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GEOLOGY OF THE VIRGINIA PORTION OF THE HURLEY, PANTHER, WHARNCLIFFE, AND MAJESTIC QUADRANGLES

James A. Lovett, William W. Whitlock, William S. Henika,
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O. Gene Dishner, Director

CONTENTS

ILLUSTRATIONS

TABLE

GEOLOGY OF THE VIRGINIA PORTION OF THE HURLEY, PANTHER, WHARNCLIFFE, AND MAJESTIC QUADRANGLES

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INTRODUCTION

The Virginia portion of the Hurley, Panther, Wharncliffe, and Majestic 7.5-minute quadrangles covers approximately 75 square miles of northern Buchanan County in the Southwest Virginia coalfield. The mapped area is bordered by Pike County, Kentucky, to the west; Mingo County, West Virginia, to the north; and McDowell County, West Virginia, to the east. The area lies on the Logan Plateau (Outerbridge, 1987) in the Appalachian Plateaus physiographic province which is characterized by steeply sloped ridges and narrow V-shaped valleys cut into nearly flat-lying sedimentary rocks of Pennsylvanian age.

Knox Creek and Tug Fork are the primary streams that drain the mapped area. Flow is generally southeast to northwest, which is perpendicular to regional strike and generally downdip of the shallow northwestward regional dip of the rocks. The lowest altitude is approximately 825 feet above sea level, on the southern bank of Tug Fork in northern Wharncliffe quadrangle. Maximum altitude is approximately 2300 feet above sea level, on the ridge west of Puncheon Camp Creek in the Hurley quadrangle. Altitudes greater than 2100 feet above sea level are common on ridges throughout the area. Local relief generally ranges from about 600 to 1100 feet.

Geologic mapping in the four quadrangles was conducted from November 1988 to December 1989. The geology of the Kentucky portion of the Hurley, Wharncliffe, and Majestic quadrangles has been mapped by Outerbridge (1968).

STRATIGRAPHY

Approximately 1450 feet of Lower and Middle Pennsylvanian sedimentary rocks are exposed in the mapped area. Siltstone, sandstone, shale, clay, limestone, and coal beds are divided into the Norton Formation, found in the creek beds and lower slopes, and the Wise Formation, found on the upper slopes and ridge tops. The exposed interval ranges from approximately 20 feet below the Kennedy coal bed of the Norton Formation, found along Knox Creek in the southeastern part of the mapped area, to approximately 100 feet above the Upper Cedar Grove coal bed of the Wise Formation, found on the ridge west of Puncheon Camp Creek in the southwestern part of the mapped area. Surface measurements and drill-hole data indicate that the stratigraphic interval thins from southeast to the northwest by about 300 feet. This trend is consistent with the northwestward stratigraphic thinning described in the Grundy quadrangle by Taylor (1989) and shown in the Patterson quadrangle by Whitlock (1989).

Lower Pennsylvanian rocks found in the subsurface include the Pocahontas and Lee Formations, and the lower part of the Norton Formation. These formations consist of shale, siltstone, sandstone (including quartzarenite), and coal. The Pocahontas, Lee, Norton, and Wise Formation nomenclature is used in this report because quartzarenite units, or tongues, of the Lee Formation are readily identified from drill-hole data (Miller, 1974). Where the quartzarenites of the Lee are identified, these formational names are used instead of the Kanawha and New River Formation names established in West Virginia and used to the southeast in Tazewell and Russell Counties, Virginia.

The lowermost coal-bearing unit of Pennsylvanian age is the Pocahontas Formation. It is composed of gray sandstone, siltstone, shale and coal beds above the red and green shale of the Upper Mississippian Bluestone Formation , and below the lower quartzarenite of the Middlesboro Member of the Lee Formation. The Pocahontas Formation ranges from 0 to about 225 feet in thickness in the mapped area. It thins from southeast to northwest, as it has been truncated by the lower quartzarenite tongue of the Middlesboro Member (See cross-section A-A'; Figure 1).

The Lee Formation ranges from about 620 to 1285 feet in thickness and contains three tongues of quartzarenite consisting of well-sorted quartzose sandstone and quartz pebble conglomeratic sandstone interbedded with siltstone, shale, and coal. Subsurface data indicate the three quartzarenite units thicken significantly from southeast to northwest, although the total thickness of the stratigraphic interval remains essentially the same. The lower quartzarenite tongue of the Middlesboro Member (lower quartzarenite member of the Lee Formation of Miller, 1974) thickens from about 135 to 450 feet from southeast to northwest. The upper quartzarenite tongue of the Middlesboro Member (middle quartzarenite member of the Lee Formation of Miller, 1974) thickens from about 20 to 360 feet from southeast to northwest. The Bee Rock Sandstone Member (upper quartzarenite member of the Lee Formation of Miller, 1974) thickens from 0 to about 210 feet from southeast to northwest. Drill-hole data indicate the distinctive well-sorted quartzarenitic character of the Bee Rock Sandstone found in the northern part of the Hurley quadrangle, grades laterally to the southeast into a gray, lithic sandstone identified as the McClure Sandstone Member of the Norton Formation. At this facies change north of Hurley, Va. (See cross-section A-A'; Miller, 1974, p.67-69), the Bee Rock Sandstone is no longer identified and the top of the Lee Formation is considered to be lowered about 530 feet to the top of the upper quartzarenite tongue of the Middlesboro Member, accounting for the extreme variation in formation thickness (Figure 1). Rocks from the McClure Sandstone Member to the upper quartzarenite of the Middlesboro

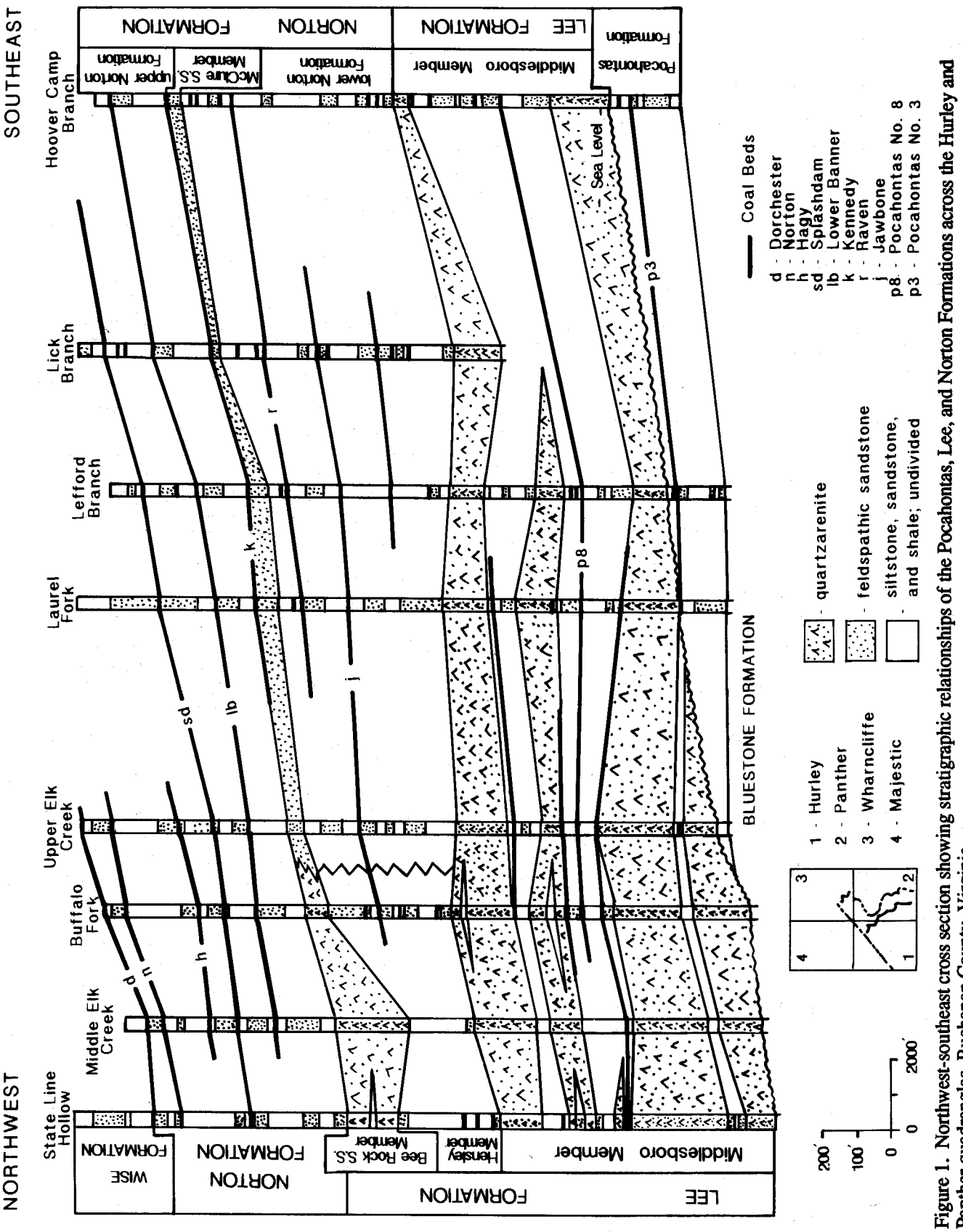

Figure 1. Northwest-southeast cross section showing stratigraphic relationships of the Pocahontas, Lee, and Norton Formations across the Hurley and Panther quadrangles, Buchanan County, Virginia.

Member are therefore included with the Norton Formation. The upper portion of the McClure Sandstone, which also thickens from southeast to northwest, is exposed along the southern and central sections of Knox Creek.

The Norton Formation ranges in thickness from about 520 feet, where the Bee Rock Sandstone Member is identified, to as much as 1330 feet, where the McClure Sandstone Member is identified and the basal contact of the Norton Formation is considered to be at the top of the Middlesboro Member of the Lee Formation. Historically, very similar clastic rocks of the Norton Formation and the overlying Wise Formation were separated by the Gladeville Sandstone, a distinctive ledge-forming quartzose sandstone stratigraphic marker south of the mapped area in Wise and Dickenson Counties, Virginia. Eby (1923, p. 68) describes the formation in Wise County, as a hard, gray, locally conglomeratic, ridge-forming, quartzose sandstone as much as 130 feet thick; which becomes more clayey, feldspathic, micaceous, and less resistant to the north. Northeast of Wise County, Giles (1921, p. 14) mapped the Gladeville Sandstone in Dickenson County and described the formation as a less distinct iron-stained, argillaceous, micaceous sandstone from 60 to 110 feet thick, which weathered readily and rarely formed cliffs. Northeast of Dickenson County, Hinds (1918) did not map the Gladeville Sandstone as a separate unit in Buchanan County, Virginia, but included it with the Norton Formation. Hinds (1918, p. 18) described it as a brownish-red, micaceous sandstone from 50 to 100 feet thick that did not form distinctive outcrops, and was similar to the other Pennsylvanian age sandstone beds of the Norton and Wise Formations. Therefore, the boundary between the Norton and Wise Formations in Buchanan County was placed at the top of the unit identified as Gladeville Sandstone .

Recent work by the Division of Mineral Resources has shown that previous stratigraphic correlations of the Gladeville Sandstone into Dickenson and Buchanan Counties were not correct. Whitlock (1987) determined the Gladeville Sandstone begins to pinch out in northern Wise County. Geologic mapping has traced the Gladeville Sandstone only to northern Wise County (Nolde and others, 1988) and central Dickenson County (Diffenbach, 1988; 1989; Henika, 1989a). Where the Gladeville Sandstone pinch out occurs, Campbell (1893), Hinds (1916), Giles (1921), and Eby (1923) incorrectly identified a regionally extensive 50- to 100-foot-thick lithic sandstone in the upper portion of the Norton Formation, below the Norton coal bed, as the Gladeville Sandstone. Therefore, the top of this Norton Formation sandstone was traced northward as the stratigraphic marker horizon, and coal beds in the upper Norton and lower Wise Formations were misidentified. Detailed statigraphic correlations and geologic mapping from Wise County to northern Buchanan County indicate the Glamorgan coal bed of Buchanan County correlates with the Norton coal bed of Wise County; the Blair coal bed of Buchanan County correlates with the Dorchester coal bed of Wise County; the Eagle coal bed of Buchanan County correlates with the Lyons coal bed of Wise County; and the Clintwood coal bed of Buchanan County remains the Clintwood. The Blair coal bed, mapped between the Lyons and Clintwood coals in central Wise County, either pinches out or merges with the Clintwood in northern Wise and southern Dickenson Counties (Diffenbach, 1988; Nolde and others, 1988; Henika, 1989a) and was not identified in the mapped area.

Although a sandstone is found at the stratigraphic position of the Gladeville Sandstone under the main Dorchester coal bed in much of the mapped area, it lacks the distinctive quartzose ledge-forming character found in Wise County. This sandstone is therefore mapped as an unnamed sandstone in the Norton Formation. The top of the Norton Formation and base of the Wise Formation is placed at the base of the Dorchester coal zone in this report. In a small area south of Pawpaw Creek and west of Left Fork, the Dorchester coal zone pinches out in the western part of the Hurley quadrangle as it did in the southeastern part of the Jamboree quadrangle (Henika, 1989b). Where the pinch out occurs, the Dorchester horizon is projected through as an approximate geologic contact between the Norton and Wise Formations.

An incomplete section of the Wise Formation, as much as 750 feet thick, is exposed on the upper slopes and ridge tops in the mapped area. A poorly exposed shale and siltstone unit 100 to 180 feet thick lies above the Clintwood coal horizon, approximately 120 feet above the base of the Wise Formation. Thin limestone lenses are found locally in the basal part of the unit, about 50 feet above the Clintwood. These limestone lenses probably correlate with the Cannelton Limestone of White (1885); and the shale and siltstone probably correlate with the Betsie Shale Member of the Breathitt Formation, (Rice and others, 1987).

Surficial deposits of Quaternary age occur as alluvium and colluvium throughout the mapped area. Alluvium is primarily silt, sand, cobbles, boulders, and gravel deposited in stream valleys and on small flood plains. Colluvium includes mass-wasting deposits of blocky rock fragments and soil material, such as sandstone, siltstone and shale talus and landslide debris, found on most slopes and hillsides. These deposits are thinnest on the upper hilltops and steep slopes, and thickest on the lower slopes. Man-made deposits, such as mine dumps, spoil heaps, valley fills, and "gob" piles associated with coal mining and preparation-plant waste, are composed of unsorted shale, siltstone, sandstone, and coal. Only the alluvial and large man-made deposits are shown on the geologic map.

STRUCTURE

The Pennsylvanian age rocks and coal beds exposed at the surface strike about N 40 to N 60 degrees E and dip about 0.5 to 1.5 degrees to the northwest. Structure contours drawn on the tops of the Kennedy, Splash Dam, and Dorchester coal beds, show the regional dip averages about 0.8 degrees (about 70 to 80 feet per mile) to the northwest. Strike directions and dip angles measured at the surface and in underground mines differ from the regional structural trend in many places, reflecting local small folds and stratigraphic variations with apparent dip angles of 2 to 10 degrees. McLoughlin (1986, Figure 1) shows the approximate location of an unnamed anticline trending about N 30 degrees W, east of Blackey, Va., and Hurley, Va. A small "roll" noted in an underground mine south of Guess Fork coincides with the axis of the

anticline; however neither surface mapping nor structure contours identified this local feature as a prominent regional structure.

The mapped area is in the Appalachian foreland structural province. Here, the foreland coincides with the southeastern flank of the Appalachian basin and the rocks dip gently to the northwest, towards the basin axis. Harris and Milici (1977) noted that northwest directed uplift and rotation across a series of tectonic ramps produced the present day structure. As a result the decollement extends from detachment surfaces in deeply buried Cambrian rocks to upper level detachments in the Pennsylvanian coal beds.

Deformation associated with the northwestward rotation of the Cumberland overthrust block (defined southwest of the mapped area by Wentworth, 1921) may have affected strata above a detachment at or above the Dorchester coal zone in the southwestern part of the Hurley quadrangle. Henika (1990) redefined the northeastern boundary of the Cumberland overthrust block to be located in northeastern Buchanan County. This includes the area between the former northern end of the block at the Russell Fork fault, located about 18 miles south of the mapped area, and the Bishop-Bradshaw Creek (Canebrake) fault, located a few miles to the east of the mapped area. Henika suggests (written communication, 1991) that the northeastern end of the Cumberland overthrust block is a gentle arc which extends across the southern portions of the Hurley, Panther, and Jamboree quadrangles. This arc includes the Bear Branch fault zone in this area, and probably connects the northeastern end of the Pine Mountain fault with the northwestern end of the Bishop-Bradshaw Creek fault (Elder and others, 1974; McLoughlin, 1986) or Canebrake fault of Johnston and others (1975). An upper level detachment identified in the Dorchester zone along the the Pine Mountain fault trend southwest of the mapped area (Henika, 1989b) may have "locked up" where the Dorchester coal zone pinches out in western Hurley quadrangle, deflecting the Pine Mountain fault trend eastwards towards the Bishop-Bradshaw Creek (Canebrake) fault zone and forming the northeastern termination of the Cumberland overthrust block.

Figure 2. Fault zone south of Blackey showing nearly flat lying beds at the Kennedy coal bed horizon and deformed beds partially covered by landslide debris, looking northwest.

The Bear Branch fault is a steeply dipping, east-trending shear zone in rocks above the base of the Dorchester coal zone. It was mapped into the western part of the Hurley quadrangle from the Jamboree quadrangle (Henika, 1989b) and can be traced about 1.4 miles into the mapped area in highwall exposures above Puncheon Camp Creek. Deflections in the structure contours drawn on the Dorchester coal bed suggest the fault may extend farther to the east. A small, steeply dipping reverse fault, which shows less than 6 feet of displacement and trends about N 40 degrees W, was located in the Kennedy coal bed south of Knox Creek at Blackey (Figure 2). The lateral extension of the fault is unknown, although deflections in the structure contours drawn on the main coal bed of the Splash Dam coal zone suggest the fault may extend to the west, towards the Bear Branch fault zone.

ECONOMIC GEOLOGY

COAL

Fourteen Pennsylvanian coal beds or coal zones crop out in the mapped area. They include in ascending order: the Kennedy, Lower Banner, Upper Banner, Splash Dam, Hagy, and Norton coals of the Norton Formation; and the Dorchester, Lyons, Clintwood, Campbell Creek, Little Alma, Alma, Lower Cedar Grove, and Upper Cedar Grove coals of the Wise Formation. These coals have been mined by surface and underground methods. An additional 14 named coal beds or coal zones from the Pocahontas, Lee, and Norton Formations of Pennsylvanian age are below drainage.

Analyses of seven coal samples collected in the mapped area from the Norton and Wise Formations indicate the coals are generally high-volatile A bituminous rank. Results of analyses are on an as-received basis: 0.8 to 3.4 percent total sulfur, 29.2 to 35.9 percent volatile matter, 3.3 to 17.3 percent ash, 52.0 to 62.2 percent fixed carbon, and 12,375 to 14,523 Btu per pound (G.P. Wilkes, written communication, 1991; Table 1).

The Virginia Division of Mineral Resources (VDMR) is standardizing the names of coal beds in southwestern Virginia, using names established in Wise County, where the formations were defined and where the present geologic mapping program began. Where correlations are uncertain, names used in earlier reports of Hinds (1918) and Outerbridge (1968) are retained. In areas where other coal names are used, or where names are out-of-sequence, the name of local usage is in parenthesis after the name presently used by VDMR.

Pocahontas Formation Coal

The Pocahontas Formation is below drainage in the mapped area. It is unconformably overlain by the Lee Formation, and thins to the northwest from about 225 feet in thickness southeast of Blackey, to a feather-edge in the central part of the area. The top of the formation dips is near sea level southeast of Blackey, and is 340 feet below sea level in the central part of the mapped area (Figure 1).

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Analyses of seven coal samples collected in the mapped area from the Norton and Wise Formations indicate the coals are generally high-volatile A bituminous rank. Results of analyses are on an as-received basis: 0.8 to 3.4 percent total sulfur, 29.2 to 35.9 percent volatile matter, 3.3 to 17.3 percent ash, 52.0 to 62.2 percent fixed carbon, and 12,375 to 14,523 Btu per pound (G.P. Wilkes, written communication, 1991; Table 1).

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Table 1. Analyses of coal samples from the Hurley and Panther quadrangles (G.P. Wilkes, written communication, 1991).

Coal bed	Repository number	total sulfur	volatile matter	ash	fixed carbon	BTU's/pound
Norton	R-8933	1.4	31.3	10.1	56.6	13,444
Dorchester	R-8632	0.8	32.4	3.3	62.2	14,523
Dorchester	R-8635	0.8	29.2	17.3	52.0	12,375
Lyons	R-8943	1.2	30.1	11.0	57.2	13,412
Clintwood/Lyons	R-8936	0.8	31.7	4.8	61.7	14,370
Clintwood	R-8935	3.4	35.9	7.0	54.9	13,853
Campbell Creek	R-7494	0.8	33.2	6.4	57.1	13,936

At its greatest thickness in the south, the Pocahontas Formation includes, in ascending order, the Pocahontas No. 3, 4, and 5 coals beds. Progressively lower coal beds are absent from southeast to northwest because of erosional thinning of the formation prior to deposition of the overlying Lee Formation. The Pocahontas No. 3 coal bed ranges in thickness from 12 inches in the southern part of the Panther quadrangle, to 3 inches in the central part of the Panther quadrangle, to 22 inches in the northern part of the mapped area. The Pocahontas No. 4 coal bed is present as a 2-inch thick coal in the southeastern part of the area. The Pocahontas No. 5 coal bed is 32 inches thick along the southern boundary of the mapped area.

Lee Formation and lower Norton Formation Coal

The Lee Formation and lower part of the Norton Formation of Pennsylvanian age are below drainage, and contain 11 named coal beds between the Pocahontas No. 5 coal bed and the Kennedy coal bed of the Norton Formation. Five of these coals are in the Lee Formation. They include, in ascending order: the Pocahontas No. 8 coal bed, which ranges from 0 to 27 inches in thickness; Pocahontas No. 9 coal bed (Little Fire Creek), 0 to 45 inches in thickness; Lower Horsepen coal bed, 0 to 5 inches in thickness; War Creek coal bed, 0 to 17 inches in thickness; and Middle Horsepen coal bed, 0 to 20 inches in thickness. Some coal beds are not named in the cross-section A-A' and Figure 1 of this report because correlation is uncertain.

Coal beds between the Middle Horsepen coal bed and the Tiller coal bed of the Norton Formation are generally thin or absent, and cannot be confidently correlated. One exception is the Castle coal bed of the Norton Formation, which ranges from 0 to 18 inches in thickness.

Five other coal beds are in the lower Norton Formation below drainage. They include, in ascending order: the Tiller coal bed, which ranges from 0 to 8 inches in thickness; the Jawbone coal bed, 0 to 16 inches in thickness; the Raven coal bed, 2 inches to approximately 52 inches in thickness; the Raven Rider (Raven No. 2) coal bed, 3 to 8 inches in thickness; and the Aily coal bed, 3 to 20 inches in thickness.

Upper Norton Formation Coal

The Kennedy coal bed is the lowest coal exposed in the mapped area. It crops out near drainage level along Knox Creek, southeast of Hurley, close above the McClure Sandstone Member of the Norton Formation. The coal bed ranges in thickness from a total of 40 inches of coal in a drill hole in central Panther quadrangle, to 24 inches of coal near the Panther-Patterson quadrangle boundary, to 13 inches of coal north of Hurley. The Kennedy coal is not found in the northern part of the mapped area. It appears to pinch out near the intersection of Knox Creek and Guess Fork, northwest of Hurley, as the McClure Sandstone Member thickens to the northwest. Another coal bed, ranging from 4 to 10 inches in thickness, is about 5 feet below the main bench near Blackey.

The Lower Banner coal bed lies 100 to 170 feet above the Kennedy coal bed. South and east of Hurley, it crops out 120 to 170 feet above the Kennedy coal bed and close above a 30- to 90-foot-thick ledge-forming sandstone. Northwest of Hurley, this interval thins and the Lower Banner is about 100 feet above the McClure Sandstone on Knox Creek, where the Kennedy coal bed pinches out and the McClure Sandstone thickens. The coal is exposed along Knox Creek, Pawpaw Creek, and their tributaries in the Hurley and Panther quadrangles, and is thickest west of Knox Creek. Hinds (1918, p. 204-205) reported 39.5 inches of coal at a mine near the community of Kelsa, and several measured sections with 26 to 32 inches of coal and thin partings along Pawpaw Creek, in the central part of the Hurley quadrangle. Farther south, he measured 31 inches of coal with 3 inches of parting near Race Fork, and 35 inches of coal with 5 inches of parting along Lester Fork, south of Hurley. East and north of Knox Creek ,the coal bed thins, occurs as thin splits in many places, and is discontinuous. Near Long Bottom Branch in the southwestern part of the Panther quadrangle, a drill hole penetrated six inches of coal. To the north, along Lick Branch, the Lower Banner consists of two splits, the lower coal bed is 15 inches thick and the upper one is 12 inches thick. The coal is 14 inches thick near the mouth of Cedar Branch, east of Knox Creek in the northern part of the Hurley quadrangle. A thin coal bed, as much as 7 inches thick, is locally about 40 feet below the Lower Banner and below a discontinuous lime-

stone horizon (Figure 3) west of Blackey, in the southeastern part of the Hurley quadrangle. This coal may correlate with the Big Fork coal bed mapped to the south by Taylor (1989) and Whitlock (1989).

Figure 3. Discontinuous limestone lenses below the Lower Banner coal bed found on the Left Fork of Lester Fork in southeastern Hurley quadrangle. White scale is 12 inches by 12 inches.

The Upper Banner coal bed is an average of 80 feet above the Lower Banner coal bed, but locally is discontinuous. In many places the coal pinches out within enclosing sandstones. The Upper Banner coal occurs as a lower bench with 19 inches of coal and an upper bench with 12 inches of coal northeast of Guess Fork, where the sandstone underlying the coal bed is absent. North of the junction of Guess Fork and Knox Creek, the sandstone overlying the coal bed in much of the southern part of the mapped area is absent, and the Upper Banner consists of 17 inches of coal and a 3 inch shale parting.

The Splash Dam coal zone is 50 to 100 feet above the Upper Banner and 220 to 360 feet above the horizon of the Kennedy coal bed. East of Blackey, the Splash Dam is 320 to 360 feet above the Kennedy coal bed. This interval thins to the northwest, in part because the McClure Sandstone thickens northwest of Hurley. The coal zone contains one to five coal beds in an interval as much as 50 feet thick, and is generally found above a 60-to 100-foot-thick sandstone that crops out in the lower portion of the valleys. The main bed contains 12 to 39 inches of coal and 1 to 29 inches of shale. As many as four discontinuous rider coal beds, ranging from 0 to 25 inches in thickness, are locally found 8 to 22 feet above the main bench. A thinner coal bed, 0 to 10 inches in thickness, is locally about 30 feet below the main bench. The Splash Dam coals have been extensively surface and underground mined throughout the area. Underground mines are active north of Hurley along Guess Fork, and south of Hurley along Knox Creek, Bill Branch, Lick Branch, and Hurricane Fork.

The Hagy coal bed lies 80 to 130 feet above the Splash Dam coal zone, and contains 0 to 20 inches of coal. In the eastern portion of the mapped area, the coal is generally above a 60- to 120-foot-thick sandstone that forms ledges in the lower valleys. This sandstone thins to the west and northwest. The Hagy has been mined locally on a small scale. Two caved adits were located east of Blackey, and small surface mines are located on Halls Branch, north of Hurley, and at the head of Left Fork in the Panther quadrangle. The coal bed is most often exposed in roadcuts made for access to other surface mines. The coal is 16 inches thick on Brierfield Branch, just north of Hurley; 13 inches thick on Bee Branch, northwest of Hurley; and 7 inches thick on Old House Branch, west of Hurley. One or two thin rider coals (Hagy Rider, Hagy 2, Hagy 3), as much as 6 inches in thickness, are found locally in drill holes 15 to 40 feet above the main bed but seldom exposed in the field.

The Norton (Glamorgan, Hagy) coal zone consists of one to three coal beds in an interval as much as 40 feet thick. The main Norton coal bed is 120 to 160 feet above the Hagy coal bed. The coal zone overlies a 30- to 80-foot-thick ledge-forming sandstone in the southwestern portion of the mapped area. This sandstone pinches out to the east and north, near Hurley. The main coal bed in the Norton coal zone ranges from 18 to 39 inches in thickness. The coal is 37 inches thick at an abandoned mine adit south of Laurel Fork, southwest of Hurley; 28 inches thick in Low Gap Branch, west of Hurley; and 19 inches thick with 9 inches of shale partings in Lefford Branch, east of Hurley. A rider coal bed, as much as 20 inches thick, is found 6 to 20 feet above the main bench in many places; and a discontinuous coal, 0 to 12 inches thick, is about 10 to 20 feet below the main bench northeast of Blackey. The Norton coal beds have been surface and underground mined throughout the area.

Wise Formation Coal

The Dorchester coal zone, Lyons coal zone, and Clintwood coal bed in the lower part of the Wise Formation are near the ridge tops in the southeastern portion of the mapped area. As the rock formations dip gently to the northwest in the map area, these coal beds are found on the steep slopes of the ridges, north and west of Hurley. The lower part of the formation is 100 to 160 feet thick and contains one to nine coal beds interbedded with shale, sandstone, siltstone and clay. This stratigraphic variation makes local and regional correlation of the coal beds difficult in northern Buchanan County.

The Dorchester (Blair, Blair Riders) coal zone contains as many as four coal beds in an interval about 40 to 60 feet thick. The main Dorchester coal bed lies 60 to 130 feet above the main Norton coal bed. It is 60 to 100 feet above the Norton west and north of Hurley, 80 to 120 feet above the Norton near Hurley, and 100 to 130 feet above the Norton southeast of Hurley. The main bench is thickest north of Blackey, where records from an abandoned underground mine report 41 to 50 inches of coal and 12 to 14 inches of shale partings. Elsewhere, the Dorchester averages 30 to 35 inches of coal with 5 to 12 inches of shale partings on Sycamore Fork, northeast of Hurley; and 24 to 30 inches of coal with 0 to 3 inches of partings on Puncheon Camp Creek, in the southwestern part of the mapped area. A discontinuous rider coal, 0 to 24 inches thick, is found locally 10 to 20 feet above the main bench east of Blackey, in the southern part of the map area, and west of Race Fork, about two miles west of Hurley. South and east of Hurley, where the Dorchester to Norton interval is thickest, one or two coal beds and a thin black shale are found locally

stone horizon (Figure 3) west of Blackey, in the southeastern part of the Hurley quadrangle. This coal may correlate with the Big Fork coal bed mapped to the south by Taylor (1989) and Whitlock (1989).

Figure 3. Discontinuous limestone lenses below the Lower Banner coal bed found on the Left Fork of Lester Fork in southeastern Hurley quadrangle. White scale is 12 inches by 12 inches.

The Upper Banner coal bed is an average of 80 feet above the Lower Banner coal bed, but locally is discontinuous. In many places the coal pinches out within enclosing sandstones. The Upper Banner coal occurs as a lower bench with 19 inches of coal and an upper bench with 12 inches of coal northeast of Guess Fork, where the sandstone underlying the coal bed is absent. North of the junction of Guess Fork and Knox Creek, the sandstone overlying the coal bed in much of the southern part of the mapped area is absent, and the Upper Banner consists of 17 inches of coal and a 3 inch shale parting.

The Splash Dam coal zone is 50 to 100 feet above the Upper Banner and 220 to 360 feet above the horizon of the Kennedy coal bed. East of Blackey, the Splash Dam is 320 to 360 feet above the Kennedy coal bed. This interval thins to the northwest, in part because the McClure Sandstone thickens northwest of Hurley. The coal zone contains one to five coal beds in an interval as much as 50 feet thick, and is generally found above a 60-to 100-foot-thick sandstone that crops out in the lower portion of the valleys. The main bed contains 12 to 39 inches of coal and 1 to 29 inches of shale. As many as four discontinuous rider coal beds, ranging from 0 to 25 inches in thickness, are locally found 8 to 22 feet above the main bench. A thinner coal bed, 0 to 10 inches in thickness, is locally about 30 feet below the main bench. The Splash Dam coals have been extensively surface and underground mined throughout the area. Underground mines are active north of Hurley along Guess Fork, and south of Hurley along Knox Creek, Bill Branch, Lick Branch, and Hurricane Fork.

The Hagy coal bed lies 80 to 130 feet above the Splash Dam coal zone, and contains 0 to 20 inches of coal. In the eastern portion of the mapped area, the coal is generally above a 60- to 120-foot-thick sandstone that forms ledges in the lower valleys. This sandstone thins to the west and northwest. The Hagy has been mined locally on a small scale. Two caved adits were located east of Blackey, and small surface mines are located on Halls Branch, north of Hurley, and at the head of Left Fork in the Panther quadrangle. The coal bed is most often exposed in roadcuts made for access to other surface mines. The coal is 16 inches thick on Brierfield Branch, just north of Hurley; 13 inches thick on Bee Branch, northwest of Hurley; and 7 inches thick on Old House Branch, west of Hurley. One or two thin rider coals (Hagy Rider, Hagy 2, Hagy 3), as much as 6 inches in thickness, are found locally in drill holes 15 to 40 feet above the main bed but seldom exposed in the field.

The Norton (Glamorgan, Hagy) coal zone consists of one to three coal beds in an interval as much as 40 feet thick. The main Norton coal bed is 120 to 160 feet above the Hagy coal bed. The coal zone overlies a 30- to 80-foot-thick ledge-forming sandstone in the southwestern portion of the mapped area. This sandstone pinches out to the east and north, near Hurley. The main coal bed in the Norton coal zone ranges from 18 to 39 inches in thickness. The coal is 37 inches thick at an abandoned mine adit south of Laurel Fork, southwest of Hurley; 28 inches thick in Low Gap Branch, west of Hurley; and 19 inches thick with 9 inches of shale partings in Lefford Branch, east of Hurley. A rider coal bed, as much as 20 inches thick, is found 6 to 20 feet above the main bench in many places; and a discontinuous coal, 0 to 12 inches thick, is about 10 to 20 feet below the main bench northeast of Blackey. The Norton coal beds have been surface and underground mined throughout the area.

Wise Formation Coal

The Dorchester coal zone, Lyons coal zone, and Clintwood coal bed in the lower part of the Wise Formation are near the ridge tops in the southeastern portion of the mapped area. As the rock formations dip gently to the northwest in the map area, these coal beds are found on the steep slopes of the ridges, north and west of Hurley. The lower part of the formation is 100 to 160 feet thick and contains one to nine coal beds interbedded with shale, sandstone, siltstone and clay. This stratigraphic variation makes local and regional correlation of the coal beds difficult in northern Buchanan County.

The Dorchester (Blair, Blair Riders) coal zone contains as many as four coal beds in an interval about 40 to 60 feet thick. The main Dorchester coal bed lies 60 to 130 feet above the main Norton coal bed. It is 60 to 100 feet above the Norton west and north of Hurley, 80 to 120 feet above the Norton near Hurley, and 100 to 130 feet above the Norton southeast of Hurley. The main bench is thickest north of Blackey, where records from an abandoned underground mine report 41 to 50 inches of coal and 12 to 14 inches of shale partings. Elsewhere, the Dorchester averages 30 to 35 inches of coal with 5 to 12 inches of shale partings on Sycamore Fork, northeast of Hurley; and 24 to 30 inches of coal with 0 to 3 inches of partings on Puncheon Camp Creek, in the southwestern part of the mapped area. A discontinuous rider coal, 0 to 24 inches thick, is found locally 10 to 20 feet above the main bench east of Blackey, in the southern part of the map area, and west of Race Fork, about two miles west of Hurley. South and east of Hurley, where the Dorchester to Norton interval is thickest, one or two coal beds and a thin black shale are found locally

about 30 to 40 feet below the main bench. These lower coal beds are thickest south of Hurley, where 30 inches of coal with 18 inches of shale partings, and 34 inches of coal with a 6-inch clay parting were measured 30 and 42 feet below the main bench. These coal beds thin to a 14-inch coal bed mined on Lefford Branch, east of Hurley; and a 6-inch coal in a drill hole on Long Bottom Branch, northeast of Blackey. The Dorchester coals have been extensively surface, auger, and underground mined. Dorchester coal beds are surface mined with the overlying Lyons and Clintwood coals in many places.

The Lyons (Eagle, Eagle Rider(s), Upper Eagle, Bald Eagle) coal zone contains one to five coal beds in an interval as much as 80 feet thick. The lowest coal bed in the Lyons coal zone is an average of 40 feet above the main Dorchester coal bed. Discontinuous upper coal beds in the Lyons coal zone may be as much as 105 feet above the main Dorchester coal bed. In the southern portion of the mapped area, the Lyons coal zone is found under a massive ledge-forming sandstone. However, this sandstone pinches out northwest of Hurley, and a sandstone below the Lyons (above the Dorchester) continues northward. Hinds (1918, p. 224) noted "As the Eagle [Lyons] lies only a few feet below a very thick and massive sandstone and there is also some sandstone a short distance above the Blair [Dorchester], it is very difficult to differentiate the two coals when only one is exposed." Stratigraphic correlations of the geology and individual coal beds from the Dorchester to Lyons coal zones continue to be difficult in this area. Based on mapping of the Dorchester and Lyons coal zones along Knox Creek and Guess Fork, the Lyons coal zone contains the most prominent coal bed in the vicinity of Cedar Branch, about three miles northwest of Hurley. Northeast of Cedar Branch, in the Upper and Lower Elk Creek areas, the main coal bed in the Lyons coal zone thins and the main coal bed in the Dorchester coal zone thickens. Although the coal beds could not be traced farther northeast, directly into the the Greenbrier Creek area, the main coal bed in the northeastern part of the mapped area is identified as the Dorchester.

East and south of Hurley, the Lyons coal zone consists of as many as three coal beds about 30 to 60 feet above the main Dorchester coal bed. The upper coal beds lie directly below a massive sandstone and have been eroded in many places (Figure 4). The sandstone is generally about 80 feet thick, but is as much as 120 feet thick locally where it cuts out all Lyons coal beds northeast of Blackey on Hoover Camp and Lick Branches (Figure 5). West of Hurley, the Lyons coal zone contains two to five coal beds from 25 to 105 feet above the main Dorchester, and the sandstone above the Lyons ranges from about 20 to 80 feet in thickness. The Lyons coal beds have been extensively surface and underground mined. Relatively thick coal beds occur locally where coals in the zone coalesce. Intervals ranging from 60 to 105 inches in thickness, containing 40 to 66 inches of coal, have been mined southeast of Hurley. North and west of Hurley, the coal beds thin, become more discontinuous, and generally range from 5 to 30 inches in thickness.

The Clintwood coal bed is discontinuous, and ranges from 0 to 43 inches in thickness. It lies an average of 120 feet above the main Dorchester coal bed and about 20 to 80 feet above the highest coal in the Lyons coal zone. In the southern and eastern portion of the mapped area, the discontinuous coal is generally found above the massive ledge-forming sandstone deposited above the Lyons coal zone. Along the Virginia and West Virginia border, 2 to 6 inches of coal is about 10 feet above the sandstone. Southwest of Hurley, near Pounding Mill Creek, the Clintwood thickens locally to 43 inches of coal with a 7 inch shale parting. The Clintwood coal bed has been surface mined locally on Lick Branch, north of Guess Fork in the Panther quadrangle; and surface and underground mined on Pawpaw and Puncheon Camp Creeks, in the western part of the Hurley quadrangle.

Figure 4. Sandstone truncating the upper split of the Lyons coal zone and irregular coal beds below the sandstone exposed in a highwall on the Dorchester and Lyons bench.

Figure 5. Sandstone truncating all coal beds in the Lyons coal zone exposed in a highwall on the Dorchester and Lyons bench.

The Campbell Creek (Pond Creek, Lower Elkhorn) coal bed is 200 to 250 feet above the Clintwood coal bed and 310 to 370 feet above the main Dorchester coal bed. The Campbell Creek lies close above a 50- to 100-foot-thick, ledge-forming sandstone. The coal is found near the ridge tops in the central part of the mapped area, and progressively lower on the slopes to the north and west, as the beds dips to the northwest. The Campbell Creek coal ranges from 9 inches in thickness in the Wharncliffe quadrangle, to 40 inches of coal plus 4 to 5 inches of parting at surface mines in the Majestic quadrangle and northern part of the Hurley quadrangle. The coal is approximately 30 inches thick in a

about 30 to 40 feet below the main bench. These lower coal beds are thickest south of Hurley, where 30 inches of coal with 18 inches of shale partings, and 34 inches of coal with a 6-inch clay parting were measured 30 and 42 feet below the main bench. These coal beds thin to a 14-inch coal bed mined on Lefford Branch, east of Hurley; and a 6-inch coal in a drill hole on Long Bottom Branch, northeast of Blackey. The Dorchester coals have been extensively surface, auger, and underground mined. Dorchester coal beds are surface mined with the overlying Lyons and Clintwood coals in many places.

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East and south of Hurley, the Lyons coal zone consists of as many as three coal beds about 30 to 60 feet above the main Dorchester coal bed. The upper coal beds lie directly below a massive sandstone and have been eroded in many places (Figure 4). The sandstone is generally about 80 feet thick, but is as much as 120 feet thick locally where it cuts out all Lyons coal beds northeast of Blackey on Hoover Camp and Lick Branches (Figure 5). West of Hurley, the Lyons coal zone contains two to five coal beds from 25 to 105 feet above the main Dorchester, and the sandstone above the Lyons ranges from about 20 to 80 feet in thickness. The Lyons coal beds have been extensively surface and underground mined. Relatively thick coal beds occur locally where coals in the zone coalesce. Intervals ranging from 60 to 105 inches in thickness, containing 40 to 66 inches of coal, have been mined southeast of Hurley. North and west of Hurley, the coal beds thin, become more discontinuous, and generally range from 5 to 30 inches in thickness.

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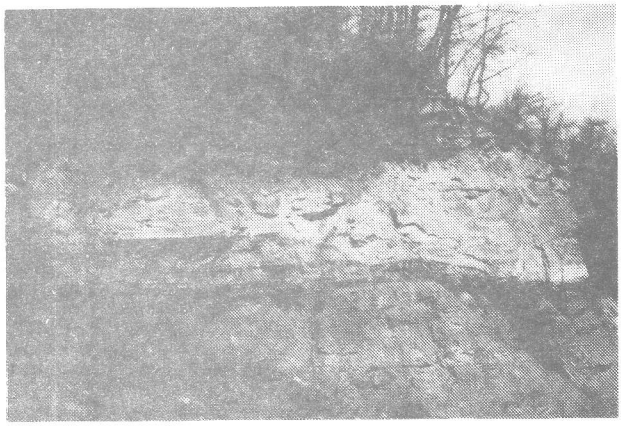

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drill hole in the eastern part of the Jamboree quadrangle, west of the Hurley quadrangle, and 22 inches thick in the eastern part of the mapped area, in the central part of the Panther quadrangle. Hinds (1918, p. 230) reported the Campbell Creek occurs at the head of Upper Elk Creek as 57 inches of coal in a lower bench, overlain by 11 feet of rock, with 36 inches of coal and 10 inches of shale in an upper bench.

The Little Alma (Alma of Outerbridge, 1968) coal bed lies 40 to 90 feet above the Campbell Creek coal bed. It is a discontinuous coal, of significant thickness only in the northern and western portion of the mapped area, and appears to pinch out to the southeast. The Little Alma contains 18 inches of coal north of Middle Elk Creek, in the northern part of the Hurley quadrangle; and occurs as two benches of coal, the lower bench is 22 inches thick and the upper bench is 12 inches thick, in a drill hole just west of the Hurley quadrangle, in the Virginia portion of the Jamboree quadrangle.

The Alma (Upper Alma of Outerbridge, 1968) coal bed lies 40 to 90 feet above the Little Alma coal bed in the northern and western part of the mapped area. It is 95 to 170 feet above the Campbell Creek coal bed, southeast of the Little Alma limits. South of Tug Fork in the Wharncliffe quadrangle, Hinds (1918, p. 231) reported the Alma coal is 31 inches thick near the head of Pounding Mill Branch. To the south, it occurs as two benches with 8 inches of coal, overlain by 45 inches of shale, and 19 inches of coal on top, near the head of Long Branch; and one coal bed 18 inches thick at the head of Lower Elk Creek. Farther south, the Alma coal bed is 14 inches thick at the head of Upper Elk Creek, along the Virginia-West Virginia state line. The coal has been eroded from the hill tops in the southern part of the mapped area.

The Lower Cedar Grove (Lower Thacker) coal beds are 40 to 130 feet above the Alma coal bed and close above a 30- to 60-foot-thick sandstone. It is present only on hill tops in the western and northern part of the mapped area. The Lower Cedar Grove coal and the overlying Upper Cedar Grove coal range greatly in thickness. A drill hole in the southeastern part of the Jamboree quadrangle, west of the Hurley quadrangle, penetrated a lower coal bed 12 inches thick, overlain by 30 feet of shale, and an upper coal bed 26 inches thick. Hinds (1918, p. 231) reported 37.5 inches of coal with 22.5 inches of parting on Lower Elk Creek, and 9 feet of coal with 8 inches of parting at the head of Pounding Mill Branch. The coal has been mined throughout much of its extent in the northern part of the mapped area.

The Upper Cedar Grove (Cedar Grove, Thacker, Upper Thacker, Red Jacket) coal bed is restricted to hilltops in the northern and southwestern parts of the mapped area. The coal bed lies 50 to 110 feet above the Lower Cedar Grove coal bed and ranges greatly in thickness. The coal is 17 inches thick in a drill hole just west of the Hurley quadrangle, in the southeastern part of the Jamboree quadrangle. In the northern part of the mapped area, Hinds (1918, p. 232) reported 15 feet 3.5 inches of coal with 4 feet 9 inches of shale along Lower Elk Creek, and 14 feet 10 inches of coal with 25 inches of shale and bone along Bull Creek. These great thicknesses in the northern portion of the mapped area were limited in areal extent and have been mined.

NATURAL GAS

Natural gas has been produced in the mapped area from rocks of Devonian and Mississippian age. Forty-one wells have been drilled; 22 are producing, 4 are shut-in, and 15 have been plugged and abandoned.

Twenty-one of the 26 wells in the northern part of the mapped area were drilled in the 1950s and early 1960s as an extension of the Kentucky Conaway District. These wells have produced primarily from the Mississippian Greenbrier Limestone ("Big Lime"). Additional production was from the Mississippian Tallery Sandstone Member of the Hinton Formation ("Ravencliff" sand), Mississippian Maccrady Shale ("Injun" sand), and one well from the Mississippian Big Stone Gap Member of the Chattanooga Shale ("Berea sand"). The Greenbrier Limestone is 2400 to 3180 feet below drainage. Wells in the Greenbrier had initial open flows that ranged from a show to 1,050 Mcf/d (thousand cubic feet of gas per day). After fracturing, acidizing, or both, final open flows ranged from 231 to 6,698 Mcf/d.

In the southern part of the mapped area, 11 of the 15 wells were drilled in the late 1970s to early 1980s. These wells have produced primarily from the Devonian Chattanooga Shale ("Devonian shale"). Additional production was from the Maccrady Shale ("Injun" sand), Greenbrier Limestone ("Big Lime"), and one well each from the Mississippian Stony Gap Sandstone Member of the Hinton Formation ("Maxton" or "Maxon" sand) and Mississippian Price Formation ("Weir" sand). The Chattanooga Shale is 3900 to 5300 feet below drainage. Wells producing from the Chattanooga Shale had initial open flows from a show of gas to 603 Mcf/d. After fracturing and acidizing, final open flow ranged from 179 to 730 Mcf/d.

SHALE, CLAY, AND SANDSTONE

The Norton and Wise Formations have abundant shale and sandstone resources. A report by Johnson and others (1966, p. 18-23) includes analyses of two shale samples collected in Buchanan County. The samples were taken from the Wise Formation and had potential use in the manufacture of lightweight aggregate. A third sample taken from a Recent(?) clay deposit, south of Grundy, Virginia, had potential use in the manufacture of brick, tile, and drain tile.

Sandstones from the Norton and Wise Formations have been used by several coal companies on a local basis. The sandstone was crushed for use in mine road construction and erosion control.

NATURAL HAZARDS

The mapped area is dominated by narrow ridges, steep slopes, and narrow stream valleys. The bedrock and topography make the area highly susceptible to mass movement of rock and soil deposits on the slopes. Several areas are covered by active or recent landslides and many of the slopes are covered with ancient landslide debris including thick colluvial deposits and sandstone talus. Outerbridge (1979, 1982,

1984a, 1984b) identified landslides and related features in the mapped area. He concluded (1987, p. 11-12) that earth flows are rare to absent; landslides are primarily debris flows and debris avalanches; and debris avalanches often concentrate colluvium in cragdingles where debris flows are rare. Excavation at the base of a landslide or other slope deposit, or the occurrence of heavy rains, or both, may result in reactivation of the landslide or mass movement of the deposit.

ACKNOWLEDGMENTS

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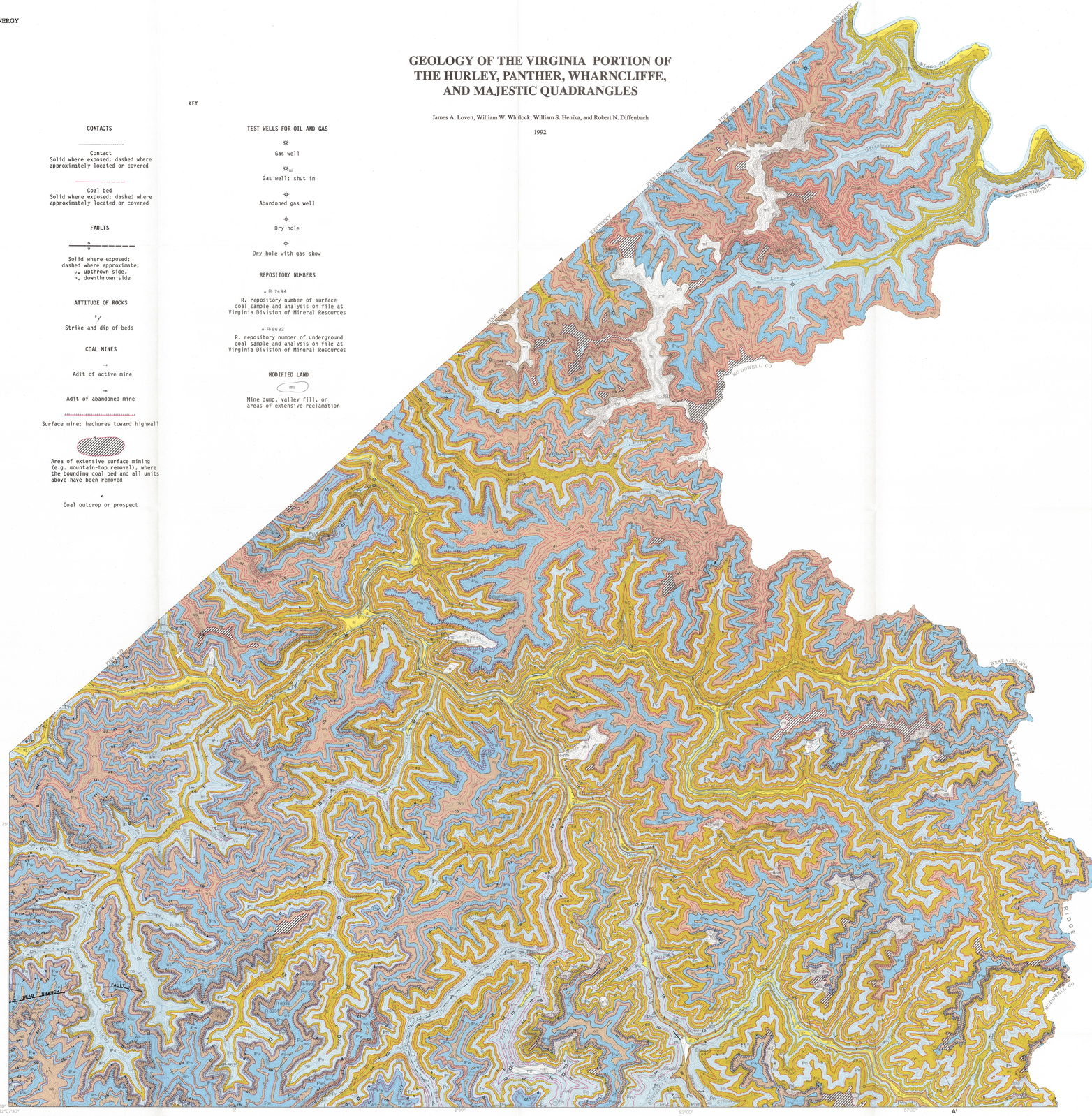
DIVISION OF MINERAL RESOURCES

PUBLICATION 121
GEOLOGY OF THE VIRGINIA PORTION OF THE HURLEY, PANTHER, WHARNCLIFFE, AND MAJESTIC QUADRANGLES

GEOLOGY OF THE VIRGINIA PORTION OF THE HURLEY, PANTHER, WHARNCLIFFE, AND MAJESTIC QUADRANGLES

James A. Lovett, William W. Whitlock, William S. Henika, and Robert N. Diffenbach

1992



Base map from U.S. Geological Survey, 7.5-minute series; Hurley, 1963, PR 1977; Panther, 1963, PR 1977; Wharncliffe, 1963, PR 1979; Majestic, 1964, PR 1977.
Project funded equally by the Commonwealth of Virginia and the U.S. Department of Interior, Office of Surface Mining, under a Technical Data Management System grant.

SCALE 1:24 000

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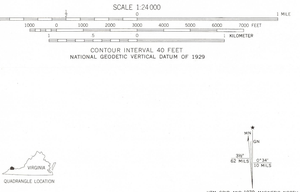
1 0 1 KILOMETER

CONTOUR INTERVAL 40 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929



QUADRANGLE LOCATION

UTM GRID AND 1979 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

EXPLANATION

QUATERNARY

al — Alluvium

PENNSYLVANIAN

Wise Formation

- Pw, interbedded siltstones, shales, and sandstones
- ws, unnamed sandstone
- uc, Upper Cedar Grove coal bed
- lc, Lower Cedar Grove coal beds
- al, Alma coal bed
- lal, Little Alma coal bed
- cb, Campbell Creek coal bed
- cl, Clintwood coal bed
- cl/l, Clintwood and Lyons coal beds
- l, Lyons coal zone
- d, Dorchester coal zone

Norton Formation

- Pn, interbedded siltstones, shales, and sandstones
- ns, unnamed sandstone
- Pnm, McClure Sandstone Member
- c, unnamed coal bed
- n, Norton coal zone
- h, Hagy coal bed
- sd, Splash Dam coal zone
- ub, Upper Banner coal bed
- lb, Lower Banner coal bed
- k, Kennedy coal bed

Norton Formation (lower part)

- Pn, interbedded siltstones, shales, and sandstones
- a, Ally coal bed
- r, Raven coal bed
- j, Jawbone coal bed
- c, unnamed coal bed

Lee Formation

- Pbr, Bee Rock Sandstone Member
- Ph, Hensley Member
- Pmu, upper quartzarenite tongue of the Middlesboro Member
- Pm, interbedded siltstones, shales, and sandstones of the Middlesboro Member
- Pml, lower quartzarenite tongue of the Middlesboro Member
- c, unnamed coal bed

Pocahontas Formation

- Pp, interbedded siltstones, shales, and sandstones
- p3, Pocahontas No. 3 coal bed

MISSISSIPPIAN

Mb — Bluestone Formation

Mu — Mississippian Rocks, undivided

In cross-section only

CONTACTS

Contact
Solid where exposed; dashed where approximately located or covered

Coal bed
Solid where exposed; dashed where approximately located or covered

FAULTS

Solid where exposed; dashed where approximate; v, upthrown side, o, downthrown side

ATTITUDE OF ROCKS

Strike and dip of beds

COAL MINES

Adit of active mine

Adit of abandoned mine

Surface mine; hachures toward highwall

Area of extensive surface mining (e.g. mountain-top removal), where the bounding coal bed and all units above have been removed

Coal outcrop or prospect

KEY

TEST WELLS FOR OIL AND GAS

Gas well

Gas well; shut in

Abandoned gas well

Dry hole

Dry hole with gas show

REPOSITORY NUMBERS

▲ R-7494
R, repository number of surface coal sample and analysis on file at Virginia Division of Mineral Resources

▲ R-8632
R, repository number of underground coal sample and analysis on file at Virginia Division of Mineral Resources

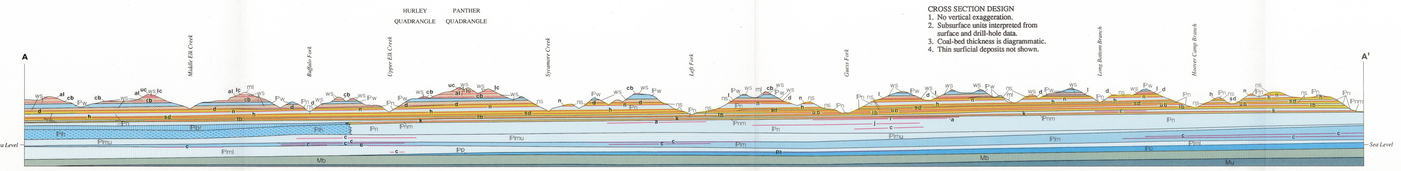
MODIFIED LAND

ml — Mine dump, valley fill, or areas of extensive reclamation

SYSTEM AND SERIES	FORMATION, MEMBER, AND BED	LITHOLOGY	COAL THICKNESS IN INCHES	UNIT THICKNESS IN FEET	DESCRIPTION
QUATERNARY	ALLUVIUM			0 - 20 ?	Silt, sand, clay, gravel, pebbles, cobbles and boulders; deposited in stream and creek valleys. Silt, sand, and clay, laminated and stratified to unstratified, light-gray to brownish-gray. Sand composed mostly of quartz grains, with minor shale, siltstone, and coal fragments, with silt and clay matrix. Gravel, pebbles, cobbles, and boulders, rounded to angular, composed of sandstone, siltstone, shale, and coal.
	COLLUVIUM			0 - 20 ?	Unconsolidated blocky boulders and cobbles, mixed with soil, sand, silt, and pebbles; accumulated on slopes and hillsides. Deposits are primarily unstratified landslide and mass-wasting debris. Pebbles, cobbles, and boulders composed primarily of sandstone, and occasionally siltstone and shale.
PENNSYLVANIAN MIDDLE	WISE FORMATION			275 - 380	
	Upper Cedar Grove coal bed		0 - 184	50 - 100	
			0 -26	50 - 110	
	Lower Cedar Grove coal beds		0 - 108	60 - 130	Sandstone, siltstone, shale, and coal. Sandstone, micaceous, feldspathic, light- to medium-gray, weathers light-brown to pale-yellowish-brown, fine- to medium-grained, thin- to thick-bedded, even- to cross-bedded; forms steep slopes, ledges, and ridge tops. Siltstone and shale, medium- to dark-gray, weathers light-brownish-gray to dark-gray, laminated to thin-bedded, locally carbonaceous; contains sparse siderite nodules and thin beds along bedding planes and laminations.
	Alma coal bed		0 -31	40 - 90	
	Little Alma coal bed		0 - 12 0 - 22	40 - 90	
	Campbell Creek coal bed		0 - 36 0 - 37	50 - 100	
				100 - 180	Siltstone, sandstone, shale, and limestone. Siltstone, medium- to dark-gray, weathers light-brown to moderate-yellowish-brown, laminated to thin-bedded; becomes more sandy up section. Sandstone, lithic, micaceous, feldspathic, light- to medium-gray, weathers yellowish-gray to moderate-yellowish-brown, fine- to medium-grained, even- to cross-bedded, thin- to very thick-bedded, flaggy to massive, generally well-indurated, friable where weathered; ledge and ridge former. Shale, brownish-gray to olive-gray, weathers medium- to dark-gray, laminated to very thin-bedded; contains sparse plant fossils along partings; poorly exposed on natural slopes. Limestone, micritic, light- to medium-gray; discontinuous lenses found locally about 50 feet above the Clintwood coal horizon. The siltstone and shale is probably equivalent to the Betsie Shale Member of the Breathitt Formation (Rice and others, 1987), and the limestone horizon found above the Clintwood is equivalent to the Cannelton Limestone of White (1885).
	Clintwood coal bed		0 - 43	70 - 120	
			0 - 36 0 - 49		
	Lyons coal zone		0 - 16 0 - 26		Sandstone, siltstone, shale, and coal. Sandstone, micaceous, feldspathic, light- to medium-gray, weathers grayish-orange to moderate-yellowish-brown with dark-yellowish-brown lenses and gang rings, fine- to medium-grained, strongly cross-bedded with large channel fills, thin- to thick-bedded, flaggy to massive, well-indurated, weathered surface friable; contains thin shale lenses, coal fragments, plant fossils, and sparse siderite nodules; ledge-former between the horizon of the Clintwood coal bed and Lyons coal zone. Siltstone and shale, interbedded, medium-gray to brownish-gray, weathers light-olive-gray to dark-yellowish-brown, laminated to very thin-bedded; contains thin siderite nodules and lenses along partings, sparse plant fossils; interbedded with thin, micaceous sandstone lenses up to 3 feet thick.
			0 - 66		
	Dorchester coal zone		0 - 24 0 - 50	60 - 130	
			0 - 30 0 - 34		
	Norton coal zone		0 - 20 18 - 39 0 - 12	120 - 160	Sandstone, siltstone, shale, limestone, and coal. Sandstone, lithic, micaceous, feldspathic, light-brown to pale-yellowish-brown, minor grayish-red iron-oxide staining along fractures, medium- to coarse-grained, even- to cross-bedded with irregular sandstone lenses that pinch to a featheredge, thin- to thick-bedded, flaggy to massive; contains sparse coal fragments and plant fossils, thin coal beds as much as 2 inches thick along irregular bedding planes; forms ledges below the Dorchester and Norton coal zones. Siltstone, micaceous, medium-gray to brownish-gray, weathers pale-yellowish-brown to yellowish-gray, laminated to thin-bedded, irregularly parted; interbedded with micaceous, irregular-bedded sandstone lenses. Shale, yellowish-gray to medium-gray, minor grayish-red iron-oxide staining along fractures and bedding planes, laminated to very thin-bedded, papery to massive; contains sparse plant fossils. Limestone, micritic, medium-gray; discontinuous lenses as much as 8 inches thick and about 4 feet long above the Hagy coal beds. The siltstone, shale and limestone between the Norton coal zone and Hagy coal beds is probably equivalent to the Eagle Shale of White (1885; 1891) and Eagle Limestone of White (1891).
			0 - 25	260 - 380	
	Hagy Rider coal bed		0 - 5		
	Hagy coal bed		0 - 20		
			0 - 25	80 - 130	
			0 - 5		
			0 - 20		
			0 - 18		
	Splash Dam coal zone		12 - 39		
			0 - 10	50 - 100	
			0 - 12		
	Upper Banner coal bed		0 - 19		Sandstone, shale, siltstone, and coal. Sandstone, micaceous and feldspathic to locally quartzose, light- to medium-gray, weathers grayish-orange, to moderate-yellowish-brown, medium-grained where more feldspathic, very fine- to fine-grained, moderately-well-sorted where more quartzose, even- to cross-bedded, medium- to thick-bedded, flaggy and blocky to massive; locally forms ledges and steep slopes. Shale, medium- to very-dark-gray, laminated to very thin-bedded, fissile; interbedded with thin silty layers and lenses of micaceous sandstone; contains sparse pyrite, coal fragments, and thin coal bands. Siltstone, medium-gray to grayish-orange, weathers light-brown to pale-yellowish-brown, very thin-bedded, interbedded with shale and sandstone.
			0 - 40	60 - 105	
	Lower Banner coal bed		0 - 7	100 - 170	
			0 - 40	220 - 360	Siltstone, shale, sandstone, limestone, and coal. Siltstone, micaceous, medium-gray, weathers yellowish-gray to light-olive-gray and grayish-orange, laminated to thin-bedded, irregularly parted to massive; grades laterally into fine-grained sandstone, and interbedded with very-pale-orange, micaceous sandstone lenses. Shale, medium-gray to olive-gray, weathers dark-gray to yellowish-gray and very pale-orange, laminated to massive; contains sparse thin coal bands and black shale laminations; interbedded with grayish-red shale above the Kennedy coal bed. Rooted, light- to medium-gray clay shale found below most coal beds. Sandstone, lithic, micaceous, feldspathic, medium-gray, weathers very-pale-orange to grayish-orange, fine- to medium-grained, very thin- to medium-bedded, even- to cross-bedded, flaggy to massive; contains sparse shale laminations, dark-gray shale fragments, coal fragments, thin coal bands, and plant fossils; ledge-forming sandstone below the Lower Banner coal bed correlates with the Bearwallow Sandstone Member of the Kanawha Formation (England, 1981). Limestone, micritic, medium-gray; discontinuous lenses as much as 16 inches thick and 4 feet long, generally 6 to 10 inches thick and 18 to 36 inches long; found above and below the Lower Banner coal bed, and above the Kennedy coal beds.
	Kennedy coal bed		0 - 40 0 - 10	100 - 170	Sandstone, micaceous and feldspathic to quartzose, light- to medium-gray, weathers grayish-orange to brownish-gray, fine- to medium-grained, very thin- to thick-bedded, flaggy to massive, even- to cross-bedded, friable where weathered; contains sparse dark-gray shale and coal fragments; upper contact sharp or locally interbedded with shale and siltstone.
	LOWER NORTON FORMATION			220 - 360	
	McClure Sandstone Member			100 - 170	

CROSS SECTION DESIGN

1. No vertical exaggeration.
2. Subsurface units interpreted from surface and drill-hole data.
3. Coal-bed thickness is diagrammatic.
4. Thin surficial deposits not shown.



CREDIT FOR GEOLOGIC MAPPING

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