Kentucky Geological Survey

CHARLES J. NORWOOD, Director

BULLETIN No. 10.

Coals of the Licking Valley Region

AND OF

SOME OF THE CONTIGUOUS TERRITORY

INCLUDING

Also an Account of Elliott County and its Dikes

BY A. R. CRANDALL, Ph. D.

OFFICE OF THE SURVEY: LEXINGTON, KY.

1910

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INDEX A.

MORGAN AND MAGOFFIN COUNTIES

LICKING VALLEY.

PAGE

Abbreviations ---- 30
Adams, William ---- 25
Adkins' (Owen) Coal ---- 10
Allen Branch Coal 2A, Magoffin County ---- 28
Allen No. 1 Coal ---- 20

Analyses of Coals:

- Back's (J. W.) Coal ---- 19
- Cannel in Caney Creek Region ---- 13, 14
- Colvin Cannel ---- 18
- May's Coal ---- 28
- Mordecai Creek and Rush Branch Cannel ---- 8
- No. 3 Coal ---- 10
- Salyersville Coal ---- 18
- Stacey Coal ---- 18
- Arnett Four-foot Coal ---- 19

Back, J. W. ---- 18
Bastard Limestone ---- 17, 25
Beetree Branch, Magoffin County ---- 21
Ben Branch Coal, Magoffin County ---- 25
Berry, A. B. ---- 8
Blackwater Creek, Morgan County ---- 31
Blair Fork Coal, Morgan County ---- 6
Blair, Judge ---- 6
Breathitt County ---- 22
Broas, R. M. ---- 13
Brushy Fork of Caney Creek, Morgan County ---- 15
Buck's Branch Coal, Morgan County ---- 10
Buffalo Fork of Lick Creek, Magoffin County ---- 25
Burning Fork, Magoffin County ---- 27, 28
Burton Fork of State Road Fork, Magoffin County ---- 22
Caney (Walnut Grove) ---- 13, 15
Caney Creek, Morgan County ---- 12, 13, 15
Cannel City ---- 13, 15

PAGE

Canter, Thos. ---- 11
Caskey's (George) Coal ---- 9
Caskey's (Richard) Coal ---- 9
Cecil Cannel ---- 15
Central Kentucky Uplift ---- 32
Chalybeate Branch, Morgan County ---- 6
Clay Lick Branch, Morgan County ---- 6

Coals:

First above the Conglomerate Series ---- 5
No. 1 ---- 7, 9, 12, 13, 15, 16, 17, 20, 23, 24
No. 2 ---- 6, 7, 9, 10, 12, 13, 15, 16, 17, 18, 20, 21, 23, 24, 25, 26, 27
No. 2A ---- 12, 16, 22, 24, 27, 28
No. 3 ---- 6, 10, 15, 16, 26
No. 4 ---- 15, 16, 26
No. 5 ---- 7, 26
No. 6 ---- 26
No. 7 ---- 26
"Subconglomerate" ---- 2

Colvin Cannel ---- 18
Combs Entry ---- 21
Conglomerate Formation, Thickness of ---- 4
Conley Cannel ---- 10
Cooper's (Judge) Coals ---- 24
Cox Cannel ---- 15
Craft's Fork Coal, Magoffin County ---- 20
Cranes Nest Branch, Magoffin County ---- 17
Cumberland Axis ---- 32
Day, Judge ---- 15
Devil Fork, Morgan County ---- 5
Dips of Formations ---- 31
Drill Well Geology ---- 29
Dulin Branch Coal, Morgan County ---- 12
Elk Bridge ---- 8
Elk Fork, Morgan County ---- 7, 9
Fannin Fork, Morgan County ---- 9, 10
Fannin, Jno. ---- 10
Faults ---- 32
Fault Line ---- 16
First Coal above the Conglomerate Series ---- 5
Floyd County ---- 16
Fossil-bearing Rocks ---- 19, 21
Frozen Creek, Breathitt County ---- 15
Gorden Bend ---- 15
Grassy Creek ---- 23
Gunn Creek, Magoffin County ---- 27

PAGE

Half Mountain Creek, Magoffin County ---- 21
Head of Right Fork of Johnson Creek, Magoffin County ---- 16
Heights of Hills ---- 3
Hollbrook's (Randolph) Place; Coal-facings at ---- 29
Honeycomb Sandstone ---- 26
Howard, D. H. ---- 20
Howard, John ---- 20
Howard, Wade ---- 6
Howe, Henry ---- 25
Hutchinson's Coal ---- 9
Indian Creek, Morgan County ---- 9
Iron Ore ---- 10, 24, 26
Ison, Dr. ---- 12
Ivyton ---- 28
Johnson County ---- 16
Johnson Creek, Magoffin County ---- 16
Keaton, B. F. ---- 9
Keller, W. W. B. ---- 27
Kenaird, D. M. ---- 20
Laurel Creek, Coal on, Morgan County ---- 10
Left Fork ---- 8
Letter of Submittal ---- xvii
Letter of Transmittal ---- xv
Lewis Coal ---- 12
Lick Creek, Morgan County ---- 7, 9
Limestone Ore Horizon ---- 26
Little Caney Creek, Morgan County ---- 15
Little Creek, Section on, Morgan County ---- 12
Little Sandy Drainage ---- 10
Lower Sand Lick Creek, Morgan County ---- 11
Lykens, P. O. ---- 16
Marshall, Ad. ---- 21
Marshall, Jack ---- 27
Marshall, Lewis ---- 27
May, Henry ---- 27
May's Coal ---- 22, 27
McCarty Place ---- 20
Meetinghouse Branch, Morgan County ---- 12
Middle Creek, Head of, Morgan County ---- 28
Middle Fork Cannel, Magoffin County ---- 20
Middle Fork, Morgan County ---- 9
Middle Fork Region, Magoffin County ---- 18
Montgomery, Ben ---- 24
Montgomery, Calloway ---- 21
Montgomery, Isaac ---- 21
Mordecai Creek, Morgan County ---- 6, 7, 8, 9
Mordecai Creek Cannel ---- 8

	PAGE
Newtown	16
North Fork Cannel, Morgan County	6
North Fork Region, Morgan County	5
Oakley Coal Seam	21
Oakley Creek, Magoffin County	21, 27
Oakley Creek, Right Fork of, Magoffin County	22
Oil Horizons	29
Open Fork, Coal 2 on, Morgan County	12
Open Fork of Paint Creek, Morgan County	11
Patrick, B. C.	27
Pipe Line Pump Station	27
Pleasant Run, Morgan County	8
Prather, Thos.	27
Pricey Creek, Magoffin County	16
Pruett, J. D.	20
Raccoon Fork, Magoffin County	25
Right Fork of Johnson Creek, Magoffin County	16
Right Fork of Oakley Creek, Magoffin County	22
Right Fork of White Oak Creek, Morgan County	15
Right and Left Forks of White Oak Creek, Magoffin County	16
Rockhouse Creek, Magoffin County	24
Rockhouse and Lick Creek Region, Magoffin County	23
Rush Branch, Coals on, Morgan County	6, 7, 8, 10
Salt Lick Creek, Magoffin County	23
Salyersville	27
Salyersville Branch, Magoffin County	27
Salyersville Coal Bed, Magoffin County	18
Sand Lick Creek, Morgan County	11
Sand Lick Coals, Section of, Morgan County	11
Second Coal above the Conglomerate Series	6
Section, General	5
Shepherd Coal	22, 27, 28
Shepherd, John	22
Shoal Branch, Morgan County	7
Silurian Axis	32
Smith Branch, Morgan County	7, 9
Smith Branch Cannel, Morgan County	12
Smith's Creek, Morgan County	11
Stacy Coal	18
Stacy Fork of Caney Creek, Morgan County	15
State Road Fork, Magoffin County	27
State Road and Burning Forks Region, Magoffin County	26
Straight Creek, Morgan County	6
Straight Creek, Left Fork of, Morgan County	9
"Subconglomerate" beds are part of the Conglomerate Series	2
Topography of Licking Region	1
Trimble, Nelson	9

	PAGE
Upheaval	16
Upper Sand Lick Creek, Morgan County	11
Upthrow (Axis of) from Elliot County to W. Virginia Line	23
Vein Deposits	1
Walnut Grove	13
Wedge's Coal	19
West Liberty, Coal near	15
White Oak Creek, Head of, Magoffin County	16
White Oak Creek, Right Fork of, Morgan County	15
Williams Coal	17
Williams Fork, Morgan County	9
Williams, J. T.	15
Williams' Store	17
Wolf Gap	19
Yearling Branch, Morgan County	13

INDEX B.

MENIFEE COUNTY

LICKING AND RED RIVERS.

	PAGE
Analyses of Coals	45
Area of the County	35
Beaver Creek	40, 43
Beaver Creek Shales and Coal	42, 43
Beaver Furnace	42, 43
Blackwater Creek	44
Blackwater Regions	38
Brushy Creek	42
Bull Fork	40, 41, 43
Cane Creek	41
Cannel	43
Cannel Slate	41
Chimney-top Creek	41
Clear Creek	44
Clear Creek Furnace	44
Drainage of the County	35
Dry Ridge	42
East Fork of Indian Creek	41
Fireclay Bed	39
Freestone	45
Frenchburg	43
Gas, Natural	45
Geology, General Statement of	35
Gibbs, Green, Farm of	41
Gilladie Creek	40, 42
Hawkins Creek	43
Indian Creek	40
Iron Ore	39, 40, 42, 43
Leatherwood Fork of Indian Creek	41, 42
Limestone, Lithographic	43
Limestone Ore	40, 42, 43
Limestone, Pure	45
Lithographic Limestone	43
Lower Formations	45
Maytown	44

	PAGE
McMurtry Quarry	43
Middle Fork of Indian Creek	42
Morgan County	42; 44
Muddy Fork of Indian Creek	41
Natural Gas	45
Old State Road Branch	43
Powell County	40
Profile Section	38
Red River	40
Red River Valley Shales	42
Salt Lick Valley	44
Shales and Cannel Slate	41
Slate Creek	40, 42
Slate Creek Valley Coal	40
Soils	45
Subconglomerate Coal	38, 40
Subconglomerate Shales	42
Subconglomerate Series	40
Wolf County	41, 44

INDEX C.

COALS ALONG A LINE FROM CAMPTON TO MOUTH OF TROUBLESOME CREEK.

PAGE

Agricultural value of the Region ---- 48
Analyses of Coals ---- 53, 57, 62, 64, 65
Bear Pen Branch of Upper Devil Creek, Coals on ---- 53
Campton, Coal near ---- 53, 54
Cannel ---- 52, 57, 58
Cannel Near Head of Nichols Fork of Frozen Creek ---- 58
Cannel on Quicksand Creek ---- 59
Coal No. 1 ---- 53
Coal No. 2 ---- 54
Coal No. 3 ---- 54, 55
Coal No. 4 ---- 59
Coals above Haddix Cannel ---- 60
Coals, Character of ---- 52
Coals, Summary regarding ---- 66
Coals, Undetermined ---- 61
Conglomerate below drainage near mouth of Frozen Creek ---- 50
Conglomerate Sandstone described ---- 50
Curly Cannel ---- 58
Day's Old Mine ---- 53
Frozen Creek ---- 53
Frozen Creek, Coals on ---- 54, 61
Georges Branch Cannel ---- 59
Georges Branch, Coals on ---- 61
Gilman Creek, Cannel on ---- 61
Haddix Cannel ---- 60
Holley Creek, Coal near mouth of ---- 53
Jackson, Coal at and near ---- 55, 56
Limestone, Subcarboniferous (Mississippian) ---- 51, 52
Quality of the Cannels ---- 64
Quicksand Creek, Cannel on ---- 59
Quicksand Creek, No. 3 Coal at mouth of ---- 55
Salt Well, Old ---- 53
Stillwater Creek, Cannel on ---- 61, 62
Swift's Camp Creek, Coal on ---- 53
Topography ---- 48
Troublesome Creek, Cannel at Mouth of ---- 60
Troublesome Creek, Coal below mouth of Buckhorn Creek ---- 62
Undetermined Coals ---- 61
Wolf Creek, Coals on ---- 55, 61

INDEX D.

COALS, ORES, ETC., OF ELLIOTT COUNTY.

PAGE

Apatite ---- 90
Bailey, George, Coal of ---- 81
Bastard Limestone ---- 73
Big Branch, Coal on ---- 80
Biotite ---- 87, 90
Blaine Trace, Coal on ---- 76, 79
Boggs', Bryan, Coal near ---- 76
Bowling, Robert, Coal of ---- 82
Branham Branch, Coal on ---- 80
Briar Branch, Coal on ---- 79
Bruin Creek, Coal ---- 75, 80
Brush Creek, Iron Ore at mouth of ---- 76
Brush Creek, Left Fork of ---- 75
Brushy Forks, Coal on ---- 76
Buck Creek, Coal on ---- 81
Caldwell, Thos., Coal of ---- 74
Cannel ---- 74, 79
Coals and Iron Ores ---- 72

Coals, Occurrences of:

Bailey's, George ---- 81
Bowling's, Robert ---- 82
Blaine Trace, on ---- 76
Blaine Trace, toward head of ---- 79
Branham Branch, on ---- 80
Briar Branch, on ---- 79
Brushy Fork, on ---- 76
Buck Branch, on ---- 81
Caldwell's, Thos. ---- 74
Conn's, Watt ---- 81
Creeches Creek, at head of ---- 74
Enoch Fork, on ---- 78, 81
Evans', Robert ---- 80
Flaghers Branch, on ---- 78
Fraley's, Wade ---- 81
Fulton's, Robert ---- 75
Gilbert Fork, on ---- 81
Greasy Ridge, in ---- 75
Ison Creek, on ---- 74, 75
Ison's, Ison ---- 74

Coals, Occurrences of—Continued:

PAGE

Lewis's, Howard ---- 81
Little Fork, on ---- 76
Little Fork Valley ---- 74
Martinsburg, Coal near ---- 80
Meadow Branch, on ---- 79
Newcomb Creek, on ---- 80
Nicholas Branch, on ---- 79
Prewitt's ---- 78
Princess Branch, on ---- 79
Porter's, Francis, near ---- 76
Redwine, at head of Billys Branch ---- 77
Ridge between Newcomb Creek and Middle Fork, in ---- 74
Robert Green Branch, on ---- 79
Stevens', Andrew ---- 74, 75
Wallowhole Creek, on ---- 79
Watson's, Martin ---- 81
Wells Branch, on ---- 81

Coals, Referred to by Number:

No. 1 ---- 69, 78, 79, 80, 82
No. 2 ---- 69, 75, 78, 79, 80, 81, 82
No. 4 ---- 80
No. 5 ---- 77, 78, 79, 82
No. 6 ---- 72, 76
No. 7 ---- 72, 73, 75, 76
No. 8 ---- 72, 73, 74, 75

Conglomerate Sandstone ---- 68
Conglomerate Tablelands ---- 69
Creeches Creek ---- 70, 74
Diamonds ---- 86, 87
Dike ---- 70, 83, 86, 87
Dolomite ---- 87, 90
Drainage of the County ---- 67
Enoch Fork, Coal on ---- 78, 81
Enstatite ---- 87, 90
Farm Lands ---- 69
Ferriferous Limestone ---- 72, 76
Greasy Ridge, Coal in ---- 75
Gilberts Fork ---- 81
Hurricane Branch ---- 79
Ilmenite ---- 87, 90
Iron Ore ---- 72, 73, 76, 77
Ison Creek ---- 71
Isonville ---- 81
Kimberlite ---- 87

PAGE

Left Fork of Brush Creek ---- 75
Limestone, "Bastard" ---- 73
Limestone, "Ferriferous" ---- 72, 76
Limestone Ore ---- 76
Limestone, the Shawnee ---- 73
Limestone, Subcarboniferous (Mississippian) ---- 68
Little Fork, Coal ---- 74, 76
Little Fork, Iron Ore ---- 73, 77
Magnetite ---- 87, 90
Martinsburg, Coal near ---- 80
Meadow Branch, Coal on ---- 79
Newcomb Creek, Coal on ---- 80
Newcomb Creek, Iron Ore on ---- 73
Nicholas Branch, Coal on ---- 79
Octahedrite ---- 87, 90
Olivine ---- 87, 90
Peridotite ---- 71
Peridotite Dike ---- 83
Precious Metals ---- 72
Precious Stones ---- 86
Princess Branch, Coal on ---- 79
Pyrope ---- 87, 90
Pyroxine ---- 87
Serpentine ---- 87, 90
Shawnee Limestone ---- 73
Subcarboniferous (Mississippian) Limestone ---- 68
Timber ---- 70
Topography ---- 67
Trap Dike ---- 70, 83
Wallowhole Creek, Coal on ---- 79
Wells Branch, Coal on ---- 81

PLATES.

	PAGE
Section for Greenup, Boyd, Carter, Etc., faces	4
Page Map of Caney Creek Region, Morgan Co., faces	12
Plates A and B, Drilled-Well Sections, between	30 and 31
Plates I, II, and III, between	34 and 35
Profile Section, Jeffersonville to Blackwater Creek, between	38 and 39
Plates IV, V and VI, between	46 and 47
Kentucky Gap, Elliott Co., faces	66
Conglomerate Cliffs, faces	72
Plates VII and VIII, between	82 and 83

LETTER OF TRANSMITTAL.

To His Excellency, AUGUSTUS E. WILSON,

Governor of Kentucky.

Sir: This report on the coals of the Licking Valley and some of the contiguous territory was prepared during the administration of your predecessor, Hon. J. C. W. Beckham, and was ordered to be printed near the close of 1907. The long delay in publication, for which, as you are aware, the present writer is not responsible, has been unfortunate, though not without some compensations as indicated in the postscript to the Letter of Submittal.

In addition to the report on the coals of the region drained by the upper waters of the Licking, in Morgan and Magoffin counties, the Bulletin includes a report on Menefee county (which is drained in part by Licking river waters and in part by tributaries of Red river); a report on the coals, ores, and dikes of Elliott county; and extracts from an older sketch-report on the region adjacent to a line from Campton, Wolfe county, to the mouth of Troublesome creek, Breathitt county. Portions of the latter report have been included only to serve as a fairly good make-shift until a more comprehensive and more detailed report on the resources of Wolfe and Breathitt counties can be prepared. An extended account of the coals on Troublesome creek and its tributaries is given in Bulletin No. 11 (Coals of the Three Forks of the Kentucky River). A report on the coals on the Quicksand creeks, based on field work done during the present year (1910), is nearing completion.

For information concerning coals of Estill, Wolfe, and Breathitt counties, Bulletins 11 and 12 (both of which are in type) and the report on the Quicksand drainage should be consulted in conjunction with this one. It is believed that they will serve general purposes until the county surveys can be undertaken, and this, for the attainment of a reasonable

degree of finality, must await the completion of more accurate maps of the regions than are now in existence. The field work for such maps is being carried on in co-operation with the U. S. Geological Survey. As explained in my last Biennial Report, it was necessary, in behalf both of accuracy and of ultimate economy, to bring the work westward from the Tug Fork of the Big Sandy river; this is being done as rapidly as circumstances will permit.

Very respectfully,

C. J. NORWOOD,

Director, State Geological Survey.

Lexington, Ky.,
November 24, 1910.

LETTER OF SUBMITTAL.

PROFESSOR CHARLES J. NORWOOD,

Director, Kentucky Geological Survey.

Dear Sir:—I herewith submit a revised report on the coals of the Licking Valley, in part based on notes of unfinished work done under my supervision in 1891 in addition to field work carried on in 1905 and 1906. Much is added to the data given in previous publications on this field, though detailed stratigraphis studies of many parts of the large territory are necessarily still lacking. It was planned to add a comprehensive report on the coals of parts of Wolfe and Breathitt counties bordering this field, but the continued illness of Mr. S. A. Denny, who had been detailed to assist in that work, prevented the completion of the necessary field work. The present expectation is to resume that work during the season of 1908.

Respectfully,

A. R. CRANDALL,

Assistant Geologist.

Lexington, Ky., September 1, 1907.

POSTSCRIPT.

Delays in printing since the foregoing was written have made it possible to include in this Bulletin revised reports on the coals of Menefee and Elliott counties, the latest data on the dikes of the latter county having been obtained in 1908, after part of the Bulletin was in type.

BRIEF REPORT ON THE COALS OF THE LICKING VALLEY REGION.

All the territory comprising the counties included in this report is within the coal-field of Eastern Kentucky, the western boundary of Morgan falling within the general outline of the Coal Measures.

In any report on the resources of this region, the coal-beds and oil basins are of central importance. Along with these the minor mineral deposits, the rock formations, as giving character to the soil and supplying building materials, and finally the timber and other products of the soil, are subjects of interest, and altogether constitute no inconsiderable part of the natural wealth of the country, as will be found in any well-directed effort to develop the resources of these counties.

The stratigraphical geology of this region forms the basis for the study of all the features that fall within the province of this report. There are, so far as known, no true vein deposits of value, nor are there antecedent reasons for supposing that mineral deposits occur otherwise than conformably with the stratification of the inclosing rocks.

The topography of this region is closely related to the stratigraphical geology. The dip to the southeast along the western border presents a succession of rocks of widely different character in that direction from the line of outcrop of the Coal Measures. The same is true in the opposite direction of the formations below; the Lower Carboniferous, Devonian, Upper and Lower Silurian rocks following in their order with characteristic surface features. The western part of Morgan shows something of the characteristic topography of the Lower Carboniferous formations,

the valleys being excavated in part out of the Waverly group of sandstones and shales, the Subcarboniferous limestone forming a bench with its ledges above. The massive conglomerate sandstone, from merely capping the hills at its western outcrop, rapidly becomes the predominating rock to the eastward, where it is exposed in cliffs and ragged escarpments, which in turn give place to the characteristic topography of the shales and sand-stones of the Coal Measures proper; the Conglomerate formation falling below the drainage. About two hundred feet thickness of the Waverly formation is shown in the Licking Valley at the western border of Morgan county. The Subcarboniferous limestone, which rests upon the Waverly without any considerable thickness of transition rocks intervening, has an average thickness of about fifty feet. The Conglomerate formation has a maximum thickness of two hundred feet, and is separated from the limestone below by from ten to fifty feet or more of shale, including a thin bed of coal, the "Sub-conglomerate" of coal of Menefee county. This shale, with its coal or coals, has been called the Sub-conglomerate shale but may be regarded as a part of the Conglomerate coal measures of Kentucky. The belt of country in which these rocks are exposed is comparatively narrow. The dip to the southeast in this belt is from thirty to fifty feet to the mile, and the Conglomerate sand-rock disappears below the drainage of the Licking Valley half a mile below the mouth of the Elk Fork. An axis of upthrow extending from the border of Elliott county into Johnson, nearly at right angles to the ordinary outcrop line, brings the Conglomerate rocks into prominence further to the eastward, and extends the characteristic topography of this formation in a narrow belt across to within a few miles of Paintsville. This wave-like elevation was not so sharply drawn as to become also a well-defined water-shed. On the other hand, it falls across the head-waters of Big Blaine, and extends into the valley of Big Paint Creek, and the Conglomerate cliffs are exposed in valleys cutting across the axis of upheaval. On Keaton's fork of Blaine, thirty feet of Conglomerate is shown; on the Laurel creeks one hundred and twenty-five feet; Hood creek cuts through this axis, exposing ninety feet; while Big and Little Paint creeks

have cut through one hundred and fifty feet or more of this rock.

The northward dip described in the report on the geology of Lawrence county, and also represented on map diagram of dips in Greenup, Carter, Boyd and Lawrence counties, will be more readily understood by its relation to this axis of upthrow, which extends in decreased prominence to the West Virginia line.

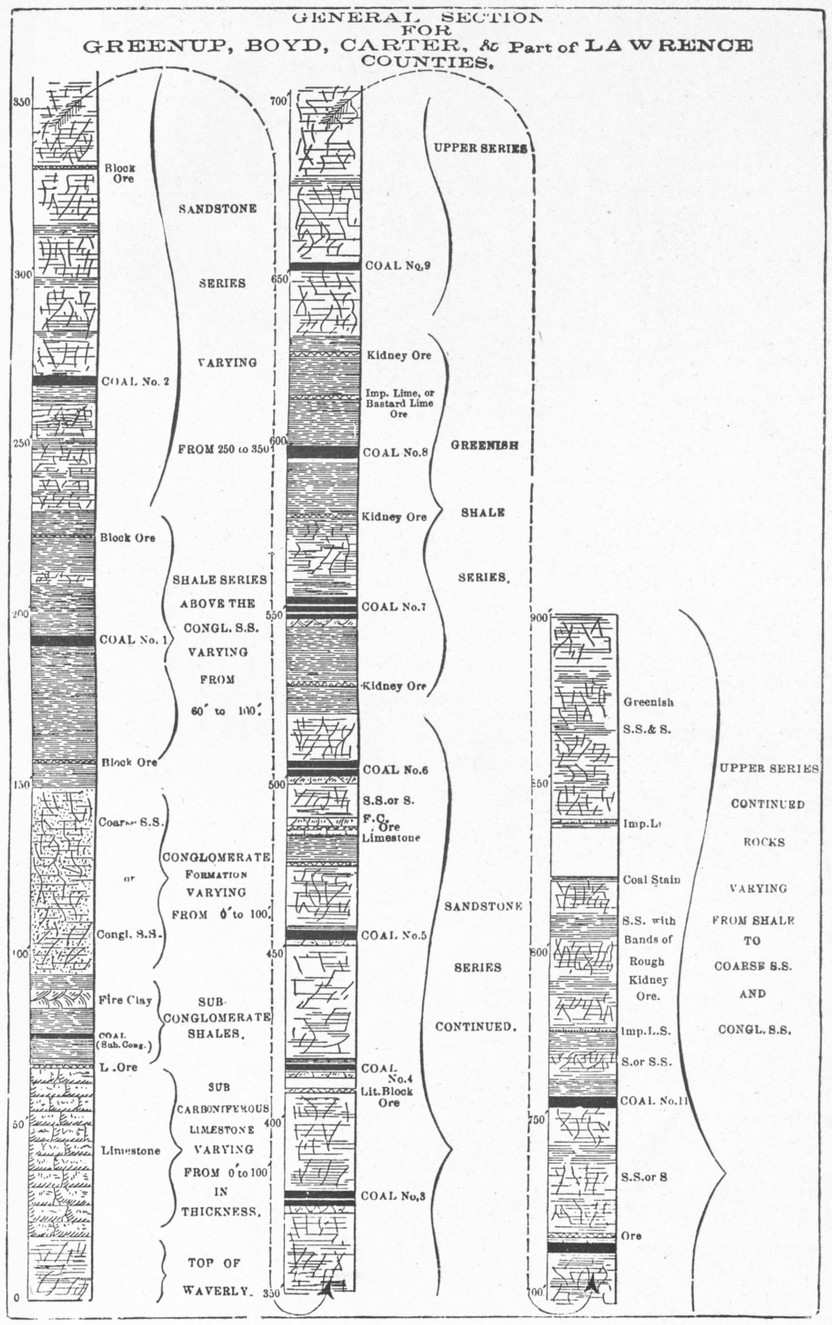
To the southward, the dip is not so well marked, and it is soon lost with the relatively greater elevation of the whole series in that direction.

East and south from the Conglomerate sand-rock belt, the shales and sandstones of the series above the Conglomerate make up the whole height of the hills, which vary from three hundred to seven hundred feet. As the Conglomerate series falls considerably below the drainage at points where the hills are highest, the whole thickness of the productive series above may be placed at about eight hundred feet, or about the same as is exposed in the block of counties to the north. (See general section from report on Greenup, Carter, Boyd and Lawrence counties, reprinted in this report). The dip of the rocks in all this region is slight and somewhat variable, and the topography is such as should be expected from like conditions—crooked streams, dividing ridges of great complexity, with minor ridges and spurs, completing an elaborate and tortuous system of drainage. The height of the hills in the eastern part of Morgan and in Magoffin is from 300 to 450 feet. To the westward they reach 550 feet, and to the eastward, in the valley of the Levisa Fork of the Chattarawha or Big Sandy river 700 feet or more. The increased height in either case is in the direction of the drainage, so that the water-shed between the Licking and Sandy waters is not a prominent feature in the profile of the country.

COALS, ORES, ETC.

Beginning at the base of the Carboniferous series, the first coal-bed is found in the shales between the Subcarboniferous limestone and the Conglomerate sandstone—the great cliff-forming member of the Coal Measurers. This is the "Sub-conglomerate" coal of previous reports on portions of the coal-field of Eastern Kentucky, which include the western outcrop. (Lesley's Report on the Western Margin of the Eastern Coal-field, volume IV, Old Series; Report on the Geology of Greenup, Carter, etc., volume I., part 1, Second Series; Report on the proposed line of the E. L. & B. S. R. R., volume I, part 10; Report on the Geology of Menefee county, volume IV, part 2.)

This coal is not known at any place in Morgan county as a workable bed for more than local purposes—for blacksmith's use, etc. It is in quality an excellent coal, and will be found nearly always where the "Sub-conglomerate" shales are exposed in thickness varying from a few inches to two feet. Section 3, plate I., near the mouth of Greasy creek, shows this coal below high-water mark, accompanied by another thin seam. Eastward from here it falls below the drainage, and is not again seen in this region. The whole thickness of the Conglomerate formation near the mouth of Greasy creek is less than two hundred feet, mostly made up of coarse, thick-bedded, somewhat conglomeratic sandrock, with prominent illustration of cross-bedding, having slant lines to the southeast, as usual in this region. On Mine Fork or Little Paint creek, in Johnson county, near the house of Gilbert Penix, a twenty-inch coal seam is exposed in a "rock-house," under one hundred feet or more of Conglomerate rock, and fifty feet above the bed of the creek. A considerable thickness of shale is exposed below at a number of points on this creek, and at one point, nearer the mouth, a dark slaty shale has embedded in it an unusual abundance of claystone iron ore. At other points a coarse sandrock appears to occupy most of the space from the base of the main cliff to the creek bed. It is reasonable to suppose that these rocks, including the coal, are a part of the Conglomerate forma-



tion; and also that the Conglomerate, as a whole, is very much thickened in this direction, as it is known to have a thickness very much exceeding 1,000 feet along the Cumberland and Pine Mountain escarpments. Several beds of coal, with accompanying shale, are included in this thickness. It is not probable that the maximum thickness, as exposed along these mountains, is attained by an abrupt increase in the thickness of the deposits that go to make up this formation. On the other hand, evidences from drilled wells indicate a rapid thickening from the outcrop line southeastward, or towards the axis of maximum deposit.

Above the Conglomerate formation the coal beds follow at irregular intervals in the upward order, conforming in a general way to the Greenup-Carter Section. For convenience in description, they will be numbered, so far as practicable, as in the report on that region, though it is not probable that the beds are all continuous in the same order throughout the two regions; and from the varying character and thickness of the intervening rocks and the distances between exposures of coal beds, the identity of beds may be a matter of opinion rather than of demonstration in some localities. Levels and elevations are barometric and therefore, at best, subject to correction. For convenience of local reference, the beds will be described by drainage regions, beginning at the western outcrop of the first coal above the Conglomerate beds. The accompanying profile section across the whole field will serve to show the relation of the coal seams to the main drainage.

The North Fork Region.

The first coal of the series above the Conglomerate ledges and cliffs of the greater part of the North Fork valley is not, so far as exposed, of sufficient prominence to require special description. It is exposed at various points in the shales which succeed the ledges of coarse sandrock at the drainage level eastward from the Devil Fork and

rise westward to cap the Conglomerate hills west and northwestward. The second coal, at the top of these shales, marks a cannel coal horizon, which is probably more widely extended in Eastern Kentucky than any other. This bed changes in character locally, in part or in whole, from cannel to splint or to common soft coal; or in places is a thin bed; but the recurrence of basins of cannel coal is a recognized feature of this bed in the counties adjoining Morgan and Magoffin. This horizon is also indicated by the occurrence of yellow calcareous concretions in the shales below, or sandy concretions in the ledges of sandrock just below the coal; features which may be noticed over still larger areas, and with greater vertical range with the thickening of the coal-bearing rock southeastward, over most of the East Kentucky Coal Field.

North Fork Cannel.—On the head of the main North Fork, Coal No. 2 is a cannel seam,—part of a basin which includes the Mordecai creek region to the south and possibly the head waters of Straight creek and of Rush branch. It is exposed from one mile above the mouth of Blair Fork, about 55 feet above the creek on both sides of the valley, to near the head, where it falls below the creek drainage. The thickness of the bed, measured at three points representative of the region, varies from 29 to 39 inches. The records of the Survey do not include a chemical analysis of an average sample of cannel seam of this particular valley; which would show a relatively large per cent of ash, as indicated by its specific gravity, though the fracture of the coal is like the purer cannel.

The Blair Fork Coal.—On the Blair Fork, as opened at Judge Blair's, this bed is wholly changed to splint or common soft coal and shows 40 inches under slate roof in one bench, 55 feet above the creek bed.

Coal No. 3, North Fork.—Coal No. 3 is opened at two places in this locality on Chalybeate branch on the right side above Wade Howards (1), and up Clay Lick branch on the left (2) at 85 feet above the cannel bed under a cliff-forming

sandrock. For comparison with the same bed in adjoining localities the bed sections are here given:

1.		2.	
Roof, S. to S. S	10 inches		10 inches
Coal	3 "		6 "
Shale	8 "		10 "
Coal	28 "		23 "

The hills here rise above the horizon of this coal from 50 to 150 feet, in one to three benches formed by sandstone ledges on which coal tailings may be seen, but no facings have been made to show the character and probable equivalent horizon. Coal 5 and the ferriferous limestone and ore of Carter county and Greenup might be included in some of the ridges.

The Elk Fork Valley.

Mention has been made of the disappearance of the Conglomerate formation below the Licking river a short distance below the mouth of Elk Fork. At no part of the main Elk drainage is the top of the Conglomerate more than about 75 feet below the flood plain of this part of the Licking drainage. Coal No. 1 is above drainage on most of the tributary creeks, represented by a bed of coal, generally two feet or less in thickness, in dark shales as exposed to show its character and thickness, or by two or more thin beds as shown in section 6, Plate I., Lick creek. Coal 1 is not a workable bed for more than local fuel supply. On Shoal branch of Licking river at Peyton's this bed is 19 inches. Coal 2, is the principal cannel coal of Morgan and the adjoining counties, but offers much larger areas of common bituminous coal than of cannel as will be seen in tracing the coal beds of this field. As a cannel it extends over a large part of Mordecai creek, Smith branch, a small part of Lick creek and joins the North Fork area as previously described. Also a small undefined boundary on Rush branch which may be found to include the ridge between the head of Rush branch and the head of the left fork of Straight creek. On Lick creek this cannel seam is about 20 inches thick in a limited area; also

on Pleasant Run it is a thin bed (Sec. 4, Plate I.), one mile above Elk bridge at A. B. Perry's, showing 23 inches, with 4 inches of ordinary coal at roof and 4 inches below separated by 2 inches of clay shale. Openings on Smith branch, which heads against main Mordecai creek, developed 26 inches.

Mordecai Creek Cannel.—On the left fork of Mordecai creek, on branches on left side, the bed measures 30 and 31 inches. Near the head of the Left fork, in a branch to the right, it shows 31 inches. Near the head of a larger branch below, on the same side, and near the head of main Left Fork, at the bed of the stream, the outcrop is shown. In all this area, as on North Fork, the ash is in large percentage, from slaty layers at the top and bottom of the bed which, though cannel in appearance, leaves more or less of slate in the burning.

Rush Branch Cannel.—The Rush Branch openings show a greater thickness. At the lower forks the thickness is 34 inches, with cannel slate roof. Up the creek one-half mile, in ravine on the right side, the coal shows a bench averaging 46 inches, in an entry driven fifty feet or more, with 6 inches of somewhat slaty cannel above, separated by 2 to 3 inches of clay shale, with 2 to 3 inches of soft coal still above at the slate roof. On the second branch above, the thickness is 47 inches, with 8 inches of cannel coal above a thin parting. Other openings on both sides of the creek, which had fallen in, are said to have shown less thickness.

Analyses representing whole thickness of the seam on Mordecai creek and on Rush branch show the following results:

	Sp. Gr.	Moisture	Vol. Com. Matter.	Fixed Carbon	Ash	Sulphur
Rush Branch, 58 inches	1.332	1.60	44.00	38.86	15.54	0.961
Mordecai Creek, 36 inches	1.373	3.90	39.30	38.80	18.00	1.106

This bed dips down the creek valleys very little, rising from the bed of the streams toward the head to fifty feet

or more above drainage along the main Elk Fork. It is between ledges of sandrock which are easily traced through this region; and below in the shales area is Coal 1. Lenticular calcareous concretions, yellowish in color and varying from six inches to as many feet in diameter, serve as horizon marks in most of the valleys.

As a common bituminous coal or as a splint, Coal 2 is shown in the Elk Fork valley at many points by an outcropping coal and clay and has been mined or faced up for examination in a few localities.

Below the mouth of Indian creek, B. F. Keaton's splint coal, 70 feet above Elk Fork is 30 inches, including 6 inches of semi-cannel 8 inches from the top.

Casky's Coal, Elk Fork.—Nearly one mile below the mouth of Rush branch, George Casky's coal, 80 feet above Elk Fork, is 37 inches without parting, the upper 2 inches being cannel; and at Richard Casky's, half a mile below, it is 36 inches. On Left fork of Straight creek, nearly a mile up a right branch, half a mile above Nelson Trimble's store, Coal 2 is opened at the bed of the branch, showing an unbroken thickness of 48 inches, partly splint or semi-cannel. This and the Blair Fork showing indicates an unexpectedly promising field near the outcrop of the Coal Measures above the Conglomerate.

Williams Fork Coal.—Near the mouth of Williams Fork Hutchinson's coal is 100 feet above the foot of the hill. This bed, which is 39 inches without parting, is referred to horizon of Coal 2 with some doubt; as is also the seam opened towards the head of Middle Fork, i. e., Smith's coal, 50 feet above the creek. The bed-section is as follows, reading downward, in inches: Roof slate; Coal, 12 inches; shale, 2; coal, 7; shale, 1½; coal 4; shale, 1; coal, 15; under clay. Coals opened on Fannin Fork are higher in the series.

Middle Fork Coal.—At a few points in the Elk Fork valley a second cannel coal is found, 85 to 100 feet above No. 2 seam, as on Lick creek (see section on Plate 1), and on Smith branch, near the mouth of Mordecai creek. This in a local thin de-

posit, which has no recognized place in the General Section, unless it represents No. 3 coal, which is about 100 feet above the main cannel coal of this region.

No. 3 Coal.—Coal 3 is faced up at a few points as follows. For thickness on Rush branch see section, Plate II.

	Roof	Coal	Parting	Coal	Parting	Coal
On Indian Creek	S. to S.S., 3 feet			19	S. & Bone C 10	20
Across on Mordecai Creek	Bit. and Cannel Sh. under S. S. Ledge			19	S. & Bit S. 17	21
Hd. Ek. Fk. Straight Creek	S.S.	3	Sh. 10	23	Sh. 11	20
Hd. Ek. Fk. Straight Creek	Sh. 3 feet to S.S.	5	Sh. 12	22	Bone C. 8	10
Strt. Cr. op. Rt. Fk. of Rush	Bit. Sh.			24	Sh. 5	12
Near Hd. op. Fannin Fk. Conly C.	S. 2 feet to S.S.	2	Bit. S. 7	2	Bit. S. 8	24
Hd. op. Laurel Cr. Fannin Fk	S. under cliff S.S.		C. & S. 5	61		

The Laurel creek coal of Owen Adkins, recently opened, is probably the No. 3 bed, though 175 feet above the creek on which sandrock resembling the Conglomerate sandstone is exposed.

A coal bed having a bed-section similar to the Conly coal of Fannin Fork is opened on opposite side of creek, at John Fannin's place, about 60 feet higher in the series. The equivalency of all these beds at the head of Fannin Fork is in doubt, as no systematic development of coals has been made, but the calcareous concretions, which are so frequently noted at the base of the sandrock ledge under Coal 2, are found along the headwater creeks and branches in this locality; and over the ridge to Buck branch of the Little Sandy river drainage Coal 2 is exposed, in the branch, as a cannel coal about 40 inches thick (see Plate II.); so there is no doubt as to the part of the General Section of the field at large which is represented by the hills, though the order of beds is not well shown. On Rush branch the iron-ore-bearing limestone over Coal 5 is exposed, see section Plate II.

The Open Fork of Paint Creek.

The series of beds on Open Fork are the same as in the Elk Fork valley. Two miles below the mouth of Smith's creek the Conglomerate formation rises above the creek in its normal character, and the Sand Lick creeks join the Open Fork in gorges which are continuous with the cliff-bound creek below. Above the Conglomerate 20 feet or so, nearly opposite the mouth of Lower Sand Lick, 4 feet of plastic fire-clay was noted in the shales, which are a conspicuous transition from the jagged Conglomerate beds, which rise above the creek here in cliff ledges 75 to 80 feet. Up the Lower Sand Lick creek about a mile, and 80 feet above the clay bed, two openings of coal have been made, on the two branches next above Thomas Canter's, less than one-fourth mile apart. The roof is slate with prominent sandrock ledge above.

SAND-LICK COALS.

Lower Branch.	Inches	Upper Branch.	Inches
Coal	6	Coal	6
Bituminous Slate	4	Bituminous Shale	4
Shale	8	Coal	8
Coal	8	Shale	1 to 2
Shale	4	Coal	18
Coal	22		

Fifty feet higher, above a sandstone ledge, fragments of splint coal show in a drain.

Upper Sand Lick Coal.—On upper Sand Lick creek, a mile or more from the mouth, 60 feet or more above the top of the Conglomerate, yellow calcareous concretions, under a sandrock ledge, were noted; and nearly 100 feet higher a coal bed is found, with roof slate 4 feet up to a sandrock cliff ledge. The upper stratum of coal is 4 inches, separated from the main body, 28 inches, by 2 inches of coal slate. The hills rise here 260 feet above this level.

Smith Branch Cannel.—On Smith's creek several drifts have been made to develop coals. Half a mile up from the mouth, on a branch to the right and 100 feet above the Open Fork, a splint and cannel seam is opened, 38 inches thick; cannel forms the lower 18 inches. The opening was not driven to firm coal. This is apparently a good commercial coal. (See Plate II., reproduced from former report.)

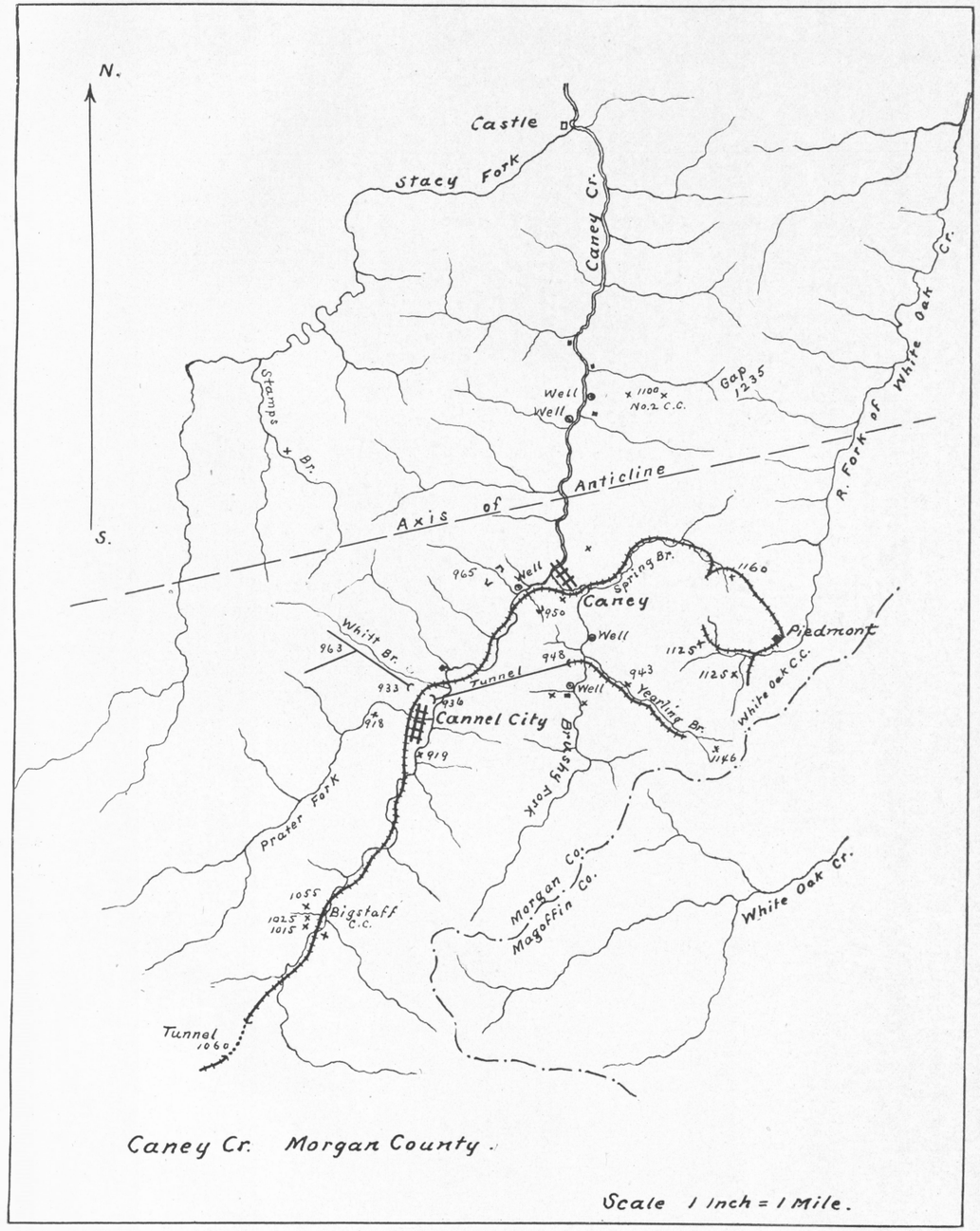
At a lower level (about 40 feet), on Dulin branch, 34 inches of coal without parting are exposed, and the sandrock ledge over it falls to the bed of the creek at the forks, the coal showing along the way for three-fourths of a mile. These coals are Nos. 1 and 2 of the cannel section. That of upper Sand Lick is probably No. 1. On Smith creek, on Meetinghouse branch, Coal 2 shows a 37-inch bench of good splint coal, 90 feet above the creek, and a 20-inch seam shows along the foot of the hill.

Open Fork, Coal 2.—Up Open Fork, Coal 2 is less prominent. As exposed near Dr. Isom's, at the mouth of Little creek, and on Caney creek, the bed is 25 and 28 inches, 65 and 40 feet above the main creek. The yellow calcareous lenticles frequently noted below Coal 2 are conspicuous along Open fork between Little creek and Caney. The order of beds upward from the creek at the mouth of Little creek is as follows:

	Feet	Inches
Sandstone, shale, bituminous shale, calcareous concretions in shales to sandstone	65	
Coal 2		25
Sandrock with shale above	55	
Coal, 2 A		27
Sandstone ledge over Coal 2, and covered	150	
Coal bed near top of spur point		48

The Lewis Coal.—The upper bed is known as the Lewis Coal and shows as follows:

Roof, slate.		
Coal with some slate	7 inches	
Clay Shale		7 inches
Coal	34 inches	
	41	7



Caney Creek Region.

Caney creek has the largest continuous area of minable cannel coal that has been developed in Kentucky. By systematic tests with a core drill, Mr. R. M. Broas, who has done much to develop the coal resources of Eastern Kentucky, proved some years ago that more than 2,000 acres are underlaid by cannel coal with an average workable bed-section, and this is now the basis of a large mining interest centered at Cannel City, on the headwaters of Caney creek. The dip of the bed in this region is modified by the uplift previously mentioned, which has its maximum of elevation of beds near Caney village (formerly Walnut Grove). No. 1 coal is thin in this region, associated in places with siderite iron ore, in small lenticles, distributed through ochreous and bituminous shales over the coal. The interval to Coal 2 in this locality is fifty feet or more. The accompanying page-map shows the locality and the elevation above tide of outcrop facings and entries of the cannel seam by which the local variable dips may be traced. The upper levels, except that on Yearling branch, are from barometric data and are of course subject to more or less of corrections. The bed-sections and localities of openings given below are taken from the notes of Mr. G. M. Sullivan, a former Assistant on the Survey, taken in 1892. Some of the branches mentioned are not located on the map, having lapsed from the present nomenclature of the region. The figures 3210, etc., are laboratory numbers. These notes will serve to describe the bed as found in this region. A bench of common soft coal, varying from 6 to 18 inches, rests on the cannel seam, with a thin seam below a parting, which is left in mining. The samples analyzed were collected by Mr. Sullivan.

3210. Cannel coal from Caney Fork of Licking river. Sample from face of Drift 3, above the mouth of Prater Fork. Seam measures 44 inches, of which 22½ inches is cannel. Collected by G. M. Sullivan, June 30, 1892.

3211. Cannel coal on Brushy fork of Caney creek. Isaac Lykins coal. Seam is 42¾ inches thick, of which 25 inches is cannel.

3212. Cannel coal on Sugar Camp branch of Brushy Fork of Caney creek. Seam is 45 inches thick, of which 25½ inches is cannel coal. Some pyrites in the block from which the sample was taken.

3213. Cannel coal on Old House branch of Caney creek. Will Ferguson's cannel. Seam is 44½ inches thick, of which 24 inches is cannel coal. Sample from the 24-inch face.

3214. Cannel coal from Drift No. 11 on Spring branch of Caney creek. Seam is 57 inches thick, of which 28½ inches is cannel. Sample from the face of the drift.

3215. Cannel coal on Benton branch of Yearling branch of Brushy fork of Caney creek. The upper cannel bed. The seam measures 28 inches, of which 22 inches is cannel.

3216. Cannel coal from face of opening on Johnson's branch of Prater fork of Caney creek, on north side of the branch. Bed 43½ inches thick, of which 21 inches is cannel coal.

3217. Coal from Drift No. 1, on Sugar Camp branch of Brushy fork of Caney creek.

3218. Cannel coal. Cuttings from Hole 10, on Caney creek.

COMPOSITION OF THESE COALS, AIR DRIED.

	Moisture	Volatile Combustible Matter	Fixed Carbon	Ash	Sulphur
No. 3210	1.60	40.00	50.00	8.40	0.549
No. 3211	1.36	41.00	45.14	12.00	0.824
No. 3212	1.30	41.06	49.10	8.54	1.640
No. 3213	1.70	40.82	48.82	8.66	0.824
No. 3214	1.80	40.40	48.80	9.00	2.710
No. 3215	1.20	52.32	36.48	10.00	0.728
No. 3216	2.20	40.60	50.20	7.00	1.200
No. 3217	2.10	40.70	51.20	6.00	0.740
No. 3218	2.40	37.92	49.68	10.00	1.098

About two inches at the base of the cannel bench is excluded in mining, having a much larger per cent. of ash than the rest of the bench of Coal 2. No. 3215 is the upper cannel

coal No. 4, 170 to 200 feet higher in the series; it is an excellent cannel, but limited to comparatively small pockets on the head of the Right Fork of White Oak creek and Brushy fork of Caney, a small area at the 1055 level on main Caney, one mile or more above Cannel City, and an undeveloped area on the Frozen creek side. The openings at 1055-1025 levels above tide disclose a local dip exceeding 5 per cent. The southward dip of the lower cannel seam for a mile below Caney village is about 3 per cent.

Coal 3 does not appear except as a thin bed in this locality. Down Caney creek, by reverse dip and fault, the beds are brought again into the normal relation with the bed of Caney creek which continues, in general, from West Liberty and the field previously described, over nearly all of the upper Licking Valley, with Coal 1 near the main drainage level.

Near the head of Stacy fork of Caney, Coal 2 is exposed at the creek bed, dipping southeastward and rising in a few rods with the northward bend of the creek to ten feet above, with the wave line or line of disturbance from Daysboro. The bed is 32 inches thick, including one inch of sulphur slate 15 inches from the top. In the lower Caney region the hills are 300 to 400 feet high and include the horizon of Coal 3, which becomes the most prominent coal around West Liberty. Near the mouth of Little Caney creek, at the Williams place as formerly opened, a good body of coal was exposed (see Hill Section No. 8, and enlarged bed section of the coal, Plate II). This section shows the order of beds in the West Liberty region. The Cox cannel and Cecil cannel, in the ridge between the Licking and Caney creek, represent Coal 2 with 18 to 24 inches of cannel, which has been mined for local fuel supply for many years. The Judge Day seam, 42 inches, including a 6-inch shale parting at the middle of the bed, and 235 feet above the river at the upper arm of the Gorden Bend, is Coal 3; and this coal in a hill section, like that of Lower Caney (section 8, Plate II.) with such variations as may occur, is the key to the order of beds along the Licking Valley above. The hill sections of plate III. show that nearly the

same order of beds continues up the Licking Valley in Magoffin county, with alternations of common bituminous with cannel coal in a part or the whole of the bed below No. 3 which may be No. 2A rather than No. 2. In the same relation to the main drainage these coals also are found in the higher hills of Johnson and Floyd. (See Bulletin No. 4, Report on the Coals of the Big Sandy Valley.)

On the tributaries of the Licking river from the south, in Magoffin, some developments have been made which show an increased thickness of coal beds along with changes in the thickness and character of the intervening rocks.

White Oak and Johnson Creek Regions.

Not much has been done to show the thickness of coal beds on White Oak creek. Coal 4, as a cannel, is found near the top of the ridge between the Right and Left forks near the head, as indicated by the page-map of the cannel coal region. This bed is mined by the White Oak Cannel Coal Co., transportation being secured by an extension of the railway from Cannel City to Newtown, the mining village at the head of the Right fork of White Oak. The bed-section of the coal and the composition are given in the table on a previous page, No. 3215. This bed as a cannel has not been found southeastward in Magoffin, and the beds below are not prominent here so far as exposed to view.

Fault Line.—The upturn of the rock beds which extends across the Caney drainage may be seen on White Oak near the forks. Beyond this valley this line of upheaval has not been noted. An extension of this wave axis eastward would coincide in a general way with the great bend of the Licking river just above the mouth of Pricey creek. Coal 1 is 20 inches thick at bed of creek at Lykens Postoffice, under a sandrock bench in dark shales with small lenticles of siderite iron ore.

Thick Coal, Head of Right Fork of Johnson Creek.—On the head of the Right fork of Johnson creek, over the ridge from the head of the Left fork of White Oak, a prominent coal bed was formerly opened about 100 feet

below the crest of the ridge and reported as a thick coal with a parting. The entry has collapsed long since, but the upper bench, 36 inches, was seen under a sandstone ledge 100 feet from top of the ridge. At 150 feet below, calcareous concretions in shale-rock associated with Coals 1 and 2 in the bed of the Right fork, shows that the hill section may be compared with that of the main Licking Valley. Thin coals are exposed along the creek, dipping down the creek to the forks where the shales associated with Coal 1 are above the creek. Up the Left fork the same features are seen, and up Cranes-nest branch about one-third of a mile, and 40 feet above the main creek, a coal is faced up to show, under slaty sandstone roof, as follows:

Coal	10 inches	
Shale		1½ inches
Coal	15 inches	
Bituminous slate		2 inches
Coal to under clay	3 inches	
	28 inches	3½ inches

About 15 feet below this seam, large concretions of impure lime ("bastard lime") with intercrossing crystal veins (septaria) occur in shales. Two miles up the creek, below William's store, 2 feet or more of coal near the creek bed represents Coal 1 probably.

Williams Coal, Head of Johnson Creek.—Half a mile or so above the store, the Williams coal is faced up under a sandrock cliff ledge with the following bed-section:

Roof. Shale to sandrock ledge, a few inches.		
Coal	4 inches	
Shale		10 inches
Coal	48 inches	
	52 inches	10 inches

This is a solid bench of splint and block coal. This seam is about 190 feet above Coal 1, and appears to be at the level of the Right Fork coal. At 60 feet below is a coal bed under a thick sandrock bench, and 140 feet down calcareous concretions are bedded in the base of a similar sandrock above Coal 1.

Stacy Coal, Johnson Creek.—Near the mouth of Johnson creek the Stacy coal, No. 2, was opened to show 48 inches of free burning coal. See section 13 and enlarged bed-section, Plate III. Analyses of the Stacy coal, of the Colvin cannel, No. 2, (see Sec. 12, Plate III.), and of the upper bench and lower bench of the Salyersville bed, (see Sec. 14, Plate III.), made in the Survey laboratory, are as follows:

	Stacy C.	Colvin Cannel	Salyersville Coal Upper Bench	Salyersville Coal Cannel Bench
Moisture	3.70	2.30	2.70	1.80
Volatile combustible matter	36.64	51.90	38.04	45.60
Fixed carbon	54.68	37.56	51.62	43.40
Ah	4.98	8.24	7.64	9.20
	100.00	100.00	100.00	100.00
Sulphur	0.944	1.415	1.470	0.688

Middle Fork Region.

The development of the coal beds of Middle Fork has also been towards the headwaters. At the J. W. Back place, near the head of the Right Fork, a specially good showing is made of Coal 2, the bed-section of which, driven under rock roof, is as follows:

Slaty roof to sandrock above.	
Soft coal little weathered	6 to 7 inches
Block coal	40 inches
Cannel coal	1 inch
Underclay	
Total	47 to 48 inches

Nearly 90 feet higher in the hill another bed, Back's coal, was opened with the following bed-section:

	Coal	Slate
Roof. Clay shale.		
Coal	4 inches	
Bituminous slate		5 inches
Coal	11 inches	
Shale		1½ inches
Coal	22 inches	
Bituminous slate		1½ inches
Coal	6 inches	
Coal and clay		1½ inches
Sandstone		1½ inches
Underclay prominent.		
	43 inches	11 inches

Both beds were sampled for analysis and the results are as follows:

	Lower Coal	Upper Coal
Moisture	1.60	2.00
Volatile combustible matter	35.80	38.00
Fixed carbon	57.32	50.56
Ash	5.28	9.44
	100.00	100.00
Sulphur	0.884	0.384

Face of upper coal was somewhat weathered and not free from clay.

Wedge's Coal.—More recently, in the point of the hill opposite J. A. Wedge's store, about a half mile down the creek, an entry driven under roof rock, 135 feet above the creek, shows as follows:

Roof, slaty rock.		
Coal	24 inches	
Clay		½ inch
Splint coal	25 "	
Shale, part bituminous		15 inches
Coal	24 "	
	73	15½

Underclay. Sandrock below for 40 to 50 feet.

The beds dip down the creek somewhat less than the fall of the stream but enough to bring this coal, by its height in the hill, at the horizon of the upper coal previously described, which is between two sandrock ledges, the upper of which is exposed in cliffs, which are features of the region.

Fossil-Bearing Rock.—Below the lower coal, 10 to 20 feet, near the house of Roland Rowe, fossil-bearing rocks, impure lime and shale, offer a good opportunity for the collection and study of Carboniferous brachiopoda and other forms.

Arnett's Four-Foot Coal.—The left fork of Middle Fork has the lower coal opened at Sherman Arnett's about two miles from Wolf Gap. It is exposed on a branch to the right, and also on the main creek a short distance from Mr. Arnett's house; at neither place so as to show the whole face free from clay, but measuring 48 inches in one bench.

Craft's Fork Coal.—On Craft's Fork, which heads nearly four miles further southeastward, the same bed is opened, near D. H. Howard's; on another branch near John Howard's, and also near the Craft place, one mile below, showing the following variations in the bed-section:

Roof, shale to sandrock ledge a few feet above.

	Inches	Inches	Inches
Coal	15	11	12
Clay shale	23	39	8
Coal	45	38	21

Underclay, somewhat bituminous.

On the main creek, above the mouth of Craft's Fork, at D. M. Kenaird's, a coal is exposed in a slip, apparently 36 to 40 inches, 190 feet above the creek; and at 40 feet below another coal stratum is partly uncovered. Large calcareous concretions in shales, with thin coal above, the horizon of Coal 1, are exposed along the creek a mile or more down the creek.

Middle Fork Cannel.—Coal 1 is above the main drainage to the mouth of Middle Fork, and No. 2 seam is part cannel at several points above the forks of Middle Fork. On a bench at the McCarty place and on a bench on the opposite side of the valley, where mined for local consumption, the bed-section under 25 to 20 feet of sandrock measures:

	Inches	Inches
Coal	8	8
Cannel coal	1½	2
Coal	0	10
Splint coal	8	6
Cannel coal	8	6
	25½	32

Allen No. 1 Coal.—No. 1 seam is opened at J. D. Pruett's, two miles above the mouth of Left Fork, and at Allen's entry, a mile or more further down, 5 to 10 feet above the creek bottom. The bed-section was seen at the latter place, and is as follows:

Roof, shale

Coal	7 inches	
Shale		3 inches
Coal	10 inches	
Shale		5 inches
Coal	12 inches	
	29 inches	8 inches

This bed is too much diffused in the shaly rock of this horizon to promise much as a basis for mining operations in the Licking Valley, but locally it may be a very convenient deposit for neighborhood need.

Oakley Creek.

Near the head of the left fork of Oakley creek, 75 to 100 feet above the creek, a promising bed is opened; above Ad. Marshall's house on a branch which heads against Half Mountain creek, at the mouth of Beetree branch, nearly a mile below, back of Isaac Montgomery's house; and near the head of Beetree branch, Combs entry. There is considerable variation in the details of the seam, but evidently all openings are at the same geological level. The overlying ledge of sandrock, and the cliff forming sandstone about 75 feet above, form conspicuous benches above the seam.

Oakley Coal Seam.—All beds dip down the creek as much as the fall of the stream. The following is a tabular view of the bed at the several points in the order mentioned.

Roof	Shale	Shale	Sandrock
Cannel slate	4 inches		6 inches
Coal	42 inches	35 inches	28 inches
Bitum. shale parting	10 inches	Sh. 7 inches	Sl. 7½ inches
Coal	10 inches	20 inches	10 inches
Underclay	Prominent	Prominent	

A sandrock ledge occurs below to shales and fossil bed and concretions, as noted on Middle Fork.

Right Fork of Oakley.

On the right fork of Oakley, at Calloway Montgomery's, this coal, 60 feet above the creek, has roof shale 6 inches to bench-forming sandrock. The bed-section is as follows:

Coal	33 inches	
Shale		7 inches
Coal to underclay	16 inches	
	49 inches	7 inches

The hills are 200 feet or more higher, but the upper beds appear not to have been opened above the forks. The lower bed is exposed in shaly rock but little above the bed of the creek near its mouth, with three partings of shales, 14 inches, in a 42-inch bed.

Coal 2A, Mouth of Oakley.—Opposite the mouth of the Right fork, 150 feet above the creek, a seam, probably coal 2A, has been opened to expose a 30-inch bed, with 2½ inches of hard bituminous slate 10 inches from the top.

Shepherd's Coal near Head of the Licking.—A coal field of more than ordinary importance extends along the head waters of the tributaries of the Licking region from the southward. Coals higher in the series, corresponding with the beds in Breathitt county, will doubtless add to the importance of this field as interest is stimulated to develope them. Near the head of the river, at John Shepherd's, one of the higher beds has been opened a little more than 200 feet above the main drainage, with the appearance of a good commercial coal. The following description and analysis present an interesting exhibit of this seam, which is not readily referred to the numeral order of the General Section. It may be compared with the Mays coal on Burton Fork of State Road Fork noted on a following page.

BED-SECTION OF THE COAL.

Roof, shale, 2 feet, to sandstone ledge.

Coal	21 inches	
Bituminous slate		1½ inches
Coal	25 inches	
Bituminous slate		1 inch
Coal	11 inches	
Bituminous slate		1 inch
Coal	8 inches	
	65 inches	3½ inches

ANALYSIS.

Moisture	3.40
Volatilecombustible matter	32.80
Fixed carbon	56.30
Ash	7.50
	100.00
Sulphur	0.826

The hills here give this coal about 100 feet of cover, and the fall of the head waters of Licking river is considerably greater than the northwestern dip. It is probable, also, that the eastward dip which goes with the Big Sandy drainage begins considerably west of the watershed, especially on the head of the main Licking, as the bed of Salt Lick creek, one mile from the gap, is more than 200 feet lower than the mouth of Grassy creek of Licking, and the shales above the Conglomerate formation, as seen down the Licking Valley, are exposed along Salt Lick creek at this lower level. The top of the Conglomerate was reached in a well near the mouth of Salt Lick creek 44 feet below the surface.

Rockhouse and Lick Creek Region.

The rocks exposed by the drainage of this region are the shales and sandrock at the base of the series above the Conglomerate measures, as in the adjoining regions, and only the lower beds are exposed in the spurs that extend down to the principal creeks. These points are generally benched by sandrock of greater or less prominence, indicating the places of coals 1 and 2, which are open at a few points for local use. The hills are 350 to 500 feet high, including other coal horizons to No. 6 of the General Section.

Ben Montgomery's Coal.—On Rockhouse creek facings were made toward the head, at the Ben Montgomery place, showing three thin coals near the bed of the creek, representing the horizon of No. 1 seam. At 85 feet up from the creek Coal 2 shows, having the following bed-section:

	Coal	Parting
Roof, shale with bituminous slate bed 20 feet above.		
Coal	12 inches	
Bituminous shale		2½ inches
Coal	27 inches	
Totals,	39 inches	2½ inches

Two thin coals show near the 150-foot level. Kidney iron ore occurs in shales at 190 feet, and a thin coal at 270 feet. The hill here is 340 feet high.

Judge Cooper's Coal's.—Towards the head of Lick creek, at Judge Cooper's, coal 1 is represented by an 18 to 20-inch seam. Ninety (90) feet higher, the following bed section of Coal 2 is exposed in an opening made for local fuel:

Judge Cooper's Second Coal.

	Coal	Parting
Roof, 40 inches of slate to sandrock ledge.		
Coal	10 inches	
Clay		½ inch
Splint coal	20 inches	
Coal and slate to underclay		

On apparently the next bench above, 75 feet higher than the coal just described, near the mouth of a branch back of Judge Cooper's house, is Coal 2A or 3, driven to roof, showing:

Judge Cooper's Upper Coal.

	Coal	Parting
Roof, slate 4 feet to sandrock ledge.		
Coal	16 inches	
Clay		1½ inches
Coal	12 inches	
	28 inches	1½ inches

On Buffalo Fork of Lick creek the lower beds have been opened, at the William Adams place, two and a half miles from the mouth of the creek, in essentially the same order On Raccoon Fork, also, these beds are reported.

Section at Henry Howe's Place.—The coal seams are broken by partings toward the mouth of Lick creek, as shown at the Henry Howe place, half a mile above the mouth of Raccoon creek. A section made here by the Survey showed a thin coal and the bastard limestone concretions 30 and 45 feet up from the creek; a thin coal at 75 feet; and at 115 feet coal as follows:

	Coal	Parting
Roof, shale.		
Coal	2 inches	
Shale		8 inches
Coal	9 inches	
Shale		5 inches
Coal	10 inches	
Nonplastic fire-clay		5 inches
Coal	11 inches	
Totals	32 inches	18 inches

Twenty feet above this bed another coal shows, with more parting than coal, in a bed of less thickness; and a black slate bed occurs 30 feet higher. At the 250-foot level is a thin coal under sandrock; at 285 and 350 feet coal croppings occur; and at 370 feet iron ore kidneys, in shale near the hilltop.

Ben Branch Coal.—What has been regarded as No. 2 Coal shows on Ben branch of the Licking river below the mouth of Lick creek, 145 feet up; consisting of cannel coal 15 to 17 inches, and cannel slate 10 to 12 inches. The variation in character and surroundings of the lower beds of this region explains, in part at least, the unequal distribution of workable seams in a large part of the region.

From Williams Fork to Rockhouse creek and across to Lacy, the "bastard limestone" concretions, or more or less continuous calcareous beds, in dark shales below the characteristic sandstone ledge under Coal 2, may be seen above the main creek in each of the respective valleys. At many points this sandstone as a cliff ledge is weathered in pitted

and pocket-like surfaces, much as in the upper Big Sandy Valley, though in less marked degree here than there, where the sandstone at this horizon has come to be called the "honeycomb sandstone." At no other horizon does this feature recur so frequently, or in such striking illustrations of "wind cavities" or "wind caves." The frontispiece of the report on the coals of the Big Sandy Valley, Bulletin No. 4 of the Survey, 1905, is an excellent representation of the "honeycomb" and "wind cave" characteristics of this rock.

Limestone Ore Horizon.—In the ridge between Rockhouse creek, Lacy creek and War creek of the Licking, and Williams Fork of Elk Fork, an iron ore resembling the "limestone ore" between coals 5 and 6 is found along the bench under the coarse sandrock which caps the ridge; and, at about 370 feet above the creek drainage, another coarse, cliff-forming sandrock shows as a bench or as a cliff just below. This points to the absence, very largely at least, of the shales which, nearer the Ohio river bear Coals 6 and 7 and the kidney ores associated with the latter, as noted southward in the Big Sandy Valley. (See pages 20-23, The Coals of the Big Sandy Valley.) How far Coal 5 continues into this field at large as a workable bed is yet to be determined, where the hills are high enough to give cover to this seam. Coal 4 appears to be represented by pockets of cannel coal. Coals 2 and 3 are variable beds, the values of which may be determined locally, especially in creek valleys north of Licking river, by systematic development.

The State Road and Burning Fork Region.

The calcareous concretions under the second coal are conspicuous at many points in this region, in the shales at the foot of the hills, and the second coal is thirty to fifty feet above the bottom land, rising up the main Forks.

Coal 2 Burning Fork.—The coal is opened more frequently on the Burning Fork as at Thomas Prather's and B. C. Patrick's, two and a half miles from Salyersville, and on Rockhouse Fork, where it is a very constant seam with 28 to 23 inches of good coal. The thickness of the bed is increased by 1 to 6 inches of shale parting. The thickness is about the same on Gunn creek, at Lewis Marshall's, at the bed of the creek, and nearer the mouth of the creek, at Jack Marshall's, 10 to 15 feet above the creek.

No. 2A Gunn Creek Coal.—In this locality, 40 to 50 feet higher in the hills, coal 2A shows as follows: (A) above the Lewis Marshall coal; (B) above the Jack Marshall coal; (C) on Salyers branch near the Pipe Line Pump station, at the mouth of Oakley creek; and (D) along the read from Burn-Fork, at W. W. B. Keller's to Gunn creek.

	A	B	C	D
Roof	Bit. S. 12 inches to SS.	Shale 40 to SS.	Sandstone	Shale
Coal	9 inches	9 inches	8 inches	6 inches
Shale parting	2 inches	Clay 2 inches	2 to 3 inches	1 inch
Coal	25 inches	24 inches	25 inches	27 inches

A prominent coal strain was noted near the top of the hill, 270 feet above the Lewis Marshall coal of Gunn creek, the horizon of the Shepherd coal of a preceding page.

The operators of the pump station find the coal from these two beds a good steam fuel. On the State Road Fork, the lower coals are supposed to be like those of Burning Fork a ready source of fuel for neighborhood needs, but higher in the series, by the systematic work begun before the suspension of the Survey in 1893, the extension of one of the more prominent coal beds of adjoining fields was proved by the opening of the Henry May coal seam, 240 feet above the Burton fork of State Road Fork.

May's Coal, State Road Fork.—The bed section of this seam and the results of analysis at the Laboratory of the Survey of a sample cut from the whole face of the coal near the outcrop are as follows:

BED SECTION.

Roof, dark shale to sandstone.

Coal	19 inches	
Bone and bituminous shale		4 inches
Coal	24 inches	
Cannel coal	7 inches	
Coal	1 inch	
	51 inches	4 inches

ANALYSIS.

Moisture	4.00
Volatile combustible matter	34.20
Fixed carbon	56.74
Ash	5.06
	100 00
Sulphur	0.862

This is probably the same bed as at Shepherd's near the head of Licking river. The higher points in the ridge rise 100 feet or more above this seam and the gaps cut away the bed more or less in this region. Where the ridges rise 300 feet or more above the drainage, areas of this coal should be found in Magoffin county.

The Head of Middle Creek.

Middle creek at Ivyton is 70 feet lower than the Burning Fork an equal distance on the other side of the low gap between the two streams, and the dip of the rock beds is nearly with the fall of the creek, as on the Burning Fork side, a mile or more from the gap. The continuity of beds is readily seen in passing from the Licking to the Big Sandy drainage.

Allen Branch Coal, 2A.—The lower excavation of the shales above the Conglomerate exposes coal 1 above the creek 10 to 15 feet, and the equivalent of the upper of the two Gunn creek coals is opened on Allen branch, nearly three-fourths of a mile up at the branch, or a little more than a hundred feet above the main creek at the mouth of the branch. The bed-section is like that given in the comparative table of coal 2A on the preceding page, as follows:

Roof, bituminous slate under thick bedded sandstone.

	Coal	Parting
Coal	9 inches	
Shale		2½ inches
Coal	28 inches	
	37 inches	2½ inches

Coal Facings at the Randolph Hollbrook Place.—A series of facings were made by the Survey two and a half miles below the Magoffin county line, in the hill at the Randolph Hollbrook place, showing coal outcrops at the following levels above the creek. Thickness at the outcrop is given, except of seams that may be called thin beds.

At or near the creek bed, coal 15 to 20 inches.
Shale and sandrock, 80 feet.
Thin coal.
Shale and sandrock to 150-foot level.
Coal seam with 3-inch shale parting, 30 inches.
Largely sandrock, 50 feet.
Thin coal at 200-foot level.
Sandstone and shale, 20 feet.
Coal, including 5-inch parting, 22 inches.
At 250-foot level, coal 20 inches with 36-inch parting.
Interval of 15 feet to thin coal.
Shales, with fossil limestone near base, 60 feet.
Coal at 370-foot level; coal 29 inches with sandstone parting 18 inches.
Sandrock and shale, 60 feet.
Kidney iron ore in shales, at 425 feet.
Coal, including 1½ inches of clay, 30 inches, at 445-foot level, under sandstone ledge.
Coal, 20 inches, at 460-foot level, under sandrock.
Coal, 26 inches, at 510-foot level.
Sandrock, mostly, to hilltop at 600 feet.

These facings show places of coal seams rather than the thickness and character. On the Ray branch, near the county line, the 370-foot level shows cannel coal, but the openings formerly made are now covered by slipped surface talus.

Drill Well Geology.

The underlying rocks of this field are penetrated by drill wells at a few points which disclose the character and thickness of formations on the southeastward slope of the Silurian anticlinal axis of Central Kentucky. The later formations of East Kentucky conform to this slope with added thickness southeastward in some of the formations, by which the Coal Measures especially become greatly increased in thickness and importance in that direction.

The discussion of the horizons of oil producing rock, the determination of which is the incentive for well drilling, is

taken up in Bulletin No. 1 by J. B. Hoeing, and will not be considered specially in this connection; neither will any hasty attempt be made to point out the occurrence of minor anticlinals and local upturned basins which are natural reservoirs for oil and gas by reason of the reduced specific gravity of those fluids as compared with the water which percolates to great depths. These will become more intelligible with the local developments and special studies in connection with deep well prospecting, which may follow lines indicated by a general description of the surface geology with its trend of rock strata.

There are some prominent facts relating to the underlying formations which are of immediate interest, and which may be given in a general way from the few borings available in this field. In doing this, reference will be made to the two accompanying plates of well sections, "A." and "B." The well sections of plate A are placed at relative distances to show the dip of well known formations along a line from Winchester, in Clark county, where the Trenton limestone (lower member of the Ordovician) falls below the drainage, to a point on Beaver creek in Floyd county. Sections 1 and 4 of plate B. show the dip of some of the lower formations from West Liberty southeastward to Robinson creek in Pike county, a distance of fifty miles. Sections 3 and 2 of this Plate show the northward dip in the Big Sandy Valley. The details of these sections appear by comparison more variable than should be found, from the lack of uniformity in keeping records of drill wells.

The abbreviations used are such as are in general use for geological features: l. s., limestone; s., or sh., shale; sl., slate; c., coal; c. c., cannel coal; cl., clay; f. c., fireclay; ss., sandstone; sh. ss., or sss., shaly sandstone; w., white; blk., black; gr., gray; br., brown; etc.

Mention has been made of the outcrop of the lower formations westward and northwestward. These groups of rocks are reached at varying depths and show varying thicknesses and interchanging of characters at equivalent horizons, so that the lines of demarkation between formations are not

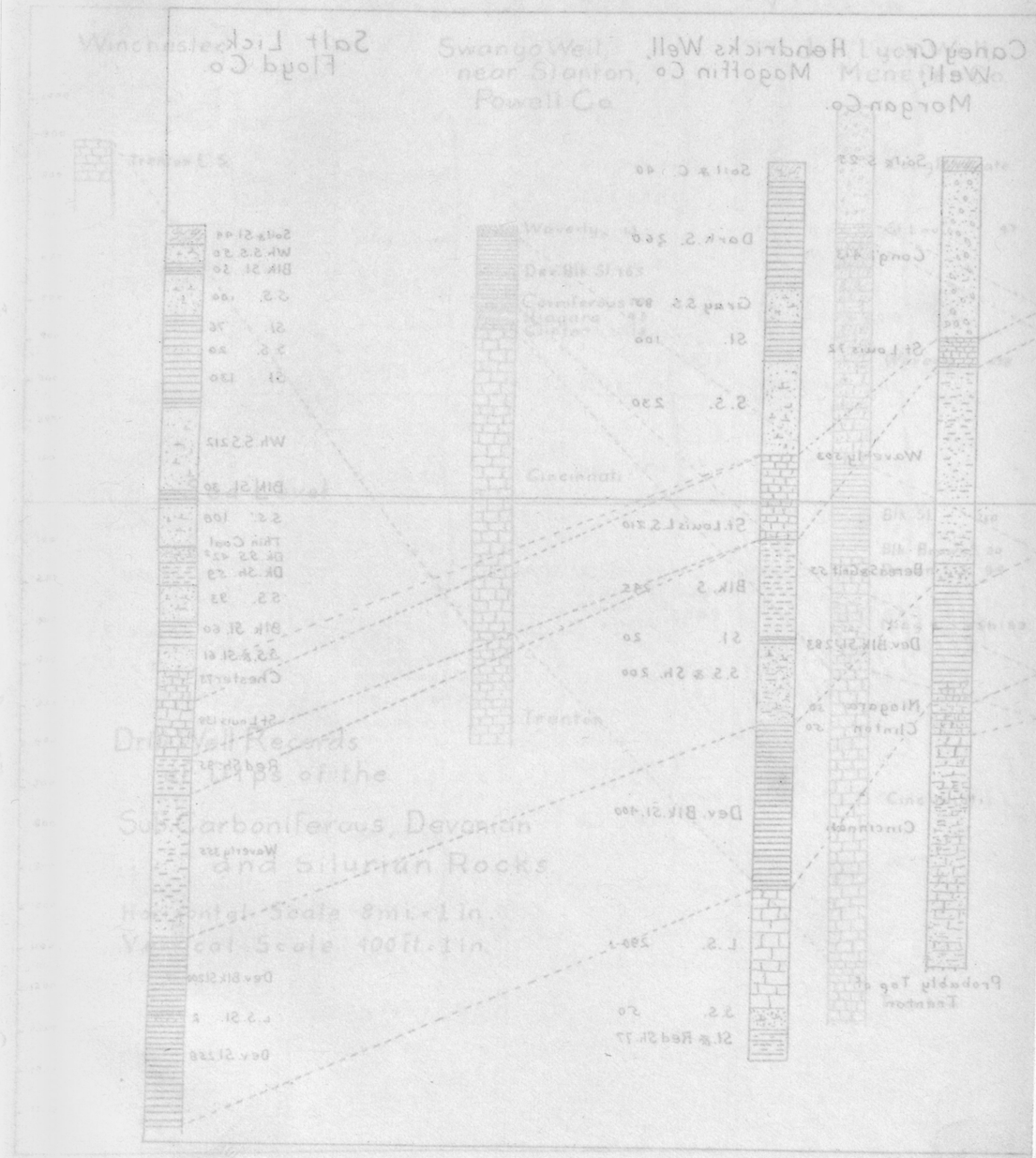


Plate A

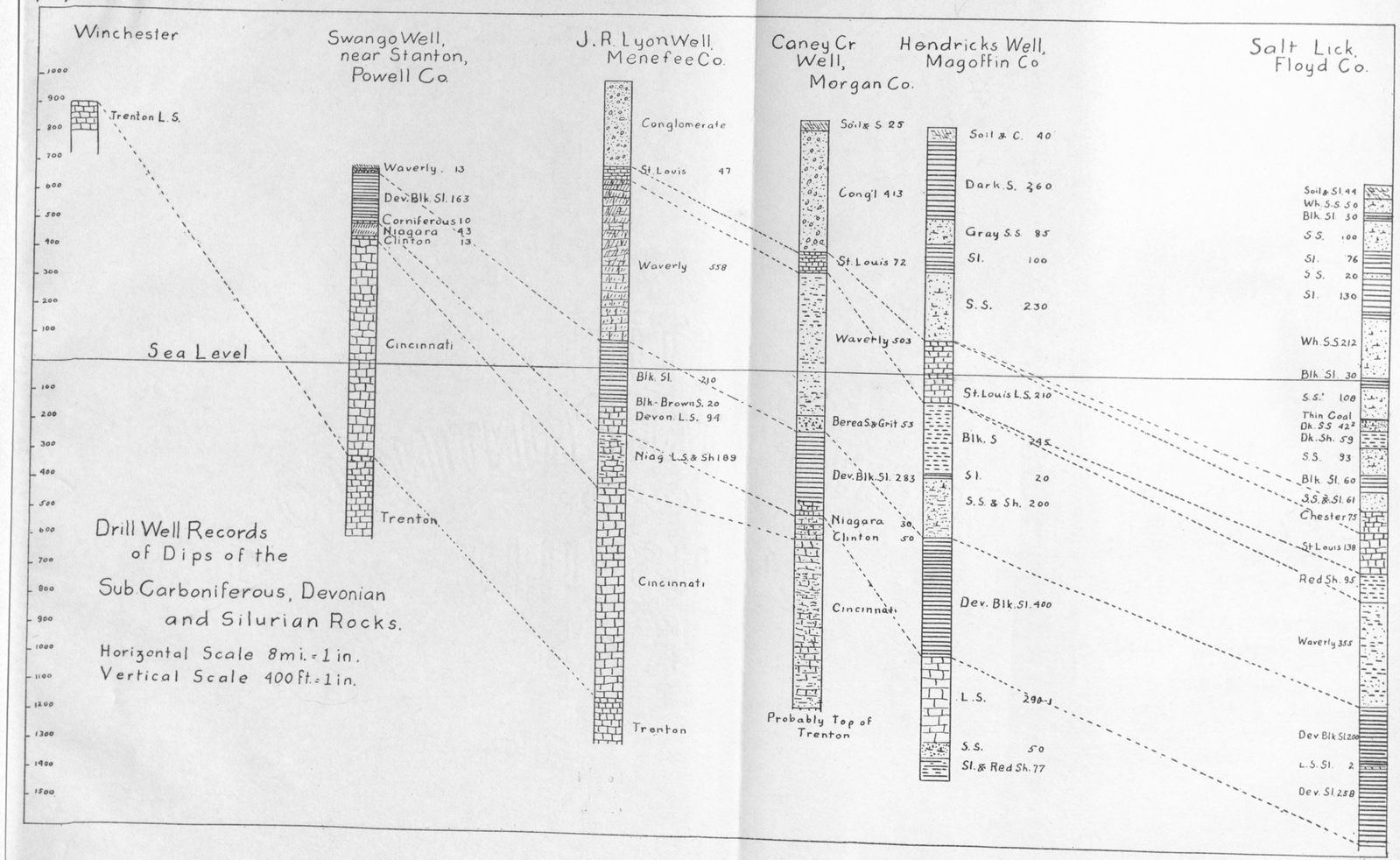
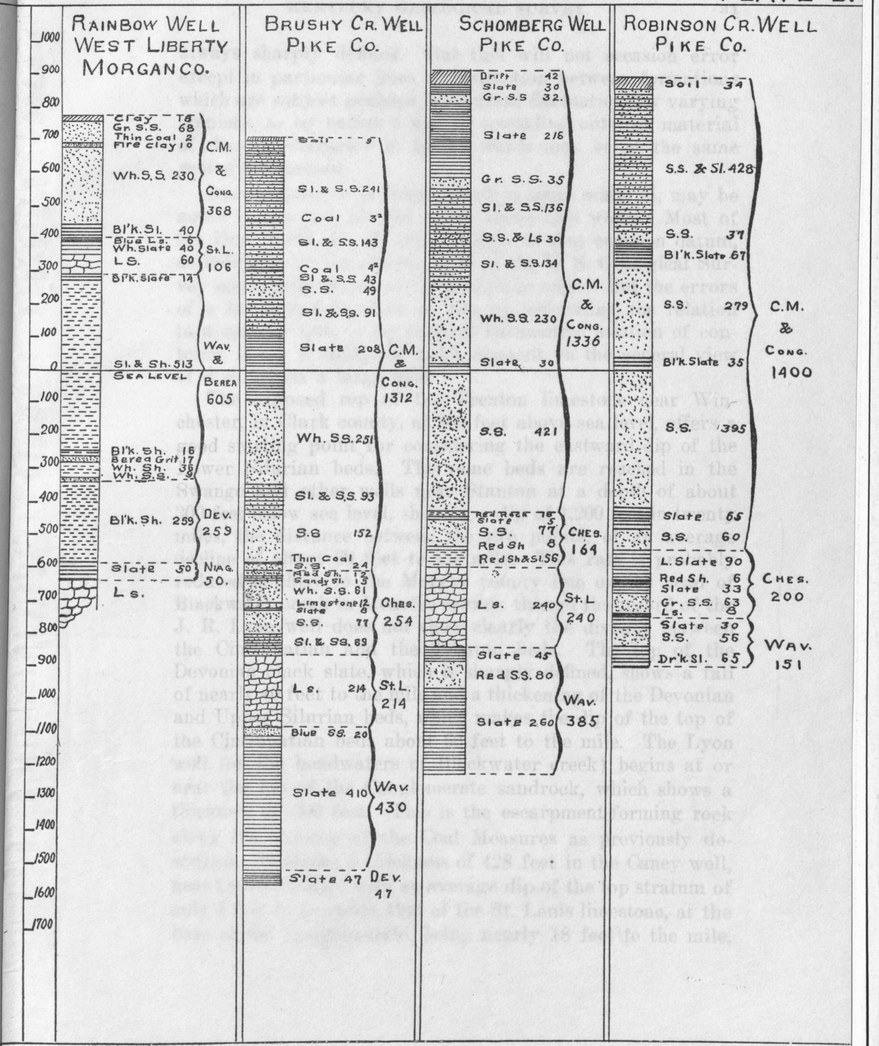
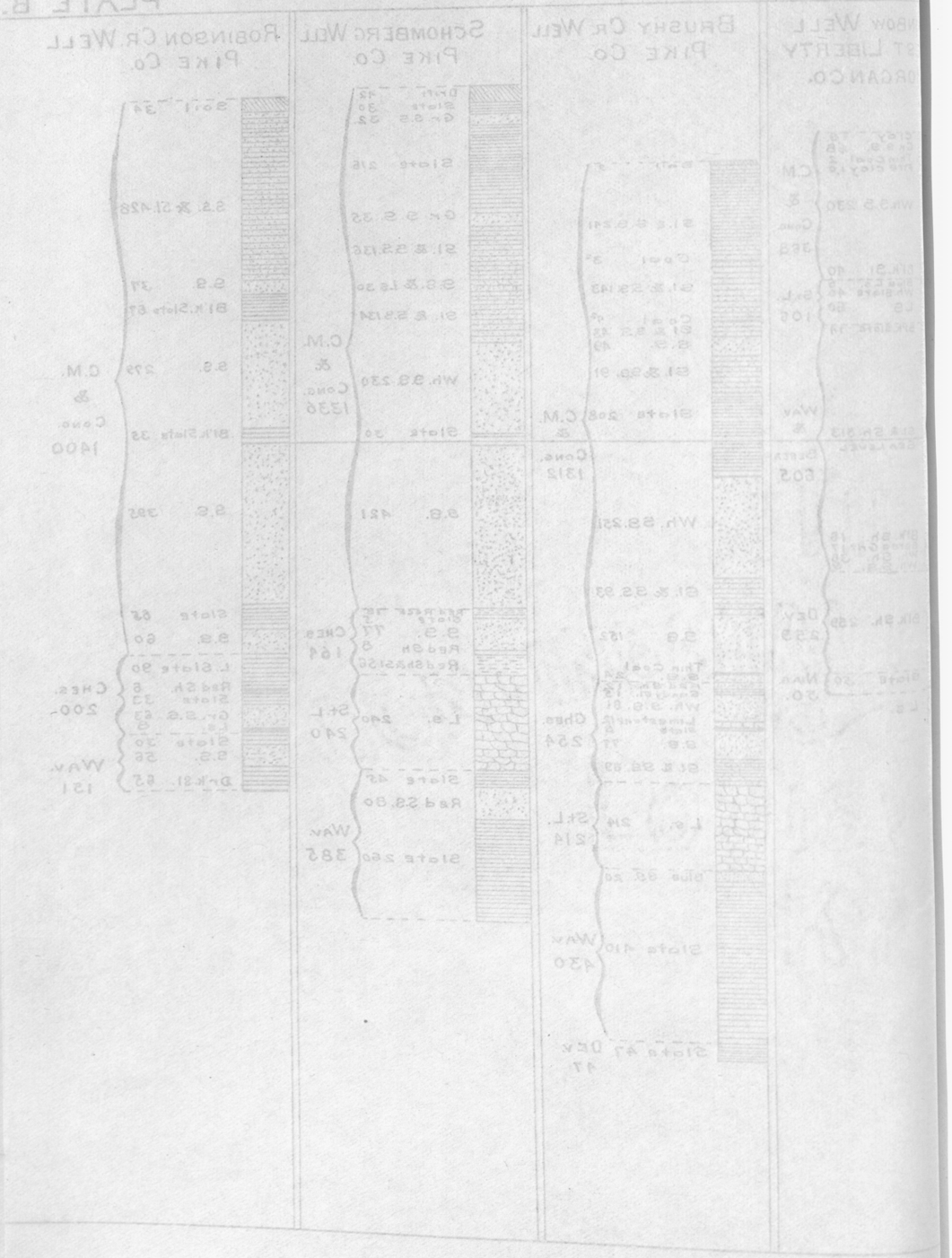


PLATE B.





always sharply defined. But this will not occasion error except in particular lines of distinction between formations which are subject perhaps to as great fluctuations by varying opinions, as by nature's way of spreading out rock material of diverse character in basins which may be at the same geological horizon.

Another source or error, which is more material, may be noted in the lack of true levels above tide water. Most of the Drill Wells are given a relation to that common datum, as indicated by the contour lines of the U. S. Geological Survey map sheets which are approximate only. But the errors of a hundred feet more or less by estimating the relation to a contour line, or by original barometric location of contours, is not a matter of much moment, in the general view of dips across a large field.

The exposed top of the Trenton limestone near Winchester, in Clark county, at 900 feet above sea level, offers a good starting point for considering the eastward dip of the Lower Silurian beds. The same beds are reached in the Swango and other wells near Stanton at a depth of about 300 feet below sea level, showing a dip of 1,200 feet in twenty miles, the distance between the two points, or an average decline of about 60 feet to the mile. This rate is probably reduced slightly to the Morgan county line on the head of Blackwater creek in Menefee county, though the record of the J. R. Lyon well does not show clearly the division between the Cincinnatian and the Trenton beds. The top of the Devonian black slate, which is sharply defined, shows a fall of nearly 40 feet to the mile and a thickening of the Devonian and Upper Silurian beds, which makes the dip of the top of the Cincinnatian beds about 60 feet to the mile. The Lyon well (on the headwaters of Blackwater creek) begins at or near the top of the Conglomerate sandrock, which shows a thickness of 300 feet. This is the escarpment-forming rock along the outcrop of the Coal Measures as previously described. It shows a thickness of 428 feet in the Caney well, near Caney village, with an average dip of the top stratum of only 8 feet to the mile, that of the St. Louis limestone, at the base of the Conglomerate, being nearly 18 feet to the mile,

and that of the Devonian black slate nearly the same; but the base of the Upper Silurian and the top of the Cincinnatian, by the wedge shape of the Upper Silurian (Silurian of some geologists), is reduced to about 6 feet to the mile, and it is presumable that the Trenton series shares in this break in the southeastern slope of the Silurian axis; a wave of disturbance which attended the development of the central Silurian axis, rather than a result of the subsequent uplift of the Cumberland axis with its series of parallel waves of flexures and faults. The faults which reach out from the Silurian uplift and involve the Conglomerate measures of the field to the southwest are also a part of the history of this anticline; the central Silurian axis of North America south of the Great Lakes. From this point on Caney creek to the Hendricks well in Magoffin county normal dips are continued with the Sub-carboniferous, Devonian, and Upper Silurian formations, and in the Cincinnatian beds so far as reached. The Conglomerate formation and the Coal Measures above are increased in thickness, and lines of separation are made uncertain by transition beds of increased thickness and of inconstant features of the thickened beds. As an instance, in the Hendricks well more than 200 feet of dark slaty rock was added to the slates and shales between Coal 1 (which is 10 to 15 feet above Middle creek at the Forks) and the top of the Conglomerate, as compared with the Caney, West Liberty, and other sections. (See Plates A. and B., or as described on preceding pages.) This appears to be the beginning of the thickening of the shales above the Conglomerate, with the intercalations of sandrock and also of coal seams as they appear further southeastward. Assuming that the sandrock at the base of these shales is the top of the Conglomerate series, the dip of this rock from Caney is 28 feet to the mile. The top of the St. Louis limestone is very slightly increased. The top of the Waverly averages 44 feet to the mile. The top of the Devonian black slate is about 33 feet, and the base of this formation is in a plain which is inclined at the rate of about 43 feet to the mile. The top of the Cincinnatian is apparently somewhat less. The Niagara and Clinton are not present in characters by

which either of them can be distinguished from the Cincinnatian limestone.

Continuing this diagrammatic representation of thickness and inclination of formations as a whole to the Big Sandy Valley, the drill well at the mouth of Salt Lick creek reaches the bottom of the Conglomerate at 437 feet below sea level, dipping from the Hendricks well at the rate of about 27 feet for 21 miles. The Chester beds thicken, to increase the dip of the St. Louis limestone to 31 feet. The St. Louis beds are reduced in thickness so that they rest on the Waverly formation with average dip of nearly 27 feet. A slight decrease in thickness reduces the base and top of the Devonian beds to 26 feet. The Upper Silurian beds are thickened by 60 feet, giving to the base and the top of the Devonian an inclination of nearly 29 feet to the mile for the twenty-one miles.

From West Liberty Rainbow well, in which the top of the Conglomerate is nearly 180 feet lower than in the Caney (Walnut Grove) region, to Robinson creek, in Pike county, a distance of fifty miles, the dip is continued in the lower formations as shown on Plate B. The thickening of the Conglomerate to 800 feet or more reduces the inclination of the top to 7 feet to the mile, and the thickening of the shales above reverses the dip of the Coal Measures as represented by the beds above the drainage. The formations below the Conglomerate, with alternating thickness, as between the Chester and the St. Louis group, continue the southeastward dip at the top of the Waverly by an average of 19 feet per mile. The Waverly rocks decrease in prominence by nearly 200 feet, reducing the top of the Devonian to 16 feet average fall to the mile on this line, which approaches the southeast direction. Locations No. 3 and 2 are down the Big Sandy Valley at a distance each of about fifty-five miles from West Liberty, and show the northward trend of the dip of the Coal Measures as well as of the lower formations. Attention was called to this in Bulletin 4, and illustrated for the Coal Measures by the Page Map sections and for the beds below by Plates A. and B. of that report, page 8, which, however, were grouped to show more especially the irregularities in thickness and character of the component rock beds of these formations.

This is also shown in the well sections here given, though arranged more particularly with reference to the dips of the southeast slope of the Central Kentucky uplift, to which the East Kentucky formations conform, with minor exceptions where faults have resulted from stress of adjustment to movements which are a part of the history of this anticlinal axis.

The replacement of the St. Louis limestone by the Chester slates, comparing Robinson creek with West Liberty, is in contrast with the Subcarboniferous limestone and slate beds, as shown in wells 2 and 3 of Plate B. The St. Louis ("Mountain Limestone") is largely or entirely wanting in the Pikeville district, as indicated by well No. 1 and by the Cedar creek well. (Bulletin No. 4, Plate B.) The lines drawn from the Robinson creek well section to corresponding horizons show a somewhat irregular, but noticeable, dip down the Big Sandy Valley by a wave of depression which determined the direction of this drainage from the Pine Mountain uplift. It will be noticed that a somewhat less striking depression is shown, as a factor in determining the direction of the Licking drainage as indicated by descriptions of coal horizons in preceding pages.

PLATE I

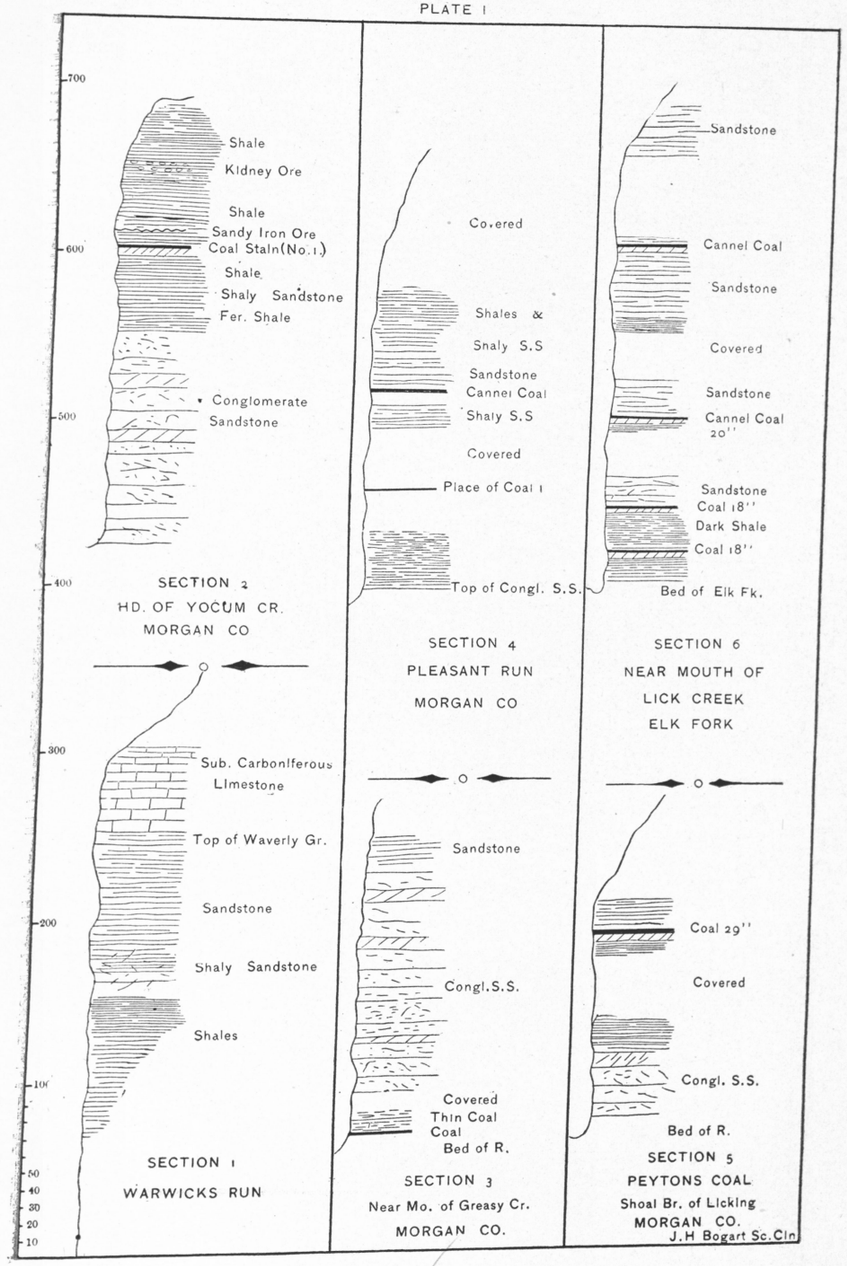


PLATE II

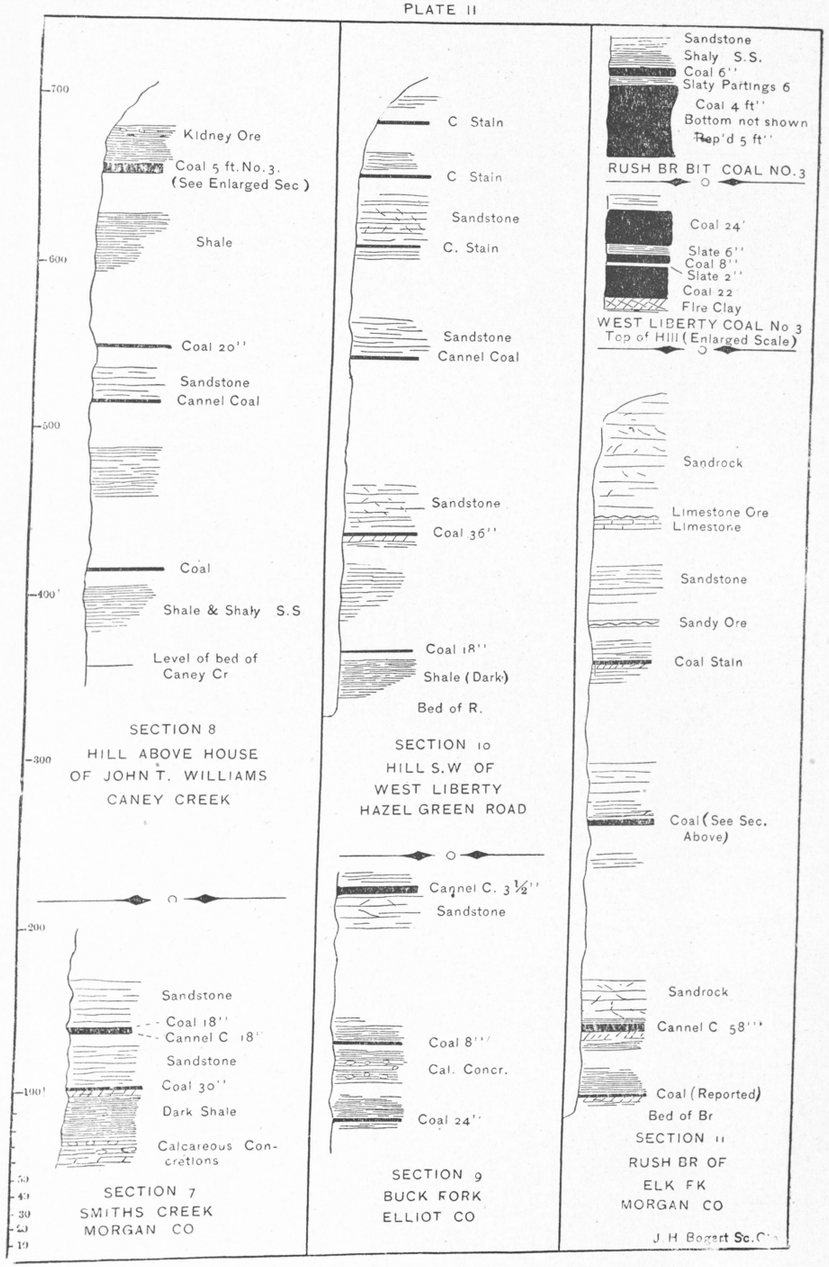
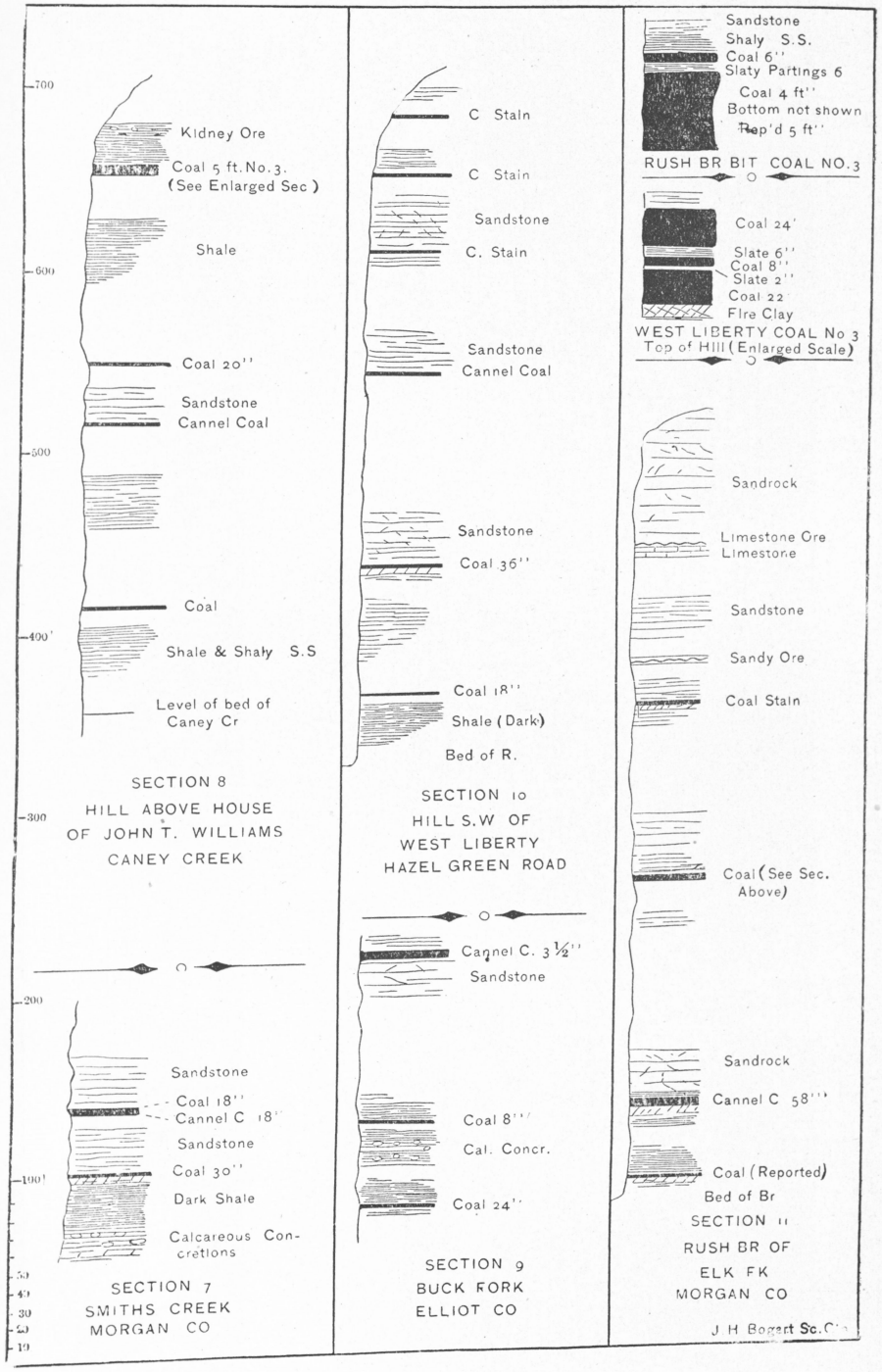

700
600
500
400'
300
200
190'
50
40
30
20
10
Kidney Ore
Coal 5 ft. No. 3.
(See Enlarged Sec)
Shale
Coal 20''
Sandstone
Cannel Coal
Coal
Shale & Shaly S.S
Level of bed of
Caney Cr
SECTION 8
HILL ABOVE HOUSE
OF JOHN T. WILLIAMS
CANEY CREEK
Sandstone
Coal 18''
Cannel C 18''
Sandstone
Coal 30''
Dark Shale
Calcareous Concretions
SECTION 7
SMITHS CREEK
MORGAN CO
C Stain
C Stain
Sandstone
C. Stain
Sandstone
Cannel Coal
Sandstone
Coal 36''
Coal 18''
Shale (Dark)
Bed of R.
SECTION 10
HILL S.W OF
WEST LIBERTY
HAZEL GREEN ROAD
Cannel C. 3 1/2''
Sandstone
Coal 8''
Cal. Concr.
Coal 24''
SECTION 9
BUCK FORK
ELLIOT CO
Sandstone
Shaly S.S.
Coal 6''
Slaty Partings 6
Coal 4 ft''
Bottom not shown
Rep'd 5 ft''
RUSH BR BIT COAL NO. 3
Coal 24'
Slate 6''
Coal 8''
Slate 2''
Coal 22'
Fire Clay
WEST LIBERTY COAL No 3
Top of Hill (Enlarged Scale)
Sandrock
Limestone Ore
Limestone
Sandstone
Sandy Ore
Coal Stain
Coal (See Sec. Above)
Sandrock
Cannel C 58''
Coal (Reported)
Bed of Br
SECTION 11
RUSH BR OF
ELK FK
MORGAN CO
J H Bogart Sc.

PLATE II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Kidney Ore
Coal 5 ft. No. 3.
(See Enlarged Sec.)
Shale
Coal 20''
Sandstone
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OF JOHN T. WILLIAMS
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Sandstone
Coal 18''
Cannel C 18'
Sandstone
Coal 30''
Dark Shale
Calcareous Con-
cretions
SECTION 7
SMITHS CREEK
MORGAN CO
C Stain
C Stain
Sandstone
C. Stain
Sandstone
Cannel Coal
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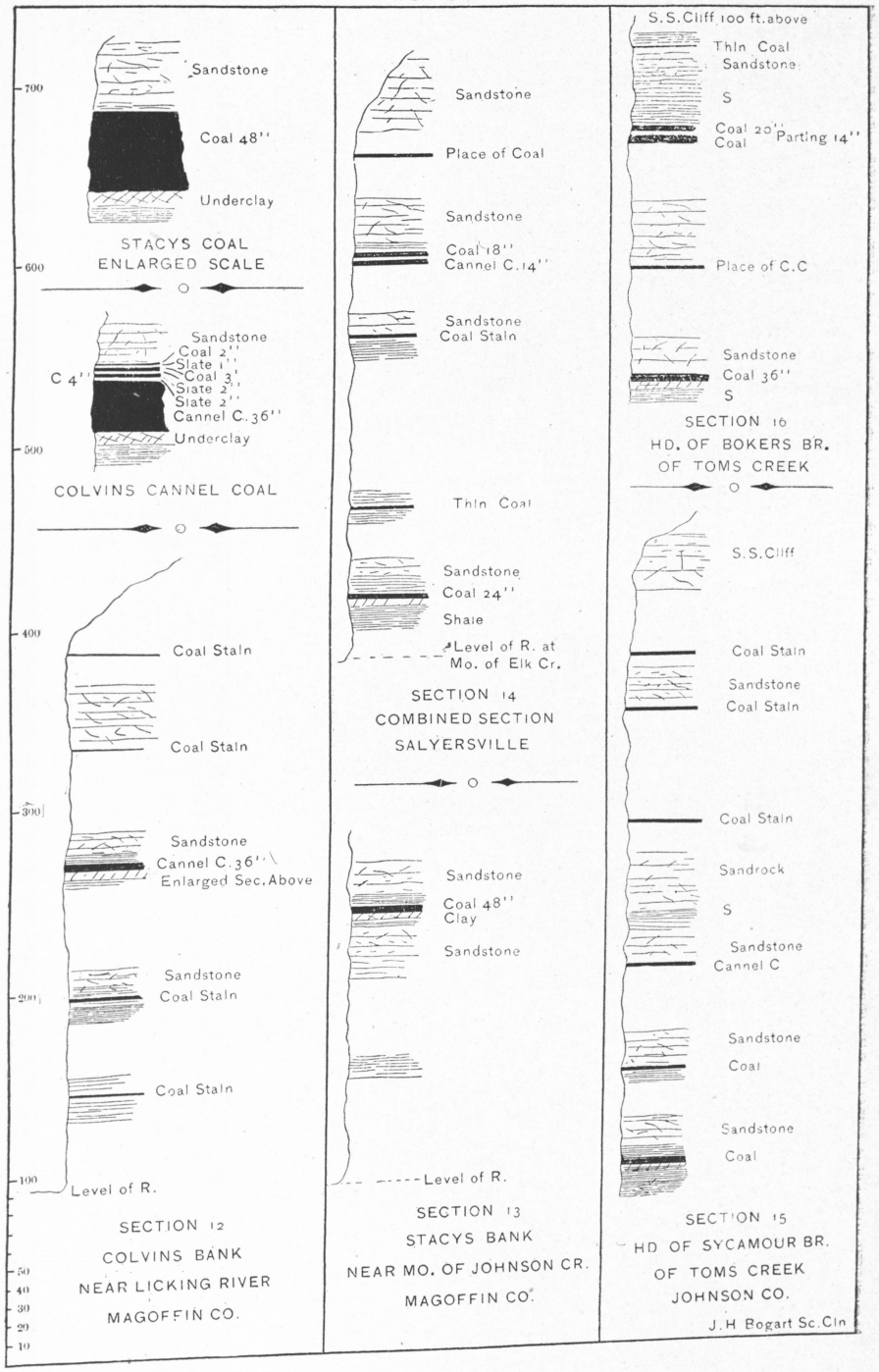
Coal 36''
Coal 18''
Shale (Dark)
Bed of R.
SECTION 10
HILL S.W OF
WEST LIBERTY
HAZEL GREEN ROAD
Cannel C. 3 1/2''
Sandstone
Coal 8''
Cal. Concr.
Coal 24''
SECTION 9
BUCK FORK
ELLIOT CO
Sandstone
Shaly S.S.
Coal 6''
Slaty Partings 6
Coal 4 ft''
Bottom not shown
Rep'd 5 ft''
RUSH BR BIT COAL NO. 3
Coal 24'
Slate 6''
Coal 8''
Slate 2''
Coal 22
Fire Clay
WEST LIBERTY COAL No 3
Top of Hill (Enlarged Scale)
Sandrock
Limestone Ore
Limestone
Sandstone
Sandy Ore
Coal Stain
Coal (See Sec.
Above)
Sandrock
Cannel C 58''
Coal (Reported)
Bed of Br
SECTION 11
RUSH BR OF
ELK FK
MORGAN CO
J H Bogart Sc.C.

PLATE III


700
600
500
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300
200
100
50
40
30
20
10
Sandstone
Coal 48''
Underclay
STACYS COAL
ENLARGED SCALE
Sandstone
Coal 2''
Slate 1''
Coal 3''
Slate 2''
Slate 2''
Cannel C. 36''
Underclay
C 4''
COLVINS CANNEL COAL
Coal Stain
Coal Stain
Sandstone
Cannel C. 36''
Enlarged Sec. Above
Sandstone
Coal Stain
Coal Stain
Level of R.
SECTION 12
COLVINS BANK
NEAR LICKING RIVER
MAGOFFIN CO.
Sandstone
Place of Coal
Sandstone
Coal 18''
Cannel C. 14''
Sandstone
Coal Stain
Thin Coal
Sandstone
Coal 24''
Shale
Level of R. at
Mo. of Elk Cr.
SECTION 14
COMBINED SECTION
SALYERSVILLE
Sandstone
Coal 48''
Clay
Sandstone
Level of R.
SECTION 13
STACYS BANK
NEAR MO. OF JOHNSON CR.
MAGOFFIN CO.
S.S.Cliff 100 ft. above
Thin Coal
Sandstone
S
Coal 20''
Coal
Parting 14''
Place of C.C
Sandstone
Coal 36''
S
SECTION 16
HD. OF BOKERS BR.
OF TOMS CREEK
S.S.Cliff
Coal Stain
Sandstone
Coal Stain
Coal Stain
Sandrock
S
Sandstone
Cannel C
Sandstone
Coal
Sandstone
Coal
SECTION 15
HD OF SYCAMOUR BR.
OF TOMS CREEK
JOHNSON CO.
J.H Bogart Sc.Cin

PART II.

THE COALS OF MENEFEE COUNTY

WITH NOTES ON

OTHER ECONOMIC RESOURCES.

A revised reprint of the larger portion of a report on the county by A. R. Crandall, now out of print. Revision by A. R. Crandall.

Milton Wisconsin

Menefee county has an area of about two hundred square miles. It reaches from the Licking river to Red river, along the Morgan and Wolf county lines, on the east and southeast, and extends, in a narrowed and somewhat irregular outline, into the valley of Slate creek, to the westward. The drainage of the county is effected by Beaver creek and its branches; by Salt Lick, the head waters of which are within the county, forming a valley that leads into Bath county on the north; by Clear Fork, Hawkins Branch and other branches of Slate creek, which rise in the western part and flow into Montgomery; by the greater part of Indian and Gilladie creeks, tributaries of Red river, on the south; and by some of the branches of Blackwater creek on the east. The Licking river forms the boundary from the mouth of North Fork to the mouth of Beaver creek, and drains a narrow belt along its tortuous course.

The area of the county is therefore made up of several drainage basins that open outward from the central part. These basins or main valleys are bounded by ridges 400 feet or more in height, which, together with the almost numberless minor ridges and spurs that determine the local drainage, cover a large part of the area, the main valleys being a complicated system of drainage by multiplied ramifications of narrow valleys, rather than basins, with broad bottom lands.

Geologically, the county is stretched across the outcrop of the lower members of the Coal Measures, and nearly across the belt of the Lower Carboniferous rocks, as represented by the Subcarboniferous limestone and the Waverly shales and sandstone. This fact, more than any other, carries with it the explanation of the character of the surface, as already described; for it brings the hard Conglomerate sandstone of the Coal Measures in that relation to the surface of the country which makes it the most important factor in the determination of the character of the drainage. The result is what has been described. A general inclination of the rock beds to the east and coutheast varies somewhat the results of erosion, as represented by the valleys in the different parts of the county; but the variation is one of degree rather than of kind; for the type of valley, as seen in the middle and eastern part, where the ridges are broad and the cliffs of Conglomerate hem in the narrow valleys, is still preserved on the head waters of Slate creek, where the Conglomerate cliffs, capping the hills, preserve the steepness of the hillsides, and continue the system of ridges and spurs, but with narrowed tops and broader valleys, out into the belt of the lower Carboniferous rocks. The cliff-making, Subcarboniferous limestone below the Conglomerate, although no more than forty to sixty feet thick, serves to extend this system beyond the present boundary of the Conglomerate.

The causes which lead to the disposition of the main valleys in a somewhat radiate order, are also closely connected with the geology of the region. Between the hard magnesian and cherty limestone of the Upper Silurian, and the cliff-making Subcarboniferous and Coal-measure rocks, about five hundred feet, mostly of shaly rock, is interposed—the Devonian black shales and the Waverly shales and sandstone. As might be supposed, this gives rise to a broad valley, having for its boundary the inclined Silurian beds, on the one side, and the receding edges of the Waverly beds, capped by the harder rocks above, on the other side.

Long-continued erosion has widened and diversified this valley, cutting in advance of the receding crests of limestone and Conglomerate the smaller valleys that head against

Beaver creek and Salt Lick. Thus, the dividing ridge between Slate creek and these streams has come to have a north and south direction, rather than northeast and southwest—the general direction of the line of outcrop. But this main ridge terminates southward in another main ridge, having its general course east and west, from which the waters of Slate and Beaver flow northward, and the tributaries of Red river southward. The westward extension of this ridge is a continuation of the boundary of the Devonian and Waverly valley already described. The eastward extension, as also the sudden change in the direction of the boundary of Slate creek valley, is explained by another set of conditions. Variations, both in the direction and the steepness of the inclination of the rock beds, becoming important factors in the determination of the direction of the drainage along this ridge. The general eastward dip of all the rocks in this region is modified by a depression which coincides in general with the Red river valley, and also by a slight depression in the direction of the Licking river. This east and west ridge follows the crest of an undulation which has its axis nearly at right-angles to the general outcrop line of the Coal Measures. It represents an elevation along which the coal-bearing rocks are preserved to the westward, somewhat beyond the general boundary of these rocks, and at the same time it reduces the width of the valley that lies between the Coal Measures and the Silurian rocks.

The exact amount and the details of the variation from the general eastward inclination of the several rock formations found in Menefee have not been ascertained, the limited time and means at command forbidding any attempt at accurate measurement. The depression and consequent dip towards Red river is apparent to the most casual observer. That towards the Licking is less noticeable. Mr. Joseph Leslie, in giving the results of his observations, made under the direction of Dr. David Dale Owen,* speaks of a number of undulations of the rock beds along the outcrop of the Coal Measures corresponding generally with the drainage basins leading to the westward. A profile section drawn by him illustrates this

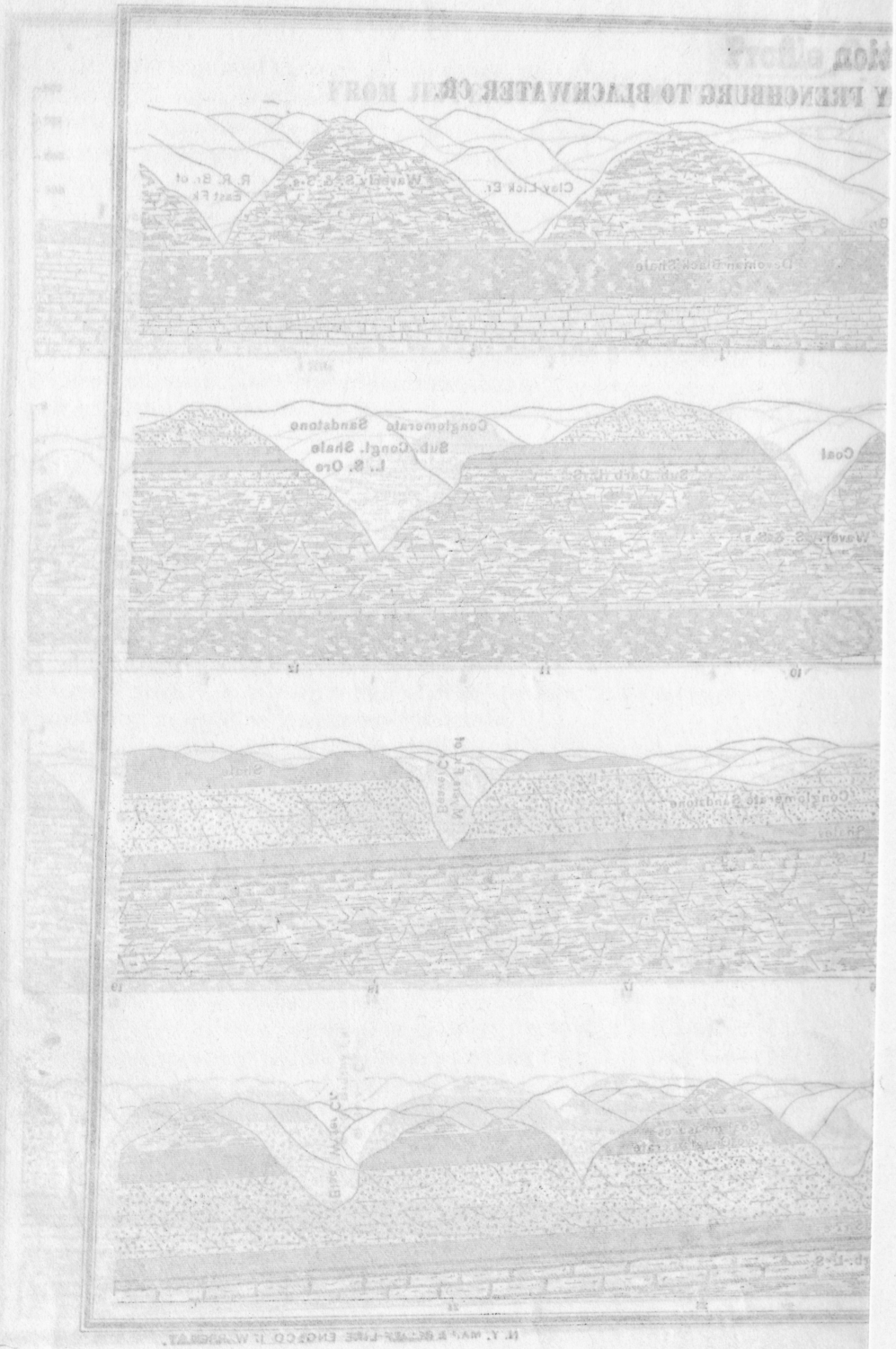
* Volume IV, page 456, old series.

feature, and gives approximate measurements of these undu lations.

These waves, at right-angles to the outcrop, doubtlessly anticipated the drainage of the country by the formation of geological valleys. The thickening of the beds above the Conglomerate to the eastward, and, finally, the change of the general dip, has caused the drainage to be westward along these geological valleys. In this last respect the thickening of the Coal Measures east and southeastward is more important, as a factor, than it has been heretofore recognized to be; but as few of the facts that come under this head are found in Menefee, it is only necessary to refer to it in this report.

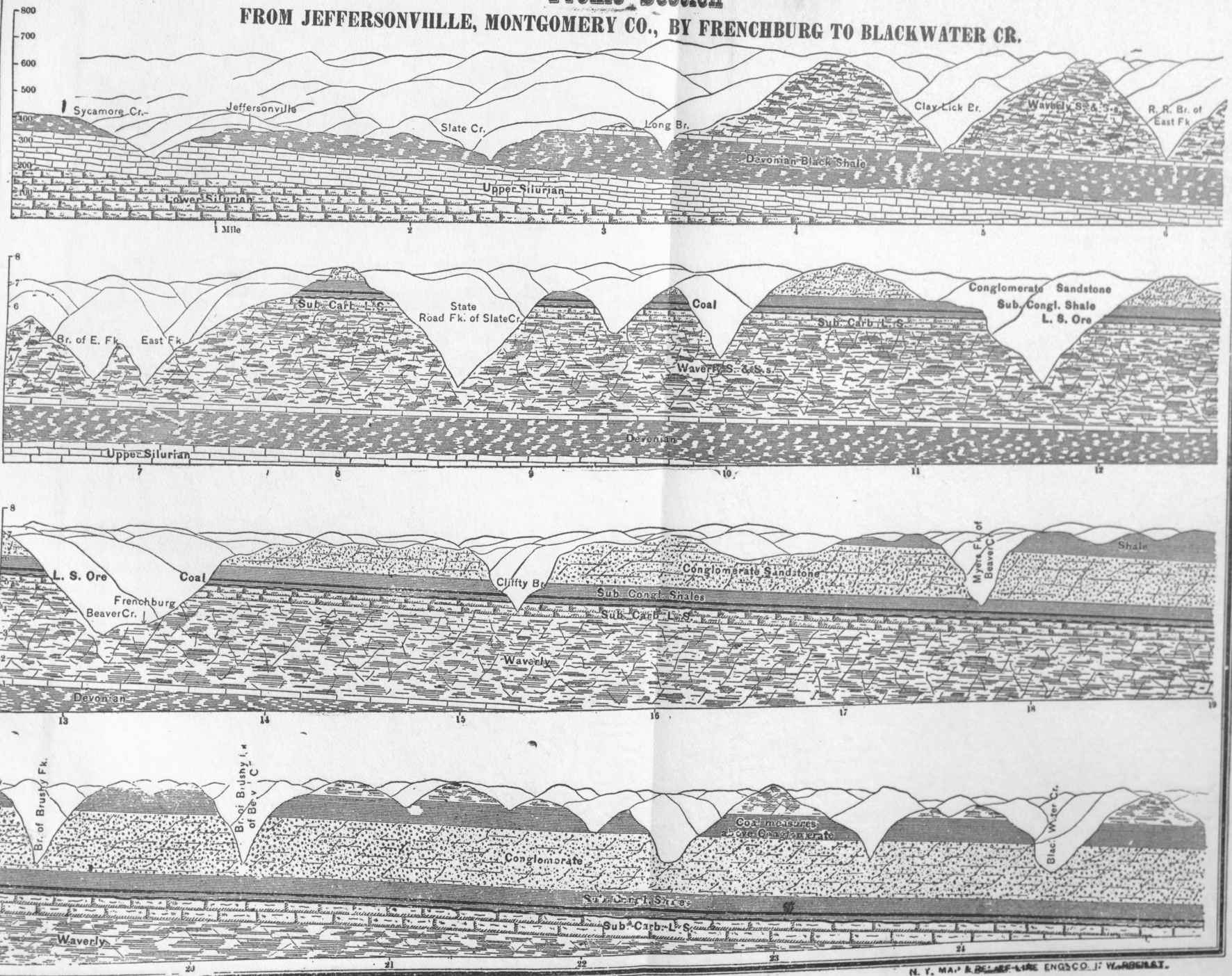
The Lower Carboniferous belt, as shown in this county, does not require particular notice, except in connection with the topography. A glance at the accompanying profile section will show the relation of the rocks of this belt to those of the Coal Measures above, and also to those of the Devonian and Silurian ages below. The section is drawn to illustrate, in a general way, the succession of beds as found in Menefee and the adjoining counties to the northeast and southwest, and more especially to show the geology along a line from Jeffersonville, Montgomery county, by Frenchburg, to Blackwater creek, near Sexton's Mill. The section is necessarily somewhat diagrammatic, the thickness of the various beds not having been ascertained at all points along the line. It is still more so as to the rocks below the drainage, the thickness being assumed to be the same as where exposed. The representation is made to aid those who have not been accustomed to trace the rocks below the surface. It should also be stated that the profile is largely diagrammatic for the Blackwater region, the plan for having a complete survey of Menefee not having been carried out.

The Coal Measures, as shown in the western part of the county, are represented by a shale series and by the Conglomerate sandstone. The former was formerly known as the Subconglomerate shale formation, and the coals found in these beds were known as the Subconglomerate coals. In this report the term is used without reference to any general classification of the Carboniferous rocks of this field.

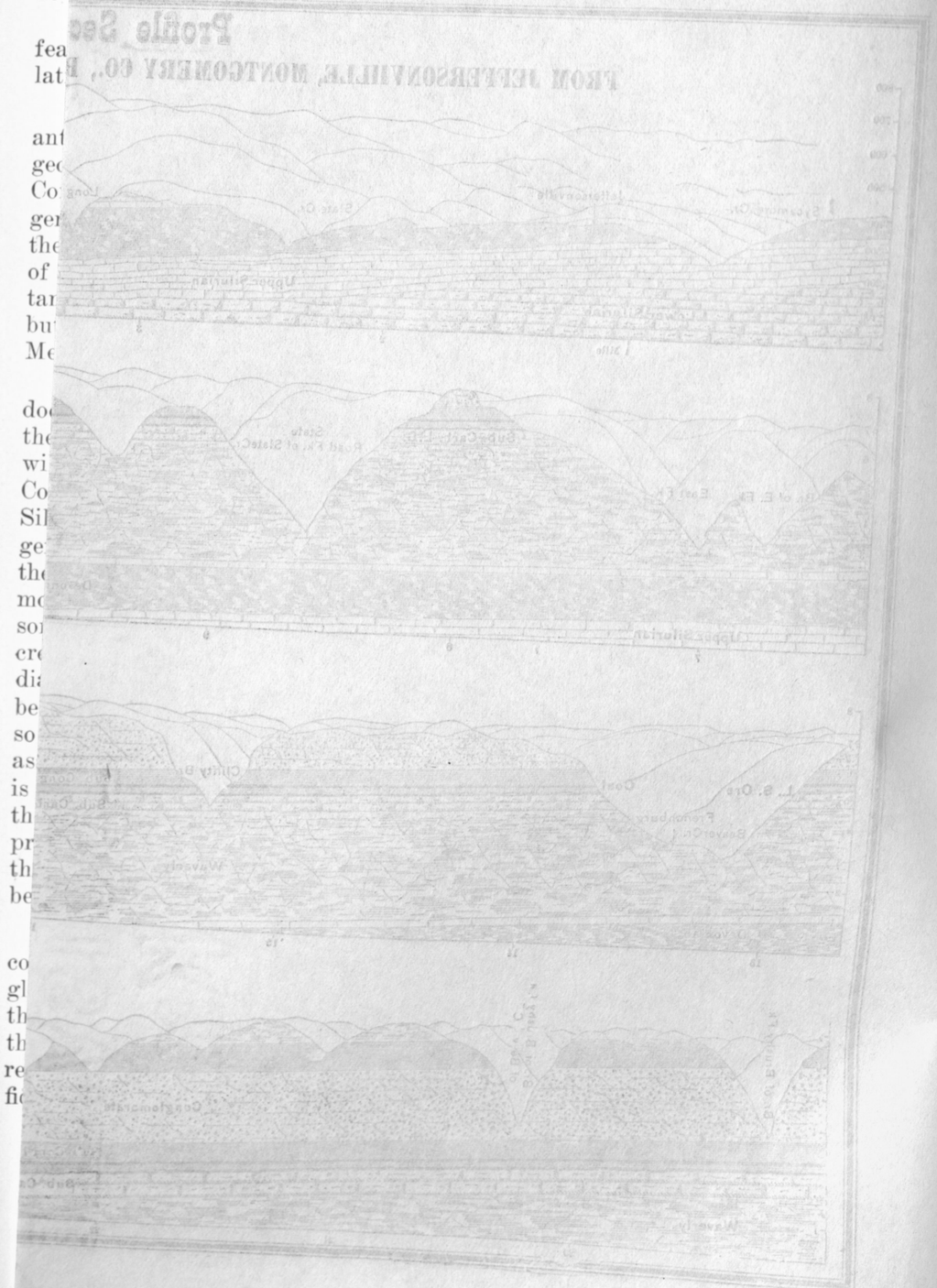


Profile Section

FROM JEFFERSONVILLE, MONTGOMERY CO., BY FRENCHBURG TO BLACKWATER CR.



N. Y. MAP & RELIEF LINE ENG. CO. J. W. ABBOTT.



In Greenup and Carter it was found that these shales were present, though not always separated from the shales above the Conglomerate, the Conglomerate sandstone being entirely wanting near the Ohio river, in places, but becoming prominent to the southwest.* In that region the lower limestone ore, a thin coal, and a thick bed of non-plastic fire-clay, are included. In this region this shale series is much more prominent; and, being surrounded by a great mass of Conglomerate sandstone, it includes nearly all the productive coal and iron-bearing rocks of Menefee.

The fire-clay bed seems to have fallen off in importance in proportion as the "Subglomerate shales" become more prominent, the only trace of it in this region, so far as known, being an occasional fragment found upon the surface. These fragments may lead to the discovery of local deposits of this clay. On the other hand, the coal deposits are increased in something like the same proportion. This increase does not always carry with it a corresponding increase in economic values, as will be seen by reference to sections 3 and 4, plate IV. (section plates accompanying this report), in which the number of beds is increased without adding greatly to the thickness of workable beds. Generally, however, the deposit is found mostly in a single bed of what proves to be an exceptionally pure coal of workable thickness.

In the earlier days of iron-making, the limestone ore bed proved to be an important deposit, both from the quality and the abundance of the ore. Whether the close association with a coal, apparently well adapted to the smelting of iron ore, gives an additional economic value to both the coal and ore, remains yet to be determined by practical experiment. It may be said that, with the present modes of iron-making, the distribution of ores in the Coal Measures is a matter of geological interest and of future importance rather than of present economic value, though the history of the rise of the iron industry in this country is closely connected with them.

The nearness to market is an important factor in any view of the economic value of the coal of this region. Reached by the railway from Mt. Sterling, this field ought, from all the conditions of the case, to supply a share of fuel to Central

*Report on the Geology of Greenup, Carter, and Boyd Counties and a Part of Lawrence by A. R. C.

Kentucky, at reasonable rates, until the heavier deposits of more remote regions are reached by this or other railroads; and even then the nearness to market will warrant a competition with more distant fields, until the best deposits of this region have been exhausted. For the same reasons, the Slate creek coal region is of more immediate importance than that of the central part of the county, although the actual coal area on Slate creek is comparatively small, the coal being found near the tops of the narrow ridges. (See profile section.)

Slate Creek Valley Coal.—Sections 1 and 5, plates IV. and V. show the position of the main "Subconglomerate" coal, and also the thickness at the two points indicated. The outcrop of this coal is found at this level, wherever the rocks of this horizon are exposed, in the Slate creek valley. Not being mined, or being exposed for local use only by benching, the thickness is rarely shown. It is probable, however, that an average thickness like that at the head of Bull Fork will be found in this region, including the main ridge between Slate and Indian creeks, and between Slate and Beaver.

Limestone Ore.—In this valley the limestone ore is not exposed as frequently as further to the eastward, although there is good reason to suppose that it will be found, in its usual variable thickness, at the top of the Subcarboniferous limestone, over the most of this region. As yet, no effort has been made to determine the value of this ore in this valley, fragments upon the surface being the only means of judging as to the range of the bed, as also, for the most part, of the thickness.

"Subconglomerate Series."—Sections 2, 3 and 4, plate IV., show a considerable variation in the character and thickness of the "Subconglomerate series" on Indian and Gilladie creeks. At the head of Indian creek the thickness continues to be about the same as on the head waters of Slate, while near the Red river and in the ridge eastward, between Gilladie and Beaver creeks, an increased thickness is found, and also an increased number of coals. Near the mouth of Indian creek, in Powell county, the thickness of the "Subconglomerate shale series" exceeds one hundred feet. Near the mouth of Gilladie creek the shales measure one hundred and twenty-five feet, as shown in section 4.

Shales and Cannel Slate.—Section 3, on the farm of Green Gibbs, on Muddy fork of Indian creek, shows a local feature that has been thought by some to promise better results from coal mining than elsewhere in this region. A considerable thickness of highly bituminous shale, in some parts an impure coal, gives to the unpracticed eye the appearance of a heavy coal deposit. Nearly the same feature, but in less thickness, is shown on one of the branches of Leatherwood Fork of Indian creek, a little to the westward. At the head of Cane creek a considerable thickness of cannel slate is found at the base of the shale series. There appears to be nothing in these beds to warrant any expectation of local deposits of exceptional value. On the contrary, it may be found that the impure coal of this locality is the equivalent of the coal of section 1. If this should prove to be the fact, then the area of the workable coal would be somewhat reduced. This feature appears to be local, however, and the main coal in workable thickness is found at the head of Leatherwood Fork, and also at a number of points on East Fork of Indian creek.

Gilladie Creek Coals.—The sections on Gilladie creek show an increased number of coals, and a change in the relative position of the main bed. Whether this last fact is owing to a decrease in the importance of the coal of section 1, or to an increase in the thickness of the shales below this coal, is not made clear from the facts at hand. It is quite probable, however, that one of the upper beds is the equivalent of the Bull Fork coal. No openings have been made in this locality to determine the real thickness of these beds. The exposures are such, however, as to show that the upper beds only may be expected to prove valuable.

Chimney-Top Creek.—Near the mouth of Chimney-Top creek, in Wolfe county, a section similar to section 4 is found. Coal of very superior quality has been shipped in small quantity to Mt. Sterling from the upper beds. The coal was obtained by benching. No authentic information has been gathered as to the exact thickness of the beds, which at the time the region was examined were mostly covered.

Limestone Ore.—The limestone ore is present in all this region, as is shown from the fragments on the surface. It is exposed in large blocks, particularly on the left fork of Gilladie creek, and in the ridge between Middle and Leatherwood Forks of Indian creek. Specimens have been sent in for the State Museum.

Beaver Creek. Shales and Coal.—Sections 6 and 8, plate IV., show the extremes in the thickness of the Subconglomerate shales in the valley of Beaver creek. A comparison with the sections near the Red river shows a decrease in thickness northward from that river; but it will be seen that, north of the main east and west ridge (known as Dry Ridge), the place of the main coal is the same as at the head of Slate creek, and that the decrease in the thickness of the shales is from the absence of the upper beds; the coal on Brushy creek, near Old Beaver Furnace, being immediately under the Conglomerate cliff. Further to the northeast, in Morgan county, this coal is again separated from the Conglomerate sandstone by shales. South of Dry Ridge, as has already been stated, the increase in the thickness of the shales appears to be mostly below the main coal. The evidence on this point is somewhat conflicting. It is an important matter only as it relates to the more general question of the equivalency of the coal beds to the south and southwest, where the "Subconglomerate" shales become still more prominent. It was the opinion of Mr. Leslie* that the lower part of the Conglomerate, changed in character to shale and shaly sandstone, and containing several beds of coal, contributes to the thickness of the "Subconglomerate" beds in this direction In Menefee the variation in thickness of the "Subconglomerate" shales is not accompanied with a corresponding variation in the thickness of the Conglomerate sandstone. On the contrary, in the Red river valley, where the shales are the most prominent, the Conglomerate is also at its maximum thickness, as shown near the mouth of Gilladie creek, the Conglomerate being more than 200 feet thick at this point, the shales reaching 125 feet, and including four coal seams, the number reported by Mr. Leslie to the southwest.

*See report on the Topography and Geology of the Western Margin of the Eastern Coal Field of Kentucky, vol. IV, old series, page 454.

Cannel.—It will be noticed that the position of the cannel coal in sections 3 and 4 indicates a thickening of the lower part of the shale series. On the other hand, the coal in section 6, near the base of the shales on the Beaver creek side of the ridge, appears to be the equivalent of the Bull Fork and Hawkins Creek beds, sections 1 and 5.

Beaver Creek Coal.—In the valley of Beaver creek, except perhaps along Dry Ridge, where the shale series is in considerable thickness, only one coal bed of importance will be found. The sections of plate VI., together with those already referred to, show the position of this bed. In thickness it is not uniform, varying where exposed from twenty inches to thirty inches, at the outcrop.

Ore on Beaver Creek.—The limestone ore is exposed at a great number of places in Beaver Creek valley. In the immediate region of Old Beaver Furnace it was formerly opened and worked. (See sections 13 and 14, plate VI.) In the region of Clear Creek Furnace it was obtained in abundance for furnace supply. (See sections 7, 12 and 15.) The region near the head of Beaver creek promises, so far as surface indications go, to become a more important iron ore region than the localities already mentioned. Sections 6, 9 and 11 show the surroundings of this bed as noted in this region. On the Old State Road branch, above Frenchburg, the ore is particularly abundant on the surface, as also at some points along the face of the ridge between the upper Beaver valley and the head of Salt Lick.

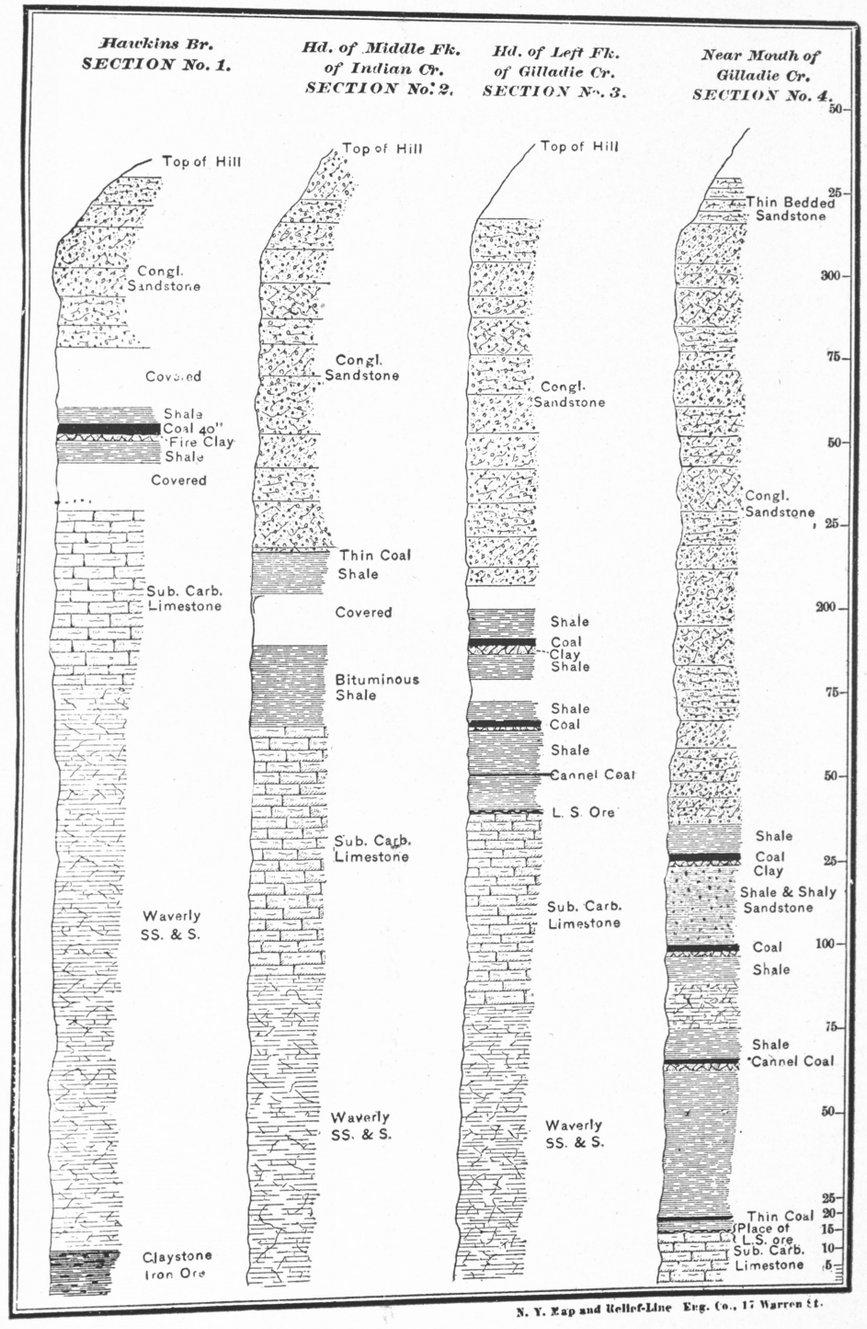
Lithographic Limestone.—Section 10, near the head of Beaver creek, and section 16, near the mouth of the same creek, show a feature which is not uncommon in the Subcarboniferous limestone of this region—a bed of so-called lithographic limestone, varying from a few inches to two feet in thickness. In the latter region this band is exposed at a number of points; and from Mr. McMurtry's quarry, on the opposite side of the Licking river, blocks were obtained some years ago and tested for lithographic use, with satisfactory results. The band is not so uniform in quality, where seen, as to insure equally good results without careful selection.

1,002 feet, and by the L. R. Lyon well, near the Morgan county line, (see Plate A. of this Bulletin), which was drilled to a depth of 929 feet below the Carboniferous beds.

Soils.

The soil of Menefee is mostly sandy loam. Where the shales below or above the Conglomerate supply the greater part of the surface material, the soil is more clayey. The disintegration of the Conglomerate sandstone, the most prominent rock of the greater part of Menefee, gives to the soil a large per cent. of coarse sand. The presence of the Subcarboniferous limestone, no doubt, adds considerably to the richness of the soil of the valleys where it is exposed; while the woodlands, which comprise the greater part of the county, are rich in vegetable mould. The unevenness of the surface is unfavorable for extensive tillage. Pasturage should become an important part of husbandry in this region. The steep hillsides are particularly unsuited to tillage. Rich in vegetable mould when first cleared of timber, it takes but a few years of plowing and washing to render them comparatively barren, and, for a time, nearly worthless. When this result has been reached, it is too late to seed for pasture. With the system, or want of system in farming, that tends to this result, there is nothing to do but to clear another tract, and to sacrifice it in the same way. It is largely owing to this way of farming that the apparent barrenness of the hill country, where cleared, so belies the natural fertility of the soil. Well directed enterprise in farming would do very much to offset the disadvantages of a hilly and broken surface.

PLATE IV.



N. Y. Map and Relief-Line Eng. Co., 17 Warren St.

PLATE V.

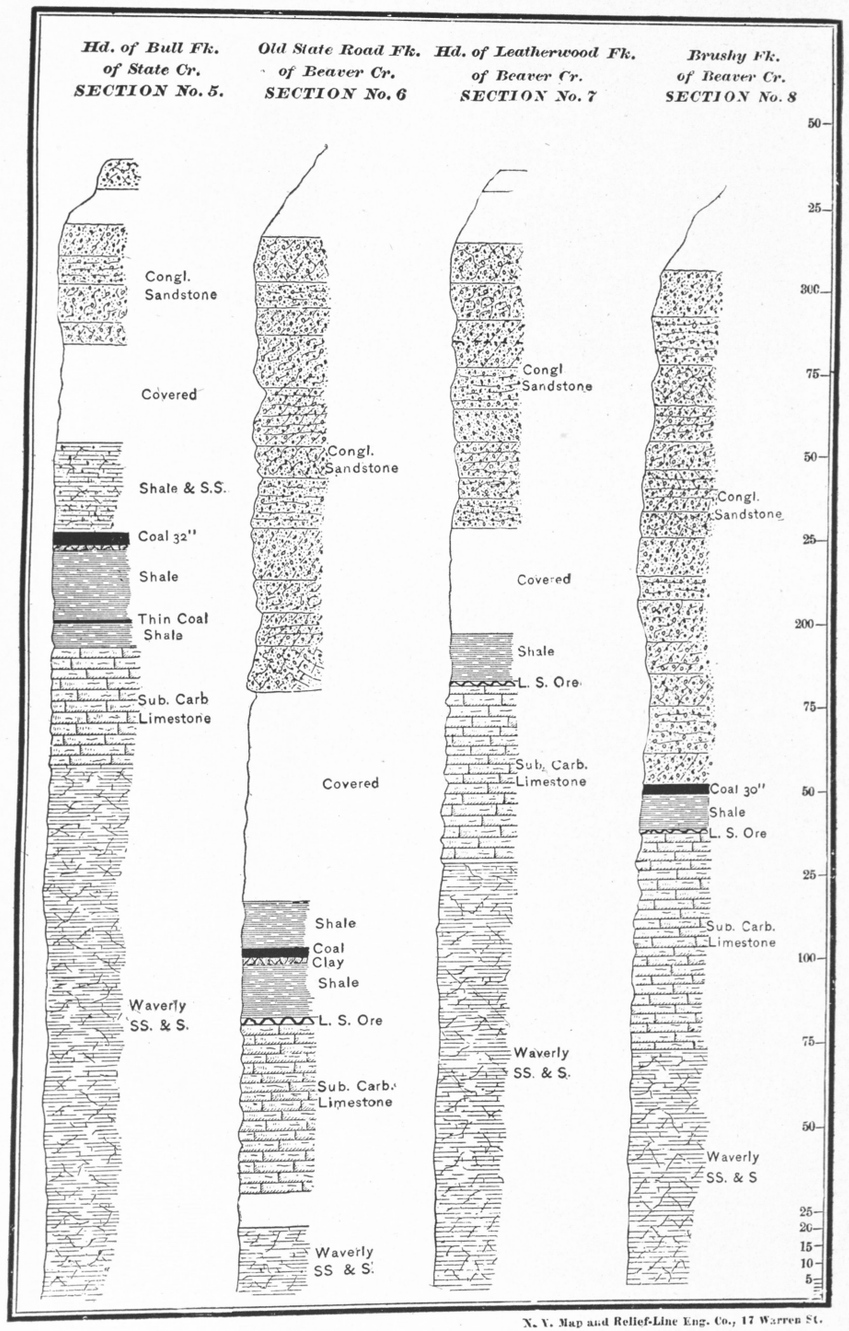


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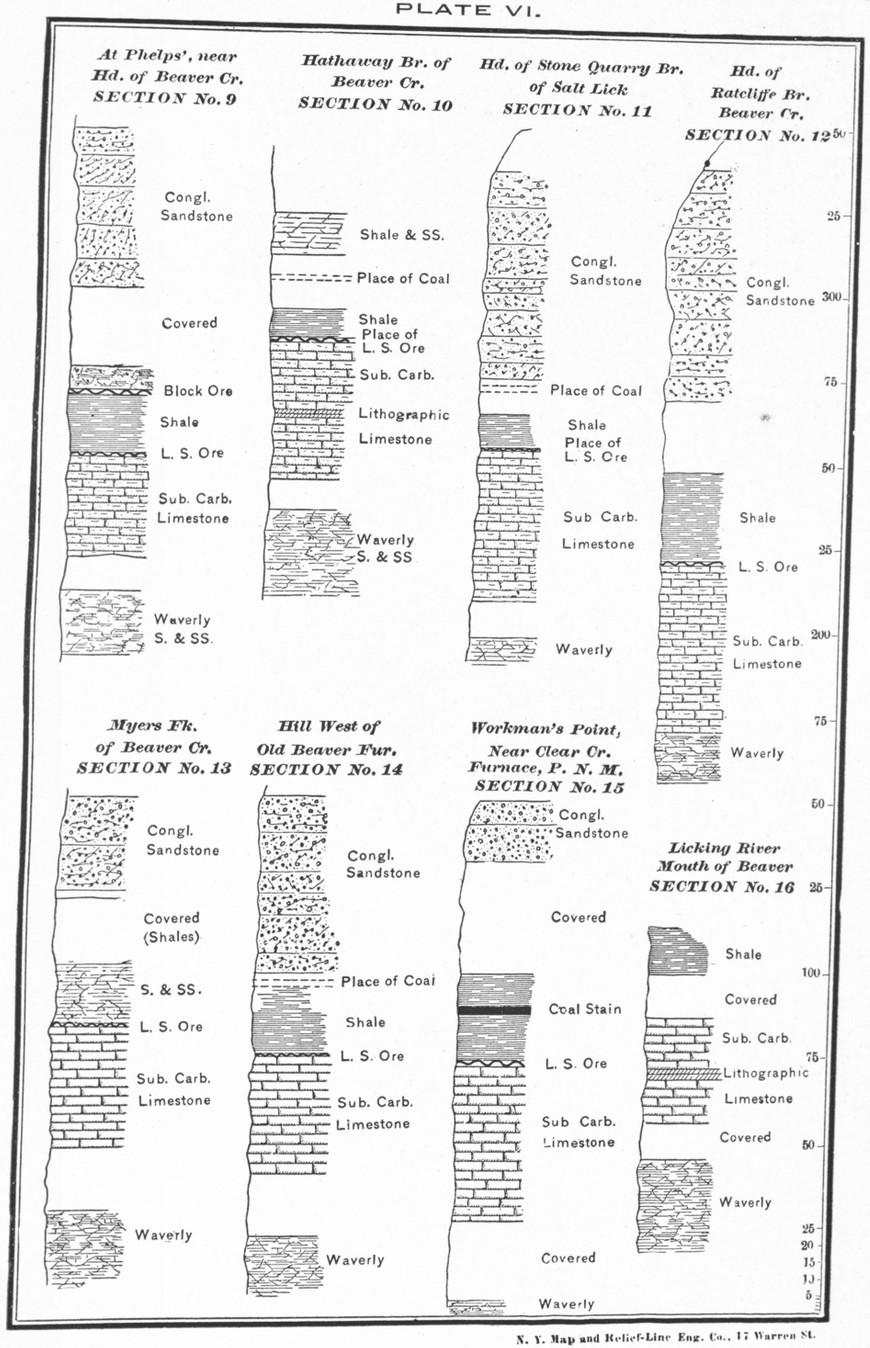
PLATE VI.



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PART III.

SOME COALS ALONG A LINE FROM NEAR CAMPTON, WOLFE COUNTY,

TO THE MOUTH OF

TROUBLESOME CREEK, BREATHITT COUNTY.

Extracts from a report by P. N. Moore, now out of print.

[In order to meet present needs to some extent, at least until a detailed report based on more recent field work can be issued, it has been deemed well to include in this Bulletin the following extracts from a report made some years ago by Mr. P. N. Moore, who at the time was a member of the State Geological Survey, then under the direction of the late N. S. Shaler. Ownership of some of the tracts upon which coals were observed has doubtless changed since the report first appeared (in volume IV. of the Shaler reports), but no doubt the old names have endured sufficiently well in the various localities to serve for identification of the places noted, and in the main the descriptions of the coal deposits will serve as well now as when they were made.

The line of Mr. Moore's examinations began at the top of the Conglomerate sandstone, at the head of Chimney-Top creek, in Wolfe county, and extended in a southeastwardly direction—crossing Campton, Upper Devil and Holly creeks, and by the mouth of Frozen creek—to the mouth of Troublesome creek, in Breathitt county. Following are the extracts:—C. J. N.]

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TOPOGRAPHY.

The country between the Red and Kentucky rivers has its topography determined for the greater portion of its area—all of it, at least, except that near the head of Red river—by the Conglomerate sandstone.

In its western extension, from the Middle Fork of Red river westward, the dividing ridge is narrow, high, and precipitous, as the sandstone, in its resistance to erosion, forms bold and massive cliffs, often extremely picturesque in outline. The ridge grows higher and narrower to the west as the determining rock, the Conglomerate, rises in conformity with the general rise in the rock formations of the country; while to the east, toward the head of Red river, as the Conglomerate descends, and is covered by an increasing thickness of overlying shales and shaly sandstones, the surface of the country becomes more even, the hills lower, and with more gentle slopes, while only that portion of the country bordering closely on the main streams shows the cliff topography.

From the head of Middle Fork of Red river eastward, for several miles, the dividing ridge is narrow, and the thickness of rock above the Conglomerate slight. After passing Chimney Top and Lower Devil creeks, the surface of the country becomes more even, the hills low, not usually extending more than one hundred and fifty or two hundred feet above the branches of the main creek, while the slopes of the hills are so gentle that they can be, and in many cases now are, cultivated clear to the tops. It is one of the best agricultural regions in Eastern Kentucky. In the ridge there are numerous low gaps, leading from one stream to another, offering a comparatively easy passage for a railroad line.

The topography is of this character on both sides of the dividing ridge, at and near the heads of Upper Devil, Swift's Camp, Stillwater, and Holly creeks; but along the Red and Kentucky rivers, as well as on the lower part of the creeks just mentioned, the country is still rocky and broken by the Conglomerate cliffs.

As we proceed southeastward from Holly creek, another change takes place in the topography, which is here determined by the alternated coarse and shaly sandstones which occur above the Conglomerate.

After the Conglomerate passes beneath the drainage, there is no one member of the rock series which alone determines the topography. On the contrary, we have the hills, showing the resultant of the different resistance to erosion of massive sandstones and shales or shaly sandstones. The hills rise from four hundred and fifty to six hundred feet above the river, and present a much steeper slope, extending in about the same degree from top to bottom; but when it comes to be examined in detail, it is seen to be made up of a series of terraces, steep, and often precipitous, where the heavy, coarse sandstones occur, and more gently sloping over the shales and shaly sandstones. The coarse sandstones, from the way they resist erosive agencies, are more often exposed than the shaly beds, and they are seen in proportion to their thickness. The shales and shaly sandstones are usually covered by the talus from the overlying coarse sandstones, and good exposures are more rare.

This character of topography begins above the mouth of Holly creek, and extends as far as the field covered by this report. Above Jackson, in the dividing ridge between the river, or the short branches emptying immediately into the river and Cane creek, a heavy sandstone, about fifty feet in thickness, caps the hills, which there rise to a greater height above the river than at any place before noted.

GEOLOGY.

In the description of the topography, or the surface configuration of the country under discussion, the character of the geology has been roughly outlined, for it is the rock structure which determines the contour of the surface of any region, and no intelligible description of the topography can well be made without reference to the determining rocks.

* * * *

As may be inferred from what has already been said, the Conglomerate sandstone is by far the most prominent member of the rock series of this region, and has exerted a greater influence upon the formation of the topography than any other.

The Conglomerate is often found in two members, with a series of shales containing coal between. The lower member is uncertain and irregular, both in occurrence and thickness; but the upper member is present all through this region, although varying somewhat in thickness. It is the most important, and is the one referred to as the Conglomerate. In thickness it is here from one hundred and fifty to two hundred feet. In character it is a coarse, massive sandstone, at places full of pebbles, and usually showing prominent cross-stratification lines. The pebbles are most abundant in the lower part of the sandstone, decreasing towards the top; and as we go to the southeast, where the greater portion of it has passed below the drainage line, and the top only is exposed, they disappear almost altogether; so that it becomes difficult to distinguish the Conglomerate from some other coarse sandstones which occur above it.

The thickness of rock above the Conglomerate at the western end of this section is small, ranging from fifty to one hundred feet, and this only in detached knobs at the heads of the small streams, while out on the points the top of the Conglomerate is often bare. This thickness increases rapidly towards the southeast, until, between Swift's Camp and Upper Devil creeks, in the neighborhood of Campton, it ranges from one hundred and twenty-five to one hundred and seventy-five feet.

In the dividing ridge at the heads of Holly and Stillwater creeks this thickness increases to two hundred feet and more; but along the lower portion of these streams it is usually less. Above Holly creek the hills rise rapidly to twice their former elevation above the Conglomerate, in consequence of a change in the character of the prevalent rock from shaly to coarse sandstone. At the western end of the section, from the head of the Middle Fork of Red River to Swift's Camp creek, the rocks above the Conglomerate are almost entirely shales or shaly sandstones, wherever seen.

In passing above Swift's Camp creek thicker and coarser sandstones begin to be seen, which increase in frequency until they form the greater portion of the rocks.

The Conglomerate passes beneath the drainage near the mouth of Frozen creek. From this point to the mouth of

Troublesome creek, coarse, massive sandstones, ranging from ten to fifty feet in thickness, are the most prominent features in the section. These sandstones are frequently exposed in cliffs on the hillsides; but, with few exceptions, they do not hold their character and position over large areas, as they frequently give place to shaly sandstones, and others, which before had been shaly, become coarse and massive.

Of bituminous and clay shales, there is not in this region any great thickness. Occasional outcrops are found, but, in comparison with the great mass of shaly and coarse sandstones, they are rare; nor do they hold any great extent in area; on the contrary, they seem to be quite local, and when the attempt is made to trace them for any distance, they are usually found becoming more and more sandy, until they change insensibly to shaly sandstone.

After passing the Subcarboniferous limestone, which lies below the Conglomerate, there is no pure limestone of any thickness found in this region. Numerous bands of dark very silicious limestone or calcareous sandstone are found, but they are usually thin; not in any case more than four feet in thickness. In many places they do not form regular strata, but occur in large lenticular or kidney-shaped masses, lying in sandstone or shale. These kidneys are usually more silicious than the beds or strata of impure limestone. In places, some of these bands of limestone become fossiliferous, but these cases are exceptional. So far as seen, they do not occur at regular, well-marked intervals, nor do they have any great horizontal range.

The limestones, so pure in quality and so persistent in position, which often serve as guides in the identification of coal seams near the Ohio river, seem to be entirely wanting here, and we have in their places these numerous, erratic, and untrustworthy bands of impure limestone, which are of almost no value whatever for use in geological identification.

The absence of these limestones, and the frequency with which sandstones and shales change character, render the construction of an accurate section, and the identification of coal seams across any great interval, a matter of considerable

difficulty. The absence of limestone and fine shales, as well as the character of the prevailing rock, which is a coarse mechanical sediment for the most part, indicates the prevalence throughout this region, during its deposition, of shallow waters much disturbed by currents, accompanied by frequent changes of level. There was no subsidence deep enough or long enough continued to allow the formation of pure limestones, nor were the waters quiet and land-locked lagoons, in which the fine mud could settle undisturbed, to be afterwards compacted into shale beds.

It is worthy of notice, that the Subcarboniferous limestone, which in Ohio is thin and frequently wanting altogether, thickens from the Ohio river to the southwestward, while the limestones of the Coal Measures, several of which are found in Ohio, disappear soon after crossing into Kentucky.

[Mr. Moore estimates a total thickness of 750 feet of strata above the top of the Conglomerate sandstone along the line examined, which, "with the 325 feet of Conglomerate and 'Subconglomerate beds,' makes a total of 1,075 feet of Carboniferous rocks above the Subcarboniferous limestone, from the river at the mouth of Troublesome to the edge of the Coal Measures."—C. J. N.]

The Coals.

The coals of this region are numerous and of excellent quality, and, taken as a whole will bear comparison with those found in any other portion of the State in quality or thickness. They are all classed as bituminous coals; but they show all the varieties of this class, known as dry-burning, caking and cannel coals. The principal coals are of the dry or free-burning variety, while the caking or fat coals are comparatively rare. Cannel coals are abundant and of excellent quality, certain of them having a reputation second to none in the State.

[In a longitudinal section accompanying the original report, the reproduction of which would be of no especial service here, Mr. Moore shows eight seams of coal above the Conglomerate.—C. J. N.]

Coal No. 1.—The first coal of the section, the equivalent of coal No. 1 of the Greenup County section and of Ohio Geological Reports, occurs from 20 to 50 feet above the top of the Conglomerate. It is first opened near Campton, on Swift's Camp creek, and also on Bear Pen Branch of Upper Devil creek. Its position, here, is about 25 feet above the top of the Conglomerate. Its thickness is from 24 to 30 inches. It is a fat or a caking coal, of very good quality, especially the lower portion of it. In this respect it differs from the No. 1 coal further north, which is there a typical dry-burning or furnace coal. * * * The percentage of sulphur present varies considerably, but is usually low. It is seen at a number of places along the river, holding an average thickness of 30 inches. Below the mouth of Frozen creek, near Mr. Nathan Day's, is an old mine, fallen in, where the coal is said to be 36 inches thick in some of the rooms. Below the mouth of Holly creek, on the Holland place, is an exposure where it measured 34 inches; but this includes a shale parting of several inches in thickness. On Frozen creek it is seen at a number of places near the mouth, usually about 28 inches thick; but above this stream it has not been seen by the writer. A coal, which is probably this one, is reported on the old Cockrill farm. It probably goes under the river not far above. This coal is an excellent blacksmith fuel, and would doubtless make a firm, hard coke.

The following analyses show something of the character of this coal in this region:

	1	2
Moisture	3.74	2.50
Volatile combustible matter	35.52	41.10
Fixed carbon	52.64	49.22
Ash	8.10	7.18
Total	100.00	100.00
Coke	60.74	56.40
Sulphur	2.466	0.818
Specific gravity	1.336	1.300

No. 1 is an average sample by Mr. A. R. Crandall, from C. M. Hanks' bank, at Campton, Wolfe county.

No. 2 is an average sample, by the writer, of a coal from an opening above Wm. Day's, on Frozen creek, Breathitt county.

Coal No. 2.—About 75 feet above the coal just described, has been found, at a few places, another coal seam, which is probably the equivalent of coal No. 2 of the Greenup section. Like that, it is usually thin, not having been seen more than 20 inches thick. At other places it is less, not more than 12 inches. It is not mined at any place, and, consequently, no samples were procured for analysis. It is best shown on the branches of Swift's Camp creek, above Campton.

Coal No. 3.—At a distance ranging from 140 to 190 feet above the Conglomerate is found a coal, which, from its character and position, seems to be the equivalent of coal No. 3 of the Greenup section.

It is better known than any other coal of this region, for the reason that it has been most extensively worked.

* * * From our present knowledge, this coal seems to be one of the most regular and trustworthy of any in this region, which characteristics it holds all through Eastern Kentucky, as far as we now know it. Along the ridge, between the Red and Kentucky rivers, it is first opened at the head of one branch of Upper Devil creek, about four and a half miles from Campton, at the Hobbs bank.

The coal here consists of three members or divisions, separated by thin shale partings. The following is the section of the coal at this place:

	Inches.
Coal	24
Shale parting	3
Coal	20
Shale parting	8
Coal	15

Giving us a total thickness of 4 feet 11 inches of coal. The quality of the coal here is excellent, as will be shown further along. It is somewhat sulphurous in appearance; but the pyrites is in small flakes, which hardly form an appreciable percentage of the whole. This splendid coal is the first of a thickness greater than three feet, which would be reached by a railroad, after crossing Red river.

On the Kentucky river, the first opening of this coal is at the Holland mine below the mouth of Holly creek. The coal is here about 3 feet in thickness, or a little less. Along the river, the thickness varies from 3 to 3½ feet of coal. The thickness, including parting, is usually much more, as there is commonly a slate parting, which varies from 3 to 12 inches. This is usually measured with the coal; hence it is commonly called 4 feet thick.

At the Hobbs bank, this coal is about 400 feet above the river. It rapidly descends to the southeast, until, at the Holland bank, it is only a little over 300 feet above. At Jackson it is only 100 feet, while above this it descends still more rapidly, until, at the mouth of Quicksand creek, it is at the level of low water in the river. From this point to the end of the section the dip changes, and the rocks are horizontal, or nearly so. From some observations made above the mouth of Troublesome creek, it seems probable that the coal, there, dips in the opposite direction, and that it rises more rapidly than the rise in the level of the river. This conclusion is based upon an identification of a coal on Wolf creek, which is not as yet supported by sufficient stratigraphical evidence to be by any means certain, as the examinations in that region have not yet been detailed. The coal on Wolf creek resembles the No. 3 very closely in physical character and chemical constitution, as will be seen by the analyses appended. It is thicker here than it is known to be at any other locality below. It is reported, on good authority, to be 7 feet in thickness. When visited by the writer, the drift had caved in, so that the whole thickness could not

be seen; but satisfactory evidence was obtained, by measuring some of the timbers which had been cut to support the roof of the drift, that the coal is more than 6 feet thick.

Below Jackson, at Spencer's mine, this coal, with a total thickness of about 4 feet, including partings, shows a little less than 3½ feet of coal. At Cardwell's bank, near Jackson, it is nearly the same. Along the river, opposite and above Jackson, this coal has been mined at many places. * * * It is stated that the shale parting grows gradually thicker and the coal thinner further up stream. This statement is corroborated by the following section, at a natural exposure of the coal in the bank of the river at the mouth of Stray branch:

	Inches
Coal	21
Shale parting	20
Coal	5
Shale parting	4
Coal	2
Shale parting	2
Coal	1
Shale parting	14
Coal	7

The total thickness of coal in the above section is 36 inches; but the numerous thin bands into which it is divided, and the shale partings between, show that at this point, during the formation of the coal, it was subject to frequent fluctuations of level, probably not of any great extent, but sufficient to check the growth of the coal vegetation, and to allow the deposition of layers of mud, which became afterwards hardened into the clay shale partings. * * * *

In character, it is usually a distinctly laminated and dry-burning coal, with considerable fibrous coal or mineral charcoal between the laminae. At places portions of it are bituminous enough to coke, but this is not its general character.

The amount of sulphur present varies considerably, but is usually low, as is also the ash, while the percentage of fixed carbon is high. * * * *

The following analyses show the composition of this coal at several places:

	1	2	3	4
Moisture	3.50	3.56	4.90	2.76
Volatile combustible matters	35.20	33.56	35.30	36.60
Fixed	56.70	58.38	55.50	56.50
Ash	4.60	4.50	4.30	4.06
Total	100.00	100.00	100.00	100.00
Coke	61.30	62.88	59.80	60.56
Sulphur	1.189	1.381	3.153	0.865
Specific Gravity	1.294	1.297	1.290	1.290

No. 1 is from the Hobbs' bank, at the head of Upper Devil creek. Average sample by the writer.

No. 2 is from Wm. Spencer's mine on Kentucky river, below Jackson. Average sample by the writer.

No. 3 is from the Holland mine, below the mouth of Holly creek. Sample taken by the writer from a large pile of coal which had lain exposed to the weather for about one year.

No. 4 is from the South mine, on Wolf creek. Average sample by Mr. J. R. Procter and the writer, from a large pile which had also been exposed to the weather for about a year. As already stated, this coal is not positively identified as the same as the others, but for convenience it is given with them. It will be noted that its chemical composition closely resembles the others.

Cannel Beds.—The first workable cannel coals near the line of the section are found above coal No. 3. Such coals occur, at various levels, all through this region; but the lower ones are usually thin.

On the Kentucky river, at a distance varying from 30 to 50 feet above coal No. 3, is found another coal, usually about 2 feet thick. It is a rather fat, bituminous coal, of very good quality; but it has not been worked. It is seen of this thickness at the Spencer and Cardwell banks, below Jackson.

Still further down the river, it is reported to be more than 3 feet thick, but it was not seen by the writer. Above Jackson this coal is thinner.

At many localities the proper level for this coal is occupied by a shale or sandstone, while at about 70 to 80 feet above Coal No. 3 we find a cannel coal. This is the cannel coal which is seen in the river hill about one mile below Wm. Spencer's. It is not well exposed here, but it seems to be thin. It is probably also the cannel coal seen at G. W. Johnson's, near the head of Nichols Fork of Frozen creek. It is here seen in outcrop along the hillsides at many places, but has not yet been opened so as to show its full thickness. Blocks of coal nearly two feet in thickness were seen tumbled out on the hillside; but beyond this there was nothing to determine its thickness.

The frequency of outcrop of this coal in this neighborhood shows it to be quite a persistent seam, and it is to be hoped that, when it is opened, it will be found of workable thickness. Two varieties of cannel coal are seen here, both probably from the same bed or seam. One is hard, of very uniform, rather coarse-grained structure, showing perfect conchoidal fracture, and abounding in brilliantly polished surfaces or slickensides, which have probably been caused by faults or slips in the hill squeezing and pressing the coal upon itself. This coal contains a considerable proportion of earthy matter, as will be seen by the analysis further along; and to this cause may possibly be due the readiness with which it assumes a polish.

Fortunately, this variety of the coal seems to be much less abundant than that other, which shows a partly laminated structure, irregular fracture, is of a less homogeneous nature, and not nearly so handsome; but which proves, on analysis, to be one of the best cannel coals of this whole region. It is sometimes called the "curly cannel," owing to its peculiar structure.

The cannel coal which is found at John Murphy's, on Stillwater creek, is probably the equivalent of this seam.

The cannel coal which is mined on Quicksand creek, about one mile above its mouth, is probably also the same.* This coal shows a total thickness of 25 to 26 inches, of which the upper 8 inches is bituminous, leaving only a thickness of 17 to 18 inches of pure cannel. * * * The analysis of this coal is given further along in this report.

On Georges branch, which empties into the Kentucky river several miles above the mouth of Troublesome creek, a cannel coal of excellent quality is mined, which, if the supposition as to the equivalency of the Wolf Creek coal with the No. 3 be correct, is the same coal as that just described on Quicksand creek. This coal shows a total thickness of 34 to 36 inches, of which 22 to 24 inches is cannel coal, the remainder bituminous. * * *

The position of this coal at the various localities corresponds very well with that of coal No. 4 of the Greenup County Section.

At a distance ranging from 60 to 80 feet above the last described coal another has been seen in imperfect outcrop at a number of places. * * * The stain or the weathered outcrop of it, is frequently seen. On a short branch emptying into the Kentucky river from the opposite side, above the mouth of Quicksand creek, this coal is washed bare by the stream, and shows a thickness of 30 inches. It is bright, glistening, caking coal, of very good quality, as far as could be judged from the limited exposure.

At the Haddix mines, on the bank of the river above Troublesome creek, this coal has been found as a cannel coal, and is reported to be 20 inches thick. The outcrop was not sufficient, when seen by the writer, to prove anything as to its thickness; but it showed the existence of cannel coal at that point.†

From 110 to 125 feet above this last coal, at a height, where best known, of 250 feet above the Kentucky river, is found the most valuable cannel coal of this region. It is commonly

*The Quicksand Cannel is regarded as No. 4.—C. J. N.

†The bed is 12½ inches thick, the upper 6 inches being slaty coal and the bottom 6½ inches cannel.—C. J. N.

known as the Haddix coal, as it is mined most largely at the Haddix mines, at the mouth of Troublesome creek.* This is the thickest cannel coal on the line of the section, and in quality it is equal to any. It does not contain as much volatile combustible matter as some of the other cannel coals, and will not make quite so brilliant a fire, but it contains less ash than the most of the others. * * * At the Haddix and Sewell mines it usually shows a thickness of 34 inches of cannel coal, with 10 to 12 inches of bituminous coal above. In one of the drifts of the Sewell mines there was seen 36 inches of cannel coal, with 10 inches of bituminous above; and the miners reported that, in some rooms, the cannel coal reached a thickness of 48 inches. The miners "bear in" on the soft bituminous coal above. and then wedge up the cannel coal in large blocks.

This coal is also found on the same side of the river two or three miles below, on land belonging to Wm. Spencer, * * * showing, at an outcrop, imperfectly seen, 34 inches thick, and reported to be three inches thicker when the whole thickness is exposed. Of this, all but the upper four or five inches is cannel coal.

In the hill at the Haddix mines, at a distance of 110 feet above the main cannel coal, a coal has been found, which is reported to be a semi-cannel coal, 4 feet in thickness; but it had caved in at the time of examination by the writer, so that nothing could be seen of it. The "stain" or "sign" of this coal was found at other places, enough to show that it holds it position with considerable persistence.

Fifty feet above this coal is found another, which has been mined on the opposite side of the river from the Haddix mines, by Mr. J. Wells. It here shows the following section:

	Inches
Coal	
Shale parting	11
Coal	2
Shale parting	13
Coal	4
	15

*The Haddix bed is regarded as No. 5 of the Greenup Section.—C. J. N.

A total thickness of 39 inches coal, excluding shale parting. It is a dry-burning, bituminous coal, quite free from sulphur, but carrying a rather large percentage of ash, as shown by the following analysis of an average sample taken by the writer. The coal sampled from was near the outcrop, and hence the analysis may possibly show more ash than properly belongs to it:

Moisture	2.78
Volatile combustible matter	35.52
Fixed carbon	44.94
Ash	16.76
Total	100.00
Coke	61.70
Sulphur	1.423
Specific gravity	1.398

Undetermined Coals.

As the examination made of this region was so largely of the nature of a reconnoissance, many exposures of coal were seen—especially when at some distance to one side of the line of the section—the geological equivalency of which was not determined, owing to lack of time for detailed examination. The coals on Wolf creek and Georges branch should really be classed here, as they are by no means certainly identified.

On main Frozen creek, above the house of Mr. Green Tolby, a coal is found about 175 feet above the bed of the creek, in natural outcrop below a sandstone cliff, showing a thickness of 45 inches clear coal, without any perceptible parting.

On Stillwater and Gilmore creeks, in Wolfe county, cannel coal is found at a number of places. * * * At Mr. James F. Ely's, a cannel coal has been opened, asserted to be 3½ feet in thickness. A thickness of 2½ feet was seen by the writer at an exposure which evidently did not show the whole thickness of the bed. The exposure was such that an average sample for analysis could not be obtained.

On Stillwater creek, at Mr. John W. Faulkner's, a cannel coal is found, commonly reported to be 3 feet thick. Only about ten inches of the upper part of the bed were seen at time of visit, the rest being covered by mud and water.

At John Murphy's, on Stillwater creek, a cannel coal is found outcropping with considerable regularity in the hills back of his house. [At the time the place was examined the bed had not been opened, hence the thickness was not known.] It is the coal before referred to as probably the first coal above No. 3.

On Troublesome creek, about fifteen miles from its mouth, below the mouth of Buckhorn creek, on the Roberts farm, is a coal which shows the following section:

	Inches
Bituminous coal	22
Shale parting	3
Bituminous coal	17
Shale parting	10
Cannel coal	22

A total thickness of 61 inches of coal.

* * * The quality of the different members of this coal is shown by the following analyses from average samples taken by myself:

	1	2	3
Moisture	3.30	2.20	3.40
Volatile combustible matter	31.44	39.20	43.40
Fixed carbon	49.76	51.14	46.96
Ash	15.50	7.46	6.24
Total	100.00	100.00	100.00
Coke	65.26	58.60	53.20
Sulphur	.991	2.525	.630
Specific gravity	1.405	1.290	1.280

No. 1 is the upper seam—bituminous.

No. 2 is the middle seam—bituminous.

No. 3 is the bottom seam—cannel.

There is a salt well on the Kentucky river, opposite the mouth of Troublesome creek, which is reported to have passed through four coals in sinking to its present depth of 410 feet. Measurements of coals by boring are always liable to error, especially if, as in this case, the boring was not made for the especial purpose of finding coal, but to obtain salt water, as the borings are very apt to become mixed by the drill. It is also difficult to tell the exact line of passage from one stratum of rock to another. The well was sunk in 1846 by Col. L. C. Bohannan. The records of the well have, unfortunately, been lost; but from memory, Col. Bohannan states the position and thickness of the coals passed through approximately, as follows:

First, about ten feet below the surface a coal reported two feet, six inches thick.

Second, from forty to fifty feet below the surface another coal, reported three feet thick.

Third, about two hundred feet from the surface a coal, said to be about four feet thick.

Fourth, after passing through a very thick, coarse sandstone, a coal was reached at a depth of three hundred and eighty to three hundred and ninety feet from the surface, which is said to be of the unusual thickness of ten feet.

This is probably one of the Subconglomerate coals, which at other places is associated with a great thickness of bituminous shale, often mistaken for coal. This is peculiarly liable to be the case when nothing but the finely comminuted fragments of the material from the well can be had for examination. It is hardly probable that the Subconglomerate coal, from what we know of it at other places, would thicken so remarkably in this direction. The heavy sandstone reported as having been passed through before reaching the last coal, is very probably the Conglomerate.

The boring is, therefore, interesting, as showing the salt-bearing rock to be either the Conglomerate or the shales below. Nothing definite could be learned as to the amount of brine yielded by this well, or its strength. The prevalent impression in regard to its strength is, that it requires eighty gallons of brine to produce one bushel of salt.

At Mr. Marcum's, above the Haddix mines, two coals have been mined near the river, one of them about 75 feet above the river, and the other about twenty. The upper coal is 3 feet thick, and is reported to be one of the very best coals mined on the river. The lower was not seen, as it was covered at the time of visit. There is another coal 2 feet thick above it, separated by about 7 feet of space. The upper coal was seen.

At Mr. McIntosh's, about two miles above, a coal about 40 feet above the river has been considerably mined. [At the time the bank was visited it had fallen in. The coal could not be seen, but was reported to be 52 inches thick by the former owner.]

In addition to the above, numerous exposures of coals too thin for working have been seen, ranging from a few inches in thickness up to two feet.

Quality of the Cannels.

* * * As has been already indicated in the descriptions of individual seams, the cannel coals vary greatly in quality as well as thickness, and the same seam often changes thickness and quality very suddenly.

The following analyses will serve to show very fairly the different qualities of these coals:

	1	2	3	4	5
Moisture	1.30	0.94	2.10	1.60	1.20
Volatile combustible matter	47.00	52.38	43.10	43.20	58 80
Fixed carbon	44.40	35.54	43.36	38.80	35.30
Ash	7.30	11.14	11.44	21.40	4.70
Total	100.00	100.00	100.00	100.00	100.00
Coke	51.70	46.68	54.80	55.20	40.00
Sulphur	1.574	1.423	6.119	2.549	.....
Specific gravity	1.265	1.280	1.328	1.360	1.180

No. 1 is an average sample from the Haddix mine. Sampled from the seam in the mine.

No. 2 from Georges branch. Average sample from the stock pile at mouth of pit.

[An analysis of a carload lot of the Georges branch cannel, made by the Consolidated Gas Company of New York, shows: Moisture, 0.70; volatile combustible matter, 54.00; fixed carbon, 34.40; ash, 10.90 per cent.—C. J. N.]

No. 3 from the Quicksand Creek mines. Average sample from the stock pile of coal at the mouth of the pit, taken by Mr. J. R. Procter.

No. 4 is from Frozen creek, near G. W. Johnson's. Sample averaged from a small pile of coal, not more than one or two tons. This is the coal which shows the brilliantly polished faces.

No. 5 from near the same locality. Analysis from a single specimen only. This specimen was not originally selected for analysis, and may, therefore, possibly represent the coal at this place as better than the average.

For the purpose of comparison with other cannels, the following table of analyses of cannel coals is appended:

	1	2	3	4
Moisture	1.30	1.50	.....	.....
Volatile combustible matter	59.60	52.20	43.37	50.18
Fixed carbon	27.00	40.60	46.50	46.42
Ash	12.10	5.70	10.10	3.40
Total	100.00	100.00	.....	100.00
Coke	39.10	46.30	.....	.....
Sulphur	1.896	0.728	.....	.....
Specific gravity	1.213	1.306	1.27	.....

No. 1 is the well-known Breckenridge cannel coal, Breckenridge county, Kentucky. Analysis by Dr. Peter and Mr. Talbutt. Average sample by Mr. C. J. Norwood.

No. 2 the Hunnewell cannel coal, Greenup county, Kentucky. Analysis by Dr. Peter and Mr. Talbutt.

No. 3 Kanawha cannel coal, below falls of Kanawha Falls, West Virginia. Analysis by U. R. Johnson; copied from his work on coals.

No. 4 the celebrated Wigan cannel coal, from Lancashire, England. Analysis by Heddle.

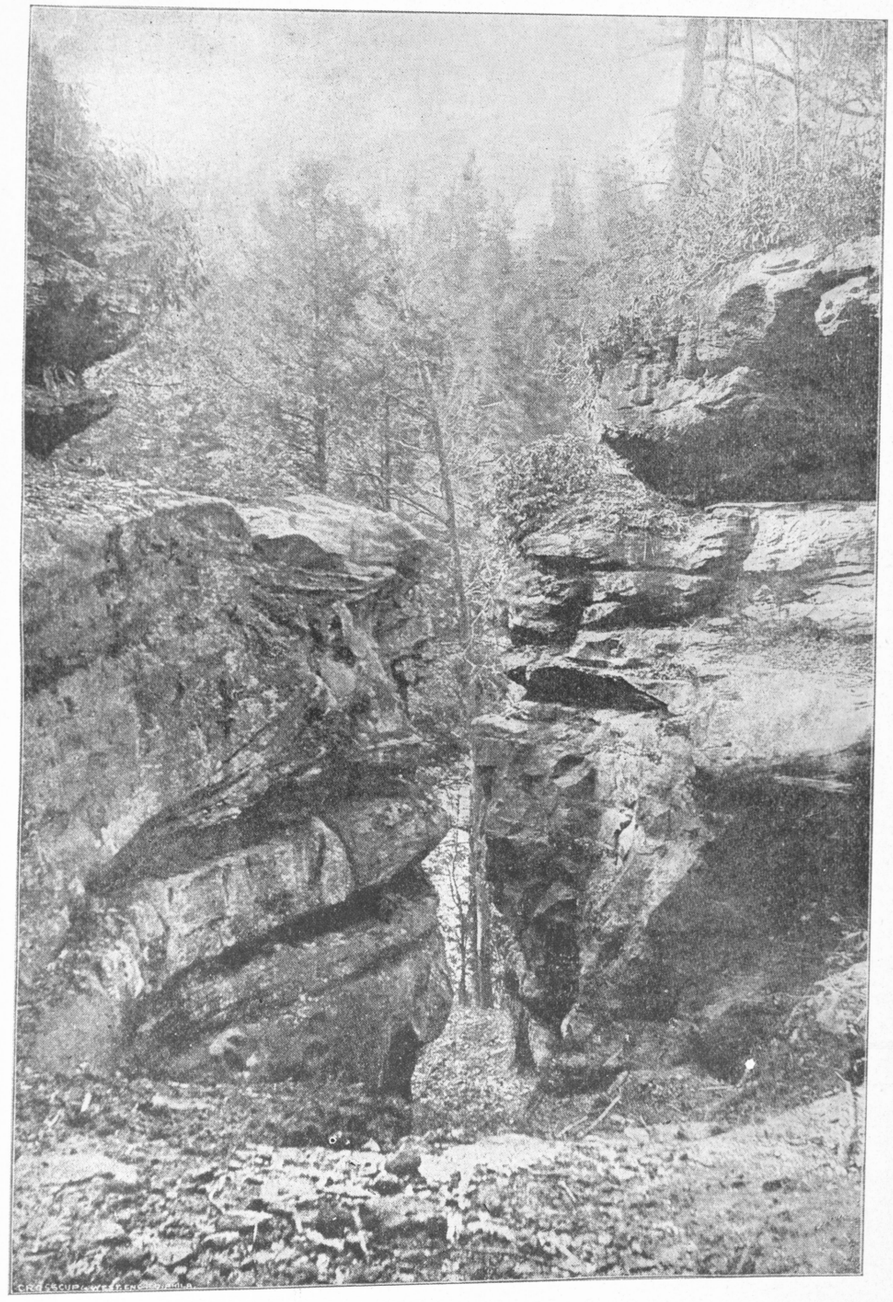
[In the report of the State Inspector of Mines for 1893 is a valuable paper, "Notes on the Cannel Coals of Kentucky," by the late Charles Hendrie. It is the purpose of the Geological Survey to issue a special bulletin on the cannels, for which much material is already in hand, at as early a day as is practicable.—C. J. N.]

Conclusions.

A brief summary of the principal points of economical importance in the foregoing report may not be out of place here.

Of the eight coals above the Conglomerate [included in the section], five are of workable thickness, considering a coal of 2½ feet as workable. These five coals range in thickness from two and one half to six feet.

Three of these coals are at places cannel coal, two of them workable, both ordinarily of excellent quality. In addition to the coals above the Conglomerate, there is at least one workable coal below, which is of excellent quality and covers a large area.



"KENTUCKY GAP," a Natural Roadway out of the Big Caney Creek Canon.

PART IV.

THE COALS, ORES, AND DIKES OF ELLIOTT COUNTY.

A Revision, with Additions, of an Older Report on the Geology of the County.

BY A. R. CRANDALL.

Elliott county is wholly within the coal-field of Eastern Kentucky. Its western boundary is very nearly also the western limit of the Coal Measures. Geographically it falls between Rowan county on the northwest, Morgan on the south and southwest, Lawrence on the southeast, and Carter on the north and northeast. In its relation to the drainage it is almost entirely in the valley of the Little Sandy; including the head waters of that river. The county line follows with some deviations the water-shed between the Little Sandy waters and the waters of Big Blaine, Big Paint, Elk Fork, North Fork and Triplet creek—tributaries of the Chatterawha or Big Sandy river and the Licking, which, with the Little Sandy, form a radial drainage from the high land of this region. On the north the line is an arbitrary one, stretching across the valley of the Little Sandy, which also includes most of Carter and Greenup counties.

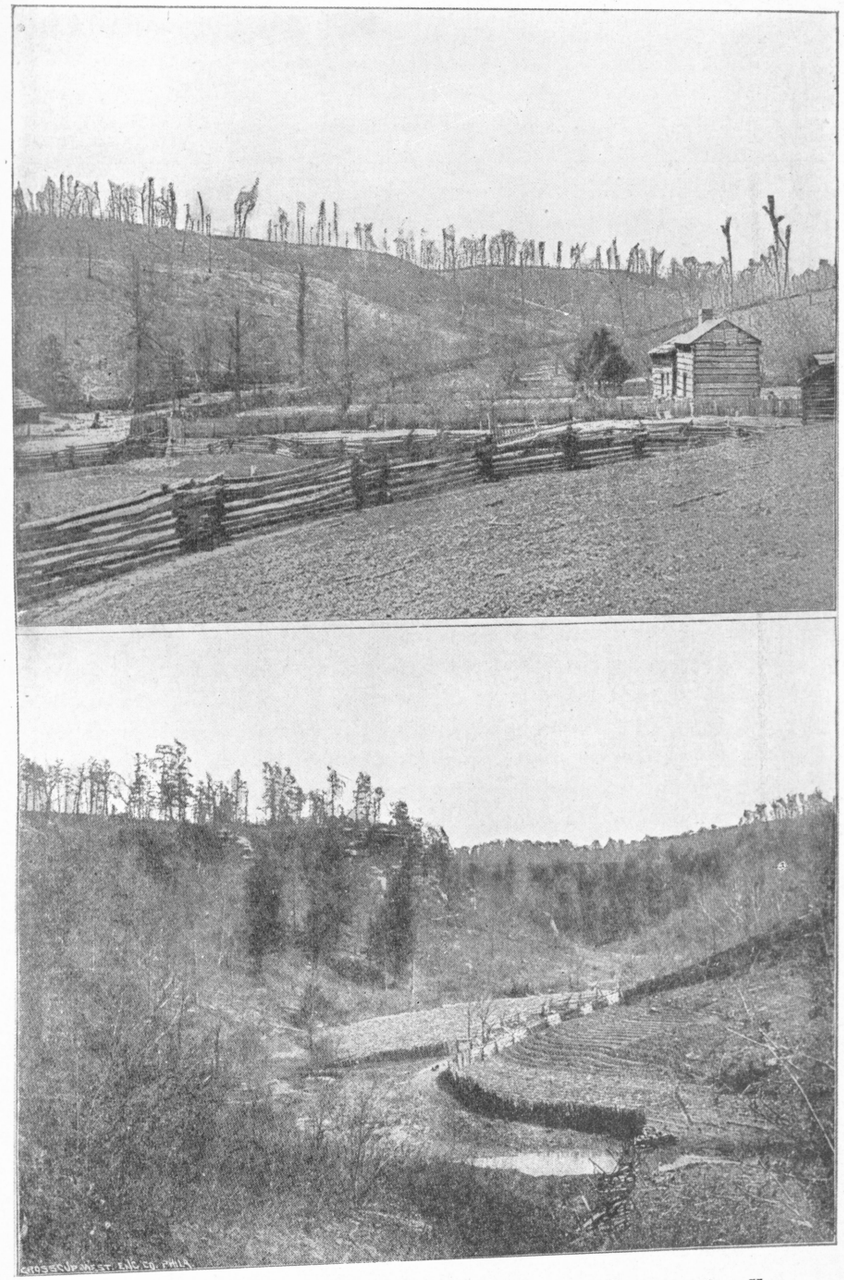
Topography.

With such modifications as follow from the geology of this county, its surface features are like those of Carter and Greenup, and in marked contrast with Morgan and

Menefee southwestward along the border of the coal-field. The Conglomerate escarpment of these counties, broken and irregular from the erosion of streams running for the most part contrary to the dip of the rock formations, disappears to the northward of the Morgan Elliott line; and the border escarpment is continued as an ordinary ridge, forming an unbroken water-shed through to the Ohio river, the western boundary of Elliott, Carter and Greenup counties. From this water-shed of Lower Carboniferous sandstone and shale (the Waverly beds) the eastward drainage follows the direction of the dip until interrupted, as it is somewhat irregularly, by successive Coal Measure ridges which deflect the main streams to the northward through these counties.

The increased thickness of the Conglomerate sandrock to the southwest along the eastward slope of this main water-shed gives greater prominence in Elliot to a feature which is one of the characteristic contributions of this formation to the topography of the country, namely, cliff-bound creeks. Travelers on the Chesapeake and Ohio Railway remark the massive walls along the Little Sinking creek in Carter. Here the Conglomerate sandstone shows a thickness of seventy to ninety feet. In Elliott the cliffs reach a maximum of one hundred and seventy-five feet. This massive formation has a dip eastward less than the whole fall of the streams. Very little of it is exposed along the eastern slope of the main ridge at the head of the cliff-bound creeks of Elliott; but it becomes prominent not far from the heads of all the main streams in question, and, by a series of rapids and falls, the whole or the greater part of the formation is exposed in the wall-like cliffs which mark the tortuous courses of the streams below. On Laurel creek and on Caney, as well as on the Little Sandy for some miles, the Subcarboniferous limestone is exposed, rising to a height of twenty-five feet above the bed in places. The Conglomerate sand rock here rests upon the limestone, with slight traces of transition beds. As may well be supposed, the natural scenery along these creeks is unusually interesting and varied. (See accompanying photo-lithographic illustrations.)

Topography above Conglomerate Cliffs on Little Caney Creek.



"CONGLOMERATE CLIFFS" at Forks of Caney Creek, Elliot Co., Ky.

East of the Little Sandy river the cliffs rapidly disappear; both the dip and the direction of the water-courses conspiring to place the Conglomerate sandrock below the beds of the creeks in this direction. Elliott county, therefore, illustrates two types of topography. In the cliff region, the narrow and abrupt valleys are separated by comparatively broad table-lands. As the cliffs disappear to the eastward the valleys become more open, and the hills are reduced to the characteristic narrow ridges and spurs of the productive Coal Measures.

Farm Lands.

The Conglomerate table-lands are diversified by drainage slopes of moderate inclination and height, including, near the river, a considerable thickness of the coal-bearing series of rocks, with Coals 1 and 2 of the General Section. These lands are, however, chiefly agricultural; and as such they offer inducements which are not found in the coal-field generally. (See photo-lithograph illustration.) The soil is of sandy and clayey loam, of medium natural fertility, and susceptible of improvement by judicious cultivation. In extent these lands include nearly one-half of the county, the area of which is about 270 square miles. This region is adjacent to the Chesapeake and Ohio Railway, being from fifteen to twenty-five miles from Morehead, in Rowan county, and eight to twenty-five miles from Olive Hill and Leon in Carter—railway stations.

The available farm land in the eastern part of the county is much less in proportion to the whole area than in the western; and it is mostly in the valleys, including the gentler slopes. The steeper hillsides and the narrow ridges should be regarded as timber land, and held as such for the benefit of the valleys, which otherwise will soon pay the penalty by excessive washing. This region is nearer the Eastern Kentucky Railway, being six to twenty miles distant from Willard or Webbville, the present terminus of that road.

Timber.

The timber growth of Elliott is largely of the hard woods, including, however, originally a considerable proportion of yellow poplar (tulip tree) and lin (basswood). Hemlock is the prevailing growth along the Conglomerate cliffs, and yellow pine (*P. mitis*) and other pines fringe the table-lands. The most valuable timber lands were found in the eastern half of the county, which has been especially noted for its superior white oak timber, much of which has been removed. The red maple is noticeably prominent in this part of the county. Black walnut and ash are represented by single trees distributed through the heavier forests, while the beech and the sugar tree are more common. No detailed study of the forest growth of this region has been made. Such a study would be of value, if only it could be made to conduce to an intelligent treatment of these natural forest lands. This, it seems to me, should be the aim in respect to the forests of East Kentucky in general, as it is evident that the commercial spirit of the age will need no incentive to carry its destructive methods wherever desirable timber can be found.

The geology of Elliott county is so much like that of the western portion of Greenup and Carter that treating of it will of necessity seem like repetition.

Trap Dike.

There is one feature of more than ordinary interest, which does not appear, so far as is known at the present time, elsewhere in the eastern part of the State, namely, exposures of trappean rock; the occurrence of profound fractures of the underlying sedimentary rocks of the region, as indicated by the upthrust of molten rock, forming dikes and producing more or less of metamorphism of the including rocks down deep in the series. At the surface the effects of heat are not prominent in the sedimentary beds.

Several of these dikes, or what may be regarded as several lateral branches of a crater-like dike, are found radiating from a point on Creeches creek, westward and northward into the valley of Ison creek. This intrusive rock, peridotite, though in part hard and to ordinary appearance very indestructible, is, in fact, as a whole even less so than the including Carboniferous beds; so that it is for the most part covered; and it is not traceable by any effect produced on the topography of the region.

A preliminary description of this interesting variation of the geology of Eastern Kentucky was given in a previous report by J. S. Diller, of the U. S. Geological Survey, and by the writer, including the petrology of these crystalline rocks, and the geological features attendant on this eruption.

Notes on recent developments in connection with the dike are appended to this report.

One of the most prominent exposures of the rock is on a branch of Creeches creek. Here, some years ago, were found the remains of a furnace, which, though rude, must have cost considerable labor, judging from the size of the mound which appears to have been thrown up to support its rude stone wall and to serve as a stock bank for ore and fuel. So far as I have been able to learn, the traditions of the immediate region throw no light on the origin of this furnace, further than to attribute it to the aborigines, or to a time anterior to the permanent settlement of the region. Attending this view is also the supposition that silver or some of the precious metals was the product of this ancient enterprise. On the other hand, it seems to me quite likely that this old furnace represents an ill-considered attempt to make iron; and that it should be regarded as one of the incidents in the history of the introduction of the iron industry in the Hanging Rock region. This supposition is consistent with the conditions which were noted about the old furnace when yet parts of the wall remained in place. So far as that goes, however, there is nothing inconsistent with the supposition that silver or some other metal was the product sought in this bootless enterprise. At all events, it seems to me probable that the precious metal view, responding as it does to the promptings of hope and of

fancy, and carrying with it an atmosphere of credulity and of mystery, has so tended to obscure the history of this old furnace and the purpose which it represented, that it may nevertheless properly be regarded as having a place in the unwritten chronicles of the settlement of this region.

Whatever may have been the specific purpose of the furnace, only the dike rock, exposed near by, appears to have been had in contemplation as a source of ore supply. The weathered rock bears some resemblance to iron ore, and in fact more or less of titaniferous iron is present; besides which, no other metallic ore has been found at any of the exposures of this rock.

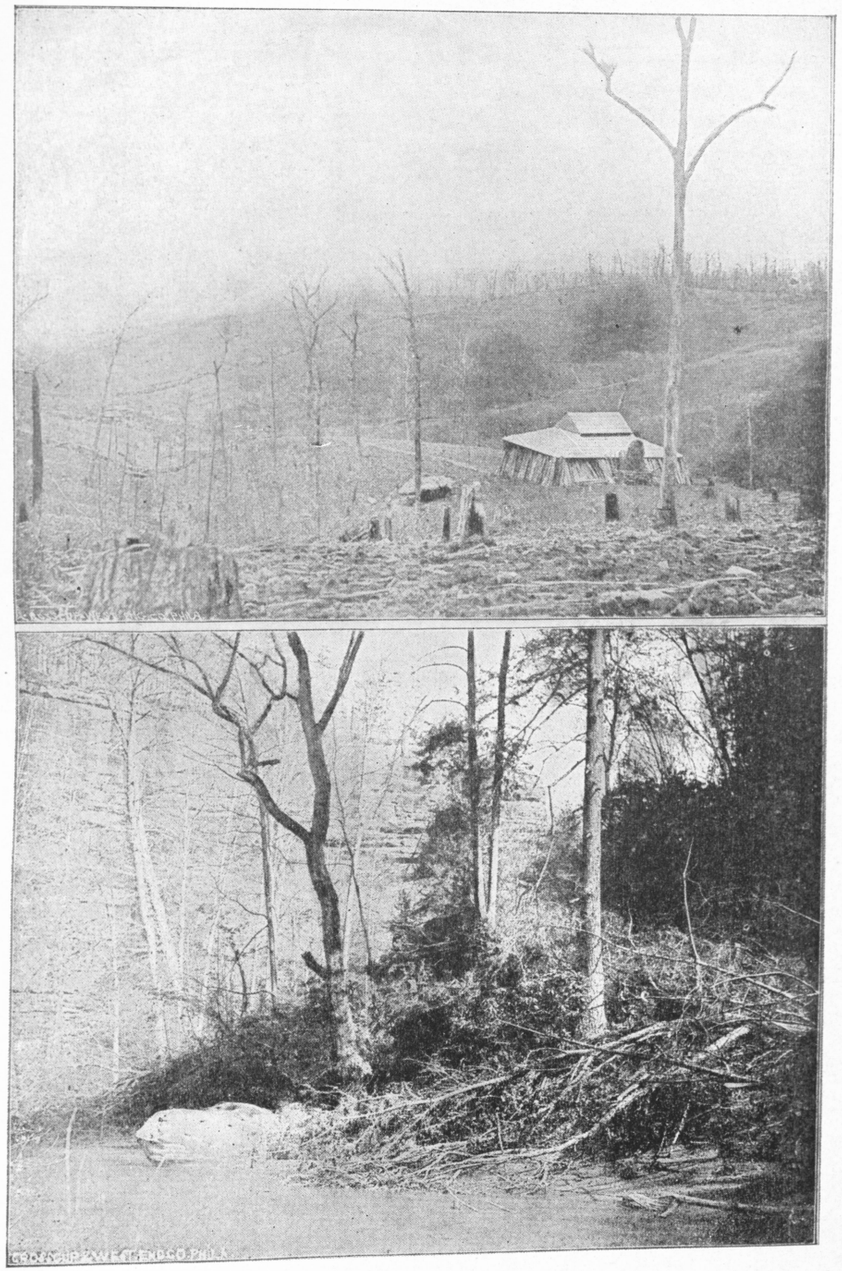
As to the probability of the occurrence of the more precious metals and minerals, which has engaged the attention of many intelligent persons in recent years, and for a more specific description of this local feature, see the notes on the recent work on the dike appended to this report.

Coals and Iron Ores.

The coal and ore horizons of Elliott county are nearly the same as those of Carter, as will be seen by comparison of Sections 1 and 2, plates VII. and VIII., of this Bulletin, with the General Section for Greenup, Carter, etc., reproduced herewith. It should be understood that at the present time the ores are important only as they serve as horizon marks or indicators of the order and equivalency of coal-bearing rocks.

Above the ferriferous limestone, both the coals (6, 7 and 8) and the ores (the kidney ores), with some exceptions, become less and less prominent towards the border of the field. This thinning out of beds of coal and of iron ore is in keeping with the tendency which has been noted generally towards their western limits; a tendency that is accompanied in an irregular way by a corresponding thinning of the intervening rocks. The limestone beds in the Coal Measures all disappear towards the Silurian axis on the west.

Topography Near Head of Gimblet Creek.



"CONGLOMERATE CLIFFS" on Little Sandy River, near Mouth of Laurel Creek.
ELLIOTT COUNTY, KY.

Towards the southern part of Elliott this diminution of beds westward is coincident with a change in the character of the rocks of this horizon, which has been noted southward from Carter and the middle of Lawrence; a change from the predominating clayey shales which carry these beds, to predominating sandrock, which soon excludes the kidney ores altogether and makes the identification of coals 7 and 8 uncertain. Whether this change is from a thinning out of the whole series, so that with its coals and ores it disappears altogether, or from a gradual change in the character of the rock deposits, has not been fully established; the latter seems to be more consistent with the somewhat contradictory data at hand, and more especially with the great thickening of the Coal Measures, and the increased prominence of sand rock towards the Pine Mountain axis.*

Iron Ores.—The kidney ores were formerly mined in the Little Fork valley near the northeast corner of the county. Their presence has been noted to the head of Little Fork, mostly on the east side of the valley, but also westward, with decreasing prominence into the valley of Newcomb creek, and in the ridge between Newcomb and the Middle Fork. In this ridge, near the Martinsburg road, the lower bastard limestone which marks the place of one of the upper kidney ores, of Boyd county, may be seen near the top of the hill. The occurrence of this earthly limestone, the Buff or Shawnee limestone of the Ohio reports, is interesting as showing the extension southward and westward of one of the four earthy limestone beds above coal 7; beds which, in Southern Ohio and in Boyd county, and parts of Lawrence and Carter, in Kentucky, may be regarded as offering the most reliable horizon marks for the guidance of the geologist. These beds mostly disappear or lose their characteristic features south of the Little Sandy drainage.

The coarse sandstone, conglomerate sandstone in places, which often rises in cliffs above the lower earthy limestone in Boyd and Carter counties, caps some of the hills towards

*This matter is discussed in the writer's report on the Pound Gap Region, now out of print. See also his report on the Coals of the Big Sandy Valley, Bulletin No. 4, 1904.

the head of Little Fork, on the east side. (See plate VII.) Dipping down the valley, as already indicated, it forms a considerable part of the ridge along the northward extension of the county line, and probably caps some of the highest hills on the west side of the valley.

Coal 8.—No trace of Coal No. 8 has been noted in Elliott county, west of the Little Fork valley. Its place is 20 feet or more below the earthly limestone above mentioned, and it would be included in all sections of the ridge along the eastern boundary of the county, and of some of the higher points across to the ridge between Newcomb and the Middle Fork.

Coal 8 appears to be represented in the Little Fork valley and possibly farther westward by a cannel coal, of considerable importance, at the head of Creeches creek and on the Ison creek side of the ridge and spurs which here intervene between the two creeks. On the Creeches creek side, the following section of this bed is shown in an entry driven under roof rock 30 yards or more, on the land of Andrew Stevens.

Roof, slate	Inches	
Cannel coal	40	
Shale parting		1
Splint coal	3	
Total coal	43	

This cannel presents a body of which only the upper 2 inches shows a slaty fracture approaching a cannel slate; the 38 inches below having the conchoidal fracture of merchantable cannel of medium richness in volatile combustible matter. In the several openings in the spurs of the Ison creek drainage, about one-fourth of a mile to the west, southwest and south, about the same features are said to have been shown. These openings are on the lands of Ison Ison and Thomas Caldwell, and show variations to a thickness of 18 inches, as should be expected. About a mile to the eastward in the ridge forming the south side of Creeches creek valley, this bed as opened on Salyer's land shows a section as follows, thickness being in inches:

Roof, shale slate	Inches	
Splint coal	24	
Shale clay		1
Coal	12	
Total coal	36	

In the Stevens entry locality the kidney ores of the shales which typically include Coals 7 and 8 are in evidence, with a coarse grained sandrock towards the top of the ridge, the latter rising 75 feet above the cannel level. The relation of the cannel seam to the several ore levels here leads to the conclusion that it represents Coal 8. In other localities where cannel is found apparently at the same level, this evidence is mostly wanting, as previously explained, by the thinning out or transformation of the including shales of this part of the General Section. This cannel seam is reported at several points on the Right Fork of Ison creek. As examined on the Greasy ridge, between Bruin creek and the headwaters of the Left Fork of Brush creek, two miles northward, this bed, which lies about 300 feet above Bruin creek, with Coal 1 at the creek bed, shows as in the following section, thicknesses being in inches:

Roof, cannel slate, 18 Inches.	Inches.
Cannel coal	24 to 30
Slate.	

This bed is not so free from slaty cannel.

At nearly the same height above the headwaters of Little Fork, near Robert Fulton's, with Coal 2 at the bed of the creek, probably the same bed shows in an entry driven under rock roof, with section as follows:

Roof, shale	Inches.
Coal, with slaty layers	13
Coal	32
Total	45

This, like the preceding coal exposure, is in shales above a sandrock ledge like that which in many places underlies the kidney-ore-bearing shales, and in such close relation to this bench-forming rock as to lead one to regard it as Coal 7. Whether both coal horizons are represented in the hilltops, which show more or less of the kidney-ore-bearing shales with decreasing evidence of horizon marks southwestward, must for the present be left as an open question.

Coal 7.—Notes of coal exposures which at the time were regarded as representing Coal 7 may be given in this connection. On Little Fork, near Francis Porter's, 220 feet above the bed of the Fork, a prominent coal stain in shales was observed. (Section 1, Plate VII.) At the head of Brushy Fork, near the place of Bryan Boggs, a bed with a facing showing 42 inches of coal, including a thin parting, was seen; and on Blain Trace, near Gallion's, a prominent outcrop was observed. The western limit of this coal horizon is the ridge between the Little Fork and Bruin creek, with its continuation between Newcomb creek and the headwaters of Little Fork, and across Newcomb to include the higher hills along the Middle Fork to the head.

Coal 6.—Coal 6 has been traced in the Little Fork valley as far as Hurricane branch, evidently a thin bed as in Carter county. Its place in the series is shown in Section 1, Plate VIII. The greatest thickness noted falls below 2 feet of good coal.

The Ferriferous Limestone.—The ferriferous limestone and the so-called limestone ore, which in Northeast Kentucky mark a geological level, are as readily traced as any other horizon mark above the Conglomerate formation. The limestone is limited to isolated pockets, and has been seen at two points only in Elliott—on the head of Ison creek, where it occurs as a fossiliferous bed five feet or more in thickness, and on the head of Elk branch of Newcomb creek, where it is less prominent. It has also been noticed at several points along the ridge west of Elk Fork, in Morgan county. The ore which rests upon this limestone when it is present is more constant, however, and can generally be found weathered out upon the surface at its proper level. At the mouth of Brushy creek it is found about one hundred and fifty feet above the bed of Little Fork, and was formerly mined for shipment. On Ison creek it is about two hundred feet above the drainage, showing very little variation from the general dip of the region—an unexpected freedom from disturbance in the immediate

region of the dike as previously described. On the head of Little Fork the limestone ore is well up towards the tops of the hills, and often has intermingled with it small quartz pebbles. Westward the ore has been traced along the ridges from Bruin creek to the head of the Middle Fork. It is especially prominent as a surface exposure on the ridge between the head of the Fannin Fork of Elk, above Hutchinson's store, and the Gilbert Branch of Middle Fork. Far more constant than the limestone which gives it its name, this bed is more or less interrupted throughout its southward extension. From exposures noted it appears to be less reliable as an outcropping horizon mark in Elliott than in those counties where it was formerly relied on for furnace supplies or iron ore.

The "lime kidney ore" found in some parts of Carter and especially near Willard, 15 to 20 feet below the ferriferous limestone, appears to be entirely wanting in Elliott.

Coal 5.—Coal 5, which in Carter and in a part of Elliott underlies a cliff-forming sandrock and is in Carter more variable in thickness and character than any other coal bed, is the source of a large part of the fuel supply of the Little Sandy valley in Elliott county.

The Redwine coal, at the head of Billy's branch, 210 feet above drainage, in an entry driven through the ridge between Middle Fork and Owen's creek, shows the following bed-section:

Roof, slate	Inches.	Inches.
Coal	7	
Shale		5 to 6
Coal	5	
Bituminous shale		8
Coal	18	
Total Coal,	30	

Toward the head of the Left Fork of Newcomb, 150 feet or more above the main creek, the bed as formerly opened shows 10 inches of cannel, as in a bed-section which is represented in Section 3, Plate VII.

On the opposite side of the creek, the bed-section showed:

Roof, shale to cliff of sandstone 10 ft.	Inches.	Inches,
Coal	8	
Clay		6
Cannel slate		20
Coal	15	
Total	23	26

At another point in the same region the following section was seen:

Roof, shale	Inches.	Inches.
Weathered coal and shale, outcrop	24	
Shale parting		8
Coal to underclay	18	
Total	42	8

In the ridge between Bruin creek and the Branham branch of the Little Sandy, this bed has been faced up near the roadside, 140 feet above Coal No. 1. The excavation was at the base of a coarse sandrock ledge.

On the Enoch Fork of the Open Fork of the Little Sandy, near the head, this bed, locally known as Prewett's coal, occurs at 175 feet above Coal No. 1. It shows the following section, in an entry driven under rock roof:

Roof, bituminous slate	Inches.	Inches.
Coal	3	
Hard bituminous slate		9
Coal	22	
Total	25	9

On Flaughers branch, one mile and a half down the creek, the entry of Newton Brown shows very nearly the same section at this level.

This coal closely resembles the bed in the Elk and North Fork region, 125 to 150 feet above the cannel seam (No. 2 Coal), where it has come to be regarded as Coal No. 3. Recent observations in Elliott, however, lead to the conclusion that the interval between the lower cannel horizon and Coal 5 is so reduced toward the westward outcrop of coal-bearing rocks

that it is more likely to be the latter bed. But the absence of readily recognized intermediate members of this part of the General Section makes this view suggestive only, leaving the question of continuity of beds for a more detailed study of the field.

Coal 5, as here described, shows an outcrop at many points, but it is opened for use only where it is more accessible or more easily mined than are other beds. Other openings of coal at this level or between Coals 5 and 2 may be mentioned, as formerly reported, showing as follows: Towards the head of Blain Trace, 36 inches without parting. On the Robert Green branch of Little Fork, 100 feet above the mouth of the branch, as shown in Section, enlarged scale, on Plate VII. On the head of Nicholas branch, 175 feet above Little Fork, 34 inches in one bench. On Wallowhole creek, 47 inches with partings which have an aggregate thickness of 21 inches. On Princess branch, 48 inches with parting of 11 inches. Near the head of Meadow branch, 125 feet above its mouth, 44 inches less partings of 6 and 4 inches. Up Briar branch of Little Fork, 160 feet above its mouth, 53 inches with partings aggregating 17 inches.

Coal 2.—Coal 2 is the lower cannel coal of Elliott, Morgan and Johnson counties, and also parts of Carter and Lawrence. It is in its southward extension, however, that it becomes a prominent cannel seam, as the Elk Fork, the West Liberty, the Pieratt and the Walnut Grove cannels in Morgan, and probably the Gilmore creek and the Frozen creek cannels in Wolfe and Breathitt counties. It is traceable on most of the creeks of Eastern Elliott, from seventy-five feet above the main drainage and downward to the creek bed. At the mouth of Hurricane Branch of Little Fork no cannel appears in this bed, and it falls below the drainage near the mouth of Ison creek. West of the Little Sandy river the coals have not been traced. It will probably be found that coals 1 and 2 will furnish a home supply for this farming region.

This bed is exposed at many points in Elliott as a cannel seam, or as a splint coal, falling below the drainage towards the heads of the larger streams. Its place in the General Section is over a sandstone ledge in the base of which are imbedded bodies, more or less concretionary, of calcareous rock. When these bodies are found in the shale beds below they weather out in yellowish lenticular forms, from a foot to six feet or more in diameter. The presence of these calcareous concretions has been mentioned as marking this horizon in reports on regions widely distributed over the Eastern Coalfield of Kentucky.

Coal No. 2, 22 inches thick with cannel slate at top, is shown on Branham branch in the point beween the forks, 40 to 50 feet above Coal 1, and about 80 feet above the top of the Conglomerate formation, which rises as a massive wall 100 feet or more at the bridge above the mouth of Branham branch. Coal 1 is raised from the bed of the branch for local use; the thickness is 14 inches.

On Bruin creek, below the forks, Coal 2 is mined for Robert Evans, at a level 110 feet above the Conglomerate cliff, and shows the following bed-section:

Roof, shale	Inches.
Coal	14
Cannel coal	16
Coal	7
Total	37

In the hill opposite Martinsburg, a thin cannel occurs, 100 feet above the top of the Conglomerate sandrock. In the Little Fork valley this bed is represented in places by cannel slate. Towards the head, as on Big branch, it shows as in the Section at the left of Plate VIII. The coal above has been regarded as No. 3. If this is correct, Coal 4 should be found at the base of the coarse sandstone above. Farther up this valley, a mile or more above Robert Fulton's, Coal 2 is in the bed of the branch, 36 inches thick, the upper 11 inches of the bed being cannel. On Newcomb creek, towards the head of the Right Fork, this bed is exposed at the foot of the hill, at the roadside, showing 26 inches of splint coal. Down this

fork a mile or more, 10 feet above the creek, the same thickness occurs, with 6 inches at the top of slaty cannel. At Howards Lewis's, three-fourths mile above the forks of Newcomb, 30 feet above the creek, an entry shows 36 inches of good coal without parting. At Isonville, as opened by George Bailey, 12 to 14 inches of cannel is reported at the bottom of this bed. One mile below, at Wade Fraley's, the thickness of the bed is 36 inches, 12 inches at the bottom being cannel coal.

On the Middle Fork of Little Sandy, Coal 2 is a good stone-coal showing some tendency to cannel, by splint structure. At the Watt Conn place, 50 feet above the creek, the coal exhibits a thickness of 30 inches without parting, as mined. The Conglomerate formation rises to the surface two miles below. At Martin Watson's, on the Left Fork, 6 feet above the creek, 32 inches in one bench of splinty coal is mined for local use. In the bed of Gilbert Fork, near the mouth, the same bed-section is found. Near the head of Left Fork, on Buck branch, about 36 inches of cannel coal is found. A large percentage of ash in this coal is indicated by its appearance and weight. An analysis made for the Survey, gives the following result:

	Per cent.
Moisture	2.10
Volatile combustible matter	41.34
Fixed carbon	35.96
Ash	20.60
Total	100.00
Sulphur	1.150

Near the head of the Enoch Fork, heading against the headwaters of the North Fork of the Licking river, the cannel horizon has been noted at a number of points, as indicated by croppings of cannel coal, but no openings showing thickness and character were available at the times when the region was visited.

On Wells branch, 125 feet above the main creek, a splint coal has recently been opened, with roof of bituminous slate 4 feet thick, the upper half resembling blackband iron ore. Following is the bed-section of the coal:

	Inches.	Inches.
Coal	14 to 17	
Parting	12	11_2
Coal		
Total		

The creek coal (Coal No. 1) at the bed of the creek at Robert Bowling's, three miles up the valley, is here 25 feet above the main creek bed and 100 feet below this Wells branch seam—an interval much greater than is known between Coals 1 and 2 elsewhere in this region.

Coal 1.—Coal 1 is a thin bed, varying from 12 to 24 inches as seen at many points in the shales above the Conglomerate formation, which have a thickness of 60 feet or more and largely give character to the low hills in the western part of the county. It falls below drainage towards the heads of the main creeks.

The rocks above the Conglomerate sandstone differ little from the section as described for Carter county. The thickening of the sandrock above Coal 5, as noticed on the head of Dry Fork and of Sycamore creek, on the Blaine side, in Carter, is also a noticeable feature along the ridge at the head of Blaine Trace in Elliott. The cliffs at the head of this creek are of coarse sandstone, resembling somewhat the conglomerate sandstone, and the horizon of coal 6 appears to be occupied by the massive rocks which are most prominent in this region. In general the most prominent bench along the hill-sides of the Little Fork valley is formed by the persistent sandrock immediately under the "limestone ore," and over Coal 5; though a number of low points extend into the main valley from the bench formed by the sandstone ledge above Coal 2, giving greater prominence to the latter bench and points along the main creek. The alternation of shale and sandstone is more or less noticeable throughout the whole series, in the benched hill-sides which figure in the topography of the county.

PLATE VII.

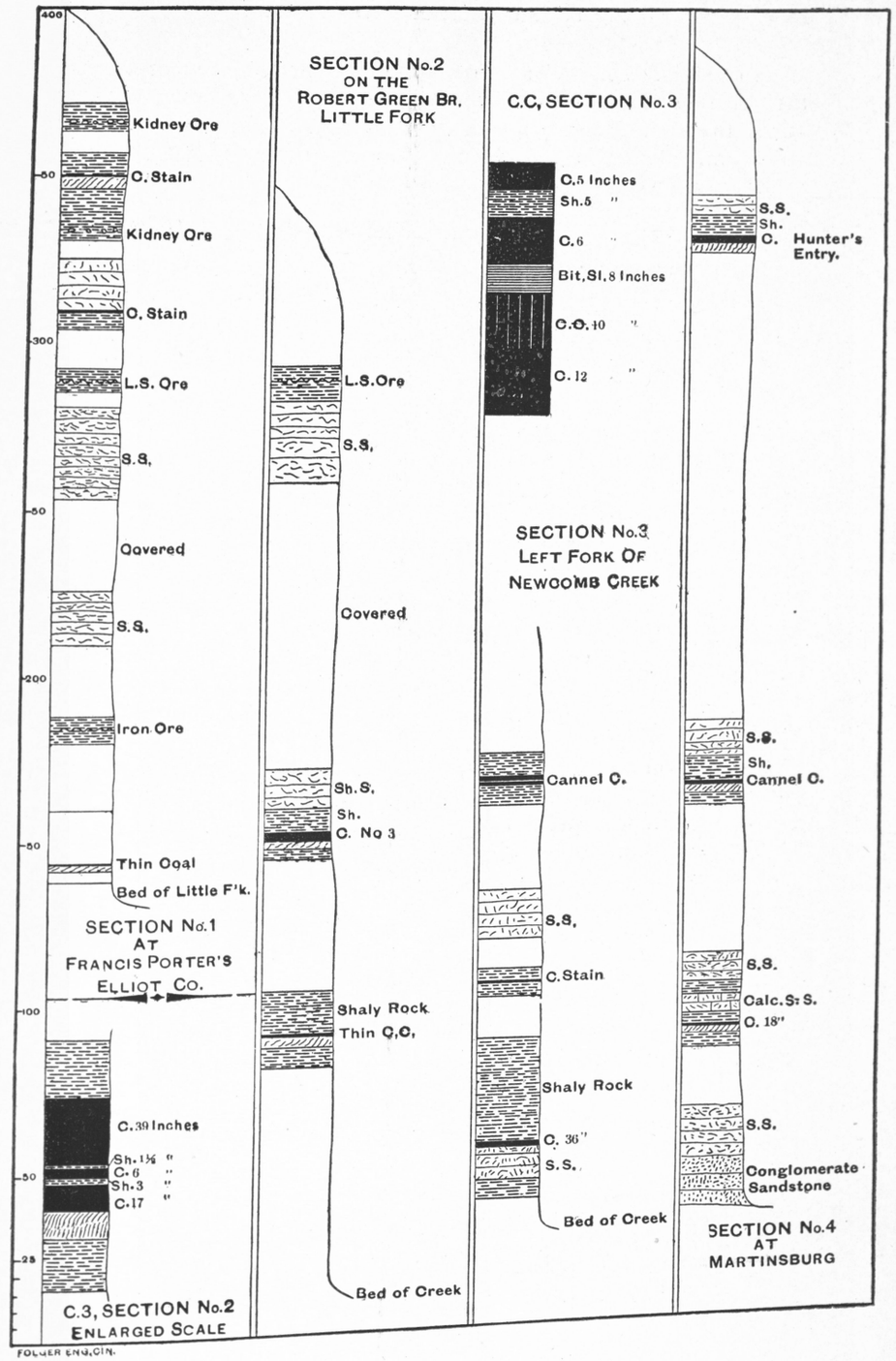
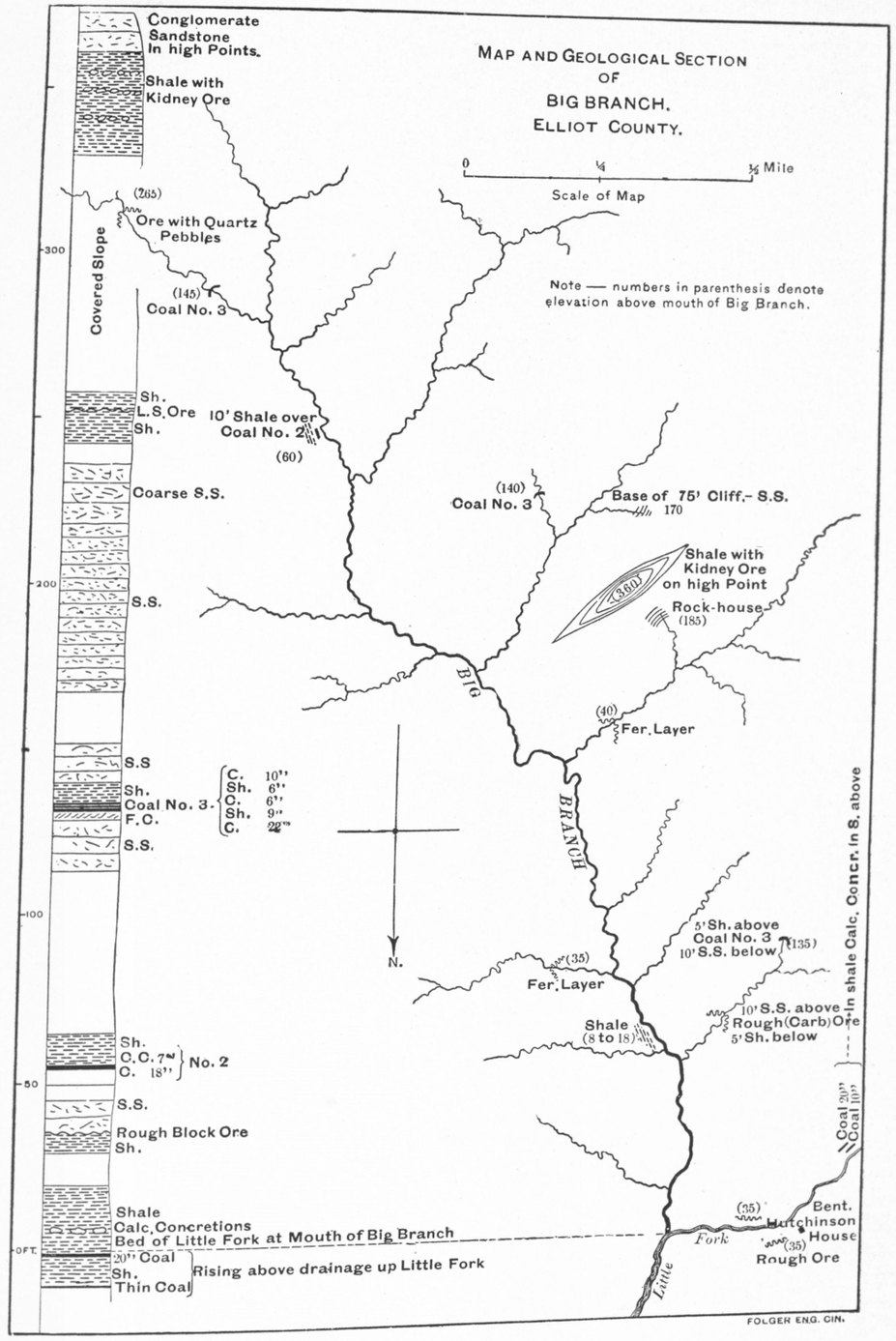


PLATE VIII.


MAP AND GEOLOGICAL SECTION
OF
BIG BRANCH.
ELLIOT COUNTY.
0
¼
½ Mile
Scale of Map
Note — numbers in parenthesis denote elevation above mouth of Big Branch.
Conglomerate Sandstone In high Points.
Shale with Kidney Ore
(265)
Ore with Quartz Pebbles
Covered Slope
300
(145)
Coal No. 3
Sh.
L.S. Ore
Sh.
10' Shale over Coal No. 2
(60)
Coarse S.S.
S.S.
200
S.S
Sh.
Coal No. 3
F.C.
C. 10"
Sh. 6"
C. 6"
Sh. 9"
C. 22"
S.S.
100
Sh.
C.C. 7"
C. 18"
No. 2
50
S.S.
Rough Block Ore
Sh.
Shale
Calc. Concretions
Bed of Little Fork at Mouth of Big Branch
0 FT.
20" Coal
Sh.
Thin Coal
Rising above drainage up Little Fork
(140)
Coal No. 3
Base of 75' Cliff.- S.S.
170
Shale with Kidney Ore on high Point
(360)
Rock-house
(185)
BIG
(40)
Fer. Layer
BRANCH
N.
5' Sh. above Coal No. 3
10' S.S. below
(135)
(35)
Fer. Layer
10' S.S. above
Rough (Carb) Ore
5' Sh. below
Shale
(8 to 18)
In shale Calc. Concr. in S. above
Coal 20"
Coal 10"
(35)
Bent.
Hutchinson
House
Fork
(35)
Rough Ore
Little
FOLGER ENG. CIN.

REVISED NOTES ON THE ELLIOTT DIKE,

With an Account of its Exploration for Diamonds.

BY A. R. CRANDALL.

The trap dike in Elliott county, which was brought to notice some years ago and upon which, recently, extensive explorations have been made in the search for diamonds or other precious stones, is, so far as known, the only illustration of intrusive rock in Eastern Kentucky. It is the only exposure of trappean rock in the region of the Cumberland Mountain uplift.

This dike represents an eruption of very limited extent, laterally, being found only in a small part of the valley of the Little Fork of the Little Sandy river.

From its limited range, and also from the readiness with which the rock of which it is composed disintegrates, it does not appear as a noticeable factor in the topography of the region; and it is with some difficulty that it can be traced beyond the exposures which mark a few points along its surface prolongations.

The dike appears to extend in two or more diverging lines from Creeches creek into the valley of Ison creek, with several minor offshoots of undetermined, but doubtless of limited extent, probably no more than wedge-like projections from the main dike cutting the strata of the Coal Measures which make up the whole height of the hills in this region.

Carboniferous rocks, including the beds up to coal No. 7 (the Coalton coal of Kentucky, the Sheridan and the Nelsonville of Ohio), are cut by both arms of the dike rock.

The dike is found near the line which marks the eastward limit of the Silurian anticlinal ridge of Ohio and Kentucky, as modified by the final uplift of the Carboniferous series. That the Silurian axis was involved somewhat in this movement is indicated by all the conditions as now observed; but there remains a clearly defined anticlinal ridge, with the border of the Coal Measures on its eastward slope, as has been pointed out in various reports on the geology of Eastern Kentucky.

The eastward dip from the Silurian anticlinal is interrupted along a line which is in general parallel with the border of the coal-field. This interruption is more or less prominent as marked by a reduction of the dip, or by horizontal beds, or by a reverse dip of the exposed strata. The last condition is more noticeable in Elliott county than elsewhere. The line of change falls a few miles east of the dike.

The reverse and the varying dips eastward from this line are the result of the upheaval of the Cumberland coal field, a movement which hinged on the Silurian axis along this line. The Silurian axis still remains a prominent, unmistakable feature, as remarked, but reduced in width eastward, and somewhat obscured in the topography as modified by the resulting drainage.

That there may have been profound fractures along this line of hinge movement follows as a matter of course. The Elliott dike may be supposed to add something to the probability of such fractures as the result of this movement, and this part of the geological history of Eastern Kentucky may, in turn, throw some light on the occurrence of this outlying dike.

Transverse to the axis of uplift are some minor wave-like undulations, especially southward, but involving Elliott county in part, as noticed by Lesley in his report on the outcrop line of the Eastern Kentucky Coalfield. These undulations have a determinative relation to the drainage, as in the case of the Licking, the Red and the Kentucky rivers; and it is not improbable that they may stand in an important relation to the faults which traverse adjacent parts of the Silurian field and terminate in the border of the coal-field.

The most striking modification of the general dip, by transverse flexure, is found along a belt which extends from the Big Sandy river south of Louisa, in Lawrence county, to a point opposite to and but a few miles east of the dike. The dip along this belt is to the northward, in places more than fifty feet to the mile, from a geological ridge of the Conglomerate formation, which elsewhere falls below the drainage a short distance within the border of the coal-field.

It is along this belt that the oil and gas developments of Lawrence and Martin counties have been made.

The prominent geological basin centering at Willard is formed by a junction of this northward dip with the general southeast dip considerably increased by a local depression. Willard is about six miles in a direct line from the dike.

The dike is found near the junction of two lines of flexure, one parallel with the axis of uplift of the Coal Measures, and the other a transverse or secondary undulation of considerable local prominence.

Whether or not these conditions throw light on the occurrence of metamorphic rock far from any region of great disturbance, they form an interesting, if not a necessary,

background to any general view of the Elliott dike and its surroundings.

Exploration of the Dike.—Recent developments of the Elliott dike along lines suggested by Professor Carville Lewis, in his discussion of the genesis of diamonds, have made it possible to give a somewhat detailed description of this interesting geological feature. The work of development was placed in charge of Mr. A. Q. Millar, of Minneapolis, Minn., by parties interested in the possibilities of the occurrence of diamonds, as suggested by Professor Lewis. It is but just to the members of the Kentucky Geological Survey and to Mr. J. S. Diller of the U. S. Geological Survey, who have formerly made reports on this dike, to state that the hope of making rich discoveries of precious stones as a leading purpose of the exploration of this dike has not been encouraged, though the resulting contribution to a knowledge of the mode of occurrence, and of the specific character of this and of similar dikes has been held as a matter of great importance. All geologists will unite in a tribute of appreciation of the work which has made possible a systematic study of this dike.

After looking over the results of this work, it gives the writer great pleasure to say that the exploration under the direction of Mr. Millar has been thoroughly intelligent and practical so far as carried on. That a large amount of work has been done, will be apparent from this brief description of the dike as now exposed to view.

Former descriptions were from surface features mostly, as indicated by the harder unweathered peridotite rock and the soil derived from the larger and more readily disintegrating body of the dike and its arm-like extensions. From these it appeared that the intrusive peridotite would prove to be comparatively narrow-fissure eruptions, and this conclusion was

favored by the lack of evidence of contact metamorphism of the inclosing carboniferous rocks.

Excavations recently made show that the hard refractory portions of the dike are narrow wall-like intrusions in a large crater-shaped mass of peridotite or kimberlite which is disintegrated to an average depth of about 20 feet, or from 10 to 40 feet according to relation to the local drainage. The central crater-like mass is located near the head of Creeches creek. The inclosing wall of nearly horizontal Carboniferous beds is found to be elliptical in horizontal section with the longer axis nearly north and south about 1,300 feet, and the lesser diameter east and west about 800 feet.

With this comparatively large mass of eruptive rock in mind, greater evidence of contact metamorphism would very naturally have been predicted, but this is not found to be true in this instance, either of the inclosing country rock or of the fragments of Carboniferous beds inclosed in the dike below the weathered wash earth derived from it. By the kindness of Mr. Millar, the Museum of the Kentucky Geological Survey contains a large piece of coal inclosed in unweathered peridotite and showing very little effect of heat. That this dike is of eruptive origin is placed beyond controversy, but evidently the eruptive action was continued through stages of upthrust which reduced the heat factor at the surface to a minimum. The crystallized minerals are in general those which are found in kimberlite dikes, namely, olivine, pyrope, ilmenite, biotite, calcite, pyroxine, enstatite, and traces of other primary minerals, with serpentine, dolomite, magnetite and octahedrite as secondary components. The former were found in the process of washing the earthy or yellow ground of the dike, but no diamonds have yet been found as was hoped, and as theorectically might have been realized with a greater degree of metamorphism of the carbon-bearing beds of the including formations.

The records of the work on the dike show that 5,000 loads of 18 cubic feet each have been washed and the mineral content carefully assorted. Shafts and tunnels have been driven to contact walls and to "blue", or unweathered, ground at various points for a comparative study of parts of the dike mass. Variations in the character of the rock and in the assemblage of minerals are found, which indicate more or less diverse sources from which they were gathered up into the ascending mass. The most noticeable variation from the ordinary type of peridotite is found in the northern portion of the exposed crater and in an arm-like extension nearly north through the ridge and across the valley of Ison creek. Here a large proportion of feldspathic material is mingled with the weathered dike rock, and silicate of aluminum also occurs as the result of the decomposition of feldspar.

The approach to the contact wall of the crater from within is marked by a red-ground rock which serves as a boundary indication when exposed. The ordinary hillside detritus covers most of the yellow ground of the disintegrating dike to a depth of 3 to 40 feet, and also the place and direction of arm-like extensions are hidden or obscured unless the axis of extension is directly across a ridge, and the gravity drift of the loosened surface material is along the axis rather than across it. Besides the arm of the dike already mentioned, which shows a width beyond Ison creek of 50 feet with a probability of considerably greater local expansion, there are two or more radial offshoots from the Creeches creek crater. One, reaching out north about 15 degrees east, apparently terminates, as noted by Mr. Millar, two miles or more away on Johnson creek as an unweathered peridotite dike of only 10 inches width—a vertical parting in a sandrock ledge. Directly to the west, also, with a show of ilmenite and of pyrope in the soil at the top of the ridge and of harder peridotite surface blocks near the old mill site, a dike line is indicated of considerable width, and attended at the point last mentioned with noticeable disturbances of the inclosing shales and

sandrock. This dike arm is exposed to view again beyond the creek, although rock ledges of the Coal Measures extend along the creek across this line apparently unbroken. This was mentioned in early notes on the dike as evidence that this offshoot from the central body was limited to the ridge between Creeches and Ison creeks. The course of the latter creek in this locality is a curve of which the distance from the Creeches creek crater is in a general way the radius. The occurrence of this westward arm of the dike beyond the unbroken ledges along Ison creek may indicate that, as appears from surface indications of this and the other outlying branches, they are not uninterrupted fissure-intrusions, but more or less crater-like in mode of occurrence and relation to the central crater or more or less broken lines.

Surface indications locate another line of radiation from this central dike to the southwest, extending into the Ison creek valley. Excavations to expose the weathered or disintegrating peridotite have been made by various parties, in the Ison creek valley, showing greater masses of dike rock than was formerly supposed, especially on the northward and westward lines of occurrence; but a systematic study of the minerals present in these outlying bodies of peridotite has not been made, as in the case of the central crater. It seems probable that, as in origin and degree of metamorphism, these bodies of peridotite will follow the central mass in the matter of the genesis of mineral species. Phases of the history of the Elliott dikes, requiring extended laboratory studies, cannot be taken up in this general description.

Mr. J. S. Diller, of the U. S. Geological Survey, in his study of this dike, gives the following table of percentage of constituent minerals as an approximate estimate.* His examination for this purpose was of the hard surface exposures of what is found to be narrow wall-like partitions of a few feet in thickness which traverse the less refractory body of the

*Notes on this Peridotite of Elliott County, Kentucky, by J. S. Diller; American Journal of Science, August, 1886. (This was reprinted in the report of Elliott County, now out of print). Also Peridotite of Elliott County, Kentucky, by J. S. Diller, U. S. Geological Survey, Bulletin 38, 1887

dike, in some of its parts. This wall rock remains hard at the surface, while the body of the dike is disintegrated to an average depth of 24 to 30 feet, a fact which would indicate a difference in composition yet to be determined.

Primary Minerals	Per Cent.	*Secondary Minerals*	Per Cent.
Olivine	40	Serpentine	30.7
Pyrope	8	Dolomite	14.0
Biotite	1	Magnetite	2.0
Enstatite	1	Octahedrite	1.1
Ilmenite	2.2		
Apatite	trace		

Mr. Diller concludes that this part of the dike was originally, at least, 80 per cent. olivine and that ultimately it would become, by natural transformation, largely serpentine. This appears to be the tendency in some part of the yellow ground of the crater. While the excavations are still comparatively new, the opportunity for the study of such problems in connection with this dike offers an inviting field for special investigation.