GEOLOGY OF THE GRUNDY QUADRANGLE, VIRGINIA

INTRODUCTION

The Grundy 7.5-minute quadrangle comprises about 60 square miles of Buchanan County in the southwestern Virginia coalfields. It is on the Logan Plateau (Outerbridge, 1987) in the Appalachian Plateaus physiographic province. The Levisa Fork which flows northwestward across part of the quadrangle is the major stream in the area.

The greatest topographic relief across the quadrangle is about 1,480 feet from the Levisa Fork at the western border to the highest hill at the eastern border south of White Oak Branch. Local relief is as much as 1,200 feet. The elevations of hills near the eastern border range up to 2,497 feet whereas the higher elevations near the western border are 2,200 to 2,320 feet. Slopes are steep and valleys are narrow with only very small floodplains locally. Most slopes are covered by colluvium and landslide debris (Outerbridge, 1979), but some are covered locally by mine waste.

STRUCTURE

The Pennsylvanian rocks and coal beds strike about N 50 to 60 degrees E and dip about 0.5 to 2 degrees to the northwest. The steepest dips are in the southeastern part of the quadrangle between an unnamed anticline and Slate Creek. Locally strikes are at various angles to the regional structural trend and dips are as much as 20 degrees. Coal beds also show local variations in strike and dip.

The Grundy quadrangle is a few miles east of the Pine Mountain thrust block, between the Little Pawpaw fault (Nolde and Mitchell, 1984) to the southwest, the Bishop-Bradshaw Creek (Canebrake) fault to the east (McLoughlin, 1986), and the Keen Mountain fault to the south. McLoughlin (1986, Fig. 1) shows the Keen Mountain fault at the southern border of the quadrangle near the mouth of Dismal Creek. This fault was not found during mapping in that area by Nolde and Mitchell (1984) and has not been found at the surface during this study. Observations in underground mines by coal company personnel indicate that the Keen Mountain fault does not extend as far north as Dismal Creek.

Many lineaments have been observed on LANDSAT and air photo imagery of the southwestern Virginia coalfields, including the Grundy quadrangle (McLoughlin, 1986; and Gathright and Miller, personal communication, 1989). A "lineament 'spur'" (LS) is shown by McLoughlin (1986) extending from near the northwest end of the Bishop-Bradshaw Creek fault in West Virginia to Roseann, Virginia, thence along Home Creek and westward. Gathright and Miller show a lineament aligned with, but a half mile to the north of McLoughlin's "LS"; their lineament is totally within the Grundy quadrangle. No evidence has been found to support either lineament being a fault. Underground mine maps show only one place with a "bad top" that stopped mining, and that was in a mine just north of Home Creek aligned with the lineament of Gathright and Miller. The area of "bad top" is also near the creek so factors other than fracturing or faulting associated with a lineament may be responsible for the mine roof instability problems.

STRATIGRAPHY

About 1960 feet of sedimentary rocks of the Norton and Wise Formations of Pennsylvanian age are exposed in the southeastern part of the mapped area. The exposed section decreases northwestward to less than 1500 feet in the northern part of the quadrangle.

The unexposed Lower Pennsylvanian section includes the lower few feet of the Norton Formation and the Lee and Pocahontas Formations which consist of sandstone, conglomerate or conglomeratic sandstone, siltstone, shale, and coal. The Pocahontas Formation, the oldest Pennsylvanian formation, overlies Mississippian-age rocks.

The Lee Formation is as much as 811 feet thick near the southern border and 657 to 793 feet in thickness near the northern border (Miller, 1974, p. 140-162, and Plate 1) and is mostly well sorted, very-light-gray quartzose sandstone in two thick bodies that contain quartz pebble conglomerate locally, and are interbedded with lesser amounts of siltstone, shale, and coal. Four thin discontinuous sandstones alternate with coal bearing siltstone and shale intervals in the middle of the formation. The upper quartzose sandstone of the Lee is 140 to 150 feet below the Tiller coal bed or 80 to 100 feet below Dismal Creek. The Upper Horsepen coal bed is at the base of the upper sandstone and just above a very thin shale interval. The lower quartzose sandstone contains conglomerate or conglomeratic sandstone in a zone 20 feet thick in both the upper and lower part. The lower sandstone is overlain by the Lower Horsepen coal bed and underlain by the Pocahontas No. 3 coal bed at the top of the underlying Pocahontas Formation.

Drill records (Miller, 1974, p. 140-162, and Plate 1) indicate the Pocahontas Formation is from 228 to 351 feet thick in the southern half of the quadrangle and 96 to 181 feet thick in the northern half.

ECONOMIC GEOLOGY

COAL

Fifteen coal beds, those below the Tiller coal bed, are below drainage and twenty-five coal beds or coal zones are above drainage.

The Pocahontas No. 3 coal bed, the lowest coal and the top bed in the Pocahontas Formation in this area, is 0 to 49 inches in thickness and lies between sea level and 185 feet above sea level in the southeastern part of the quadrangle; to the northwest it is below sea level or absent. It is also absent in the northern quarter of the quadrangle at the heads of Lynn Camp Creek, Elkins Branch, and Upper Mill Branch. Miller (1974, p. 40-42) discusses the unconformity at the base of the Lee Formation, the absence of the Pocahontas No. 3 coal bed, and states that the Pocahontas Formation is absent to the northwest. The dip of the Pocahontas No. 3 is from 0.33 to 1 degree to the northwest in the southeastern part of the quadrangle where the steepest dips occur. Thin, less than 2 inches thick, coal beds are in the upper 40 to 120 feet of the Pocahontas Formation.

Miller (1974, p. 4) believed the Pocahontas No. 3 coal bed to be the most important in Virginia and perhaps one of the most important in the Appalachian coalfields. It is mined in a very deep mine near the southern border of this quadrangle from a shaft on Dismal Creek in the Vansant quadrangle (Nolde and Mitchell, 1984); the mine workings extends from the vicinity of Hobbs Branch southward to the southern border of the Grundy quadrangle.

Fourteen coal beds are between the base of the Lee Formation and the Tiller coal bed. Coal beds in the Lee Formation in descending order are: the Upper Horsepen coal bed, 0 to 17 inches in thickness at the base of the upper quartzarenite; the Middle Horsepen coal bed, 0 to 21 inches in thickness; the Middle Horsepen Marker coal bed, 0 to 3 inches in thickness about 15 to 20 feet below the Middle Horsepen; the War Creek coal bed, 0 to 18 inches in thickness; the Lower Horsepen rider(?) coal bed, 0 to 6 inches in thickness about 25 feet below the War Creek; and the Lower Horsepen coal bed, 0 to 30 inches in thickness at the top of or just above the lower quartzarenite. Three thinner coal beds are present locally in shale beds. The upper four coal beds, in the subsurface, are in the Norton Formation and are 0 to 18 inches in thickness.

The Norton and Wise Formations contain medium to high-volatile A bituminous coal. Analyses of twenty-one samples from six coal beds in the Norton and Wise Formations on an "as received" basis indicate the following: percent volatile matter 27.6 to 33.0, percent fixed carbon 50.9 to 65.1, percent ash 3.1 to 17.8, percent sulfur 0.7 to 1.7, and 12,220 to 14,799 Btu per pound (Gerry Wilkes, written communication, Dec. 22, 1988). Individual analyses are in the Economic Section's files of the Virginia Division of Mineral Resources in Charlottesville, Virginia.

Eight or nine of the coal beds, or coal zones have been mined by surface and underground methods in this quadrangle. Probably the most important of these are the Kennedy, Splash Dam, Norton, Dorchester, Lyons, and Clintwood coal beds or coal zones. The Virginia Division of Mineral Resources (DMR) is standardizing the names of the coal beds in southwestern Virginia and is using names common to Wise County where the present study began. Where correlation is uncertain the name used in earlier reports of Hinds (1918) or Nolde and Mitchell (1984) are used. Other names in common use in this area are shown in parentheses after the name presently used by DMR.

The Tiller coal bed, the lowest coal bed above drainage, (crops out) only along Dismal Creek where it is in highway cuts at the southern border of the quadrangle. It and the Tiller rider coal bed range from 0 to 12 inches in thickness south of Slate Creek.

The Jawbone coal bed is 5 to 35 inches in thickness and 50 to 75 feet above the Tiller coal bed in the southern part of the quadrangle. It is in one to four beds; some of which pinch out or, south of Newhouse Branch merge to make a coal bed 35 inches thick with shale partings 1 to 2 inches in thickness. The Jawbone rider coal bed is 0 to 17 inches in thickness with a parting, and is 15 to 50 feet above the Jawbone coal bed.

The Raven Marker coal bed (Raven No. 1) was found in a shale sequence in one drillhole located between Grapevine Branch and Harper Creek; this interval is commonly sandstone. The coal is in two beds 0 to 5 inches in thickness separated by about 3 feet of shale 130 feet above the Jawbone coal bed. It appears only in the southeastern part of the quadrangle.

The Raven No. 1 coal bed (Raven No. 2, Raven Red Ash, Garden Hole, or Jewell) is 6 to 29 inches in thickness and is 100 to 170 feet above the Jawbone coal bed. The Raven No. 1 to Jawbone interval thins toward the northwest.

The Raven No. 1 is 0 to 12 feet above a sandstone along Levisa Fork and in the town of Grundy. The Raven No. 2 coal bed (Raven No. 3) is 1 to 21 inches in thickness and 60 to 90 feet above the Raven No. 1 coal bed south of Slate Creek and 15 to 40 feet above it in the north-central part of the quadrangle near the heads of Elkins and Upper Mill branches.

The Aily coal bed is 0 to 24 inches in thickness and is 60 to 105 feet above the Raven No. 1 coal bed, and 165 to 230 feet

above the Jawbone coal bed. It is 19 to 20 inches in thickness and lies 2 to 4 feet below the McClure Sandstone Member of the Norton Formation near Slate Creek on the eastern side of the quadrangle. Elsewhere it is separated from the McClure by as much as 20 feet of shale or siltstone. It is less than six inches thick in the southern part of the quadrangle and is absent south of Newhouse Branch where sandstone occupies the horizon in which the Aily normally occurs.

The Kennedy coal bed (Widow Kennedy, Grundy, or Harris) is 8 to 35 inches in thickness with a gray shale parting 0.5 to 3 inches in thickness. At the Winston No. 9 mine on Grapevine Branch the Kennedy coal bed is 28 to 30 inches in thickness. Hinds (1918, p. 161) reported 30 to 34 inches of coal along Grapevine Branch that included an inch of shale 11 inches above the base. At an abandoned Kennedy mine on Lick Branch 34 inches of coal is overlain by 10 inches of shale with 1 inch of coal at the top. In the southwestern part of the quadrangle the coal is 12 to 26 inches in thickness, and in the north-central part, where it is below drainage, the coal is 23 to 26 inches in thickness. It is 2 to 10 feet above the McClure Sandstone Member and about 165 to 205 feet above the Raven No. 1 coal bed. The Kennedy coal bed is above drainage from Dismal Creek to Looney Creek and has been mined since the early 1900s when a mine at Grundy (Hinds, 1918) supplied the town. It is now mined on Grapevine Branch in the Winston No. 9 mine. Other underground mines are now abandoned; the larger ones were south of Slate Creek particularly in the vicinity of Childress, Harper Creeks, and Grapevine Branch. The Kennedy rider coal bed, a very impure, rashy, discontinuous coal, is locally 10 to 20 feet above the Kennedy coal bed. It is exposed in a cut at the fork in Harper Creek.

The Big Fork coal bed (Puncheon Camp?) is 0 to 17 inches in thickness 110 to 145 feet above the Kennedy coal bed.

The Lower Banner coal bed (Cary) is 0 to 47 inches in thickness and is 145 to 215 feet above the Kennedy coal bed. Hinds (1918, p. 164) reported 48 inches of coal on Grapevine Branch, 36 or more inches on the right fork of Harper Creek and 18 inches on the left fork. Recent excavations on the right fork of Harper Creek exposed 29 inches of coal. On Lower Mill and Elkins branches it is 2 to 24 inches in thickness. It is absent just north of Stilton Branch in the south-central part of the quadrangle. The Lower Banner was mined underground in the southeastern part of the quadrangle, but apparently the mines have been abandoned for many years.

The Upper Banner coal bed is 0 to 17 inches in thickness and 175 to 275 feet above the Kennedy coal bed. It occurs as two beds locally in the southeastern part of the quadrangle where each bed is less than 12 inches thick and 6 to 48 inches apart. It is absent from drillhole cores from Childress Branch to Watkins and Newhouse branches where sandstone underlying the Splash Dam coal zone is thickest and appears to occupy the Upper Banner interval.

The Splash Dam coal zone consists of two to five beds that merge locally and range from 0 to 48 inches in thickness. The zone is 50 feet thick in the southern part of the quadrangle and 5 to 20 feet thick in the northern part. It is 20 to 47 feet above the Upper Banner coal bed. The Splash Dam coal zone contains two main coal beds that are 38 inches and 14 inches thick in the area just south of Slate Creek and east of Lick Branch. Elsewhere south of Slate Creek and west of Levisa Fork the thickest Splash Dam coal bed is about 39 inches. Near the southwestern corner of the quadrangle 40 to 49 inches of coal is present in two beds with five partings in a shale and rash sequence 66 to 71 inches thick. It has been mined underground in several places north of Slate Creek and in a few places to the south. Active underground mines are along the tributaries north of Slate Creek, Lynn Camp and Home creeks, and Lester Fork. Some underground mine workings are in the southwestern part of the quadrangle where as much as 49 inches of coal is being mined but the mine portals are in the Harman quadrangle to the west. A typical mine north of Slate Creek is on Lower Mill Branch where the bed being mined ranges from 19 to 30 inches in thickness.

The Hagy coal bed is 0 to 33 inches in thickness, is commonly less than 12 inches thick, and is 105 to 170 feet above the thickest bed in the Splash Dam coal zone. Hinds (1918, p. 187) reported about 40 inches of coal with an 8-inch parting within the Hagy at the lower part of Enochs Branch but it contains only 33 inches of coal in two beds near the mouth of Elkins Branch, 8 to 18 inches of coal from the head of Looney Creek westward, 14 inches of coal in two beds on the right fork of Stonecoal Branch, and less than 6 inches of coal south of Newhouse Branch. It is absent south of Three and Twenty Mile Branch, and north of Home Creek. The Hagy No. 2 and No. 3 coal beds are 0 to 20 inches and 0 to 4 inches in thickness, respectively. The Hagy No. 2 coal bed is more widespread than the No. 3 and is 20 to 45 feet above the Hagy coal. The Hagy No. 3 coal bed is present in the southeastern part of the quadrangle and in the northern part of the quadrangle west of Roseann, Virginia.

The Norton coal (Glamorgan, Hagy) is 12 to 80 inches in thickness and is a single bed in the southern part of the quadrangle but is two or three beds in the northwestern part with black- to gray-shale partings up to 27 inches in thickness. It is 245 to 340 feet above the Splash Dam coal zone's main bed. The Norton No. 2 coal bed is 0 to 36 inches in thickness with one or two thin partings and the Norton No. 3 coal bed is 0 to 5 inches in thickness with very thin shale partings, locally, north of Home Creek. The Norton and Norton No. 2 coal beds are 1.5 to 35 feet apart but commonly 20 to 35 feet apart. The Norton No. 3 coal bed is 5 to 12 feet above the No. 2. North of Slate Creek the Norton and Norton No. 2 coal beds have been mined together by surface mining, underground mining, and augering. In many surface mines they have been mined with the overlying Dorchester and Lyons coal beds. They are currently being mined underground just east of Left Fork of Looney Creek.

The Dorchester coal bed (Blair, Glamorgan, or Eagle) is at the base of the Wise Formation. It is 3 to 70 inches in thickness, with about 35 inches of coal in two to eleven beds within an interval of up to 15 feet. The Dorchester is interlayered with gray

to black, carbonaceous-shale partings and rash up to 2 inches in thickness. Locally, two beds are separated by a "middleman" of shale that is as much as 11 inches thick. The Dorchester coal bed is 45 to 90 feet above the Norton coal bed and about 570 to 730 feet above the Kennedy coal bed. The Dorchester has been mined extensively north of Slate Creek by surface, auger, and underground mining. The largest underground mines, now abandoned, are between Slate and Lynn Camp creeks, and Enochs Branch, and near Home Creek. In 1988 an active mine south of Home Creek was probably working this coal bed as was a mine just north of the village of Home Creek.

The Lyons coal bed (Eagle, Blair) and the Lyons? coal bed (Eagle) are 0 to 89 inches in thickness and 10 to 85 feet above the Dorchester coal bed. The Lyons occurs as one or two beds and commonly contains 35 to 50 inches of coal. Where there is only one bed it locally is as much as 61 inches thick with knife-edge partings; where there are two beds 34 to 89 inches of coal is present with partings of 1 to 46 inches in thickness. The Lyons? (Eagle) coal bed is 0 to 52 inches in thickness and is called Eagle north of Home Creek where it could be considered a bed in the overlying Clintwood coal zone. It is mapped with the Clintwood north of Home Creek where it is within 10 feet of the Clintwood bed. The Lyons and Lyons? coal beds have been mined by surface, auger, and underground mining methods in many places. Surface mining of other coal beds has been primarily in the northwestern and extreme southwestern parts of the quadrangle. A coal bed mined south of Slate Creek and called the Eagle is probably the Dorchester coal bed.

The Clintwood coal is 10 to 95 feet above the Lyons and Lyons? coal beds and is comprised of one or two coal beds with two shale or sandstone partings locally in the lower bed. The Clintwood contains 72 inches of coal in a 97-inch-thick section north of Home Creek where the lower bed contains 63 inches of coal with two partings and the upper bed is 10 inches thick above a 19-inch shale bed. A Clintwood coal bed exposure in a highwall 4000 feet southeast of Roseann, Virginia is 60 inches thick. If the Lyons? coal north of Home Creek is included in the Clintwood coal zone, the Clintwood would contain as much as 124 inches of coal in a zone 23 feet thick. Hinds (1918, p. 189) reported that the Clintwood was found about 20 feet above the Eagle (Lyons of this report) in one place.

The Addington coal bed is 0 to 6 inches in thickness and is 15 to 35 feet above the Clintwood coal bed near the bottom of a thick shale sequence. It is visible in highwalls of the Clintwood surface mines in the northern part of the quadrangle.

The Campbell Creek coal bed, probably the Imboden or Imboden Marker coal bed of Wise County, is near the ridge tops in the northern part of the quadrangle. There may be two beds in this interval but only "blooms" and reclaimed areas were observed in 1988. The coal is 440 to 630 feet above the Splash Dam coal zone, and is the topographically and stratigraphically highest coal mined in this quadrangle. It appears to correlate with the Lower Elkhorn coal bed in Kentucky (Outerbridge, 1968), less than three miles to the northwest.

Younger coal beds may be above the Campbell Creek on the highest hills north of Home Creek. Beds have been found in that part of the section to the northwest (Outerbridge, 1968; Hinds, 1918, p. 201).

GAS

Natural gas has been produced in the Grundy quadrangle from rocks of Devonian and Mississippian age. Records of drillholes on file with the Division of Gas and Oil indicate that 23 holes have been drilled in this quadrangle since 1948. Ten were producing gas in 1988. The gas production appears to be unrelated to structure observed at the surface.

The drillholes ranged from 2898 to 6453 feet in depth, but most of the gas was produced from the Greenbrier Limestone of Mississippian age ("Big Lime" of drillers) at depths of 3370 to 3950 feet or 1520 to 1810 feet below sea level and 1650 to 1740 feet below the Pocahontas No. 3 coal bed. Production in one well was from the "Injun" sandstone in the Mccrady Formation and possibly from the "Injun" and "Big lime" in another well. Many holes were drilled into Devonian rocks below the Mississippian but plugged back to the "Big Lime," shot, and acidized in some cases. One abandoned well had an oil show and another, a dry hole on the left fork of Upper Mill Branch, had shows of oil and gas in the Lee Formation of Pennsylvanian age. One hole, now plugged, had shows of gas from 630 feet to 5620 feet in depth. Many holes had shows of gas from 700 to 4000 feet in depth. Initial production from four of the wells that are still in production was 1138 to 3052 thousand cubic feet of gas per day.

CLAY AND SHALE

Clay and shale samples collected from just south of Grundy, Virginia and to the southwest of this quadrangle show potential for use as brick, tile, lightweight aggregate, and probably drain tile (Johnson and others, 1966).

WATER RESOURCES

The Grundy quadrangle is in the Big Sandy River basin and has small quantities of surface and groundwater. Slopes are steep and the first order streams are short with steep gradients allowing rapid runoff of precipitation. During extended periods of low precipitation the streams are only a trickle.

Epps (1978) and Scales (1988) have discussed water in the southwest Virginia coalfields and Buchanan County. Precipitation is 37 to 44 inches a year (Epps, 1978, p. 7) but the last few years have brought below average precipitation. Because of thin soil, steep slopes, and relatively impermeable rocks, little water goes into the ground in the mountains. On the small flats along the Levisa Fork and Slate Creek where ground-water recharge rates are higher and where most development occurs flooding is common and precludes most groundwater development. The best aquifers are coal beds, abandoned mines, and stress-relief and tectonic fractures within a few hundred feet of the surface. The stress-relief fractures may be closed below 400 feet in depth where water volume and flow is diminished and where the water becomes increasingly saline. The groundwater is hard, slightly acidic, saline at greater depths, and contains iron and other elements as well as hydrogen sulfide and methane locally. Epps (1978) discusses ways to vent gases and reduce undesirable elements and bacteria from groundwater.

NATURAL HAZARDS

This area of steep slopes, narrow V-shaped valleys, and little flat land has been sculptured by streams and modified by landslides and rockfalls. Surface mining and other excavation contributes to the instability of slopes locally. Abandoned surface mines that have not been reclaimed to the original contour offer good foundation conditions but they also create potential rock fall or ground slumping conditions from highwalls and spoil areas respectively. Recent mining has been followed closely by reclamation to restore the areas to the approximate original contour of steep slopes. The steeper reclaimed areas may still have potentially unstable slopes. The Division of Mined Land Reclamation monitors reclamation during and after mining to prevent erosion and forestall landslides. Commercial builders as well as home builders should be made aware of the many colluvial slopes, old as well as recent landslides, cliffs, and mine highwalls that are potentially unstable. Landslide deposits may become active landslides after heavy rains if the "toe" or base of a slide deposit is cut by road, surface mine or foundation excavation. Slow-moving earthflows, debris avalanches, and rockfalls damage property, temporarily block transportation routes, and can endanger life. If potentially unstable areas cannot be avoided, detailed engineering studies should be made to identify and mitigate the slope instability. Outerbridge (1979) shows landslides and related features in the Grundy quadrangle.

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DEPARTMENT OF MINES, MINERALS AND ENERGY
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PUBLICATION 97
GEOLOGY OF THE GRUNDY QUADRANGLE, VIRGINIA

QUATERNARY

PENNSYLVANIAN

MISSISSIPPIAN

EXPLANATION

al — Alluvium

Wise Formation

Fw — interbedded sandstone, siltstone, and shale
ws — unnamed sandstone
cb — Campbell Creek coal bed
c1 — Clintwood coal bed
c1/1 — Clintwood and Lyons? coal bed
l — Lyons coal bed
d — Dorchester coal bed

Fw/Fn — n/d — Norton and Dorchester coal beds mapped together in highwall of coal mine

Norton Formation

Fn — interbedded sandstone, siltstone, and shale
ns — unnamed sandstone
Fnm — McClure Sandstone Member
Fnc — Council Sandstone Member
n — Norton coal bed
h — Hagy coal bed
sd — Splash Dam coal zone
ub — Upper Banner coal bed
lb — Lower Banner coal bed
br — Big Fork coal bed
k — Kennedy coal bed
a — Ally coal bed
r2 — Raven No. 2 coal bed
r — Raven coal bed
j — Jawbone coal bed
t — Tiller coal bed

In Cross Section Only

Norton Formation (lower part), Lee Formation, and Pocahontas Formation

Fn — (Norton Formation), interbedded siltstone, shale, sandstone, and thin coal beds
c — unnamed coal bed
Fl — (Lee Formation), interbedded sandstone, siltstone, shale, and coal beds
wh — Upper Horsepen coal bed
mh — Middle Horsepen coal bed
wc — War Creek coal bed
lh — Lower Horsepen coal bed
Fp — (Pocahontas Formation), interbedded siltstone, sandstone, shale, and coal beds
p3 — Pocahontas No. 3 coal bed

Mzu — Mississippian rocks, undivided

KEY

Contact
Dashed where approximate

Coal bed
Dashed where approximate

Anticlinal axis
Arrows indicate direction of plunge

Strike and dip of bed

Strike and dip of inverted

Strike of vertical joint

Strike and dip of multiple joint

Mine adit

Abandoned mine adit

Coal outcrop or prospect

Surface mine; hachures toward highwall

Open-pit surface mine; mined down through level of coal indicated; hachures toward highwall

Modified land (surface-mined area, hill- or mountaintop removal, mine dump, valley fill, and area of extensive reclamation)

Gas well

Abandoned gas well

Abandoned gas well (oil show)

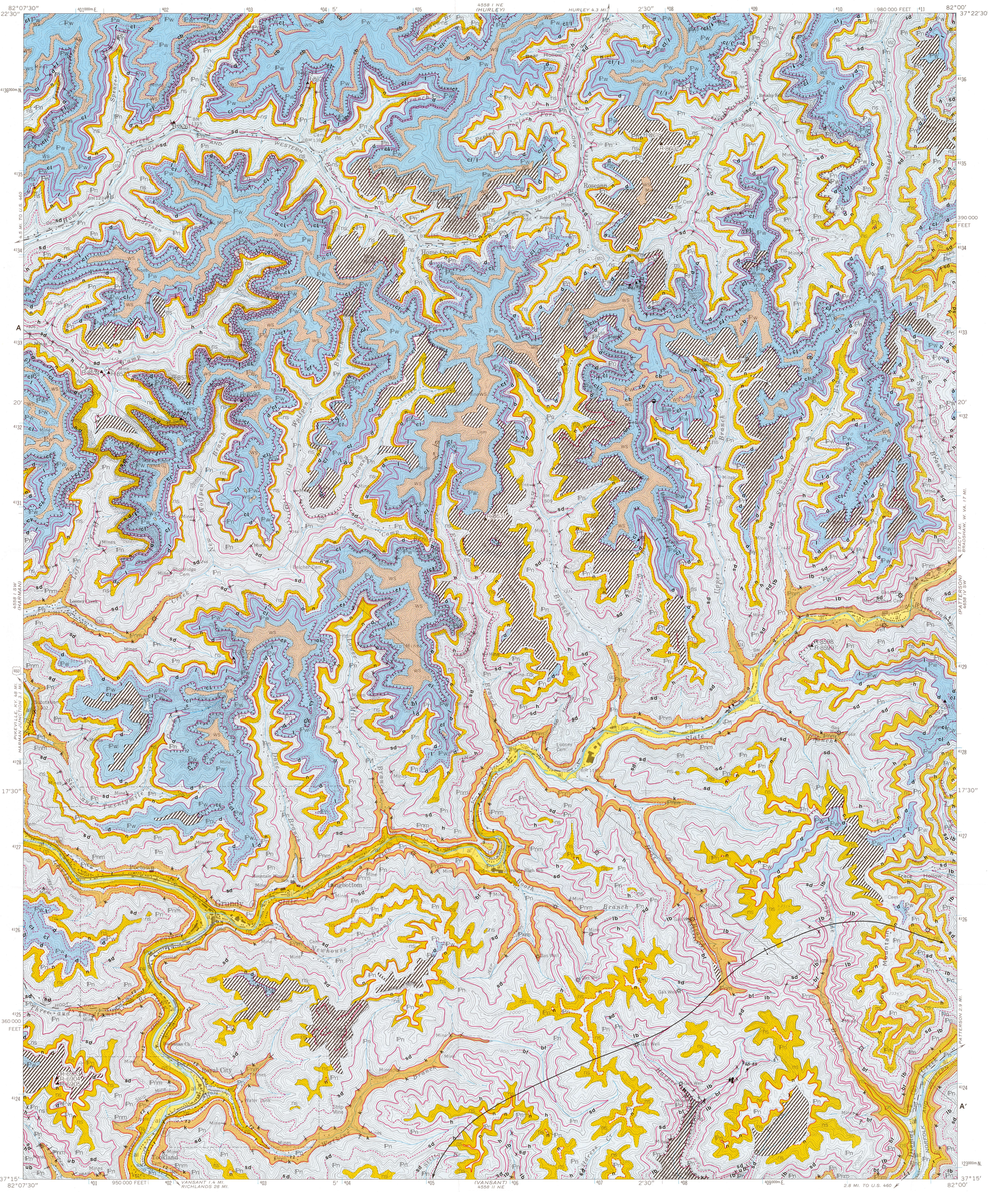
Dry hole with oil and gas show

Dry hole

Dry hole with gas show

Limestone outcrop

R-0245 — R, repository number of coal sample, analysis on file at Virginia Division of Mineral Resources



Base map from U.S. Geological Survey, 1963, PR 1977
Grundy quadrangle, 7.5-minute series

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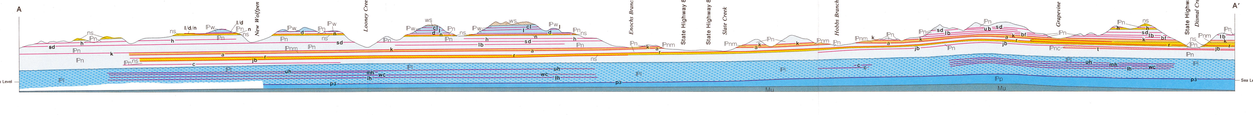
GEOLOGY OF THE GRUNDY QUADRANGLE
BUCHANAN COUNTY, VIRGINIA
by
Alfred R. Taylor
1989

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.



GEOLOGY OF THE GRUNDY QUADRANGLE, VIRGINIA

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INTRODUCTION

The Grundy 7.5-minute quadrangle comprises about 60 square miles of Buchanan County in the southwestern Virginia coalfields. It is on the Logan Plateau (Outerbridge, 1987) in the Appalachian Plateaus physiographic province. The Levisa Fork which flows northwestward across part of the quadrangle is the major stream in the area.

The present topographic relief across the quadrangle is about 1400 feet from the Levisa Fork at the western border to the highest hill at the eastern border south of White Oak Branch. Local relief is as much as 1200 feet. The elevations of hills near the eastern border range up to 2497 feet whereas the higher elevations near the western border are 2200 to 2320 feet. Slopes are steep and valleys are narrow with only very small floodplains locally. Most slopes are covered by colluvium and landslide debris (Outerbridge, 1979), but some are covered locally by mine waste.

STRUCTURE

The Pennsylvanian rocks and coal beds strike about N 50 to 60 degrees E and dip about 0.5 to 2 degrees to the northwest. The steepest dips are in the southeastern part of the quadrangle between an unnamed anticline and Slate Creek. Locally, strikes are at various angles to the regional structural trend and dips are as much as 20 degrees. Coal beds also show local variations in strike and dip.

The Grundy quadrangle is a few miles east of the Pine Mountain thrust block, between the Little Pawpaw fault (Noble and Mitchell, 1984) to the southwest, the Bishop-Bradshaw Creek (Canebrake) fault to the east (McLoughlin, 1986), and the Keen Mountain fault to the south. McLoughlin (1986, Fig. 1) shows the Keen Mountain fault at the southern border of the quadrangle near the mouth of Dismal Creek. This fault was not found during mapping in that area by Noble and Mitchell (1984) and has not been found at the surface during this study. Observations in underground mines by coal company personnel indicate that the Keen Mountain fault does not extend as far north as Dismal Creek.

Many lineaments have been observed on LANDSAT and air photo imagery of the southwestern Virginia coalfields, including the Grundy quadrangle (McLoughlin, 1986; and Gathright and Miller, personal communication, 1989). A "lineament 'spur'" (L5) is shown by McLoughlin (1986) extending from near the northwest end of the Bishop-Bradshaw Creek fault in West Virginia to Rosearn, Virginia, thence along Horse Creek and westward. Gathright and Miller show a lineament aligned with, but a half mile to the north of McLoughlin's "L5"; their lineament is totally within the Grundy quadrangle. No evidence has been found to support either lineament being a fault. Underground mine maps show only one place with a "bad top" that stopped mining, and that was in a mine just north of Home Creek aligned with the lineament of Gathright and Miller. The area of "bad top" is also near the creek so factors other than fracturing or faulting associated with a lineament may be responsible for the mine roof stability problems.

STRATIGRAPHY

About 1960 feet of sedimentary rocks of the Norton and Wise Formations of Pennsylvanian age are exposed in the southeastern part of the mapped area. The exposed section decreases northwestward to less than 1500 feet in the northern part of the quadrangle.

The unexposed Lower Pennsylvanian section includes the lower few feet of the Norton Formation and the Lee and Pocahontas Formations which consist of sandstone, conglomerate or conglomeratic sandstone, siltstone, shale, and coal. The Pocahontas Formation, the oldest Pennsylvanian formation, overlies Mississippian-age rocks.

The Lee Formation is as much as 811 feet thick near the southern border and 657 to 793 feet in thickness near the northern border (Miller, 1974, p. 140-162, and Plate 1). It is mostly well sorted, very-light-gray quartzose sandstone in two thick bodies that contain quartz pebble conglomerate locally, and are interbedded with lesser amounts of siltstone, shale, and coal. Four thin discontinuous sandstones alternate with coal bearing siltstone and shale intervals in the middle of the formation. The upper quartzose sandstone of the Lee is 140 to 150 feet below the Tiller coal bed or 80 to 100 feet below Dismal Creek. The Upper Horsepen coal bed is at the base of the upper sandstone and just above a very thin shale interval. The lower quartzose sandstone contains conglomerate or conglomeratic sandstone in a zone 20 feet thick in both the upper and lower part. The lower sandstone is overlain by the Lower Horsepen coal bed and underlain by the Pocahontas No. 3 coal bed at the top of the underlying Pocahontas Formation.

Drill records (Miller, 1974, p. 140-162, and Plate 1) indicate the Pocahontas Formation is from 228 to 351 feet thick in the southern half of the quadrangle and 96 to 181 feet thick in the northern half.

ECONOMIC GEOLOGY

COAL

Fifteen coal beds below the Tiller are below drainage and twenty-five coal beds or coal zones are above drainage.

The Pocahontas No. 3 coal bed, the lowest coal and the top bed in the Pocahontas Formation in this area, is 0 to 49 inches thick and in places is absent. The Pocahontas No. 3 is 0 to 49 feet below the Lee Formation and is absent in the southeastern part of the quadrangle; to the northwest it is below sea level or absent. It is also absent in the northern quarter of the quadrangle at the heads of Lynn Camp Creek, Elkins Branch, and Upper Mill Branch. Miller (1974, p. 40-42) discusses the unconformity at the base of the Lee Formation, the absence of the Pocahontas No. 3 coal bed, and states that the Pocahontas Formation is absent to the northwest. The dip of the Pocahontas No. 3 is from 0.33 to 1 degree to the northwest in the southeastern part of the quadrangle where the steepest dips occur. Thin, less than 2 inches thick, coal beds are in the upper 40 to 120 feet of the Pocahontas Formation.

Miller (1974, p. 4) believed the Pocahontas No. 3 coal bed to be the most important in Virginia and perhaps one of the most important in the Appalachian coalfields. It is mined in a very deep mine near the southern border of this quadrangle from a shaft on Dismal Creek in the Vansant quadrangle (Noble and Mitchell, 1984); the mine workings extends from the vicinity of Hobbs Branch southward to the southern border of the Grundy quadrangle.

Fourteen coal beds are between the base of the Lee Formation and the Tiller coal bed. Coal beds in the Lee Formation in descending order are: the Upper Horsepen coal bed, 0 to 17 inches in thickness at the base of the upper quartzarenite; the Middle Horsepen coal bed, 0 to 21 inches in thickness; the Middle Horsepen Marker coal bed, 0 to 3 inches in thickness about 15 to 20 feet below the Middle Horsepen; the War Creek coal bed, 0 to 18 inches in thickness; the Lower Horsepen (sler?) coal bed, 0 to 6 inches in thickness about 25 feet below the War Creek; and the Lower Horsepen coal bed, 0 to 30 inches in thickness at the top of or just above the lower quartzarenite. Three thinner coal beds are present locally in shale beds. The upper four coal beds, in the subsurface, are in the Norton Formation and are 0 to 18 inches in thickness.

The Norton and Wise Formations contain medium to high-volatile A bituminous coal. Analyses of twenty-one samples from six coal beds in the Norton and Wise Formations on an as-received basis indicate the following: percent volatile matter 27.6 to 33.0, percent fixed carbon 50.9 to 65.1, percent ash 3.1 to 17.8, percent sulfur 0.7 to 1.7, and 12,220 to 14,799 Btu per pound (Gerry Wilkes, written communication, Dec. 22, 1988). Individual analyses are in the Economic Section's files of the Virginia Division of Mineral Resources in Charlottesville, Virginia.

Eight or nine of the coal beds, or coal zones have been mined by surface and underground methods in this quadrangle. Probably the most important of these are the Kennedy, Splash Dam, Norton, Dorchester, Lyons, and Clintwood coal beds or coal zones. The Virginia Division of Mineral Resources (DMR) is standardizing the names of the coal beds in southwestern Virginia and is using names common to Wise County where the present study began. Where correlation is uncertain the name used in earlier reports of Hinds (1918) in the area just south of Slate Creek and east of Lick Branch. Elsewhere south of Slate Creek and west of Levisa Fork the thickest Splash Dam coal bed is about 39 inches. Near the southwestern corner of the quadrangle 40 to 49 inches of coal is present in two beds with five partings in a shale and rash sequence 66 to 71 inches thick. It has been mined underground in several places north of Slate Creek and in a few places to the south. Active underground mines are along the tributaries north of Slate Creek, Lynn Camp and Home creeks, and Lester Fork. Some underground mine workings are in the southeastern part of the quadrangle where as much as 49 inches of coal is being mined but the mine portals are in the Harman quadrangle to the west. A typical mine north of Slate Creek is on Lower Mill Branch where the bed being mined ranges from 19 to 30 inches in thickness.

The Hagy coal bed is 0 to 33 inches in thickness, is commonly less than 12 inches thick, and is 105 to 170 feet above the thickest bed in the Splash Dam coal zone. Hinds (1918, p. 187) reported about 40 inches of coal with an 8-inch parting within the Hagy at the lower part of Ezocha Branch but it contains only 33 inches of coal in two beds near the mouth of Elkins Branch, 8 to 18 inches of coal from the head of Looney Creek westward, 14 inches of coal in two beds on the right fork of Jesuscoal Branch, and less than 6 inches of coal south of Newhouse Branch. It is absent south of Three and Twenty Mile Branch, and north of Home Creek. The Hagy No. 2 and No. 3 coal beds are 0 to 20 inches and 0 to 4 inches in thickness, respectively. The Hagy No. 2 coal bed is more widespread than the No. 3 and is 20 to 45 feet above the Hagy coal. The Hagy No. 3 coal bed is present in the southeastern part of the quadrangle and in the northern part of the quadrangle west of Rosearn.

The Norton coal (Glamorgan, Hagy) is 12 to 80 inches in thickness and is a single bed in the southern part of the quadrangle but is two or three beds in the northwestern part with black- to gray-shale partings up to 27 inches in thickness. It is 245 to 340 feet above the Splash Dam coal zone's main bed. The Norton No. 2 coal bed is 0 to 36 inches in thickness with one or two thin partings and the Norton No. 3 coal is 0 to 5 inches in thickness with very thin shale partings, locally, north of Home Creek. The Norton and Norton No. 2 coal beds are 1.5 to 35 feet apart but commonly 20 to 35 feet apart. The Norton No. 3 coal bed is 5 to 12 feet above the No. 2. North of Slate Creek the Norton and Norton No. 2 coal beds have been mined together by surface mining, underground mining, and augering. In many surface mines they have been mined with the overlying Dorchester and Lyons coal beds. They are currently being mined underground just east of Left Fork of Looney Creek.

The Dorchester coal bed (Blair, Glamorgan, or Eagle) is at the base of the Wise Formation. It is 3 to 70 inches in thickness, with about 35 inches of coal in two to eleven beds within an interval of up to 15 feet. The Dorchester is interlayered with gray to black, carbonaceous shale partings and rash up to 2 inches in thickness. Locally, two beds are separated by a "middleman" of shale that is as much as 11 inches thick. The Dorchester coal bed is 45 to 90 feet above the Norton coal bed and about 570 to 730 feet above the Kennedy coal bed. The Dorchester has been mined extensively north of Slate Creek by surface, auger, and underground mining. The largest underground mines, now abandoned, are between Slate and Lynn Camp creeks, and Lewis Branch, and near Home Creek. In 1988 an active mine south of Home Creek was probably working this coal bed as was a mine just north of the village of Home Creek.

The Lyons coal bed (Eagle, Blair) and the Lyons? coal bed (Eagle) are 0 to 89 inches in thickness and 10 to 85 feet above the Dorchester coal bed. The Lyons occurs as one or two beds and commonly contains 35 to 50 inches of coal. Where there is only one bed it locally is as much as 61 inches thick with knife-edge partings; where there are two beds 34 to 89 inches of coal is present with partings of 1 to 46 inches in thickness. The Lyons? (Eagle) coal bed is 0 to 52 inches in thickness and is called Eagle north of Home Creek where it could be considered a bed in the overlying Clintwood coal zone. It is mapped with the Clintwood north of Home Creek where it is within 10 feet of the Clintwood bed. The Lyons and Lyons? coal beds have been mined by surface, auger, and underground mining methods in many places. Surface mining with other coal beds has been primarily in the northwestern and extreme southwestern parts of the quadrangle. A coal bed mined south of Slate Creek and called the Eagle is probably the Dorchester coal bed.

The Clintwood coal is 10 to 95 feet above the Lyons and Lyons? coal beds and is comprised of one or two coal beds with two shale or sandstone partings locally in the lower bed. The Clintwood contains 72 inches of coal in a 97-inch-thick section north of Home Creek where the lower bed contains 63 inches of coal with two partings and the upper bed is 10 inches thick above a 19-inch shale bed. A Clintwood coal bed exposure in a highwall 4000 feet southeast of Rosearn is 60 inches thick. If the Lyons? coal north of Home Creek is included in the Clintwood coal zone, the Clintwood would contain as much as 124 inches of coal in a zone 23 feet thick. Hinds (1918, p. 189) reported that the Clintwood was found at Noble and Mitchell (1984) are used. Other names in common use in this area are shown in parentheses after the name presently used by DMR.

The Tiller coal bed, the lowest coal bed above drainage, crops out only along Dismal Creek where it is in highway cuts at the southern border of the quadrangle. It and the Tiller rider coal bed range from 0 to 12 inches in thickness south of Slate Creek.

The Jawbone coal bed is 5 to 35 inches in thickness and 50 to 75 feet above the Tiller coal bed in the southern part of the quadrangle. It is in one to four beds, some of which pinch out or, south of Newhouse Branch, merge to make a coal bed 55 inches thick with shale partings 1 to 2 inches in thickness. The Jawbone rider coal bed is 0 to 17 inches in thickness with a parting, and is 15 to 50 feet above the Jawbone coal bed.

The Raven Marker coal bed (Raven No. 1) was found in a shale sequence in one drillhole located between Grapevine Branch and Harper Creek; this interval is commonly sandstone. The coal is in two beds 0 to 5 inches in thickness separated by about 5 feet of shale 130 feet above the Jawbone coal bed. It appears only in the southeastern part of the quadrangle.

The Raven No. 1 coal bed (Raven No. 2, Raven Red Ash, Garden Hole, or Jewell) is 6 to 29 inches in thickness and is 100 to 170 feet above the Jawbone coal bed. The Raven No. 1 to Jawbone interval thins toward the northwest. The Raven No. 1 is 0 to 12 feet above a sandstone along Levisa Fork and in the town of Grundy. The Raven No. 2 coal bed (Raven No. 3) is 1 to 21 inches in thickness and 60 to 90 feet above the Raven No. 1 coal bed south of Slate Creek and 15 to 40 feet above it in the north-central part of the quadrangle near the heads of Elkins and Upper Mill branches.

The Ally coal bed is 0 to 24 inches in thickness and is 60 to 105 feet above the Raven No. 1 coal bed, and 165 to 230 feet above the Jawbone coal bed. It is 19 to 20 inches in thickness and lies 2 to 4 feet below the McClure Sandstone Member of the Norton Formation near Slate Creek on the eastern side of the quadrangle. Elsewhere it is separated from the McClure by as much as 20 feet of shale or siltstone. It is less than six inches thick in the southern part of the quadrangle and is absent south of Newhouse Branch where sandstone occupies the horizon in which the Ally normally occurs.

The Kennedy coal bed (Widow Kennedy, Grundy, or Harris) is 8 to 35 inches in thickness with a gray shale parting 0.5 to 3 inches in thickness. At the Winston No. 9 mine on Grapevine Branch the Kennedy coal bed is 28 to 30 inches in thickness. Hinds (1918, p. 161) reported 30 to 34 inches of coal along Grapevine Branch that included an inch of shale 11 inches above the base. At an abandoned Kennedy mine on Lick Branch 34 inches of coal is overlain by 10 inches of shale with 1 inch of coal at the top. In the southwestern part of the quadrangle the coal is 12 to 26 inches in thickness, and in the north-central part, where it is below drainage, the coal is 23 to 26 inches in thickness. It is 2 to 10 feet above the McClure Sandstone Member and about 165 to 205 feet above the Raven No. 1 coal bed. The Kennedy coal bed is above drainage from Dismal Creek to Looney Creek and has been mined since the early 1900s when a mine at Grundy (Hinds, 1918) supplied the town. It is now mined on Grapevine Branch in the Winston No. 9 mine. Other underground mines are now abandoned; the larger ones were south of Slate Creek particularly in the vicinity of Childress, Harper Creeks, and Grapevine Branch. The Kennedy rider coal bed, a very impure, rashy, discontinuous coal, is locally 10 to 20 feet above the Kennedy coal bed. It is exposed in a cut at the fork in Harper Creek.

The Big Fork coal bed (Puncheon Camp?) is 0 to 17 inches in thickness 110 to 145 feet above the Kennedy coal bed.

The Lower Banner coal bed (Clary) is 0 to 47 inches in thickness and is 145 to 215 feet above the Kennedy coal bed. Hinds (1918, p. 164) reported 48 inches of coal on Grapevine Branch, 36 or more inches on the right fork of Harper Creek, and 18 inches on the left fork. Recent excavations on the right fork of Harper Creek exposed 29 inches of coal. On Lower Mill and Elkins branches it is 2 to 24 inches in thickness. It is absent just north of Silkon Branch in the south-central part of the quadrangle. The Lower Banner was mined underground in the southeastern part of the quadrangle, but apparently the mines have been abandoned for many years.

The Upper Banner coal bed is 0 to 17 inches in thickness and 175 to 275 feet above the Kennedy coal bed. It occurs as two beds locally in the southeastern part of the quadrangle where each bed is less than 12 inches thick and 6 to 48 inches apart. It is absent from drillhole cores from Childress Branch to Watkins and Newhouse branches where sandstone underlying the Splash Dam coal zone is thickest and appears to occupy the Upper Banner interval.

The Splash Dam coal zone consists of two to five beds that merge locally and range from 0 to 48 inches in thickness. The zone is 50 feet thick in the southern part of the quadrangle and 5 to 20 feet thick in the northern part. It is 20 to 47 feet above the Upper Banner coal bed. The Splash Dam coal zone contains two main coal beds that are 38 inches and 14 inches thick about 20 feet above the Eagle (Lyons of this report) in one place.

The Addington coal bed is 0 to 6 inches in thickness and is 15 to 35 feet above the Clintwood coal bed near the bottom of a thick shale sequence. It is visible in highwalls of the Clintwood surface mines in the northern part of the quadrangle.

The Campbell Creek coal bed, probably the Imboden or Imboden Marker coal bed of Wise County, is near the ridge tops in the northern part of the quadrangle. There may be two beds in this interval but only "blooms" and reclaimed areas were observed in 1988. The coal is 440 to 630 feet above the Splash Dam coal zone, and is the stratigraphically highest coal mined in this quadrangle. It appears to correlate with the Lower Elkhorn coal bed in Kentucky (Outerbridge, 1968), less than three miles to the northwest.

Younger coal beds have been mined on the Campbell Creek coal on the highest hills north of Home Creek. Beds have been found in that part of the section to the northwest (Outerbridge, 1968; Hinds, 1918, p. 201).

GAS

Natural gas has been produced in the Grundy quadrangle from rocks of Devonian and Mississippian age. Records of drillholes on file with the Division of Gas and Oil indicate that 23 holes have been drilled in this quadrangle since 1948. Ten were producing gas in 1988. The gas production appears to be unrelated to structure observed at the surface.

The drillholes ranged from 2898 to 6453 feet in depth, but most of the gas was produced from the Greenbrier Limestone of Mississippian age ("Big Lime" of drillers) at depths of 3370 to 3950 feet or 1520 to 1810 feet below sea level and 1650 to 1740 feet below the Pocahontas No. 3 coal bed. Production in one well was from the "Injun" sandstone in the Macrady Formation and possibly from the "Injun" and "Big lime" in another well. Many holes were drilled into Devonian rocks below the Mississippian but plugged back to the "Big Lime," shot, and acidized in some cases. One abandoned well had an oil show and another, a dry hole on the left fork of Upper Mill Branch, had shows of oil and gas in the Lee Formation of Pennsylvanian age. One hole, now plugged, had shows of gas from 630 feet to 5620 feet in depth. Many holes had shows of gas from 700 to 4000 feet in depth. Initial production from four of the wells that are still in production was 1138 to 3052 thousand cubic feet of gas per day.

CLAY AND SHALE

Clay and shale samples collected from just south of Grundy and to the southwest of this quadrangle show potential for use as brick, tile, lightweight aggregate, and probably drain tile (Johnson and others, 1966).

WATER RESOURCES

The Grundy quadrangle is in the Big Sandy River basin and has small quantities of surface and ground water. Streams in steep and the first order streams are short with steep gradients allowing rapid runoff of precipitation. During extended periods of low precipitation the streams are only trickles.

Epps (1978) and Scales (1988) have discussed water in the southwest Virginia coalfields and Buchanan County. Precipitation is 37 to 44 inches a year (Epps, 1978, p. 7) but the last few years have brought below average precipitation. Because of thin soil, steep slopes, and relatively impermeable rocks, little water goes into the ground in the mountains. On the small flats along the Levisa Fork and Slate Creek where ground-water recharge rates are higher and where most development occurs, flooding is common and precludes most groundwater development. The best aquifers are coal beds, abandoned mines, and stress-relief and tectonic fractures within a few hundred feet of the surface. The stress-relief fractures may be closed below 400 feet in depth where water volume and flow is diminished and where the water becomes increasingly saline. The groundwater is hard, slightly acidic, saline at greater depths, and contains iron and other elements as well as hydrogen sulfide and methane locally. Epps (1978) discusses ways to vent gases and reduce undesirable elements and bacteria from groundwater.

NATURAL HAZARDS

This area of steep slopes, narrow V-shaped valleys, and little flat land has been sculptured by streams and modified by landslides and rockfalls. Surface mining and other excavation contributes to the instability of slopes locally. Abandoned surface mines that have not been reclaimed to the original contour offer good foundation conditions but they also create potential rock fall or ground slumping conditions from highwalls and spoil areas respectively. Recent mining has been followed closely by reclamation to restore the areas to the approximate original contour of steep slopes. The steeper reclaimed areas may still have potentially unstable slopes. The Division of Mined Land Reclamation monitors reclamation during and after mining to prevent erosion and forestall landslides. Commercial builders as well as home builders should be made aware of the many colluvial slopes, old as well as recent landslides, cliffs, and mine highwalls that are potentially unstable. Landslide deposits may become active landslides after heavy rains if the "toe" or base of a slide deposit is cut by road, surface mine, or foundation excavation. Slow-moving earthflows, debris avalanches, and rockfalls damage property, temporarily block transportation routes, and can endanger life. If potentially unstable areas cannot be avoided, detailed engineering studies should be made to identify and mitigate the slope instability. Outerbridge (1979) shows landslides and related features in the Grundy quadrangle.

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SYSTEM AND SERIES	FORMATION, MEMBER, AND BED	COAL THICKNESS IN INCHES	UNIT THICKNESS IN FEET
QUATERNARY	Alluvium		0-20 (?)
	Colluvium		0-25 (?)
PENNSYLVANIAN, MIDDLE, WISE FORMATION	Campbell Creek coal	27-467	280+
	Addington coal	0-6	780+
	Clintwood coal	1-72	200-240
	Lyons ? coal	0-34	
	Lyons coal	0-89	90-165
	Dorchester coal	3-72	
PENNSYLVANIAN, MIDDLE, NORTON FORMATION	Norton 3 coal	0-5	245-340
	Norton 2 coal	0-36	
	Norton coal	12-80	
	Hagy 3 coal	0-4	255-260
	Hagy 2 coal	0-20	105-170
	Hagy coal	0-24	
	Splash Dam coal zone	0-48	20-47
	Upper Banner coal	0-17	95-145
	Lower Banner coal	0-47	
	Big Fork coal	0-17	145-215
	Kennedy rider coal	0-7	110-145
	Kennedy coal	8-35	
PENNSYLVANIAN, LOWER, NORTON FORMATION	McClure Sandstone Member		2-20
	Ally coal	0-24	60-105
	Raven 2 coal	1-21	
	Raven coal	6-29	100-170
	Raven Marker coal	0-5	
	Jawbone rider coal	0-12	15-50
	Jawbone coal	5-35	50-75
	Coucourse Sandstone Mbr.	0-12	20-45
	Tiller rider coal	0-12	0-12
	Tiller coal	0-12	50-75

DESCRIPTION

Silt, sand, gravel, cobbles, and boulders, unstratified, light- to medium-gray, brownish-gray, and brown. Silt and sand mostly quartz. Gravel, cobbles, and boulders, rounded to angular, composed of sandstone, conglomerate, siltstone, shale, and coal.

Silt, clay, sand, pebbles, cobbles, and boulders, mixed, very light-gray, brownish-gray and light-brown; on slopes. Colluvium and landslides shown on map by Outerbridge (1979).

Sandstone, siltstone, shale, and coal. Sandstone, micaceous, feldspathic, light- to medium-gray and pale-yellowish-brown to yellowish-brown, fine- to medium-grained, thin- to thick-bedded, crossbedded to even-bedded, indurated, friable when highly weathered. Siltstone and silty shale, medium- to dark-gray, weathers brown. Campbell Creek coal at base.

Sandstone, siltstone, shale, limestone, and coal. Sandstone, micaceous, feldspathic, light- to medium-gray, weathered yellowish-gray to light- to moderate-brown-brown and grayish-orange, fine- to coarse-grained, crossbedded to even-bedded, thin to medium beds, massive, well-indurated, friable when weathered; bench and cliff-former below Campbell Creek coal. Siltstone, silty shale and shale, medium to dark-gray, weathers to shades of brown; contains plant fossils, thin ironstone or iron-siltstone lenses and nodules; interbedded with medium-gray, fine- to medium-grained, micaceous, thin-bedded sandstone 0 to 15 feet in thickness below Addington coal; comprises lower part of unit locally. Limestone, micritic, medium- to dark-gray, weathers very light-gray, unfossiliferous; occurs locally as 0 to 8-inch thick bed or lenses in shale, locally 50 to 60 feet above the Clintwood coal; an extensive marine zone to the south (Noble and Mitchell, 1984, p. 6) about 35 feet above the Clintwood is believed to be equivalent to the Cameron Limestone of White (1885). The shale and siltstone may also be equivalent to the Betsie Shale Member of the Breathitt Formation (Rice and others 1987). The Addington coal is thin and apparently discontinuous.

Sandstone, siltstone, shale, and coal. Sandstone, micaceous, feldspathic, light- to medium-gray, weathers grayish-orange to grayish-brown and pale-yellowish-brown, fine- to medium-grained, crossbedded, locally even-bedded, thin- to thick-bedded and massive, well-indurated, weathered surface friable; cliff former; contains sandy shale lenses and carbonized plant fossils, siltstone, shale, and siderite nodules as large as 6 x 24 inches locally below the Clintwood coal. Similar sandstone beds are below the Lyons coal. Siltstone, and silty shale, light-olive-gray, and medium- to dark-gray, weathers brown, laminated to thin-bedded; contains ironstone lenses and nodules as much as 1-inch thick.

Sandstone, siltstone, shale, and coal. Sandstone, micaceous, feldspathic, light- to medium-gray, weathers yellowish-brown to yellowish-gray, fine- to medium-grained, thin- to thick-bedded, crossbedded. Sandstone above the Norton coal on White Oak Creek contains quartz pebbles. A regionally extensive sandstone below the Norton coal ranges from 25 to 100 feet in thickness; Thinner sand stones also above Hagy No. 2 coal and locally above Hagy coal. Siltstone and silty shale, medium- to dark-gray, weathers yellowish-brown, laminated to thin-bedded, sparse plant fossils in lower part; most common above Hagy coal bed in southern part of quadrangle, locally above Hagy No. 2 and Hagy No. 3 coal beds north of Home Creek. Noble and Diffenbach (1988), Whitlock and others (1988), and Outerbridge and Van Vlesten (1968), correlate these shales with Eagle Shale of White (1885 and 1891) and Eagle Limestone of White (1891).

Sandstone, siltstone, shale, and coal. Sandstone, micaceous, feldspathic, light- to medium-gray, weathers yellowish-brown to yellowish-gray, very fine- to medium-grained, very thin- to thick-bedded and massive; contains crossbedded plant fossils as much as 6 inches in diameter and 5 feet long, gray shale, and ferruginous nodules and lenses 0.5 inch thick; 2 to 97 feet in thickness; north of Home Creek sandstone comprises most of section from the Splash Dam coal to the Hagy No. 3 coal. Very fine-grained sandstone within Splash Dam coal zone grades laterally into fossiliferous silty shale. Siltstone and silty shale, medium- to dark-gray, laminated to thick-bedded; contains plant fossils and thin sandstone bodies within Splash Dam coal zone.

Siltstone, shale, limestone, sandstone, and coal. Siltstone and shale, light- to medium-gray, weathers light-olive-gray to dark-yellowish-brown and pale-brown, poorly laminated to laminated, very thin- to thin-bedded, platy to very fissile, interlaminated and interbedded with sandstone, grades into very fine-grained sandstone locally a few feet above the Kennedy and Kennedy rider coal beds; contains plant fossils. Sandstone, micaceous, feldspathic, light- to medium-gray, weathers yellowish-brown, fine- to medium-grained, Cre