to thin-bedded, fossiliferous, with thin gray shale partings | 34 |
| | 187 | Siltstone, gray, weathers to brown, dense, medium-bedded with fossiliferous layers including the pelecypod *Sulcatopinna missouriensis* (Swallow), nautiloids, and spiriferid and productid brachipods | 45 |
| | 186 | Argillaceous limestone, gray, thick-bedded; with abundant fossils throughout: *Pentremites* blastoids, fenestrate bryozoans, five species of brachiopods, two species of pelecypods, crinoids and a horn coral | 67 |
| | 185 | Silty shale, gray, very carbonaceous grades upward in unit to calcareous siltstone | 32 |
| | 184 | Silty shale, reddish-brown, calcareous, hackly, with abundant carbonaceous plant fragments on some bedding planes | 15 |
| | 183 | Sandstone, dark-red-brown, very fine-grained, thick-bedded | 7 |
| | 182 | Sandstone, gray, very fine-grained, medium-bedded, with abundant plant fragments, with shale interbeds | 21 |
| | 181 | Sandstone, gray, very fine-grained, thin-bedded; some shale, greenish-gray | 5 |
| | 180 | Silty shale, dark-red and purplish-brown, fossiliferous with three species of pelecypods, worm-trail-like markings and plant fragments; few thin interbeds of purplish-brown, very fine-grained, calcareous sandstone | 13 |
| 4.95 | 179 | Siltstone, gray, thick-bedded, with very large crinoid stem sections | 32 |
| | 178 | Shale, gray | 1 |
| | 177 | Siltstone, gray, dense, fossiliferous | 3 |
| | 176 | Silty shale, gray | 6 |
| | 175 | Siltstone and sandstone, very fine-grained, gray thick-bedded with some interbedded shale; some zones of abundant large crinoid stems (Figure 3). | 14 |
| | 174 | Silty-shale, gray | 6 |
| | 173 | Siltstone and sandstone, as unit 175 | 23 |
| | 172 | Shale with scattered rounded siltstone "balls" to 2.5 feet in diameter suggesting | |

Figure 3. Limy siltstone containing abundant large crinoid columnal sections in upper Pennington Formation (measured section unit #175).

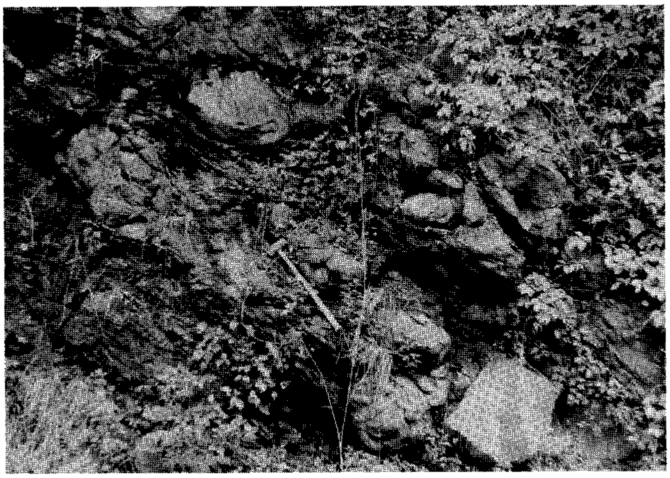

Figure 4. Penecontemporaneous slump "balls" of limy siltstone enclosed in shale of Pennington Formation (measured section unit #172) on east side of U.S. 19-58 A. Sledge hammer is 90 cm long. Dip is 25°southeast toward Saltville fault which has concealed the axis of the Greendale syncline.

| | UNIT NO. | | THICKNESS (FEET) |
|---|---|---|---|
| | | slumping contemporaneous with deposition. Exposed in high roadcut (Figure 4) | 17 |
| | 171 | Siltstone and argillaceous sandstone, gray, thin-to medium-bedded; moderately fossiliferous with brachiopods and large crinoid stems | 90 |
| | 170 | Sandstone, light-gray, very fine-grained with large carbonized plant stems | 5 |
| | 169 | Siltstone and sandstone, gray, very fine-grained, calcareous, with large productid brachiopods | 55 |
| | 168 | Silty to sandy shale, gray, with spheroidal weathering | 18 |
| | 167 | Shaly sandstone and siltstone, gray; fossils include pelecypods and productid brachiopods | 36 |
| | 166 | Shale, gray, platy, brittle, very fine-grained sandstone beds which become more numerous toward upper part of unit; strike N 20° E, dip 25° SE. Base of Pennington exposed at house on east side of highway | 153 |
| 5.1 | | Cove Creek Limestone (876 feet) | |
| | 165 | Argillaceous limestone, gray, dense, thick-bedded | 143 |
| | 164 | Ferruginous limestone, dark-red-brown, medium-bedded, with abundant bryozoans in lower part | 28 |
| | 163 | Limestone, gray, dense | 114 |
| | 162 | Limestone, gray, dense, thick-bedded; zones of abundant fossils which contain brachipods and bryozoans including *Archimedes* sp | 31 |
| 5.35 | 161 | Limestone, gray, dense, fossils rare; becomes shaly in middle part (best exposed on west side of road) | 287 |
| | 160 | Shale, black to dark-gray, crumpled, with slickensides | 3 |
| | 159 | Limestone, dark-gray, dense, thick-bedded, dip 28° SE | 135 |
| | 158 | Covered | 60 |
| | 157 | Argillaceous limestone, gray, thinly-laminated to medium-bedded, weathers to shaly appearance, dip 23° SE | 75 |
| 5.5 | | | |
| | | Fido Sandstone (43 feet) (exposed best on west side of highway) | |
| | 156 | Very sandy limestone, dark-red-brown, cross-bedded; weathers to friable sandstone | 38 |
| | 155 | Hematitic sandstone, dark-brown, medium-grained, subangular to subrounded, thick-bedded, friable | 5 |
| | | Gasper limestone (738 feet) | |
| | 154 | Argillaceous limestone, gray, thick-bedded; crinoidal near top and with abundant *Pentremites* blastoids | 78 |
| | 153 | Argillaceous limestone, gray, partly covered | 39 |
| | 152 | Argillaceous and crinoidal limestone, gray, thick-bedded | 50 |
| | 151 | Crinoidal limestone, dark-red-brown, medium-grained, thick-to medium-bedded, with three species of crinoids, numerous *Pentremites* blastoids and brachiopods | 53 |
| | 150 | Argillaceous limestone, gray, weathers to shaly appearance; poorly exposed | 39 |
| | 149 | Crinoidal limestone, light-gray, coarse-to medium-grained, medium-bedded | 10 |
| | 148 | Argillaceous limestone, gray, thick-bedded; poorly exposed | 469 |
| 5.9 | | Ste. Genevieve Limestone (1029 feet) | |
| | 147 | Ferruginous, crinoidal limestone, dark-red-brown, thick-bedded | 18 |
| | 146 | Argillaceous limestone, gray, shaly weathered appearance | 12 |
| | 145 | Ferruginous limestone, dark-red-brown, medium bedded | 32 |
| | 144 | Argillaceous limestone, gray, weathers to brown, thick-bedded, zones of rounded clay pebbles | 25 |
| | 143 | Shaly limestone, gray, very thin-bedded | 8 |
| | 142 | Sandstone, brown, fine-grained | 1 |
| | 141 | Argillaceous limestone, gray, weathers to brown, medium-bedded | 8 |
| | 140 | Limestone, gray, coarse-grained; fossils include bryozoans, brachiopods and crinoids | 2 |
| | 139 | Argillaceous limestone, gray, weathers to brown | 75 |
| | 138 | Shaly limestone, light-gray, weathers to brown; partly covered | 24 |
| | 137 | Calcareous sandstone, gray-brown, fine-grained, dense, thin-bedded | 10 |
| | 136 | Argillaceous limestone, gray, weathers to shaly appearance | 30 |
| | 135 | Calcareous sandstone, gray, very fine-grained, uneven bedding, with scattered, rounded, gray-shale pebbles and shale partings; locally is siltstone | 47 |

| | UNIT NO. | | THICKNESS (FEET) |
|---|---|---|---|
| | 134 | Argillaceous limestone, light-gray, weathers to brown, shaly appearance | 70 |
| | 133 | Shale, brown, slightly silty, sub-fissile | 12 |
| | 132 | Argillaceous limestone, gray, dense, thin-to medium-bedded | 55 |
| | 131 | Limestone, gray, dense, medium-bedded | 62 |
| | 130 | Crinoidal limestone, gray, coarse-grained, medium-bedded | 16 |
| | 129 | Shaly limestone, gray, laminated with carbonaceous fragments on partings | 8 |
| | 128 | Limestone, greenish-gray, to dark-gray, coarse-grained, thick-bedded; sulfur odor on fresh break in top layers; fossils include brachiopods and crinoids | 7 |
| | 127 | Argillaceous limestone, weathers to brown clay | 45 |
| | 126 | Limestone, dark-gray, coarse-grained, thick-bedded; strong sulfur odor on fresh break; very fossiliferous with brachiopods and crinoids | 8 |
| | 125 | Shaly limestone, light-blue-gray, silty, hackly | 43 |
| | 124 | Argillaceous limestone, gray, thin-bedded, weathers to brown silty clay. | 60 |
| | 123 | Limestone, gray, thinly-laminated to medium-bedded, ripple-marked | 5 |
| | 122 | Limestone, light-gray, coarse-grained, thick-bedded, fossiliferous | 16 |
| | 121 | Argillaceous limestone, gray, dense, thick-bedded | 10 |
| | 120 | Argillaceous limestone, light-gray, laminated, weathers to shaly appearance | 1 |
| | 119 | Limestone, light-gray, coarse-grained, with greenish-gray, widely spaced silty laminae | 11 |
| | 118 | Siltstone, gray-green, laminated reddish-brown, thick bedded | 13 |
| | 117 | Limestone, light-gray, coarse-grained, fossiliferous, oolitic | 1 |
| 6.5 | 116 | Interbedded limestone, gray, coarse-grained and siltstone, gray-brown, thick-laminated, cross-bedded; with some reddish-to greenish-gray silty shale partings | 14 |
| | 115 | Limestone, gray, coarse-grained, medium-bedded, with layers of laminated greenish-gray siltstone | 64 |
| | 114 | Argillaceous limestone, gray, with abundant gray chert nodules, thick-bedded | 7 |
| | 113 | Calcareous siltstone, gray, weathering to gray-green, dense, thick-to massive-bedded; shattered zone near base with calcite veinlets | 18 |
| | 112 | Crinoidal limestone, light-gray, coarse-grained, medium-bedded, fossils include crinoids, brachiopods and horn corals | 10 |
| | 111 | Argillaceous limestone, light-gray, weathers to light-brown, thick-bedded, very fossiliferous including fenestrate bryozoan, productid brachiopods and horn corals | 52 |
| | 110 | Shale, black, fissile, calcareous, fossiliferous | 2 |
| | 109 | Shaly limestone, gray | 10 |
| | 108 | Limestone, gray, dense, thick-bedded | 2 |
| | 107 | Limestone, gray, fine-grained, thick-bedded, with crinoidal zones with abundant crinoid *Platycrinus penicillus* (Meek and Worthen), also horn corals | 34 |
| | 106 | Crinoidal limestone, dark-gray, grades toward top of unit into cherty limestone with irregular and rounded, gray chert nodules, partly algal banded | 78 |
| | 105 | Oolitic limestone, light-gray, thick-bedded | 3 |
| 6.5 | | Hillsdale Limestone (267.4 feet) | |
| | 104 | Limestone, light-gray, weathers to greenish-gray, very fossiliferous including spiriferid brachiopods, nautiloids, bryozoan, and a horn coral; weathers to shaly appearance | 30 |
| | 103 | Limestone, gray, dense, some shaly partings; zone of gray, algal-chert nodules in middle of unit; fossiliferous, especially in upper portion of unit (Figure 5) | 41 |
| | 102 | Shale, dark-gray to black, fissile | 1 |
| | 101 | Argillaceous limestone, dark-gray, thick-bedded, slightly fossiliferous | 21 |
| | 100 | Argillaceous cherty limestone, dark-gray, with abundant algal banded gray chert nodules | 1 |
| | 99 | Argillaceous cherty limestone, dark-gray, abundant light-gray to gray, partly algal-banded chert nodules, massive-bedded, fossils rare, dip 21° SE | 40.7 |
| | 98 | Oolitic limestone, light-gray, medium-to coarse-grained, with well-rounded ooids; middle of unit with non-oolitic layer | 15 |

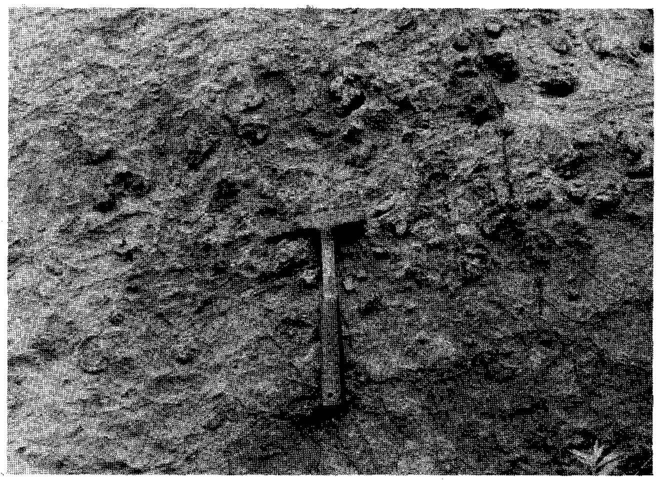

Figure 5. Algal-banded and siliceous fossiliferous chert nodules in Hillsdale Limestone (measured section unit # 103). On freshly broken pieces the rock smells of petroleum.

| | UNIT NO. | | THICKNESS (FEET) |
|---|---|---|---|
| | 97 | Limestone, dark-gray, dense, thick-bedded, in part argillaceous, very fossiliferous throughout (abundant bryozoan, three species; three species of brachiopods, pelecypods, crinoids, horn coral and the tabulate coral *Syringopora virginica* Butts) | 101.7 |
| | 96 | Shaly limestone, gray, fossiliferous | 16 |
| 6.7 | | Little Valley Formation (549 feet; base of formation covered). (Highway "curve" sign is located near this boundary).<br>Note: At the western edge of Washington County, about 15 miles southwest of here, is located the Early Grove Gas Field which has production from the Little Valley Formation and the upper sandstone member of the Price Formation. | |
| | 95 | Shale, gray, calcareous | 13 |
| | 94 | Limestone, gray, medium-grained, fossiliferous | 1 |
| | 93 | Shale, black, coaly, with lustrous surfaces, contorted | 3 |
| | 92 | Agillaceous limestone, gray, dense to shaly, strong odor in fresh break in lower part; very fossiliferous with abundant bryozoans, three species of brachiopod, and a horn coral, dip 27° SE | 82 |
| | 91 | Shale, dark-gray, fissile, with one thin bed of dense limestone near top, fossiliferous in part | 40 |
| | 90 | Argillaceous limestone, gray, dense, abundant fossils with bryozoan and productid brachiopods | 28 |
| | 89 | Shaly limestone and shale, gray, calcareous, slightly fossiliferous | 17 |
| | 88 | Limestone, gray, dense, strong sulfur odor on fresh break, with a few gray chert nodules in upper part; coral bioherm composed of large colony of tabulate corals (exposed in highway median area) | 12 |
| | 87 | Shaly limestone, gray, thinly-laminated, rare fossils | 5 |
| | 86 | Siltstone and sandstone, brown to light-gray, very fine-to fine-grained, calcareous | 5 |
| | 85 | Limestone, gray, dense, sulfur odor on fresh break, calcite-lined geodes to 0.5 inch diameter common, thick-bedded; sparsely fossiliferous | 5 |
| | 84 | Shaly limestone, dark-gray, with two dense argillaceous limestone beds in middle portion, abundant fossils with three species of brachiopods, four species of bryozoans, two species of pelecypods, crinoids, horn and colonial rugose corals | 50 |
| | 83 | Limestone, blue-gray, medium-grained, with dark-gray rounded chert nodules, thick-bedded; fossils include brachiopods, bryozoans, and crinoids | 22 |

| | UNIT NO. | | THICKNESS (FEET) |
|---|---|---|---|
| | 82 | Calcareous sandstone, light-gray, weathers to brown, very fine-grained, medium-bedded, grades upward to arenaceous limestone, fossiliferous | 10 |
| | 81 | Argillaceous limestone, dark-gray, medium-bedded, with brachiopods in upper part | 20 |
| 6.85 | 80 | Covered, formerly partly exposed before road was rebuilt. Averitt (1941, p. 16) and Butts (1940, p. 356) found 90 feet of partially exposed sandstone and limestone which could be assigned to the Little Valley Formation. The North Fork of the Holston River conceals an additional 146 feet of section which includes the lower beds of the Little Valley Formation | 236 |
| | | Maccrady Formation (39.2 feet) (Partial exposure on State Road 611 about ½ mile west of U.S. 19-58A). | |
| | 79 | Mostly covered by State Road 611, upper part of unit is exposed above road on south bank of river. Clay shale, partly silty, pale-olive, yellowish-gray, and grayish-red. Yellowish-gray shale is dolomitic | 39.2 |
| 7.1 | | Price Formation (751.3 feet)<br>Hayters Sandstone Member (137.8 feet) | |
| | 78 | Arkosic sandstone, fine to medium-grained, subrounded, light-gray-brown, coarse muscovite flakes, fair porosity; contains one-inch-thick layer of quartz-pebble conglomorate with pebbles to 15 mm | 8.5 |
| | 77 | Sandstone, very fine-grained, angular, medium-gray, sparsely carbonaceous, very fine to medium muscovite, medium-bedded, tabular cross-laminated, rare imprints of brachiopods; about 8.5 feet above base is a interval of quartz pebbles to 20 mm., another pebble interval at 12.0 feet above base of unit. At base is thin parting of slightly silty shale, micaeous, light-gray | 18.0 |
| | 76 | Arkosic sandstone, coarse- to very coarse-grained, with scattered quartz pebbles, and subrounded pebbles to 49 mm on upper bedding plane, pale-yellowish-brown | 5.0 |
| | 75 | Arkosic sandstone, very fine-grained, olive-gray, trace of very shiny coal grains, fine muscovite flakes, medium-bedded, thin-laminated | 8.5 |
| | 74 | Covered interval | 4.0 |
| | 73 | Arkosic sandstone, fine- to medium-grained, with rare coarse grains, subangular pebbles to 20 mm on top bedding plane, grayish-brown, medium-bedded, cross-laminated, cross-bedding dipping 26° E and 28° S60°E, top surface wavy | 7.0 |
| | 72 | Arkosic sandstone, fine- to medium-grained, subangular, very pale-orange feldspar grains, few flakes muscovite, | |

| UNIT NO. | | THICKNESS (FEET) |
|---|---|---|
| | scattered rounded quartz pebbles to 8 mm, mostly in upper part . . . . . . . . . . . . | 4.8 |
| 71 | Concealed by river terrace gravels . . . . . | 43.0 |
| 70 | Partly covered. Interbedded coarse siltstone to very fine-grained sandstone, light-gray, very fine muscovite, very thin-bedded and silty shale . . . . . . . . . . | 8.0 |
| 69 | Interbedded argillaceous sandstone, very fine-grained, slightly glauconitic, dense, light-olive-gray, carbonaceous, few imprints of *Chonetes* sp. and *Productella* sp. brachiopods, and coarse siltstone, medium-gray, trace amounts of very fine muscovite, some spheroidal weathering . . . . . . . . . . . . . . . . . . . . . . . . | 31.0 |

Greendale Member (290.2 feet) (Exposed in bank behind ARCO service station across the highway from intersection of State Road 8)

| UNIT NO. | | THICKNESS (FEET) |
|---|---|---|
| 7.3 68 | Interbedded argillaceous siltstone, light-gray, very fine muscovite; sandstone, very fine-grained, slightly glauconitic, light-olive-gray, glauconite very dark-green, very fine muscovite, fossil fragments, very thin-bedded and silty shale, medium-light-gray, carbonaceous; siltstone/sandstone ratio 1/2. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . | 27.5 |
| 67 | Silty shale, slightly glauconitic, light-olive-gray, glauconite very dark-green, very fine muscovite, partly weathers spheroidal, few fossils in thin ferruginous bed, with *Spirifer* sp. and *Syringothyris* sp . . . . . . . . . . . . . . . . . . . . . . . . . | 24.8 |
| 66 | Argillaceous siltstone, light-gray, partly ferruginous, light-olive-gray, very fine muscovite, about 10.0 feet above base some molds of *Spirifer* sp.; some silty shale in upper part, light-gray, slightly glauconitic, very fine muscovite . . . . . . | 15.8 |
| 65 | Sandy siltstone, slightly glauconitic, light-gray, partly stained brown, very fine quartz grains, very fine muscovite, fossiliferous, with *Spirifer bifurcatus(? )* *Productella* sp., and *Spirifer solidirostris(?)* brachiopods, *Fenestrellina* sp., *Cystodictya* sp. bryozoans, and crinoid columnals. | 3.5 |
| 64 | Glauconitic shale, silty, dusky-yellowish-green to grayish-green, very fine muscovite, glauconite most abundant in two beds 0 to 0.5 feet and 4.3 to 5.5 feet above base . . . . . . . . . . . . . . . . . . . . . . . . | 5.5 |
| 63 | Silty shale, medium-light-gray, very fine muscovite, very fossiliferous with imprints of *Syringothyris texta*, and *Productella* sp. brachiopods, *Fenestrellina* sp., *Rhombopora* sp. bryozoans, large pectenoid clam (44 mm by 46 mm ) crinoid columnals, and carbonaceous plant stems . . . . . . . . . . . . . . . . . . . . . . . . | 6.0 |
| 62 | Very slightly silty shale, light-olive-gray, very fine muscovite, hackly . . . . . . | 9.0 |
| 61 | Glauconitic siltstone and silty shale with glauconite concentrated in four zones at 3.0-4.0, 6.0-6.5, 9.9-10.4, and 21. 3-24.3 feet above unit base; fossil imprints, mainly in upper zone, include *Chonetes* sp., and *Spirifer winchelli* brachiopods, *Fenestrellina* sp. and *Rhombopora* sp. bryozoans, ostracodes, and crinoid columnals . . . . . . . . . . . . . . . . . . . . . . . . . . | 24.3 |
| 60 | Glauconitic shale, very silty, dusky-yellowish-green, glauconite very fine-grained, very fine muscovite, and siltstone, fossiliferous, trace amounts of scattered glaucontie, light-yellowish-brown, very fine muscovite, fossils include *Fenestrellina* sp. and *Rhombopora* sp. and crinoid columnals . . . . . . . . . . . . . | 2.0 |
| 59 | Interbedded very silty shale, grayish-brown, micaceous, and siltstone, light-grayish-brown, very fine muscovite, scattered dark-green, very fine to fine grains of glauconite . . . . . . . . . . . . . . . . . . | 26.0 |
| 58 | Covered interval . . . . . . . . . . . . . . . . . . . . . | 75.4 |
| 57 | Poorly exposed. Slightly silty shale, grayish-orange, micaceous, and very fine-grained sandstone, light-gray, partly very thin-laminated; one thin bed ferruginous, fossiliferous with *Syringothyris* sp., lowspired gastropods, crinoid columnals, and bryozoans . . . . . . . . . | 16.2 |
| 56 | Argillaceous ferruginous sandstone, brownish reddish-purple, very fine-grained with subrounded coarse to very coarse grains scattered, very fine muscovite, friable . . . . . . . . . . . . . . . . . . . . . . . . | 2.0 |
| 55 | Ferruginous sandstone, fine- to very coarse-grained, conglomeratic in upper part with subrounded pebbles to 10 mm, some siltstone and feldspar, grayish-reddish-purple . . . . . . . . . . . . . . . . . . . . . . | 5.5 |
| 54 | Partly covered. Shale, yellowish-gray, very fine muscovite, carbonaceous, with minor interbedded siltstone, very thin-bedded . . . . . . . . . . . . . . . . . . . . . . . . . . . . . | 12.5 |
| 53 | Sandstone, feldspathic, medium- to very coarse-grained, subangular, sparsely carbonaceous, thick-bedded; one bed ferruginous, reddish-brown . . . . . . . | 8.0 |
| 52 | Very silty shale, light-gray, micaceous, carbonaceous, blocky; with interbeds of arkosic sandstone, very fine-grained, angular, dense, light-gray . . . . . . . . . . . | 26.2 |

Broad Ford Sandstone Member (217.3 feet)

| UNIT NO. | | THICKNESS (FEET) |
|---|---|---|
| 51 | Interbedded sandstone (40%) and shale (60%) with thin- to medium-bedded sandstone layers spaced at 0.5- to 1.5-foot intervals. Sandstone, feldspathic, medium- to very coarse-grained, subangular, very light-gray, fair porosity, | |

| | UNIT NO. | | THICKNESS (FEET) |
|---|---|---|---|
| | | some sandstone very fine-grained, light-gray, micaceous. Silty to sandy shale, light-gray, very micaceous, some feldspar | 61.0 |
| | 50 | Silty shale, medium-gray, medium to coarse muscovite, slightly carbonaceous with 25% interbeds of quartzitic sandstone, very fine-grained, angular, thin- to medium-bedded. Normal fault with 1.0 foot displacement near top of unit. Rare *Chonetes* sp. imprint | 44.7 |
| | 49 | Arkosic sandstone, quartzitic, very fine-grained, angular, light-gray | 1.2 |
| | 48 | Sandy, arkosic shale, medium-gray, very micaceous, sparsely carbonaceous, varies in thickness 3.7 to 3.0 feet; contains two very thin beds of sandstone, very fine-grained, quartzitic, grayish-brown, cross-laminated | 3.0 |
| | 47 | Arkosic sandstone, quartzitic, fine-grained, angular, light-gray, with 0.2-foot-thick shale bed in middle, sandy, arkosic, medium-gray, very carbonaceous with plant stem fragments, micaceous | 8.0 |
| | 46 | Interbedded sandstone and shale (25%). Sandstone, arkosic, argillaceous in part, quartzitic in part, fine-grained, medium- to light-gray, carbonaceous, medium to coarse muscovite, very thin- to thick-bedded, cross-bedded, dips 18° S15°W, ripple-marked, crest to crest 5.1 inches, trough trend N85°W. Silty shale, medium-gray, micaceous, slightly carbonaceous, hackly. Clay-pebble conglomerate on one bedding plane near top | 28.3 |
| | 45 | Sandstone, very fine- to fine-grained, angular, dense, light-gray with some medium-light-brownish-gray in lower 15 feet, medium to very coarse muscovite, few carbonaceous fragments, clay pebbles on some bedding, thin- to thick-bedded, even, flat bedding; some arkosic beds; 2.0-foot-thick fractured zone 15.0 feet above base. Few silty shale partings in lower 15.0 feet | 62.3 |
| | 44 | Interbedded sandstone, fine-grained, angular, dense, light-gray, micaceous, very carbonaceous layers, even medium-bedded, and very silty shale, mottled gray and brownish-gray, micaceous | 8.8 |
| | | Ceres Member (63.4 feet) | |
| 7.5 | 43 | Silty shale, partly sandy, medium-gray to olive-gray, very micaceous, fine to very coarse flakes, layers very carbonaceous, subfissile to partly pencil; minor, very thin-bedded sandstone, very fine- to fine-grained, slightly arkosic, dense, light gray, few carbonized plant stems. Normal fault with about 20.0-foot displacement about 40.0 feet below unit top | 63.4 |
| | | Big Stone Gap Shale Member (20.6 feet) (Exposed on hillslope about 300 yards east of highway.) | |
| 7.55 | 42 | Silty shale and clay shale, dark-gray to medium-dark-gray, brittle, fissile | 20.6 |
| | | Cloyd Conglomerate Member (22.0 feet) (Exposed on hillslopes off highway.) | |
| | 41 | Sandstone, fine- to very fine-grained with lensing beds to 5.0-foot-thick quartz-pebble conglomerate, rounded pebbles to 20 mm., dense, clean, quartzitic, medium- to thick-bedded | 22.0 |
| | | Devonian: | |
| | | "Chemung" Formation (147.6 feet) (Exposed on hillslopes off highway). | |
| | 40 | Covered interval. Some fossiliferous siltstone float with *Camarotoechia* sp. brachiopod imprints | 103.0 |
| | 39 | Siltstone, medium-gray, very micaceous, few carbonaceous plant fragments, very thin- to thin-bedded, thinly laminated | 5.6 |
| | 38 | Partly covered. Siltstone, very fine muscovite and slightly silty shale | 28.0 |
| | 37 | Argillaceous siltstone, light-olive-gray, bedding surfaces brownish-gray, very fine muscovite, very thin- to medium-bedded, some plant fragments | 11.0 |
| | | Brallier Formation (679 feet ±, top and base of formation covered.) | |
| | 36 | Covered interval | 42.8 |
| 7.7 | 35 | Slightly silty shale, light-olive-gray, very fine muscovite, very fine carbonaceous plant fragments; few siltstone beds, light-olive-gray, very fine muscovite, some disc-shaped specimens of *Sporangites* sp., very thin-bedded | 28.6 |
| | 34 | Shale, greenish-gray to gray-brown weathers to light-yellow, hackly; partly exposed along highway and in creek bed east of highway | 607.6 |
| | | Millboro Shale (684 ± feet: top and base of formation covered) | |
| | 33 | Mostly covered, except for two small outcrops of shale in creek east of highway dark-gray, hackly to fissile, with very fine mica | 684 |
| | | Huntersville Formation (83.9 ±feet: top and base of formation covered.) | |
| 8.4 | 32 | Chert, light-gray to white, blocky, medium-bedded, fossiliferous; poorly exposed in creek, roadcut excavated in 1969 exposed chert and sandstone containing eight brachiopod and one gastropod species | 10 |
| | 31 | Covered: probably shale and sandstone (may include Oriskany and Keefer sandstones) | 48.9 |
| | 30 | Conglomeratic sandstone, light-gray to purplish-brown, medium- to very coarse-grained with rounded, frosted quartz pebbles up to 10 mm diameter massive- to thick-bedded | 25 |

| | UNIT NO. | | THICKNESS (FEET) |
|---|---|---|---|
| | Silurian: | | |
| | Rose Hill Formation (147.5 ±feet) | | |
| | 29 | Siltstone and sandstone, dark-purplish-brown fine-grained, dense, medium- to thick-bedded | 13 |
| | 28 | Silty shale, reddish-brown and light-greenish-gray | 25 |
| | 27 | Siltstone, dark-purplish-brown, medium-bedded | 2 |
| | 26 | Interbedded siltstone, thin-bedded, and shale, light-brown, with polished bedding surfaces | 22 |
| | 25 | Sandstone, gray to dark-gray, fine-grained, medium- to thick-bedded: grades upward to silty sandstone | 19 |
| | 24 | Clay shale, light-gray, fissile | 2 |
| | 23 | Clay shale, light-gray, fissile, with thin interbeds of siltstone | 12 |
| | 22 | Siltstone, gray, dense, thick- to thin-bedded | 10 |
| | 21 | Ferruginous shale, mottled brown, with oolitic iron structures | 0.5 |
| | 20 | Siltstone, light-gray, with some red-brown tubular worm borings perpendicular to bedding, with interbedded ferruginous shale partings | 8 |
| | 19 | Shaly siltstone, dark-purplish-brown, weathers mottled, medium-bedded | 5 |
| | 18 | Siltstone, iron-stained brown to purple, thick-bedded | 17 |
| | 17 | Shaly siltstone, mostly covered | 12 |
| | Tuscarora Sandstone (196.1 ±feet) | | |
| 8.5 | 16 | Sandstone, light-gray, quartzitic, thick-bedded | 9 |
| | 15 | Siltstone, light-purplish-gray, thick-bedded | 4 |
| | 14 | Silty shale, gray | 0.5 |
| | 13 | Sandstone, light-gray, quartzitic, thick-bedded | 25 |
| | 12 | Shale, light-gray, slightly silty with some gray, thin-bedded siltstone | 3 |
| | 11 | Sandstone, light-gray, quartzitic, medium- to thin-bedded | 40 |
| | 10 | Sandstone, gray, fine-grained, dense, siliceous, thin- to medium-bedded with thin argillaceous beds at top | 11 |
| | 9 | Mostly covered: two beds of medium-bedded quartzitic sandstone crop out; dip 22° SE | 42.4 |
| | 8 | Quartzitic sandstone, light-gray, massive | 10 |
| | 7 | Silty shale, light-gray, with siltstone lense in middle | 1.2 |
| | 6 | Quartzitic sandstone, light-brown, fine- to medium-grained, massive-bedding | 24 |
| | 5 | Quartzitic sandstone, light-brown, fine- to medium-grained, massive-bedding, with planar and festoon cross-bedding; depositional dip computed to be 3°-5° N47°W | 2 |
| | 4 | Sandstone light-brown with reddish-to yellowish-brown iron-stained laminae, fine- to medium-grained, massive-bedded, planar cross-bedding: ripple-marked surfaces with crest line trend S° 40° E; quartzitic | 24 |
| | Ordovician: | | |
| | Juniata Formation (26 ±feet) | | |
| | 3 | Covered: probably siltstone | 9 |
| | 2 | Siltstone, maroon and gray, thin- to medium-bedded, with worm-boring-like markings | 5 |
| | 1 | Interbedded silty shale, hackly, and siltstone, purplish-red, grades upward into mottled greenish- and purplish-gray, knobby, thin- to medium-bedded. | 12 |

8.9 Highway cross-over to John Douglas Memorial Wayside.

END OF ROAD LOG.

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# SCHEDULED MEETINGS

October 23-25, Carolina Geological Society, Gaffney, South Carolina (Carolina Geological Society, Box 6665, College Station, Duke University, Durham, NC 27708).

November 2-5, Geological Society of America, Cincinnati, Ohio (Lois J. Campbell, Dept. of Geology, University of Kentucky, Lexington, KY 40506).

November 5-6, Virginia Association for Environmental Education, Skyland, Shenandoah National Park (Tim Tigner, Division of Forestry, Box 3758, Charlottesville, VA 22903).

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# NEW PUBLICATIONS

## PUBLICATION 28

Lineament and Fracture Trace Analysis and Its Application to Oil Exploration in Lee County, Virginia by Thomas M. Gathright, II, has just been published by the Division as Publication 28. Linear traces from aerial photography and LANDSAT imagery are used to evaluate oil producing areas. The methodology of interpreting these linear traces and positioning them on geographic bases is discussed in the publication. The fracture traces, related by means of Cartesian Azimuth distributions and rose diagrams, are shown on 21 separate topographic maps. These maps also show the location of 126 test wells in the county. The publication also gives information on oil bearing strata, their structural position, and their relation to linear traces.

Publication 28 is available from the Division for $3.84 postpaid.

## PUBLICATION 30

The Geology of Hanover Academy Quadrangle, Virginia is available for $4.62 postpaid. The map shows the distribution of rock units on a topographic map base with interpretive cross-sections. Present or historical economic resources of the area include gravel, crushed stone, dimension stone, iron, mica, coal, and zircon. The publication also discusses soil types, excavation problems of the area; and water possibilities.

## PUBLICATION 31

The Geology of Glen Allen Quadrangle not only describes the geology of the area but also lists geologic and economic factors affecting land modification of the rock units. Interpretive cross-sections are also included with the map. The text portion of the publication discusses the availability of materials suitable for producing crushed stone, bricks, and coal. The usefulness of the rock units for solid and liquid waste disposal, building and road construction, and water supply are also indicated. Publication 31 is available from the Division for $4.62 postpaid.

## PUBLICATION 32

Publication 32, High-silica Resources in Augusta, Bath, Highland, and Rockbridge Counties, Virginia is available for $3.06 postpaid. Physical descriptions, sieve analyses, and chemical test data are presented so that the commercial potential of high-silica resources in these counties can be evaluated.

Most of the area's silica resources are contained within the Antietam and Tuscarora formations and the Keefer and Ridgeley sandstones. A total of 249 sandstone and quartzite localities were examined. Composite samples from each of the principal resource units were analyzed for silica content in a raw or unbeneficiated condition; silica content of the units ranges from 97.2 to 99.1 percent. The percentage of silica in beneficiated samples ranges from 98.9 to 99.5 percent for the same samples. Grain-size distribution, average grain size, and degree of sorting for most samples are shown by histograms and cumulative frequency curves. The study is similar to an earlier publication on the silica resources of five northwestern Virginia counties.