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Preliminary report of the oil and gas possibilities between Pine and Cumberland Mountains, southeastern Kentucky

A J. Froelich
University of Kentucky

KENTUCKY GEOLOGICAL SURVEY
WALLACE W. HAGAN Director and State Geologist
UNIVERSITY OF KENTUCKY LEXINGTON, KENTUCKY
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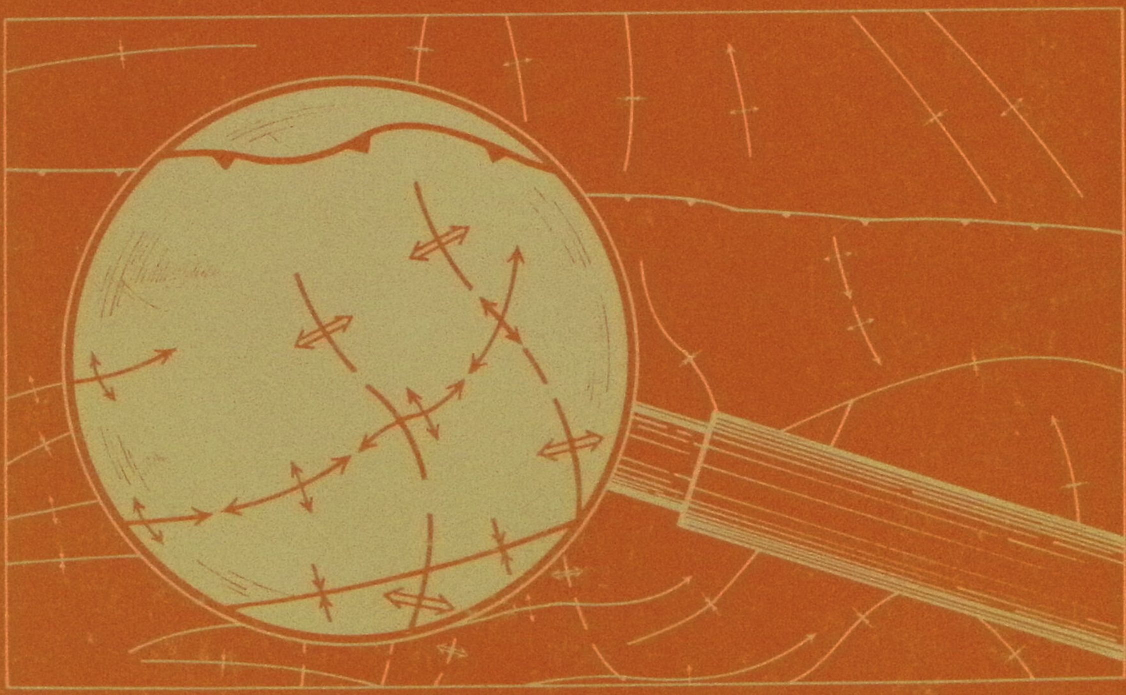
A. J. Froelich
U. S. Geological Survey

Prepared by the United States Geological Survey
in cooperation with the Kentucky Geological Survey



REPORT OF INVESTIGATIONS 14

KENTUCKY GEOLOGICAL SURVEY
UNIVERSITY OF KENTUCKY, LEXINGTON SERIES X, 1973
Wallace W. Hagan, Director and State Geologist

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LETTER OF TRANSMITTAL

September 12, 1973

Dr. Wimberly C. Royster
Dean of Graduate School and
Coordinator of Research
University of Kentucky

Dear Dr. Royster:

The Kentucky Geological Survey in cooperation with the United States Geological Survey presents this *Preliminary Report of the Oil and Gas Possibilities between Pine and Cumberland Mountains, Southeastern Kentucky* to give the oil and gas explorationist and others a better understanding of the geologic structure and the oil and gas possibilities of this area. This is a progress report of investigations which will continue with more detailed studies of the area, and it is in no sense a final report. Our Oil and Gas Section will continue further studies as information is developed.

The report was prepared by A. J. Froelich on his own time as a contribution to Kentucky geology, while he was located in Middlesboro as Geologist in Charge of that office in the cooperative Kentucky and United States Geological Surveys Areal Geologic Mapping Program. Such dedication to one's profession is most appreciated.

Respectfully submitted,

Wallace W. Hagan

Wallace W. Hagan
Director and State Geologist

CONTENTS

ILLUSTRATIONS

TABLE

PRELIMINARY REPORT OF THE OIL AND GAS POSSIBILITIES BETWEEN PINE AND CUMBERLAND MOUNTAINS, SOUTHEASTERN KENTUCKY

A. J. Froelich

ABSTRACT

Elongate, low-amplitude flexures in strata of Pennsylvanian age have been delineated in recent mapping by the U. S. Geological Survey in cooperation with the Kentucky Geological Survey in a 600-square-mile (1,536-square-kilometer) area between Pine and Cumberland Mountains in southeastern Kentucky. Crestal culminations on gentle anticlinal folds may indicate loci of subsurface closures for entrapment of oil and gas. The area studied is underlain by more than 15,000 feet (4,500 meters) of Paleozoic strata containing potential source beds, reservoirs, and cap rocks. Faults, unconformities, abrupt facies changes, and regional thickness variations enhance the geologic setting for possible oil and gas accumulations. Although the area is not producing oil and gas, shows were reported from each of seven exploratory test holes. Drilling depths to potential reservoirs are moderate, and markets are relatively close and accessible.

The area between Pine and Cumberland Mountains is a composite structural basin, as the flat-lying Pine Mountain overthrust fault separates a deep sequence of lower Paleozoic marine strata from the overlying upper Paleozoic marine and nonmarine rocks. The gentle flexures in surface strata of Pennsylvanian age trend east-northeasterly, but the attitude, size, and shape of structures below the thrust fault are unknown. A possible north-northwest interference pattern suggested by a series of axial culminations and depressions may reflect subthrust structural or paleogeomorphic alignments. Geophysical surveys or additional deep well control are necessary to provide data on the deep subsurface configuration.

INTRODUCTION

Elongate, anticlinal flexures within the Middlesboro structural basin between Pine and Cumberland Mountains may provide closure for entrapment of oil and gas. These gentle anticlines are separated by several en echelon synclines. The Middlesboro basin is a trough[1] formed in Paleozoic rocks of the Cumberland overthrust block (Fig. 1). The trough lies along the eastern edge of the greater Allegheny basin where it flanks the southern Appalachian fold belt (King, 1969).

The Middlesboro basin has an average width of 12 miles (19 kilometers) and trends east-northeastward across southeastern Kentucky for about 80 miles (128 kilometers); it extends an additional 24 miles (38 kilometers) into Tennessee where the basin terminates along the Jacksboro fault, and 22 miles (35 kilometers) into Virginia where it ends along the Russell Fork fault (Plate 1). On the southeast, the basin is bounded by a linear strike ridge that forms Cumberland Mountain and its easterly extension, Stone Mountain; steeply dipping strata of this ridge lie upon the northwestern limb of Powell Valley anticline. The northwestern

[1] Wentworth (1927) referred to the trough interchangeably as the Middlesboro basin and as the Middlesboro syncline, and McFarlan (1943, p. 175, 180) called it the Middlesboro basin. Englund, Smith, Harris, and Stephens (1963, p. B18) and Miller and Fuller (1954, p. 10) also referred to it as the Middlesboro syncline, but, because of its multiple structure, it is here referred to as the Middlesboro basin. It should not be confused with the alluvial valley in which the town of Middlesboro is situated which has been referred to as the Middlesboro basin by some writers (Ashley and Glenn, 1906, p. 23; Rich, 1933, p. 1229; Fenneman, 1938, p. 324; and Englund, Smith, Harris, and Stephens, 1963, p. B18).

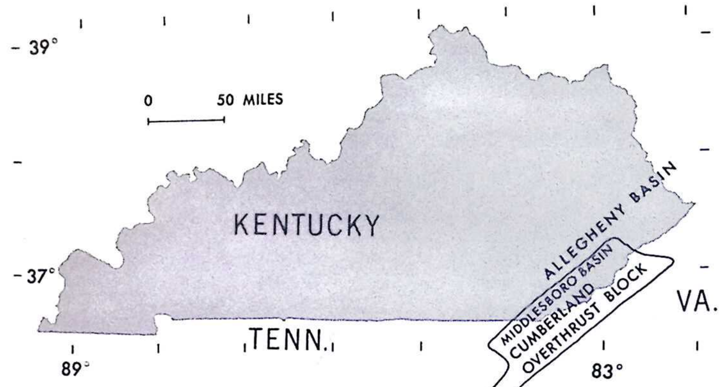

Figure 1. Index map showing location of Middlesboro basin and Cumberland overthrust block.

margin of the basin is formed by southeastward-tilted strata overlying the Pine Mountain overthrust fault, the surface trace of which crops out low along the northern slope of Pine Mountain (Plate 1). Pine Mountain overthrust fault underlies the Middlesboro basin where gently folded upper Paleozoic rocks are superimposed upon and separated from gently southward-dipping lower Paleozoic rocks by the nearly horizontial bedding-plane overthrust fault in Devonian and Mississippian shale (Plate 1).

The sedimentary section underlying the Middlesboro basin ranges in age from Cambrian to Pennsylvanian and exceeds 15,000 feet (4,500 meters) in thickness (Figs. 2 and 3). The sequence is composed of varied lithologies with thick units that include potential source beds, cap rocks, and reservoirs for oil and gas. The section contains abrupt lateral facies changes, local and regional unconformities, and extreme thickness variations. The central part of the basin, encompassing some 600 square miles (1,536 square kilometers) and underlain by a volume of 16,000 cubic miles (65,600 cubic kilometers) of unmetamorphosed sedimentary rocks, may have potential for significant structural and stratigraphic oil and gas accumulations. No detailed geophysical surveys have been made within this area, and only seven exploratory test holes for oil and gas have been drilled. Shows of oil or gas were reported from every hole. Although six tests penetrated the Pine Mountain overthrust fault, only one hole reached Cambrian rocks, and none entered the Precambrian basement.

Recent mapping by the U. S. Geological Survey in cooperation with the Kentucky Geological Survey (Plate 2) has delineated some large subtle flexures in the coal measures of the central part of the Middlesboro basin; this mapping also provides a basis for correlation of upper Paleozoic stratigraphic units. Other parts of the greater Allegheny basin are currently yielding favorable results to the sharpened skills of oil explorers; this justifies another look at the oil and gas prospects of an area where drilling depths to potential reservoirs are moderate and major markets are readily accessible.

STRATIGRAPHY

The thick lower Paleozoic sequence (Fig. 2) below Pine Mountain fault is entirely marine in origin (Englund and others, 1961). Most of this section crops out in the core of Powell Valley anticline (Plate 1). Despite a plethora of local stratigraphic nomenclature, regional lithologic generalizations can be summarized as follows. The lower part of the Cambrian section is about 3,000 feet (900 meters) thick and is composed mainly of shale and sandstone; the upper part of the Cambrian and the Lower, Middle, and part of the Upper Ordovician sequence are mostly shelf-type limestone and dolomite which attain a thickness

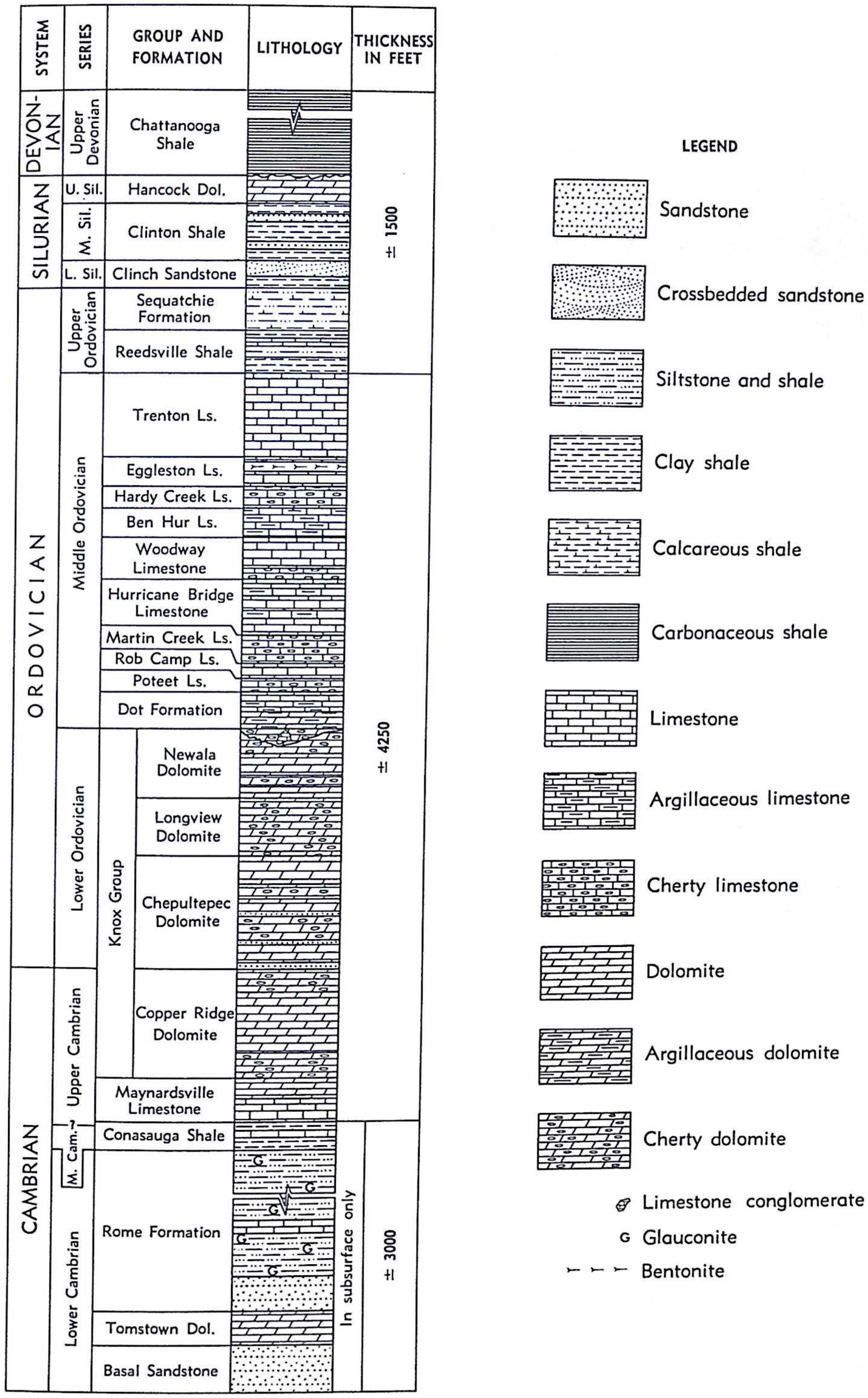

Figure 2. Columnar section of lower Paleozoic rocks in part of Cumberland Mountain. (Modified from Englund and others, 1961.)

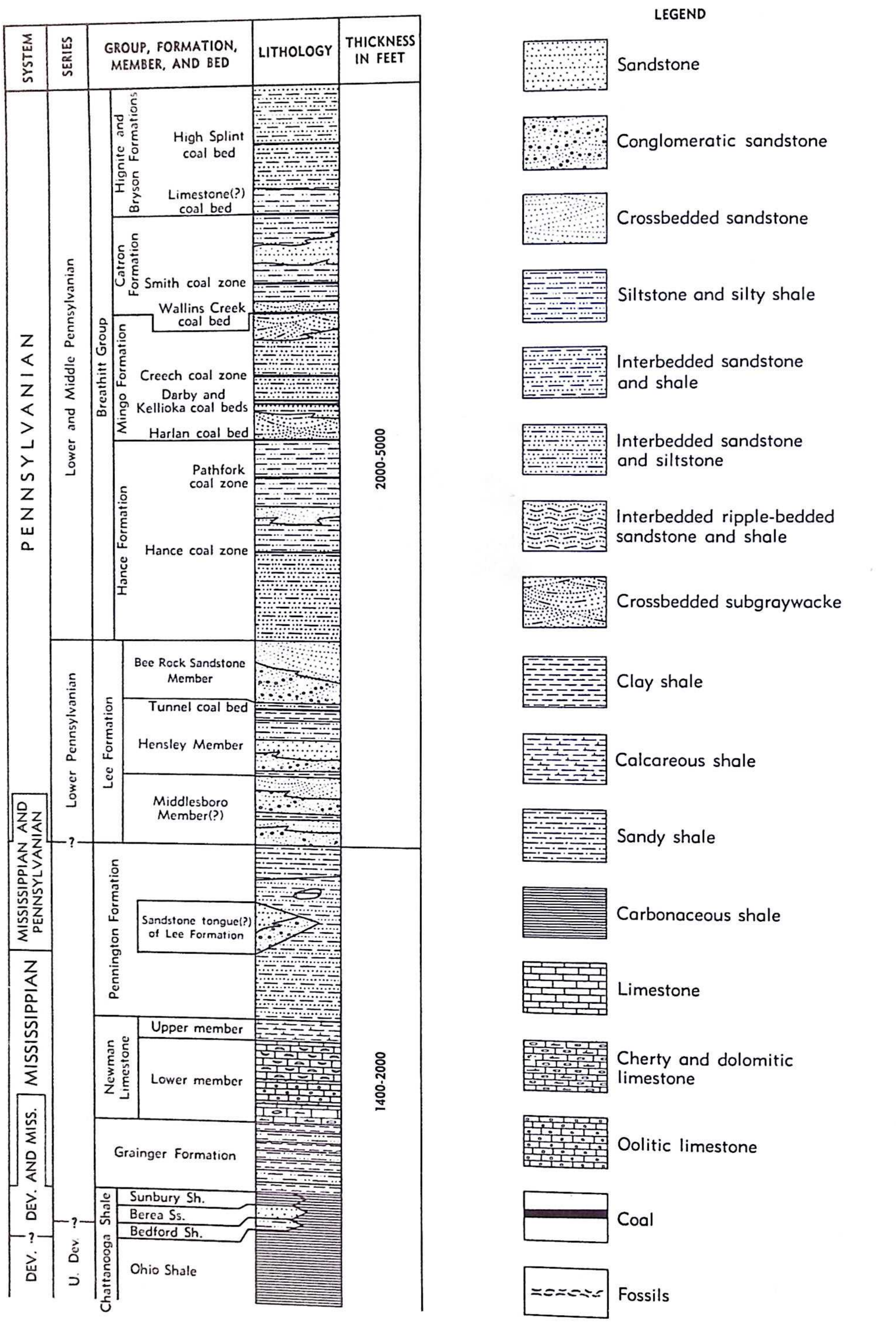

Figure 3. Columnar section of upper Paleozoic rocks in parts of Middlesboro basin and Pine and Cumberland Mountains.

of 4,250 feet (1,275 meters). The upper part of the Upper Ordovician and the Silurian and Devonian units consist chiefly of shale and siltstone with minor sandstone and carbonate rocks which average 1,500 feet (450 meters) in thickness.

The lower Paleozoic marine section contains few large breaks in the sedimentation record; however, a major unconformity separating the Cambrian and Ordovician Knox Group from overlying Ordovician beds, and a regional hiatus representing all of Early and Middle Devonian time have been recognized throughout the area. McGuire and Howell (1963) published a comprehensive regional study of oil and gas possibilities of Cambrian and Lower Ordovician rocks in Kentucky, which summarizes and integrates what is known of subsurface characteristics of lower Paleozoic rocks in the state. Unfortunately, because of the paucity of deep drill holes, their study provides meager information on the subsurface of the Middlesboro basin. Regional stratigraphic relations clearly indicate that all units thicken to the southeast across this area (Woodward, 1961).

The upper Paleozoic sequence (Fig. 3) of the shallow basin above the Pine Mountain fault is better understood than the lower Paleozoic succession because it crops out in both Pine and Cumberland Mountains. It consists of about 2,000 feet (600 meters) of Devonian and Mississippian marine rocks overlain by 2,000 to 5,000 feet (600 to 1,500 meters) of mainly nonmarine Pennsylvanian coal-bearing strata. In ascending order the marine sequence consists of black, carbonaceous, Devonian shale (Chattanooga or Ohio Shale); Mississippian red and green shale and siltstone which is locally cherty at the top (Grainger Formation and Fort Payne Chert); fossiliferous and oolitic carbonate rock (lower member of the Newman Limestone); thin limestones and calcareous, fossiliferous shale (upper member of the Newman Limestone); and fine-grained, ripple-marked sandstone and siltstone (Pennington Formation). Pennington strata intertongue with overlying Lower Pennsylvanian pebbly quartzose sandstone (Lee Formation) of fluviatile or barrier-bar origin, which in turn intertongues with overlying Lower to Middle Pennsylvanian sandstone, shale, and coal beds (Breathitt Group) of a repetitive, cyclic, paludal and fluviatile sequence.

Local unconformities within Pennsylvanian strata are common, but the regional disconformity near the top of the Lee Formation described by Englund (1964a, p. B38) in the Cumberland Mountains, has not been recognized along Pine or Cumberland Mountains east of the Varilla quadrangle. Regional studies indicate that the entire upper Paleozoic sequence thickens southeastward across the Middlesboro basin. The Lower Pennsylvanian conglomeratic sandstone bodies are thicker and coarser grained to the southeast; to the northwest they wedge out or grade laterally into and intertongue with marginal and shallow marine rocks of the underlying Pennington Formation (Englund, 1964a, p. B33).

Potential source beds for hydrocarbons are present in thick, fossiliferous marine shale and carbonate rocks. Clean, porous sandstones of the Lee and Pennington Formations and vuggy, oolitic, fragmental limestone and dolomite of the Newman and of the lower Paleozoic succession offer thick, prospective reservoirs for a variety of potentially major structural and stratigraphic traps. Although none of the seven exploratory tests shown on Plate 3 was located on anticlinal structures that are evident at the surface, it is encouraging that hydrocarbon shows and good to poor porosity were reported from all the tests. The few electrical logs are inadequate for porosity calculations. It appears very likely that future drilling located on structural crests will also encounter porous zones in the Lee and Pennington Formations, Newman Limestone, and lower Paleozoic carbonate rocks.

Based on evaluation of all available subsurface data as of 1963, McGuire and Howell (1963, p. 5-1) were optimistic about the presence of oil and gas in the Cambrian and Ordovician rocks of Kentucky, ". . . as indicated by the occurrence of oil and gas shows in all stratigraphic units from the Tyrone-Oregon to the basal sandstone." They stated (1963, p. 5-1): "Although the amount of well control is not great, it is now known that the Cambrian, Lower Ordovician, and Middle Ordovician rocks in Kentucky include clastic and carbonate reservoir beds with sufficient thickness, porosity, and permeability to provide for major oil and gas accumulations." They continue: "The thick shales of the Rome Formation, some of which are black and carbonaceous, and the characteristic bitumen and asphaltic residue indigenous to the Copper Ridge Dolomite, indicate possible organic sources for hydrocarbons."[1]

The United Fuel Gas Company No. 2 Knuckles, a 10,034-foot (3,058-meter) Cambrian test hole in Bell County on the south flank of Pine Mountain (Plate 3), yielded a good show of oil and gas approximately 140 feet (42 meters) below the top of the Tyrone (Eggleston) Limestone. According to McGuire and Howell (1963, p. 5-13): "This zone is correlated approximately with the producing zone in the Rose Hill field in Lee County, Virginia." The geology of the fenster area and the Rose Hill (Trenton) oil field has been thoroughly discussed in a comprehensive report by Miller and Fuller (1954). In addition, the No. 2 Knuckles test, the only well in the area to have penetrated the Knox carbonate sequence, had shows of oil and gas from three separate zones in the Knox Group.

Wilpolt and Marden (1959) published a regional surface and subsurface study of the geology and oil and gas possibilities of Upper Mississippian rocks of southwestern Virginia, southern West Virginia, and eastern Kentucky, including the eastern part of the Middlesboro basin. They anticipated (p. 613) that additional discoveries would be made in the Mississippian limestone and in the overlying sandstone beds, units which are already productive in southwestern Virginia at the northeast end of the Middlesboro basin. They stated (p. 613) that: ". . . the gas-producing possibilities of the Mississippian rocks are excellent in that part of the area studied in which beds of the Pottsville Formation of Pennsylvanian age are present at the surface." They concluded (p. 614): "The writers believe that structural controls in the area have not played so important a part as stratigraphic traps in the accumulation of oil and gas, but structures may have localized accumulations where they are associated with stratigraphic traps."

Oil and gas shows from fractured black shale and associated carbonate rocks were reported from every well penetrating the Pine Mountain fault. Gas shows were also reported from the lower member of the Newman Limestone in the Rodman No. 1 and No. 2 Asher wells in Bell County, and gas and minor free oil were reported from the same unit in the Columbian Fuel Corp. No. 1 Kentenia Corp. well in Harlan County; oil shows were present in fractured Newman Limestone from shallow core holes drilled near the crest of Pine Mountain east of Cumberland (Plate 3). Types of porosity reported in the lower member of the Newman Limestone include interoolitic or intergranular, vuggy, and saccharoidal, as well as fracture porosity. Porous saccharoidal dolomites are common near the base of the unit, and, locally, dolomitic beds occur as much as several hundred feet above the base. These dolomites might have originated as beach, bank, or offshore-bar deposits along relatively narrow zones aligned parallel to the ancient shoreline (Wilpolt and Marden, 1959, p. 612). Thus the Newman Limestone is a promising intermediate objective for exploratory drilling.[2]

The rate of south-southeasterly thickening of the sections from the Harlan coal bed to the top of the lower member of the Newman Limestone, to the Grainger Formation, and to the Chattanooga Shale across the Middlesboro basin was calculated on the basis of published outcrop sections and well logs (Table 1 and Plate 3). Although local irregularities obtain, southward thickening averages 100 feet per mile (18.7 meters per kilometer) between Pineville and Middlesboro and about 150 feet per mile (28.1 meters per kilometer) between Cumberland and Appalachia-Big Stone Gap. Figures

[1] *Editor's note:* The Raccoon Mountain pool in Clay and Laurel Counties in eastern Kentucky produces gas and oil from the top of the Knox Group on a sharp fold structure (Wilson, 1968). In Casey, Pulaski, and (since 1969) Adair Counties in central Kentucky oil production has been obtained from the top of the Knox Group in unconformity traps modified by structure. In addition, in eastern Kentucky the "Avila Chert," a vuggy zone near the base of the Ordovician Knox just above the Rose Run Sandstone Member (of McGuire and Howell, 1963) of the Chepultepec Dolomite, became oil productive in the Moon pool, Morgan County, in 1971. The Antietam Sandstone (not younger than Early Cambrian) has produced oil (and recently gas) in Boyd County since 1967.

[2] *Editor's note:* A porous zone near the base of the Newman Limestone (called Big Lime by drillers) has been widely productive of gas in eastern Kentucky. The Bull Creek field (Webb, 1972), discovered in 1965, is the newest significant pool producing from this zone; this pool, which lies about 10 miles (16 kilometers) northwest of the surface trace of the Pine Mountain overthrust fault, produces nearly all of the oil coming from Letcher and Perry Counties. The Neon (District of Big Sandy) pool, located in Letcher County about 4 miles (6.4 kilometers) northwest of the Pine Mountain front, produces gas from the Berea and Maxon Sandstones of Mississippian age (Walker, 1967).

Table 1.—Approximate Intervals between Harlan Coal Bed and Lower Member of Newman Limestone, Grainger Formation, and Chattanooga Shale across the Middlesboro Basin. Well Data Based on Drillers' Logs. Numbers Refer to Localities on Plate 3.

Measured or calculated interval	2 United Fuel Gas No. 2 Knuckles	4 Rodman No. 2 Asher	6 Columbian Fuel Corp. No. 1 Bailey	5 Columbian Fuel Corp. No. 1 Kentenia Corp.	10 Clinchfield Coal Co. No. 176	1 Benedum-Trees No. 1 Hurst	11 Ely Gap area (*From* Englund, Harris, and Stephens, 1963)	12 Big Stone Gap area (*From* Miller, 1965)
	Interval in feet and (meters)							
Harlan coal bed to lower Newman Limestone	3,130 (954.0)	3,140 (957.1)	3,270 (996.7)	3,375 (1,028.7)	3,355 (1,022.6)	3,400 (1,036.3)	3,900 (1,188.7)	4,490 (1,368.6)
Harlan coal bed to Grainger Formation	3,500 (1,066.8)	3,726 (1,135.7)	3,673 (1,119.5)	3,787 (1,154.3)	3,722 (1,134.5)	3,917 (1,193.9)	4,170 (1,271.0)	4,930 (1,502.7)
Harlan coal bed to Chattanooga Shale	3,713 (1,131.7)	3,946 (1,202.7)	3,982 (1,213.7)	4,193 (1,278.0)	4,150 (1,264.9)	4,155 (1,266.4)	4,495 (1,370.1)	5,230 (1,594.1)

Comparison of thickness of section 2 with 11 and of 10 with 12 shows southerly component of thickening from Pine Mountain to Cumberland Mountain; comparison of thickness of section 11 with 12 shows easterly component of thickening along strike in Cumberland-Stone Mountain.

4A and 4B illustrate diagrammatically that closure at depth may result solely from a southerly increase in thickness on northward-plunging anticlinal structures.

STRUCTURE

The gross "pie-platter" synclinal configuration between Pine and Cumberland Mountains (Plate 1) has been known since the early 1900's as a result of studies of the coal-bearing formations by Ashley and Glenn (1906). Recent geologic quadrangle mapping at a scale of 1:24,000 has shown that Pennsylvanian "Coal Measures" at the surface of the flat-bottomed synclinorium are warped into large, elongate, very low amplitude, subparallel flexures about 1.5 miles (2.4 kilometers) wide (Plate 3).

Most of the gentle folds plunge east-northeastward parallel to the structurally controlled basin margins; however, some en echelon flexures extend north-northeastward for tens of miles from Cumberland Mountain at the south margin, transect the entire basin, and merge with plunging anticlinal noses on Pine Mountain (Plate 3). These elongate flexures commonly have local axial closures. The crests and troughs along these elongate flexures appear to form a system of culminations and depressions (Billings, 1942, p. 49) which are subparallel and aligned north-northwesterly. This subtle and obscure cross-basin alignment is more or less parallel to the trend of transverse Jacksboro, Rocky Face, and Russell Fork tear faults (Plate 3); it is subparallel to Buck Knob anticline and to flexures in Breathitt strata in the Ivydell quadrangle; it is also parallel to warps and plunging folds on Pine Mountain (Plate 3). More significantly, perhaps, this trend is subparallel to White Mountain and Dorton Branch faults, and to subtle anticlinal and synclinal flexures in the Pennsylvanian strata of the stationary block north of Pine Mountain overthrust fault (Plate 3). Tectonic configurations similar to that of the Middlesboro basin may result from interference patterns where one

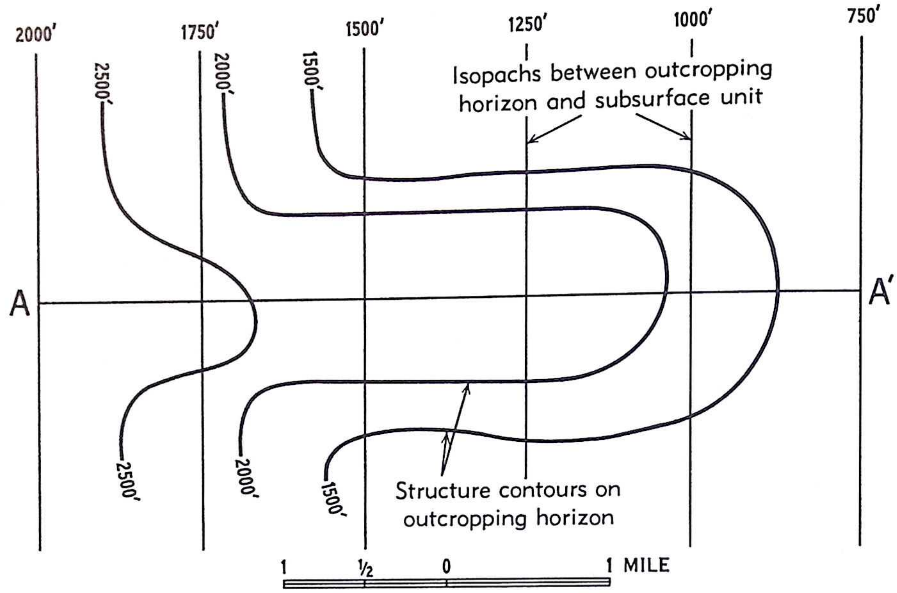

Figure 4A. Schematic map showing eastward-plunging nose and westerly thickening of section between outcrop and hypothetical reservoir at depth.

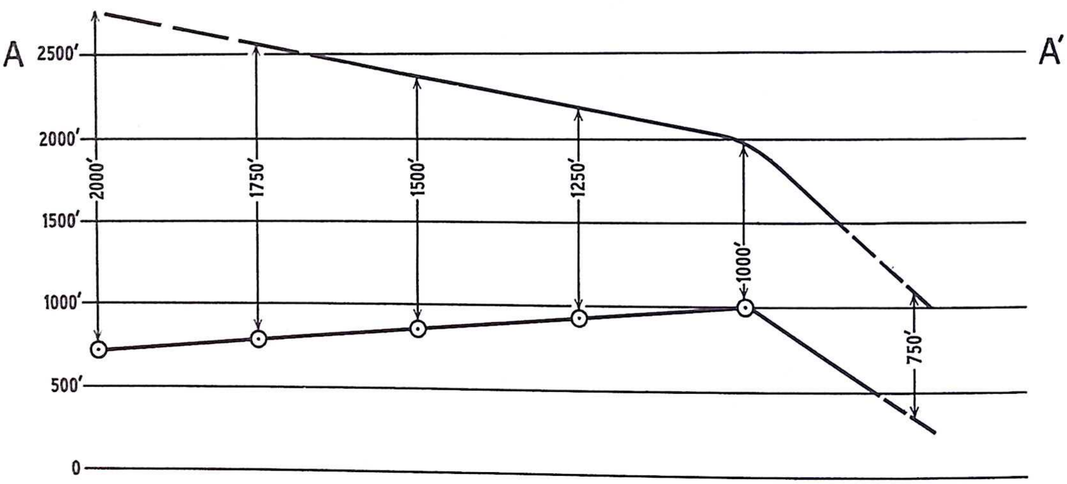

Figure 4B. Diagrammatic cross section A-A′ showing structural closure at depth below plunging anticlinal nose in Figure 4A.

fold belt is superimposed on another pre-existing fold belt or on an underlying structural grain, as shown in other areas (O'Driscoll, 1962; Workum, 1962; Ramsay, 1967, p. 519-533).

In a regional report on structure of the Appalachians, Rodgers (1953) observed that much of the structure is disharmonic, so that the folds and faults overlie surfaces of décollement in various units low in the sequence; the underlying strata and the basement beneath are probably little deformed, or deformed in a different manner. Wilpolt and Marden (1959, p. 611) stated: "If the rocks beneath the Cumberland overthrust block are folded and truncated by Pine Mountain fault, local petroliferous zones may occur directly beneath the fault zone."

Possibly the structural alignments in Middlesboro basin result from two successive events; the prominent east-northeast trend may define tectonic elements which are limited to post-Devonian rocks above the Pine Mountain fault, and the subdued north-northwest alignment of culminations and depressions may reflect subthrust structure or the morphology of the pre-Knox or the pre-Devonian surface.

GEOPHYSICAL STUDIES

The Middlesboro basin has been covered by a regional gravity survey (Watkins, 1963) and partially covered by airborne magnetometer and radiometric surveys (Watkins, 1964; Bates, 1962). Systematic detailed gravity, ground magnetometer, or seismic surveys have not been reported, nor have modern seismic surveys utilizing common depth point or digital recording yet been attempted. The ruggedness of the terrain may be a deterrent to systematic geophysical surveys, as local relief exceeds 1,500 feet (450 meters); however, roads and river valleys provide adequate access for reconnaissance coverage of most of the basin. Doubtless, good quality seismic records can be made of the shallow basin above Pine Mountain overthrust fault. Modern common depth point techniques with analog or digital processing may yield usable subthrust data.

To test the possibility that the subtle north-northwesterly structural trend might reflect subthrust structure, closely spaced reconnaissance gravity traverses were made in 1969. Measurements were made across the crestal culmination of an accessible anticlinal flexure (Plate 4). The Bouguer gravity values, based on 2.67 g/cm^3, were corrected for the effects of terrain. Preliminary results indicate a residual 5-milligal anomaly coincident with the surface apex of the structure (Plate 4). The disturbed core of this structure is exposed at a roadcut east of Catron Creek (Figs. 5 and 6) where the shales are faulted, deformed, and possibly diapiric.

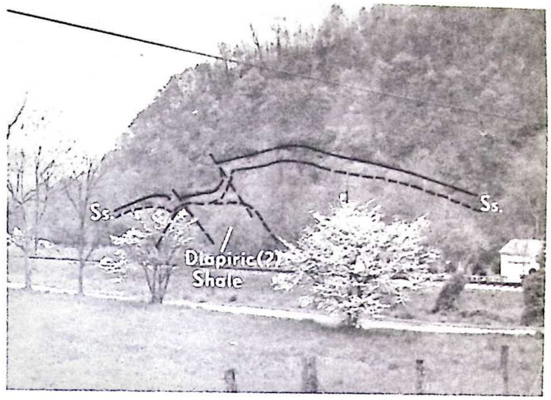

Figure 5. Core of anticline east of Catron Creek, Harlan County, Ky. View eastward from gravity station 3 on Plate 4.


Figure 6. Closer view of disturbed (diapiric?) rocks in core of anticline shown in Figure 5.

SUMMARY

The Middlesboro basin area is underlain by a thick section of Paleozoic strata containing potential source, reservoir, and cap rocks considered favorable for oil and gas accumulation. It is a composite structural basin with a lower sequence consisting of lower Paleozoic marine strata separated from an overlying sequence of upper Paleozoic marine and nonmarine strata by an essentially flat-lying overthrust fault. Both sequences thicken to the southeast.

Oil and gas shows were reported in all seven exploratory tests in the central part of the basin. Potential reservoir objectives below Pine Mountain overthrust fault are the Copper Ridge Dolomite (Cambrian), Trenton Limestone (Ordovician), and Hancock Dolomite (Silurian). Little is known about the strata below the thrust fault, and almost nothing about relief on the post-Knox unconformity. Reservoir objectives above the thrust fault include fractured Chattanooga Shale (Devonian), lower member of the Newman Limestone (Mississippian), and sandstone of the Pennington and Lee Formations (Mississippian and Pennsylvanian). Updip "pinchouts" of porous quartzose Lee-type sandstone in impermeable Pennington shales and siltstones may form stratigraphic traps.

Large gentle flexures in surface strata of Middle Pennsylvanian age apparently reflect the prevailing east-northeasterly structural grain that resulted from post-Pennsylvanian overthrust faulting. The attitude, size, and shape of structures below the thrust fault are unknown; however, a possible north-northwest interference pattern which may reflect subthrust structural or paleogeomorphic alignments is suggested by: the trend of the Jacksboro, Rocky Face, and Russell Fork tear faults; the trend of Buck Knob anticline and flexures in the Ivydell quadrangle; the orientation of structures on Pine Mountain overthrust fault; and the alignment of axial culminations and depressions along parallel elongate flexures.

Because the entire stratigraphic section thickens markedly to the south and east, significant structural closure on potential reservoirs at depth is possible even though closure is absent at the surface due to shallow saddles to the south and east (Figs. 4A and 4B) or where closure is minor.

Regional geophysical coverage is needed to provide data on the structural configurations above and below the thrust fault and unconformities, and to investigate subsurface continuity of exposed structures. Despite the rugged terrain, major roads and low-gradient valleys provide adequate access for semi-detailed gravity and seismic investigations.

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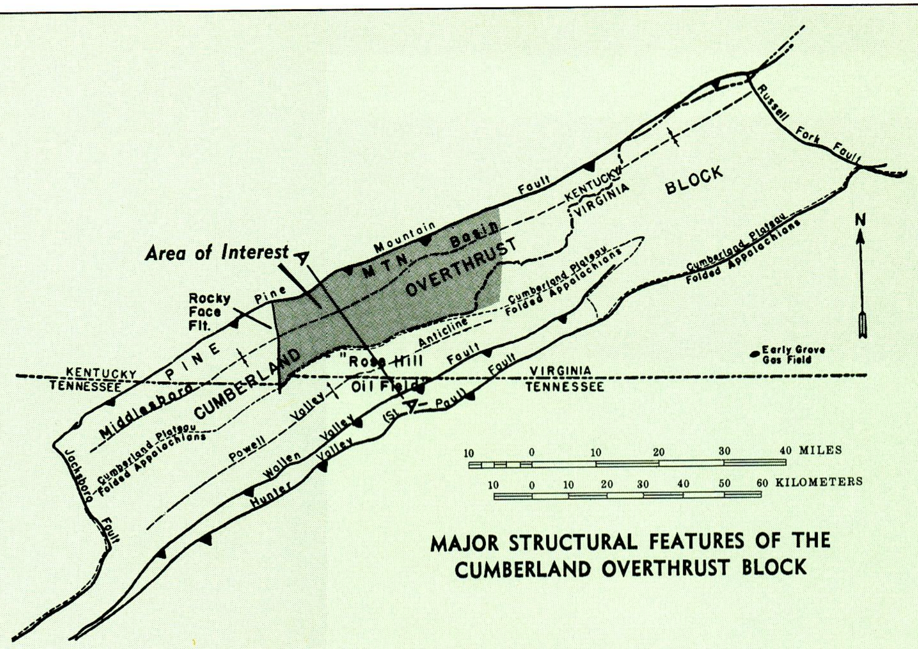
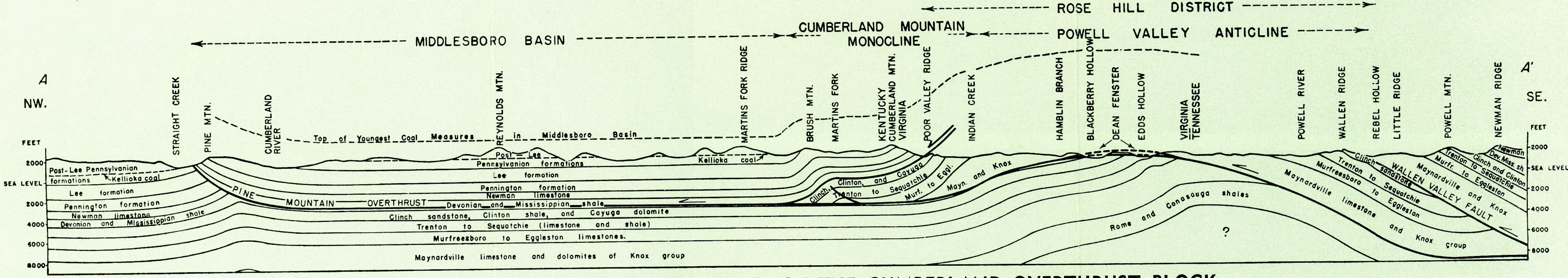
KENTUCKY GEOLOGICAL SURVEY, SERIES X
Wallace W. Hagan, Director and State Geologist

REPORT OF INVESTIGATIONS 14
PLATE 1



MAJOR STRUCTURAL FEATURES OF THE CUMBERLAND OVERTHRUST BLOCK



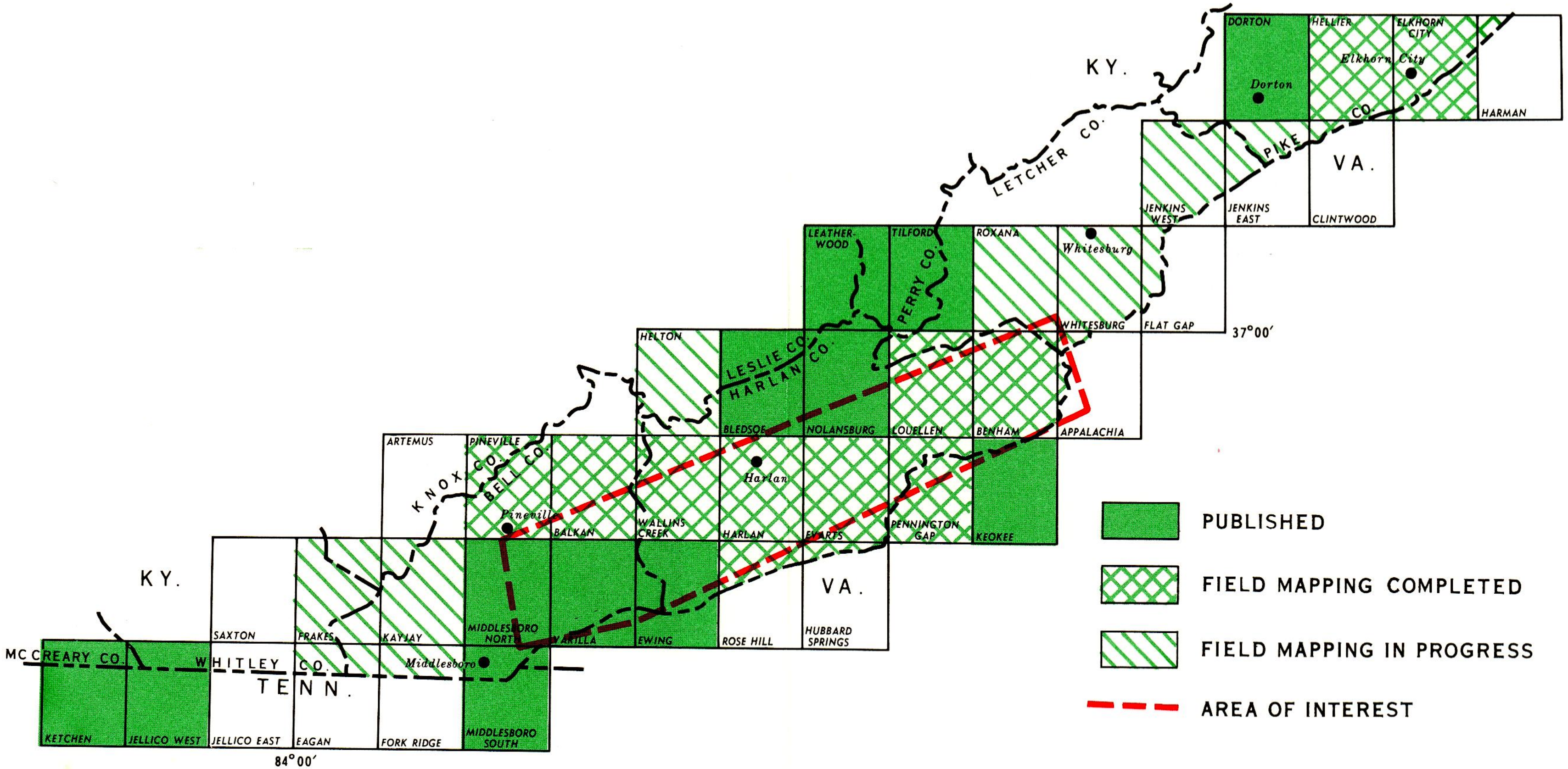
GENERALIZED GEOLOGIC SECTION THROUGH THE CUMBERLAND OVERTHRUST BLOCK

Line of section A-A' shown on map above. Length of section is 27 miles (43 kilometers).

Modified from Miller and Fuller (1954, Pl. 5)

KENTUCKY GEOLOGICAL SURVEY, SERIES X
Wallace W. Hagan, Director and State Geologist

REPORT OF INVESTIGATIONS 14
PLATE 2



STATUS OF GEOLOGIC MAPPING AT A SCALE OF 1:24,000 IN SOUTHEASTERN KENTUCKY AS OF OCTOBER 1971

EXPLANATION

Structures in pre-Breathitt rocks

Outcrop area—rocks of pre-Breathitt age

Anticline or salient showing approximate position of crest line and direction of plunge; locally overturned

Syncline or recess showing approximate position of trough line and direction of plunge

Monocline or structural terrace

Strike and dip of beds; measured, vertical, and approximate

Thrust fault; dashed where approximately located. Saw teeth on upper plate

Fault; dashed where approximately located. Bar and ball on downthrown side; arrows show relative movement

UNMAPPED AREA — Areas not yet mapped at scale of 1:24,000 (Includes areas mapped at 1 in. = 3 mi. or 1 in. = 1 mi.)

Structures in Breathitt rocks

Outcrop area—Breathitt rocks

Anticlinal flexure showing approximate position of crest line and direction of plunge

Culmination, showing approximate position of crest line

Synclinal flexure showing approximate position of trough line and direction of plunge

Depression, showing approximate position of trough line

2000 — Structure contours drawn on base of Harlan coal bed; dashed where projected. Contour interval 100 and 200 feet

DRILL HOLES AND OUTCROPS FROM WHICH GEOLOGIC DATA WERE OBTAINED

4 — Dry hole with show of gas or gas and oil, or oil or gas well

8 — Core hole with show of oil

11 — Outcrop locality

Numbers refer to localities described in Table 1

Cartography By Terry Hounshell

1 Benedum-Trees No. 1 Hurst; Bell Co., Ky., 21-C-70; TD 5,697 ft (Ordovician); gas show reported

2 United Fuel Gas No. 2 Knuckles; Bell Co., Ky., 5-C-71; TD 10,034 ft (Cambrian); Tyrone (Eggleston) oil and gas shows

3 Rodman No. 1 Asher; Bell Co., Ky., 5-C-72; TD 3,318 ft (Silurian); Newman gas well (shut in)

4 Rodman No. 2 Asher; Bell Co., Ky., 23-D-72; TD 3,597 ft (Silurian); show of gas

5 Columbian Fuel Corp. No. 1 Kentenia Corp.; Harlan Co., Ky., 16-D-74; TD 4,826 ft (Silurian); Newman oil and gas shows, Chattanooga gas show

6 Columbian Fuel Corp. No. 1 Bailey; Harlan Co., Ky., 3-D-74; TD 5,149 ft (Ordovician); Chattanooga and Hancock gas and oil shows

7 U. S. Steel No. 1 Big Looney; Harlan Co., Ky., 11-F-79; TD 3,043 ft (Mississippian); Pennington gas show reported

8 Kentucky Department of Highways Pine Mountain core holes Nos. 2 and 4; Letcher Co., Ky., 14-G-80 and 18-G-80; TD 880 ft and 832 ft (Devonian); Newman oil stained

9 Callahan Creek gas field; Wise Co., Va.; (Silurian); Newman and Chattanooga gas

10a 10b 10c Clinchfield Coal Co. Nos. 176, 111, and 210; Dickenson Co., Va.; TD 5,889 ft, 6,064 ft, and 5,866 ft (Silurian); Chattanooga, Berea, Pennington, and Lee gas shows

11 Ely Gap outcrop section; Lee Co., Va.

12 Appalachia-Big Stone Gap outcrop section; Wise Co., Va.

13 Rose Hill oil field; Lee Co., Va.; (Cambrian); Trenton oil

14 Gilbert and Moulton No. 1 American Assoc.; Claiborne Co., Tenn., 21-A-67; TD 3,030 (Mississippian); Fort Payne oil

15 Kettle Island gas field; Bell Co., Ky., 9-D-71 (Silurian); Newman and Hancock gas

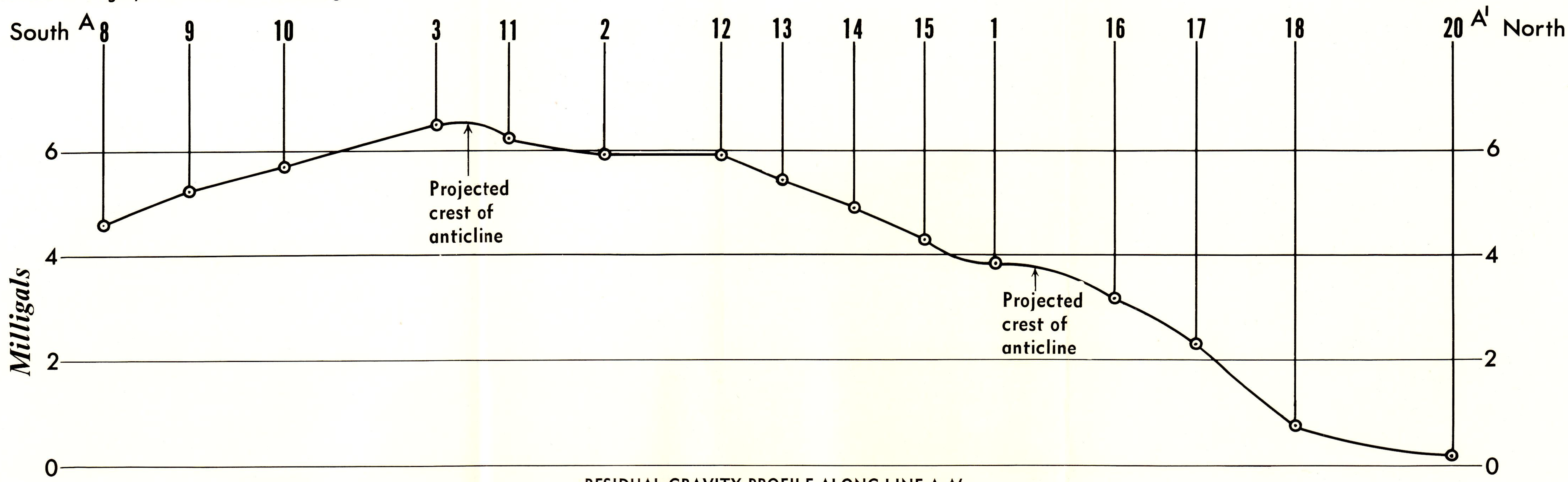
16 Stoney Fork gas field; Bell Co., Ky., 17-E-72 (Silurian); Newman and Hancock gas

Scale 1:250,000

5 0 5 10 15 20 Statute Miles

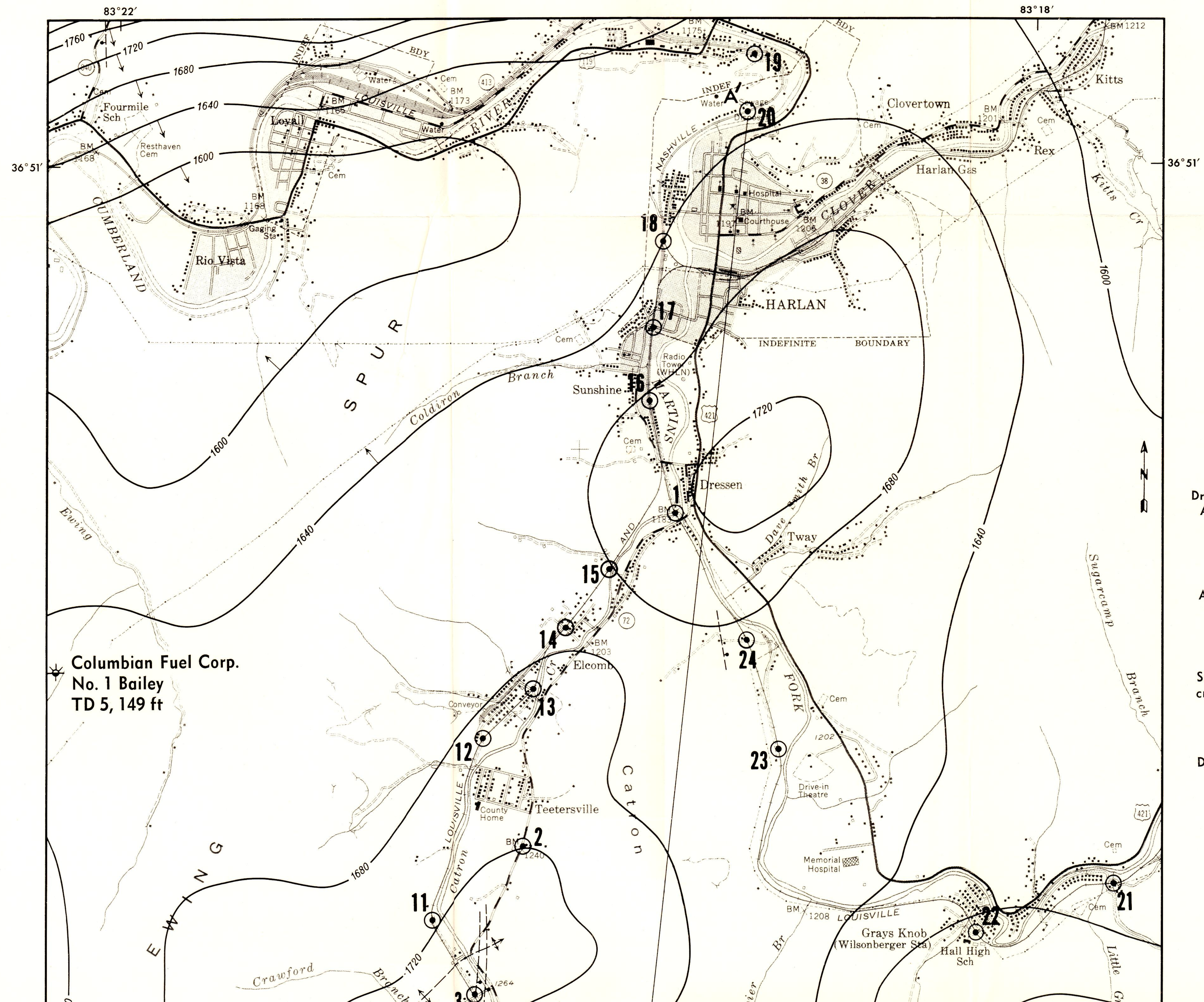
5 0 5 10 15 20 25 30 Kilometers

MAP OF GEOLOGIC STRUCTURE SHOWING LOCATIONS OF TEST HOLES AND OUTCROP SECTIONS IN THE MIDDLESBORO BASIN



RESIDUAL GRAVITY PROFILE ALONG LINE A-A'

Modified from preliminary studies by J. C. Allingham, July 1969



MAP SHOWING STRUCTURE ON BASE OF THE HARLAN COAL BED AND LOCATIONS OF GRAVITY STATIONS, HARLAN COUNTY, KENTUCKY

SCALE 1:24 000

1 ½ 0 1 MILE

1 .5 0 1 KILOMETER

EXPLANATION

1800

Structure Contours
Drawn on base of Harlan coal bed. Arrows indicate direction of dip. Contour interval, 40 feet

Fault
Approximately located; bar and ball on downthrown side

Anticline
Showing approximate position of crest line and direction of plunge

T.D. 5149'
Dry hole with shows of oil and gas

12
Location of gravity station

A———A'
Location of gravity profile