GEOLOGY OF THE CUB RUN QUADRANGLE, KENTUCKY

BY

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THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
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THE DEGREE OF [illegible]

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*Subject to successful final examination in the case of the doctorate.
†Required for doctor's degree but not for master's.

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UNIVERSITY OF ILLINOIS

THE GRADUATE SCHOOL

May 18, 1942.

I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY SUPERVISION BY Wallace Woodrow Hagan

ENTITLED Geology of the Cub Run Quadrangle, Kentucky

BE ACCEPTED* AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE OF Doctor of Philosophy in Geology

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TABLE OF CONTENTS

Page

Page

Page

ILLUSTRATIONS

Plates — Page

GEOLOGY OF THE CUB RUN QUADRANGLE, KENTUCKY

CHAPTER I

INTRODUCTION

Location

The Cub Run quadrangle is located in western Kentucky (Fig. 1) between 86° 00' and 86° 15' west longitude and between 37° 15' and 37° 30' north latitude. It comprises an area of approximately 245 square miles and includes parts of Hardin, Grayson, Hart, and Edmonson counties, Kentucky. A previous report (Weller, 1927)[1] and map (Weller, 1929) have been published on the Edmonson County part. This report covers the remaining area of approximately 204 square miles.

The northeast corner of the quadrangle is about fifty-two miles air line south-southwest from Louisville. Elizabethtown, county seat of Hardin County, is twenty-five and one-half miles northeast of the point where U. S. highway No. 62 enters the quadrangle northeast of Clarkson. The northwest corner of the quadrangle is two and one-half miles northeast of Leitchfield, county seat of Grayson County. The southwest corner of the Meredith rectangle (Fig. 1) is twelve and one-half miles north of Brownsville, Edmonson county seat, by way of Kentucky highway 65. The east central margin of the Winesap rectangle is eight and one-half miles west of Munfordville, county seat of Hart County, by way of Kentucky route 88.

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1. Numbers in parentheses refer to bibliography at end of report.

Mammoth Cave National Park indents the southern boundary of the quadrangle at several localities, but only a few square miles of the north side of the park are within its confines.

Adjacent to and surrounding the area are the following quadrangles: Big Clifty on the north, Elizabethtown to the northeast, Munfordville on the east, Horse Cave on the southeast, Mammoth Cave on the south, Brownsville to the southwest, and Leitchfield on the west.

Importance

The Cub Run quadrangle possesses certain economic products which are of some importance. Rock asphalt or black rock, good calcareous shales, limestone for agricultural and road building purposes, minor amounts of coal, and clays are present, all of which give some importance to the area. Some oil and/or gas possibilities may exist. Reports of lead ore are apparently with some foundation. However, at present agriculture is the chief asset of the region.

The region is particularly interesting to the student of geology because of its complex structural relationships and its stratigraphic problems, especially the problems of the thinning and disappearance of certain clastic units in the Chester. It is also of interest to the economic geologist for its asphalt deposits.

The physiographic characteristics of the region are worthy of note. The entrenched meandering course of the Nolin river, the influence of structure and bed rock on topography, and other

features shed definite light on the geologic development of the region.

Culture

The towns in this area are small, ordinarily consisting of a general store or stores, a small cluster of individual dwellings, and possibly one or several churches. Most of the towns are small agricultural centers, some of which specialized in milling and thus were located along the Nolin river. Grayson Springs was a well known health resort in the 1860's and 1870's, and owes its growth to the mineral springs present there.

One railroad, the Illinois Central, Louisville branch, crosses the northwest corner of the area. Several good gravel highways cross the region, namely: Kentucky routes 88, 224, 65, and 226. U. S. route 62 parallels the Illinois Central railroad. With the advent of these highways during recent years, the secondary roads have declined noticeably and during a considerable portion of the year much of the region is inaccessible by car.

Previous Field Work

In 1924 J. M. Weller mapped the Mississippian strata of the Edmonson County portion of the quadrangle. A. J. Culbertson and H. D. Crider were his field assistants, and Stuart Weller aided in some of the work. T. F. Jackson worked out the Pennsylvanian of the same area in 1924, and J. M. Weller and A. H. Sutton reviewed and supplemented this work in parts of June and July, 1925. The results of this work were published by the Kentucky Geological Survey (Weller, 1927 and 1929).

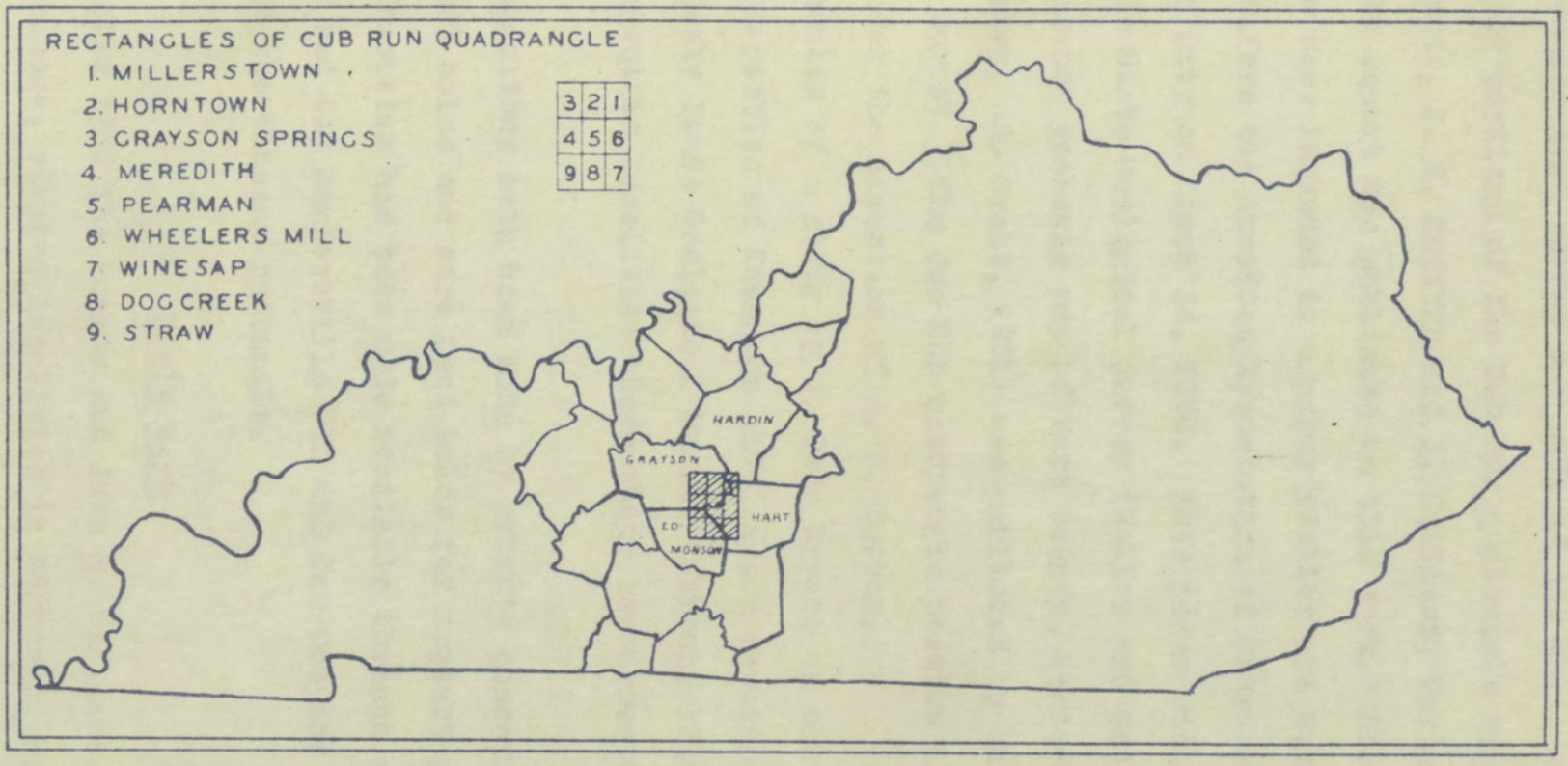

FIG.1 MAP OF KENTUCKY SHOWING LOCATION OF THE CUB RUN QUADRANGLE AND THE REFERENCE NAMES OF THE RECTANGLES IN THE QUADRANGLE AS USED IN THIS REPORT.

A reconnaissance survey was made of the Hart, Grayson, and Hardin county portions of the Cub Run quadrangle by A. H. Sutton and assistants, J. R. Griffin and J. Cullison, during the summer of 1927. No report was published on this work. However, some of the results were included in a paper (Weller and Sutton, 1940a) presented before the American Association of Petroleum Geologists at Oklahoma City on March 24, 1939. This paper was reissued by the Illinois State Geological Survey (Weller and Sutton 1940b). A reconnaissance geologic map of Hart County, Kentucky (Withers, Sutton, Wesley, and Crabb, 1931) was published by the Kentucky Geological Survey. The Cub Run quadrangle portion of this map was prepared under the direction of A. H. Sutton.

The results of a study by J. Owen Bryant on the coals and asphalt of a portion of Edmonson and Grayson counties were published by the Kentucky State Geological Survey (Bryant, 1914). It mentioned specific localities where these resources were supposed to occur.

Investigations have been made by private concerns to locate oil well test holes and core test holes for asphalt pits, but none of this information has been made available through publication. Paul Farmer and the Munfordville Oil and Gas Company mapped the structure in the Winesap rectangle.

Field Work

In October 1939 the author and John R. Williams, now with The Texas Oil Company, visited localities in Edmonson, Breckenridge, Hart, Grayson, and Hardin counties in order to become more familiar

with the various stratigraphic units in the general region. The type localities at Glen Dean, Hardinsburg, Tar Springs, and Buffalo Wallow were visited. Work was discontinued at the end of that month but resumed by the author in October 1940 and continued to completion in November 1941, without field assistants except in the collection of fossils where he was ably assisted by his wife.

The instruments used in the collection of data were a hand level and a Brunton compass. Due to the nature of the topography and roads the work was of necessity slow and tedious. Sufficient data were accumulated to construct areal and structural maps of a detailed nature. Formation contacts were taken at some 1600 different localities and were so spaced as to give as accurate and representative a picture of the geologic conditions as might be possible with the use of such instruments and a topographic map as a base.

Particular care was taken to locate all oil and/or gas test holes which had been drilled in the area, as well as many of the core test holes for asphalt. Also asphalt outcrops and pits were located and sampled. Many detailed sections of the various formations were studied and recorded. In the faulted areas readings and information were taken much closer together than in other portions.

Acknowledgments

The author expresses his thanks to A. H. Sutton for the helpful suggestions and criticisms which he has made both in the field and in connection with the preparation of the manuscript. He personally checked over the author's work on some of the more com-

plex structures such as at Grayson Springs, Snap, Sims Ford area with the pre-Pennsylvanian fault, Lone Oak Church area, Rock Creek fault complex, and Wheeler's Mill. He also checked the author's interpretation of the Ste. Genevieve-Renault contact in the Wheeler's Mill to Millerstown area. He looked over some of the stratigraphic sections such as the Leitchfield section about three quarters of a mile southeast of Rock Creek, a section near the head of Conoloway creek, and one on the Daniel Sims farm south of Sims Ford in Hart County, Kentucky, and viewed the field evidence concerning the Sample sandstone. Dr. Sutton checked the field work at various stages in its progress. He visited the area in December 1940, and in April, June, and July 1941 and spent several days in the field at each visit.

The helpful suggestions of the author's colleagues at the University of Illinois are appreciated. Paul Sims who is now employed by the Illinois State Geological Survey has studied many collections from the Leitchfield formations of western Kentucky in his work on the micro fauna and has submitted results to the author.

H. R. Wanless of the Department of Geology and Geography at the University of Illinois has made useful suggestions regarding the Pennsylvanian sections which occur in the area. Thanks are due him and other members of the department for helpful suggestions.

Don Miller of the Department of Geology and Geography at the University of Illinois has prepared the macro-fossil collections for study and made initial identifications. These were then carefully checked by the author and then rechecked by A. H. Sutton.

The included fossil lists are a result of this work.

Various government agencies in Kentucky have been quite helpful in furnishing data they possessed. D. J. Jones and staff members of the Kentucky Geological Survey accorded the author many courtesies and opened the survey files to him. R. T. Faulkner, County Farm Agent of Grayson County furnished data on crops, fertilizers, marls, acre yields, and distribution of crops.

Thanks are due F. A. Lenfesty, a Chemical Engineer for the Seneca Oil Company, who is located at Leitchfield, Kentucky.. He ran ignition tests on all asphaltic sandstones collected by the author. He also furnished material for a brief history of asphalt in the region, and conducted the author through the quarry and plant of the asphalt company in Edmonson County of which he is superintendent.

Fred J. Hughes of the Leitchfield Gazette furnished information on the history of Grayson Springs and other general information. The consideration of John Ed Bratcher and other business men of Leitchfield aided materially.

Special thanks are due to Mr. Scott of the Munfordville Oil and Gas Company, to Ralph E. Stouder of the Louisville Gas and Electric Company, to Carter Oil Company, to Dr. Hohnes of the Gulf Oil Company, Charles Hoke and Phillips Petroleum Company, Donald Sutton and Ed Harde of the Sun Oil Company, Skelly Oil Company, and Nick Shiarella of Owensboro, Kentucky who opened their files of logs of test holes for oil and gas. Other oil men contributed bits of information.

Appreciation is expressed to the local inhabitants of the area who volunteered information concerning outcrops, commercial developments, history and other subjects relative to the project. Oscar Constant, Henry Miller, H. G. Craddock, C. J. Huffman, Curt Logsdon and B. F. Thompson were outstanding contributors among the local people.

The work was made possible in part by a University of Illinois fellowship grant for the school year 1940-1941.

Topographic Map

The Cub Run Quadrangle map, which was surveyed in the years 1922-1924, published in 1925, and reprinted in 1941, was used as a base for this work. The horizontal scale is 1:62,500 and the contour interval twenty feet. The reprinted edition shows highways in red and the boundaries of Mammoth Cave National Park. These were not on the 1925 edition.

The topography as shown on the map is generally good, especially where roads traverse the area. However, in a few of the more inaccessible hollows where roads are lacking, the depths of the ravines have been as much as seventy feet in error. The author believes that because of the ruggedness and dissection of the area, the road conditions which must have prevailed at the time of the survey, and the wooded character of the country that the map is fairly good.

For purposes of discussion, the individual rectangles have been designated by names chosen for some town located within the bounds of each (Fig. 1). They are: Grayson Springs, Horntown,

Millerstown, Wheelers Mill, Pearman, Meredith, Straw, Dog Creek, and Winesap. Because the State of Kentucky is not divided into townships and sections, the location of points has in the past required much description. The oil companies operating in Kentucky have adopted a system of location by coordinates, which is called the Carter Coordinate System. The state of Kentucky is divided into five minute rectangles of latitude and longitude. Each rectangle is designated by a number and a capital letter. The numbers refer to longitude and the letters to latitude. The lettering and numbering was started in the lower left hand corner of the Kentucky map. The rectangles in the Cub Run quadrangle are lettered J, K, and L from south to north, and numbered 40, 41, and 42 from west to east (Fig. 2). Each five minute rectangle is subdivided into twenty-five divisions, each of which is a square mile, more or less, in area. Due to the northwest convergence of meridians these divisions become slightly smaller from south to north. These divisions are numbered from one to twenty-five in the same manner that sections are numbered by the Federal Land Survey, except that there are five rows of five divisions each instead of six rows of six sections each which constitute an ordinary township of the Federal Survey system. Each of the twenty-five divisions may be further subdivided into halves, quarters, etc., as in the division of sections in the Federal Land Survey system. The Carter Coordinate system of location has been adopted by the writer for use in this report.

CARTER COORDINATE SYSTEM

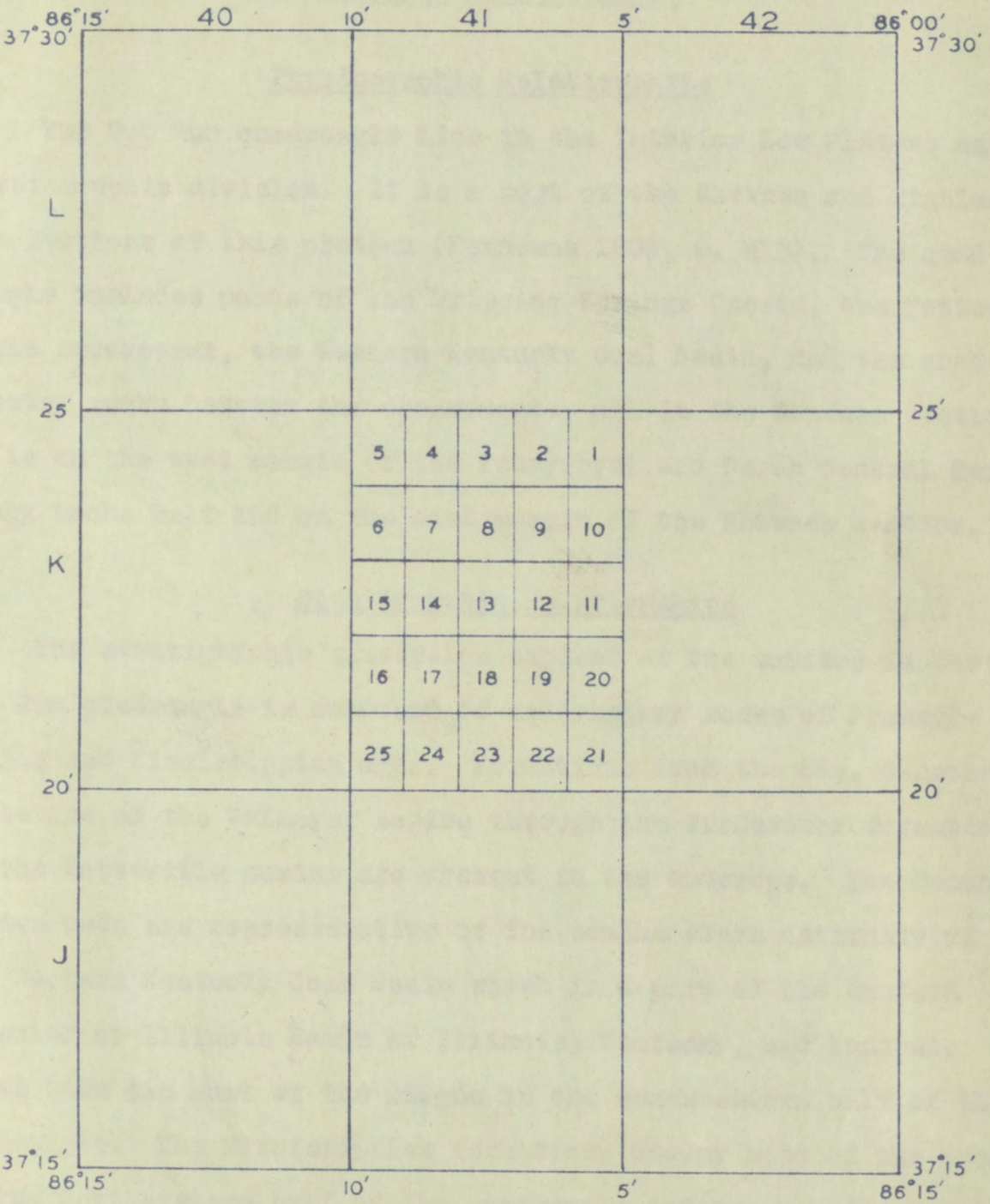

FIG. 2 CUB RUN QUADRANGLE

CENTER RECTANGLE SHOWS METHOD OF NUMBERING "SECTIONS." LETTERS J, K, L, INDICATE LATITUDE. NUMBERS 40, 41, 42, INDICATE LONGITUDE.

CHAPTER II

GEOLOGIC RELATIONSHIPS

Physiographic Relationships

The Cub Run quadrangle lies in the Interior Low Plateau major physiographic division. It is a part of the Shawnee and Highland Rim Sections of this plateau (Fenneman 1938, p. 415). The quadrangle includes parts of the Dripping Springs Cuesta, the Pottsville escarpment, the Western Kentucky Coal Basin, and the area of Chester rocks between the escarpments, all in the Shawnee section. It is on the west margin of the Pennyroyal and North Central Kentucky Knobs belt and on the east margin of the Shawnee section.

Stratigraphic Relationships

The stratigraphic succession exposed at the surface in the Cub Run quadrangle is composed of sedimentary rocks of Pennsylvanian and Mississippian ages. Formations from the Ste. Genevieve limestone of the Valmeyer series through the Tradewater formation of the Pottsville series are present in the outcrops. The Pennsylvanian beds are representative of the southeastern extremity of the Western Kentucky Coal Basin which is a part of the Eastern Interior or Illinois Basin of Illinois, Kentucky, and Indiana. These beds cap most of the ridges in the southwestern half of the quadrangle. The Mississippian formations occupy most of the area in the northeastern half of the quadrangle and are exposed below the Pennsylvanian beds in much of the remainder. The Pennsylvanian --Mississippian unconformity is pronounced. In the west-central

part of the Grayson Springs rectangle, the youngest Chester beds of this area are exposed below the higher Pottsville strata of the Tradewater formation whereas to the southeast older Chester beds are exposed below older Pottsville strata. The oldest formation exposed in the region is the Ste. Genevieve limestone which crops out in the eastern tier of rectangles--namely; Millerstown, Wheelers Mill, and Winesap.

The Mississippian strata are exposed northward across Hardin, Meade, and Breckenridge counties into south central Indiana. They are also continuous westward along the south rim of the basin into southern Illinois.

Some of the clastics of the Chester series disappear from the section by lateral gradation in the Cub Run quadrangle toward the Gasper River region of Warren County and expand toward Ohio River.

The beds which crop out on the southwestern flanks of the Cincinnati arch and the Nashville dome and which are older than the oldest formation exposed in the Cub Run quadrangle, probably dip under this area. This is known in part by information obtained from drillers' logs of test wells and sample studies from test wells surrounding the area. Louise Freeman has made micro-lithologic and insoluble residue studies which indicate the presence of certain recognizable stratigraphic zones in the Devonian and Silurian beds. These zones are grouped by her (1941a, fig. 5) into certain "zone combinations" whose pre-Chattanooga areal distribution is shown for western Kentucky. Certain of these Devonian and Silurian "zone combinations" should be present beneath the area of the Cub Run quadrangle. Ordovician strata were penetrated in

the Sun Oil Company's deep test drilled on a dome about seven miles west of Leitchfield, and they are probably present under the Cub Run quadrangle.

Structural Relationships

The Western Kentucky Coal Basin, which has an area of approximately 5000 square miles (Bell, 1940), is about ten per cent of the Eastern Interior basin which has an area of approximately 49,000 square miles. This southeastward portion of the Illinois basin extends eastward to form a saddle between the Lexington and Nashville domes.

The Cub Run quadrangle is located on the southwestern flank of the Cincinnati arch and north of the Nashville dome in the southeastern extension of the basin. The axis of this syncline crosses the center of the quadrangle through the Meredith, Pearman, and Wheelers Mill rectangles. This is evinced by the regional dips of the areas north and south of the axis. The regional dip in the northern half of the quadrangle is in general to the southwest. Stouder (1941, p. 56) indicates an average regional dip of S60W for the rocks of the Big Clifty quadrangle which is located directly north of the Cub Run quadrangle. The quadrangle area south of the axis has a general regional dip to the northwest. South of this area, in Edmonson County, Weller (1927, p. 9) expresses a general dip to the northwest of about thirty feet per mile.

A zone of faults and anticlines, known as the Shawneetown-Rough Creek fault, crosses the southern Illinois and western Kentucky coal basin in an east-west direction. It begins in Saline

County, Illinois, about eighteen miles northwest of Hicks Dome, continues east through Gallatin County, crosses the Ohio river just south of Shawneetown, and then extends on eastward in Kentucky across central Union, northern Webster, northern McClean, north-central Ohio, and north-central Grayson counties. About five miles northwest of Leitchfield in Grayson County the fault zone swings to the southeast and extends across the Cub Run quadrangle (see Structural Map) into Hart County. This en échelon arrangement of faults considerably modifies the regional dip in various portions of the quadrangle and has been instrumental in the development of several small anticlines, synclines, basins, noses, and domes. Such modification of regional dip also occurs in the Big Clifty quadrangle and in Edmonson County both north and south of this area.

CHAPTER III

PHYSIOGRAPHY

Relief

The Cub Run quadrangle is predominantly a highly dissected region. The highest point in this area and in Grayson County is Buzzard Ridge, in the southeast part of the Horntown rectangle, the crest of which rises above the 960 foot contour. The lowest surface point in the portion of the quadrangle considered in this report is below the 460 foot contour at the junction of Conoloway Creek and Nolin River in the Meredith rectangle. The maximum relief for the region is 500 feet. The maximum local relief is 400 feet from the crest of Dug Hill, on Kentucky Highway 88 in the Pearman rectangle, to its base at Nolin River. Relief of 200 to 300 feet is common for the region.

Physiographic Divisions

Fenneman (1938, pp. 411-448) has placed parts of Kentucky, Illinois, Indiana, Tennessee, Alabama, and Ohio in the Interior Low Plateau and has subdivided this major division into: (1) the Highland Rim section, (2) the Nashville Basin, (3) the Bluegrass section, and (4) the Shawnee section. The Cub Run quadrangle is in the Highland Rim and Shawnee sections of the Interior Low Plateau.

Fenneman (1938, pp. 415-416) states "Highland Rim is the name given to the lower plateau on Mississippian rocks at the foot of the Pottsville (Cumberland) escarpment. This same upland entirely surrounds the Nashville Basin, goes south and west to the Tennessee

River and north to the glacial boundary in Indiana. It embraces much rolling land between sharply incised valleys. Near the larger streams it is generally cut to maturity." Although the Highland Rim area has several subdivisions, this report is concerned with only the Pennyroyal and Knobs district of northern Kentucky, and the area included in the Cavern Cycle. Fenneman (1938, p. 419) uses the term "Pennyroyal" in a restricted sense as contrasted to Sauer's (1927, p. 21) broader use. Fenneman states that it is ".... only the limestone plateau south of the western Kentucky coal field. The terrace of Chester sandstone, limited on the south and east by the Dripping Springs escarpment, is not here included."

The Pennyroyal and Knobs district of northern Kentucky is the Elizabethtown division of Sauer's (1927, p. 46) classification of the Pennyroyal. It is an area north of Green River which extends northwestward between the Dripping Springs escarpment and the Knobs Cuesta to the east as represented by Muldraugh hill. It has typical solution topography but more streams and stream valleys and less subterranean drainage than does the Pennyroyal plains district to the south. It is an upland country of rolling topography with an abundance of sink holes.

The Shawnee section of the Interior Low Plateau according to Fenneman (1938, pp. 434-435) ".... has been defined as an area bounded on the east and south by a continuous outfacing sandstone escarpment and characterized by a maturely dissected surface on sandstone and shales. For a short distance near the western end the southern boundary is drawn arbitrarily westward from Princeton,

Kentucky. By so doing the section is made to include a small area underlain by the Highland Rim limestones whose topography here is peculiar (page 438). The rest of the boundary is against the Coastal Plain and the Ozark Highland on the west, and the Till Plains on the north. The Ozark Highland is made to begin (somewhat arbitrarily) where the deformation is sufficient to bring to the surface rocks older than Carboniferous."

The Shawnee section includes the Northern and Southern Clifty areas of Sauer (1927, p. 35, fig. 8) and the Western Kentucky Coal Basin divisions in which the Cub Run quadrangle is located.

The Shawnee section is characterized by Chester and Pennsylvanian rocks which dip into a synclinal basin, and are bevelled by an old surface which is now dissected. There are two outward facing cuestas, the Dripping Springs escarpment and the Pottsville escarpment, which form a wide belt of rugged country where relief is greatest near Green River. The Dripping Springs escarpment is formed of Chester rocks. Fenneman (1938, p. 436) states "In the middle of the syncline, i.e., in the western Kentucky coal field, the surface is maturely dissected, but because of the weakness of the rocks the slopes are less steep. Moreover, since the general level declines toward the west, the valleys are less deep, but rarely less than 200 feet."

The Cub Run quadrangle is situated chiefly in the Shawnee section of the Interior Low Plateaus. The Dripping Springs escarpment crosses the northeast corner of the Millerstown rectangle and borders Akers valley on the south and west. It also indents the

area in Copeland valley near the Hart-Hardin county line, crosses Nolin River north of Millerstown and extends back toward the east a short distance south of it. Another sink hole area surrounded by Chester escarpments is located in the east-central portion of the Wheelers Mill rectangle between Wheelers Mill, Priceville, and Bacon Creek. These three sink hole regions are in the Highland Rim section of the Interior Low Plateau in the division which Fenneman named the Pennyroyal and Northern Knobs country, formerly known as the Elizabethtown Area of the Pennyroyal as described by Sauer (1927, pp. 45-54). The three sink hole areas, (1) Akers Valley, (2) Copeland Valley, and (3) Chatten School Area, are chiefly underlain by the Ste. Genevieve limestone.

Weller (1927, pp. 11-12) divided Edmonson County into seven topographic areas, the following four of which can be adopted for use in this area: (1) the Dripping Springs Escarpment, (2) the Interior Plains, (3) the Valley Sink Area, and (4) the Hilly Country. The above subdivisions all occur in the Shawnee section. The term Dissected Interior Plains is proposed by the writer as a fifth subdivision.

Hilly Country.--A rough, maturely, dissected region with narrow flat topped ridges, steep sided slopes, and V-shaped valleys forms about 85% of the Cub Run quadrangle (Pl. I, figs. 1 and 2). Most of the ridges are capped by resistant Pennsylvanian sandstones. Chester strata form many of the intervening valleys. The Hilly Country is located west and south of an irregular line which begins near the northwest corner of the quadrangle, immediately west of Clarkson,

and passes near Grayson Springs, Rock Creek, and Black Rock to Lone Oak Church. From this point it extends south and west through Broad Ford and Wax to Dog Creek, and eastward from there to Macon and the east side of the quadrangle. Local small areas of the Interior Plains occur in the southeast corner of the Winesap rectangle and around Dixie School.

The Hilly Country is a region of high relief. The highest point of the quadrangle at Buzzard Ridge and the maximum relief for the region at Dug Hill are within the limits of the area. Elevations of 800 to 920 feet above sea level occur on the ridge tops in the Hart County portion of the Hilly Country and in the zone of influence of the Rough Creek faults, especially in the Pearman rectangle east of a line which follows the Snap fault southeast to the base of Dug Hill, then continues southwest around the hill, and then southeast to Dog Creek in Hart County. A narrow, elongated area of down dropped fault blocks with a northwest-southeast trend lies between the Higdon and Snap faults on the northeast and the Rock Creek fault on the southwest. The elevations of the ridge tops in this area are in general lower than the regions on either side or at the northwest and southeast ends of the zone itself. In this trough northwest of Dug Hill, ridge top elevations drop from 800 feet and above on Dug Hill to 620 feet west of Snap. They rise toward the sides and ends of the trough. The ridge crests in the northwest end of the block west of Higdon and Skaggstown rise to elevations in the neighborhood of 780 feet. This indicates structural control of the topography for this trough.

PLATE I

Fig. 1. Hilly Country.
View looking north from Dug Hill in Pearman rectangle. Uplands composed mainly of Pennsylvanian strata. Upper Chester beds in valleys.

Fig. 2. Hilly Country.
Pennsylvanian capped ridges along Hunting Fork Creek.

In the Grayson Springs and Meredith rectangles, south and southwest of the main fault zone, elevations of ridge tops are lower on the average than in Hart County and in the area northeast of the Snap fault. They range from 600 feet to 800 feet with most of them between 700 and 800 feet elevation. There is a locally higher area in these rectangles in the neighborhood of Meredith and Peonia. Cedar Lick, Pearson Branch, Conoloway Creek, and Miller Fork head on the sides of this upland. The higher ridge elevations lie between 800 and 880 feet elevation. Meredith and Peonia are near the crest of a northeast-southwest plunging anticline.

The valleys north of the Meredith upland in the Hilly Country of the Grayson Springs rectangle also reflect the influence of structural conditions on topography. The regional dip is southwest in this area. The valleys roughly parallel the Rough Creek fault zone and the valley slopes which face this zone are in general steeper than those which face away from them or to the southwest. Cedar Lick and other tributaries of Bear Creek, Pearson Branch and Rock Creek and some of their tributaries illustrate this relationship very well. The drainage pattern in this local region is somewhat trellised. The ridge top elevations decrease from Meredith and Peonia to the north toward Cedar Lick, then increase to the Rough Creek fault zone on the northeast. South of Meredith and Peonia the tops of ridges on either side of Conoloway Creek are more or less between 760 and 800 feet. Southward from St. James church and Van Metre school the ridges gradually decrease to an

elevation of 600 feet near Dickey's Mills with 660 to 700 feet being more common on either side of Dickey's Mills.

The valleys and ravines in the Hilly Country are in general V-shaped, although most of the larger stream valleys possess narrow strips of bottom land on one or both sides as along Conoloway Creek and Dog Creek. The massive sandstone members of the Pottsville may form sheer cliffs which rise abruptly above the more gentle slopes formed on the underlying shales or rise steeply from the valley floor. This is well illustrated by valley slopes of Conoloway Creek, by cliffs at Indian Bluffs along Rock Creek about three-fourths of a mile north of Iberia, and by the steep cliffs on the sides of some of the valleys tributary to Dog Creek and Little Dog Creek. The valleys formed in the massive Kyrock conglomerate of the basal Pottsville in many places are quite steep sided with cirque-like areas near their heads, which may produce waterfalls sixty to eighty feet high. Pine Branch hollow in the Dog Creek Rectangle near the Edmonson-Hart County line is an excellent example of such a valley. Large blocks of sandstone may be present in jumbled heaps at the bases of these massive cliffs, or scattered down the slopes below them (Plate II, fig. 1). The parts of the valley slopes, which have developed on Chester strata, possess benches on the more resistant limestone and sandstone layers and terraces on the shales. The precipitous lower Pottsville sandstone cliffs generally rise abruptly from the more gentle Chester slopes (Plate II, fig. 1). Local flats with small knob-like hills are present in areas of Chester rocks in the Hilly Country where the

protective overlying Pottsville sandstones have been almost if not entirely eroded. There is a good example on the south side of Little Dog Creek between Pine Grove School and Pine Grove Church. Here two small hills rise gently above narrow flats developed on Hardinsburg sandstone (Plate II, fig. 2).

Valleys and ravines eroded in the upper parts of the Pottsville section, as around Meredith and Peonia or near the crest of Dug Hill (Plate I, fig. 1), are more or less V-shaped. The topography is typically a rolling upland type but with somewhat more gentle slopes than that developed in the lower part of the Pottsville.

In the Hilly Country, bed rock may crop out intermittently along the bottoms of the valleys and ravines, or an abundance of jumbled angular blocks of sandstones with minor amounts of rounded limestones may cover the floors of the ravines and be scattered in the valleys, or the bed rock may be masked by a great abundance of loose sand which gives more rounded profiles to the valley bottoms. The latter condition occurs largely in those areas of great thickness of the Kyrock conglomerate where weathering and erosion of the massive sandstone has furnished an abundance of loose sand with occasional quartz pebbles which has been gradually carried into the valley bottoms. This condition is well illustrated in Hart County in the Winesap and Dog Creek rectangles on the headwaters of Little Dog Creek west of Cub Run and in the upper reaches of the valleys heading along the ridges between Cub Run and Denison. It is also characteristic of much of the Hilly Country between Cub Run and Macon. The floor of the stream bed in Cub Run Hollow has much loose sand on it.

PLATE II

Fig. 1. Hilly Country
Kyrock Conglomerate cliff over gentle Leitchfield slope of Chester.

Fig. 2. Hilly Country
In the right foreground is a gently sloping Leitchfield and Glen Dean capped hill resting on an almost flat Hardinsburg upland.

The Hilly Country north of Nolin River is drained primarily by Conoloway Creek, Rock Creek, Bear Creek, and their tributaries. The tributary valleys on the west side of Barton's Run drain part of the east margin of the Hilly Country. Most of the drainage leads south to Nolin River. However, Bear Creek soon leaves the Cub Run quadrangle toward the southwest and empties into Green River at the Edmonson-Butler County line. The drainage in the Hart County part is mainly west and northwest to Nolin River, although Cub Run and Dry Run drain to the southeast and south to Green River. Cub Run hollow follows the Cub Run fault.

In summary, the Hilly Country is a maturely dissected region with V-shaped ravines and valleys of which many of the larger have narrow flat bottom lands. The higher uplands are along the northeast, east, and southeast margins of the region. The decrease in elevation of this upland is in general to the west and northwest in the Winesap Dog Creek, and Pearman rectangles south of Nolin River, and to the southwest and south off the Rough Creek fault zone north of Nolin River. These regional slopes are modified by such structures as the high near Meredith and Peonia and the downdropped fault block northwest of Dug Hill. Physiographic forms are somewhat controlled by the Rough Creek fault zone. Most of the Hilly Country is drained by Nolin River and its tributaries, with the exception of two widely separated areas on the northwest and southeast which are drained into Green River. Bear Creek and its tributaries drain the northwestern area which is situated between Meredith, Peonia, Grayson Springs, Lizard branch, and the west margin of the quadrangle.

Bear Creek enters Green River at the Edmonson-Butler County line. The other area is situated south of the ridge which extends east and southeast from Cub Run village through Winesap to the eastern edge of the quadrangle, and is located east of a ridge which extends south from Cub Run village to Cox Store, then west and southwest to the Hart-Edmonson County line. These ridges act as drainage divides between Nolin River and Green River. Ugly Creek, Cub Run, Dry Run, and their tributaries drain this region to Green River.

The narrow more or less flat topped upland ridges in the Hilly Country are probably remnants of the Lexington or Highland Rim peneplain which is, according to Fenneman (1938, p. 441) "provisionally correlated with the Harrisburg peneplain", and which forms most of the Highland Rim and Blue Grass sections of his classification. The hill tops which rise above the general peneplain level are possibly similar to hills on the wavy surface of Muldraugh's Hill. They are probably residual remnants on the Lexington peneplain and are not correlations of the Cumberland peneplain.

Interior Plains.--The Interior Plains are areas of fairly broad, gently sloping upland flats with occasional low hills rising above them. The broad flats are in general so closely underlain by the Hardinsburg sandstone that the approximate limits of the plains can be readily ascertained from the areal geologic map. In addition to low hills, these relatively flat uplands are further modified in areas where the Hardinsburg sandstone has become thin and the Golconda limestone lies close below the surface. Solution of the limestone has formed small depressions or sinks on the Hardinsburg surfaces where the sandstone has folded down into the sinks.

PLATE III

Fig. 1. Interior Plains
View of Oak Grove Plains and small sinks. Northeast from Rough Creek Fault Zone along Grayson Springs-Skaggstown road.

Fig. 2. Interior Plains
Oak Grove Plains with Buzzard Ridge of the Hilly Country rising abruptly in the background.

Three pronounced areas of Interior Plains occur within the Cub Run quadrangle. They all abut the Hilly Country on at least one side and are interconnected by thin necks of Hardinsburg upland. The largest region is in the Grayson Springs and Horntown rectangles northeast of the Hilly Country and is here designated as the Oak Grove plains (Plate III). The Oak Grove Plains region is bounded from Clarkson to Lone Oak Church by the Hilly Country. From Lone Oak Church the boundary line extends generally northwest near Royal, Horntown, Little Clifty Church, and to the north edge of the quadrangle along Clifty Creek.

The Hardinsburg flats in this area slope gently from elevations of about 760 feet above sea level on the northeast side to elevations of about 660 to 700 feet on the southwest. They begin to rise toward the Rough Creek fault zone about one-quarter to one-half of a mile northeast of the fault zone. The slope of the surface conforms fairly closely to the dip of the underlying strata. The maximum relief of the region is about 260 feet, between a lowest point of approximately 560 feet in Rock Creek near the village of Rock Creek and the highest point of about 820 feet on top of the Leitchfield capped hill in the Horntown rectangle oneand one-half miles northeast of Fragrant.

The valleys in the Oak Grove plains are steep sided and flat bottomed. The bottoms are narrow, and the streams may have bed rock floors along parts of their courses. The more resistant Chester sandstones stand as bluffs whereas the weaker limestones and shales form gentler slopes between them. Often large blocks of

sandstone, which have slid down the slopes, mask the limestone below. The bed rock is more or less exposed along the valley slopes from the base up. Small waterfalls have developed over the sandstone bluffs near the heads of the ravines and narrow gorges occur in the ravines below them. The average relief from valley floor to upland in the deeper parts of the valley is approximately eighty feet. The drainage pattern is dendritic with most of the area draining to the southwest through Grindstone Fork, Rock Creek, Bear Creek, and Lizard Branch, into the Hilly Country to the south. The stream valleys probably were developed on the Lexington peneplain and have maintained their courses with some difficulty across the Rough Creek fault zone. This area is drained by streams which empty into Nolin River on the east and south, into Green River by way of Bear Creek, and into Rough River to the north by way of Little Clifty Creek.

Several hills, from 80 to 100 feet in height, rise above the Oak Grove plains. They are elongate to rounded, possess gentle slopes and are capped by Glen Dean and Leitchfield beds (Plate IV, fig. 1).

A second area of Interior Plains is east of Buzzard Ridge in parts of the Millerstown, Wheelers Mill, Pearman, and Horntown rectangles. These flats are designated by the writer as the Spike Laurel Plains and it is delimited on the north by a line extending eastward from Lone Oak Church through Copley School to the east side of the quadrangle. The southern boundary extends from the east side of the quadrangle, east of Wheelers Mill to Broad Ford. From Broad

PLATE IV

Fig. 1. Interior Plains
Leitchfield-Glen Dean hill rising above Oak Grove Plains on Kentucky Highway 224 one and one-half miles southeast of Clarkson.

Fig. 2. Golconda Ravine Bed
Stream bed in Spike Laurel Plains carved in Golconda limestone. The upper slopes are Hardinsburg sandstone.

Ford to Lone Oak Church it borders the Hilly Country. The margin of these plains south of an east-west line from Wheeler's Mill to the mouth of Spike Laurel Run and north of the Broad Ford fault and Dripping Springs escarpment could be classified in the Dissected Interior plains.

The Spike Laurel plains are quite similar to the Oak Grove plains. One, somewhat circular, gently sloping hill capped with Leitchfield beds immediately underlain by Glen Dean, rises about one hundred feet above these Hardinsburg plains. The higher portions of the plains are near the faults on the north and south, near the Dripping Springs escarpment in Hart County north of Broad Ford fault, and along the eastern margin. Elevations in these areas range from 700 feet to 780 feet. The plains decrease in elevation from these boundaries toward the center of the plains to elevations of 660 and 680 feet on the flats in the vicinity of the mouth of Round Stone Creek and between Wheelers Mill, Spike Laurel Run and the isolated Leitchfield capped hill. West of Spike Laurel Run the surface elevations of the Spike Laurel plains decrease to 620 feet, then increase to the west. The whole surface resembles a huge basin which decreases in general elevation from east to west.

The Oak Grove plains as a whole have higher surface elevations than the central areas of the Spike Laurel plains, but the relief is less because of the proximity of the Spike Laurel plains to the deeply entrenched meanders of Nolin River. The valley bottoms of some of the tributaries to Spike Laurel Run are carved in Hardinsburg sandstone and Golconda limestone (Plate IV, fig. 2). There is

a greater abundance of sink holes in the Spike Laurel plains than in the Oak Grove plains. They border the uplands and are present near the deep valleys of Nolin River and Round Stone Creek. Nolin River follows a deeply entrenched, meandering course across the plains. Drainage is westward on the east side of Nolin River by Round Stone Creek and its tributaries, and to the south on the west side of Nolin River.

A third area of Interior Plains is herein named the Pearman Plains (Plate V). It is located southeast and south of the Hilly Country in the Pearman rectangle and north of the Hilly Country in the Dog Creek, Winesap, and Wheelers Mill rectangles. This area is similar to the other two Interior Plains areas, but differs in the greater abundance of sink holes, a somewhat greater amount of dissection, and more structural control of the topography.

The Pearman Plains are bounded by the Hilly Country from Broad Ford to Macon. The boundary northwest from Macon is the Dripping Springs escarpment to Craddock School and the Broad Ford fault, thence along the fault to Broad Ford. East of this district is a small area of Pennyroyal.

The Pearman Plains are somewhat connected with the Spike Laurel Plains by a neck of upland between Broad Ford and the mouth of Spike Laurel Run. A northwest-southeast trending valley is cut into this upland. The eastern part of the Pearman Plains along Nolin River and east of it between Roseburg, Lines Mill, Craddock School, Broad Ford Fault, and the river is considerably dissected, and the Hardinsburg sandstone has been eroded from most of the northern margin of

PLATE V

Fig. 1. Pearman Plains
View across Pearman Plains toward Hilly Country in Proper Center School area from Pottsville hill east of Dog Creek.

Fig. 2. Pearman Plains
View to northwest toward Wax from a Hart County hill one mile east of Dog Creek. Hilly Country in background. Pearman Plains in central foreground.

the upland south of Craddock school. This dissected area closely resembles the Dissected Interior Plains of the Millerstown and Horntown rectangles. However there seems to be sufficient broad uplands to group it with the Pearman Plains. It is realized that the delimitation of boundaries in this eastern part is difficult due to the transitional nature of the area, and that any boundary must of necessity be more or less arbitrary.

The Pearman Plains possess numerous small sink holes on their surfaces. A large northwest-southeast elongated sink between Broad Ford school and Pearman has formed in the Golconda and Glen Dean limestones along the trend of the Cub Run fault. In the NW. ¼, NW. ¼, NW. ¼ of sec. 11-K-41, about one mile west of Broad Ford, a double sink exists which has two separate floor levels, one about thirty feet above the other in a step arrangement. A small ridge, which is a topographic expression of the Broad Ford fault, separates the lower sink on the north from the upper sink on the south, both of which have developed in the Golconda limestone.

The slope of the upland surfaces is somewhat influenced by the faults and the underlying beds. North of the Broad Ford fault the surfaces rise to the west and southwest from Nolin River to Barton Run. The upland area between the Broad Ford fault and the Cub Run fault in Grayson County rises from an elevation of 660 feet near Nolin River in the SE. ¼, SE. ¼, SE. ¼ of sec. 16-K-42 to the northwest to elevations of 760 feet near the junction of the Broad Ford and Cub Run faults. In Hart County between the Broad Ford fault and the Big Sink fault the Pearman Plains are at a general elevation of 740 feet, more or less. There is a slight decline toward Nolin River

and a slight rise toward the faults on either side.

Southwest and south of the Cub Run fault the Pearman Plains slope in general to the southwest from about 700 feet near the fault to about 660 feet in the Roseburg region and 580 to 600 in the Wax area (Pl. V, figs. 1 and 2). In Hart County, between the Big Sink and Cub Run faults, the uplands slope from approximately 760 feet west of Macon to 720 feet on the uplands southwest of Morris school, and to about 680 feet in the vicinity of Roseburg. The upland immediately south of Lick Run is approximately at 660 foot elevation. Some gentle hills rise above the uplands as in the other Interior Plains.

Drainage of the Pearman Plains is to Nolin River. In Hart County this drainage is chiefly to the west and northwest, in Grayson County it is to the southeast and south. Relief in the area of the deeper parts of the valleys tributary to Nolin River averages 140 feet, whereas along the river it is from 80 to 260 feet. The relief along the valley of Bacon Creek near its mouth is approximately 260 feet. Nolin River has a tortuous, entrenched meandering course across the area from Broad Ford to Wax. Its valley walls in many places are precipitous cliffs of Chester strata, elsewhere they are fairly steep sided. Flood plains are quite narrow or lacking.

In the Winesap rectangle near Dixie school is a small area of Hardinsburg flats which extend northwest along the ridge road from one-half mile northwest of Winesap to one-half mile northwest of Dixie school. The surface elevation of the area is around 800 feet above sea level. The Cub Run hollow tributaries are cut as deep as

the 500 foot contour level, and valley walls are quite steep. The ridge acts as a drainage divide between Nolin and Green Rivers. The Cane Run tributaries on the Nolin River side of the divide are in an area of 200 feet of relief with gentle slopes in contrast to a relief of 300 feet on the Green River side, an area of steep valley walls.

A similar upland area is present east of Mammoth Cave National Park, and south of the Pottsville outcrop at elevations between 880 and 840 feet. This surface slopes to the west. Drainage is to Green River on the south. The greatest relief is approximately 380 feet and valley walls are quite steep. These two regions are intermediate between Hilly Country and Interior Plains and are in reality a combination of the two.

Dissected Interior Plains.--The Dissected Interior Plains constitute a region of narrow, flat to rolling uplands which are considerably dissected. Rolling topography and a great abundance of ravines and stream valleys is characteristic. They are a dissected extension of the Interior Plains of the Shawnee section. The narrow flats are developed either on Hardinsburg or Cypress sandstones or both. Where the overlying Hardinsburg is thin or removed, the topography formed on the Golconda limestone is more rolling than that on the Hardinsburg or Cypress sandstones.

In the Horntown and Millerstown rectangles of Grayson County is a large area of Dissected Interior Plains which is transitional into the Oak Grove Plains on the west and southwest. The headwaters of Clifty Creek, Nosey Creek, Berry Run Creek, and Dry Run form a rough

margin between the Dissected Interior Plains and the broad Hardinsburg flats of the Interior Plains. On the south the boundary extends from Lone Oak Church eastward along Lone Oak fault, then northeast around three elongate valley sinks, northwest along the west side of Nolin River and crosses the river above the mouth of Berry Run Creek into Hardin County. It extends eastward along the south side of the knob-like ridges for two and one-half miles. Then it turns north on the west side of some valley sinks, then west along the south side of Akers valley, crosses Nolin River into Grayson County, and continues northward on the west side of the river to the north edge of the Millerstown rectangle. The outside margin of this upland surface which overlooks the Ste. Genevieve limestone valley floors of Akers valley and Copeland valley is the Dripping Springs escarpment.

These Dissected Interior Plains show three general erosion stages from the Oak Grove Plains on the west to the Valley Sinks on the east. The uplands next the Oak Grove plains have many ravines cutting back into the uplands from various sides. The slopes are gentle and valley bottoms are level and somewhat broader than in the deeper incised areas. The uplands are rolling to flat topped. This region is located between Clifty Creek and Lacon. Nosey Creek, Berry Run, Dry Run and their headwaters form the second topographic type. They are deeply incised into the uplands which are quite flat. Their slopes are steep, the valleys are V-shaped and valley floors are narrow. Relief in this province varies from 120 feet near the uplands to 220 feet, more or less, near Nolin River. This

area occupies most of the Grayson County area between Horntown Royal, Millerstown, Nolin River, and Lacon. The third area includes Dry Run, southwest of Millerstown, and the greater part is in Hardin County. The valley floors are broader than in the other two divisions. Relief is from 120 to 200 feet, more or less, but the slopes of the valley walls are intermediate between those of the other two areas. The three narrow elongated east-west ridgesin Hardin County have many knobs rising above the small flat upland areas. This region is not characteristic knob country as exists further east, but is intermediate between the Dissected Interior plains topography and the Knobs type.

The uplands of the Hardin County area decrease to the west from about 860 feet elevation on the east to 720 feet near Nolin River. In Grayson County the uplands slope to the southwest from 800 feet near Lacon to 760 feet near Horntown and the southeast margin. The uplands slope south from Lacon to 740 feet elevation near Berry Run and then rise toward Lone Oak church to elevations of 780 to 800 feet. Drainage is to Nolin River except for Clifty Creek which drains to Rough River.

The Valley Sinks in the Shawnee section are elongated sink holes arranged in somewhat dendritic drainage patterns with flat to hilly uplands between or around them. Drainage is subsurface. There are eight small areas of Valley Sink topography in the eastern tier of rectangles and part of the Horntown rectangle. One region is in Hardin County about three-fourths of a mile north of the Edmonson-Hart County line and one-half mile east and one-half mile north of

Akers School. Seven large elongated sinks arranged in a partial to good dendritic drainage pattern exist in this area. The sinks range from small to three-quarters of a mile long. Some of the larger sinks have several smaller sinks separated by low divides within them. The sinks are developed in Ste. Genevieve and Girkin limestones with the bottoms between 640 and 580 feet in elevation.

A second area of Valley sinks is located in Hart County on the uplands two-tenths of a mile west of Copley School in the Millerstown rectangle. They are elongated in a northeast-southwest direction on a dip slope and are developed in the Golconda limestone. Flat uplands lie between them. The bottom of the one on the west is at about 700 feet elevation, and the one on the east at 660 feet.

Two valley sink areas exist in Grayson County. A region of elongated coalescing sinks is located one mile northeast of Lone Oak Church. These sinks trend northwest to southeast and are three-tenths to one-half a mile long. The other area is three-tenths of a mile west of Lone Oak Church. Here two long sinks, arranged with a marked resemblance to stream drainage, are separated from Dry Run to the northeast by a drainage divide forty feet or more high, and from Spike Laurel Run by a divide 120 feet or more high. Jillson (1927, p. 29) states: "In Western Kentucky one of the most notable examples of piracy due to the effects of underground waters is to be seen on the Cub Run quadrangle in the vicinity of Lone Oak Church. Here the headwaters of Dry Run, a rather considerable stream plunging into a sink hole by subterranean channels, have evidently been captured and diverted to Spike Laurel Run, a southward flowing branch

that its reappearance is not definitely known. The proper use of some red aniline dye in the sinks should clarify this point.

A valley sink is present in the Ste. Geneveive limestone just west of Craddock School in Hart County. It is perched on the uplands with its base at about 820 feet elevation. The subterranean drainage apparently appears at the base of the massive Ste. Genevieve cliff to the west on Nolin River, as this cliff has a small stream issuing from a cave opening at its base, and there is an opening about forty feet above the river which was dry at the time this cliff was visited. The dip of the strata to the west from the sink would aid solution toward the cliff.

Another elongate valley sink is located north of Winesap in Cane Run hollow, dissolved in the Girkin limestone. The main sink is at least eighty feet deep and is separated from the lower Cave Run hollow by a small divide from twenty to forty feet high. It is over one mile long and has several smaller sinks within it. A stream flows into it from Kessinger, two miles east. The slopes above it are steep and high. Relief from the deepest part of the sink to the crest of the upland is 240 feet on the north and 360 feet on the south side.

Another area of perched Valley Sinks exists east of Cub Run hollow, and west of Center Point, Dry Run School, and Dry Run hollow. It begins one-half mile north of Green River between Cub Run hollow and Dry Run hollow. They are all formed in the Girkin limestone and are elongated toward Cub Run hollow except the two on the south which are elongated toward Dry Run. The two west of

Center Point are perched 180 feet below the flat uplands and 100 feet above Cub Run hollow. The sinks west of Dry Run School are 220 feet, more or less, above Cub Run hollow and 100 to 180 feet below the flat uplands. The others southward toward Green River are smaller and are 140 feet or more above Cub Run hollow.

The Dripping Springs escarpment was first described in Edmonson County, Kentucky, where it is over 13 miles long and is between 160 and 240 feet high (Weller, 1927, p. 13). Stouder (1941, p. 8) speaks of the Dripping Springs escarpment in Big Clifty quadrangle as extending "in a northeasterly direction from Shaw Creek, at the south end of the quadrangle, to Howes Valley Church in the northeast quadrant, and thence in a northwesterly direction to Mays Grove church at the north end of the quadrangle." It extends into Cub Run quadrangle from Big Clifty quadrangle margining the Dissected Interior Plains to a point two-tenths of a mile north of Spurrier. From there it extends east off the quadrangle for a distance and reappears along the Hart-Hardin County line and borders the Copeland valley and Millerstown sink hole uplands on the north, west, and south. The Dripping Springs escarpment is not a very steep and continuous escarpment in the Hardin or Hart County parts of the quadrangle. It borders the Chester upland areas, overlooks the Pennyroyal sink hole areas and it is somewhat dissected. It varies from 240 feet to 140 feet or less in height above the Pennyroyal plain.

The Highland Rim section is represented by the three sink hole uplands: (1) Akers Valley (Pl. VI, fig. 1), (2) Copeland Valley

PLATE VI

Fig. 1. Akers Valley
Pennyroyal valley between Chester hills of Shawnee section. View from Grayson County eastward into Akers valley of Hardin County.

Fig. 2. Dry Run Valley
View northwest from Dripping Springs escarpment south of Millerstown. Ste. Genevieve valley is a westward extension of Pennyroyal district of Copeland Valley. Dissected Interior Plains form uplands.

(Pl. III, fig. 2), and (3) Chatten School Area (Pl. VIII, fig. 1 and 2). These three areas are quite similar. The land is gently rolling with numerous sinks dotting its surface. Outcrops of white, smooth, limestone are in contrast to the red to red brown soil so characteristic of the region. The close spacing and greater relief of some of the sinks form locally rough areas directly south of the Dripping Springs escarpment and north of the Priceville-Wheelers Mill road in the Chatten School area. Many ponds occur in the sinks. Drainage is subsurface and surface. Surface drainage by streams or ravines flows into Nolin River from the west margins.

Drainage

The Drainage of Cub Run quadrangle has been indicated specifically for each physiographic unit, therefore, only the regional aspects of drainage in the quadrangle remains for discussion. Nolin River meanders in an entrenched valley across the quadrangle from the Millerstown rectangle on the northeast through the Straw rectangle to the southwest. It carries most of the drainage from the area. Green River receives some from parts of the Winesap and Grayson Springs rectangles. The north central part of Horntown rectangle is drained by the waters of Clifty Creek and interconnecting creeks into Rough River to the northwest of the quadrangle.

Nolin River is an entrenched meandering stream which probably had its present course, determined on the Lexington or Highland Rim peneplain in Late Tertiary time. The Lexington peneplain has been provisionally correlated with the Harrisburg peneplain (Fenneman, 1938, p. 441). Since the uplift of the Lexington peneplain the

PLATE VII

Fig. 1. Pennyroyal
View to the east, north of Wheelers Mill-Priceville road across Ste. Genevieve rolling Pennyroyal toward Dripping Springs escarpment.

Fig. 2. Pennyroyal
Looking east across rolling Ste. Genevieve Pennyroyal landscape in Chatten school area. Dripping Springs escarpment in background.

present topography has been formed by normal processes of weathering and stream and subsurface erosion.

Flats such as the Interior Plains exist at different localities on the uplands above the river. Their formation has been controlled by the underlying strata and they are not old flood plains on erosion surfaces indicative of uplift after their formation.

The meanders of Nolin River and some of its tributaries are entrenched as much as 400 feet below the upland. Up the river from Wax 220 to 240 feet is about average and from 280 to 300 feet, more or less, is common in the vicinity of Wax and downstream. In places where the river is bordered by the Pennyroyal belt it is commonly entrenched from only 40 to 60 feet. After uplift of the surface on which the present course was mainly formed, Nolin River confined its work chiefly to downward cutting with a minor amount of lateral erosion. However, lateral cutting is progressing to a certain extent, especially during the times of high water. A loop in Nolin River, which is so narrow and low that the river cuts across it in times of flood, is located one mile west of Wheelers Mill, and is locally called the Narrows. In time this neck will be severed. The oxbow formed by Lick Run north of Roseburg in the southwest part of the Wheelers Mill rectangle is probably the remnants of an old meander in Nolin River which has been cut off leaving a remnant of upland in the middle. A similar island of upland surrounded by valleys on all sides exists just east of the mouth of Round Stone creek. This may be another cut off meander, and Round Stone Creek may have formerly emptied into Nolin River, one and one-quarter miles above its present mouth. It would, therefore, at present

follow the old course of Nolin River from the former mouth of Round Stone to its present mouth. A similar example of a cut off meander exists one-half mile west of Proper Center School on Dog Creek in the northwest part of Dog Creek rectangle. In the formation of each cut off meander the stream has cut through a neck of land and below the level of the water which occupied the old meander, consequently, these abandoned meanders now drain into the existing streams and no lakes occupy the oxbows.

The present flood plain of Nolin River is narrow to absent on one side or the other of the river. In the Pearman rectangle four-tenths mile southeast of Sims Ford at NW. ¼, NW. ¼, NW. ¼ of sec. 24-K-41 in a Hart County loop of Nolin River, there is a small natural levee of loose sand close to the river. It rises three feet above the flood plain which is less than twenty-five feet in width from the inner margin of the levee to an outer margin of a terrace, which rises twelve feet above the flood plain. Another example of a terrace and natural levees exists along Nolin River below Sims Ford at SE. ¼, NW. ¼, SW. ¼, NE. ¼ of sec. 25-K-41, in Hart County. Here a small levee has been formed close to the river on the flood plain. A terrace (Pl. VIII, Fig. 1) rises about four or five feet above this flood plain. On its inner margin there is a broad, natural levee which slopes back away from the river (Pl. VIII, fig. 2). The natural levee on the alluvial terrace was probably formed during the Pleistocene when aggradation was taking place along Ohio River and its tributaries. Weller (1927, pp. 72-78) indicated that a lake was formed in Green River valley during the Pleistocene and

PLATE VIII

Fig. 1. Nolin River Terrace
A river terrace on East side of Nolin River one-half mile south of Sims Ford, Hart County, Kentucky.

Fig. 2. Natural Levee
At the same locality as fig. 1 is a natural levee at the crest of the terrace. It slopes off to the flood plain to the east.

extended into Edmonson County as far as Honey Creek. He (p. 78) stated that, "Above this point the river flows in a channel which has probably been little modified since early Pleistocene times, while below the old channel has been silted up to a greater and greater depth." The water level may have been higher along Nolin River during the Pleistocene and consequently the flood plain and natural levees formed would be at a higher level than those produced after the recession of the continental glaciers to the north, when downcutting and channel clearing began, and the terrace and lower flood plain were produced.

Since the easternmost extension of the lake in Green River valley was indicated as the mouth of Honey Creek, and since this point is more than fifteen miles downstream from the terraces here described, to properly correlate the production of the terraces with Pleistocene aggradation and subsequent degradation would require a regional study along Nolin River between the terraces and Honey Creek on Green River. If they are not due to the above conditions, they may then indicate slight uplift at some time after the Late Tertiary uplift.

Drainage in the Cub Run quadrangle is also accomplished by subsurface means. The valley sinks, the sinks in the Pennyroyal district, and other sinks in the quadrangle are surface indications of subterranean drainage. Underground streams emerge along Nolin River at Blowing Springs, west of Craddock school, and northwest of Broad Ford on a tributary to Nolin River. Local inhabitants have spoken of surface debris such as cornstalks and pumpkins emerging

from the mouths of these streams after periods of rains at different localities. This establishes the connection of these subterranean streams with surface drainage. No doubt caves are present in the region below some of the sinks. Cave openings have been seen at various localities, in the Glen Dean and Ste. Genevieve limestones.

Control of the drainage pattern in the quadrangle is due to several factors including Late Tertiary peneplanation, subsurface structure, and stratigraphic relations. The predominant pattern is dendritic, but is modified to a sub-trellis pattern in Grayson Springs rectangle. Rock Creek and Bear Creek were probably established on the Lexington peneplain and have maintained their courses across the Rough Creek fault zone although they have been modified to parallel the fault zone for a short distance.

Physiographic History

The Physiographic history of the area within the Cub Run quadrangle is not known back of Late Tertiary time. No record of the post Cretaceous-pre-Late Tertiary Cumberland peneplain is preserved in this region. The Highland Rim or Lexington peneplain is provisionally correlated with the Harrisburg peneplain of the Appalachian Mountains. The Cub Run quadrangle possesses remnants of this Late Tertiary peneplain. After the uplift of this peneplain surface the streams which had developed on that surface entrenched themselves, and normal processes of differential weathering and erosion have reduced the region to its present state. A period of minor uplift may be indicated by the Nolin River terraces. However, it is more

probable that they are to be correlated with the aggradation and following degradation associated with the Pleistocene Glacial epoch. The terraces probably formed after the lowering of glacial waters permitted downcutting of alluvium deposited during the last Glacial stage.

Most of the quadrangle is in the mature stage of the erosion cycle. The Interior Plains are in the youthful stage, whereas the Dissected Interior Plains are in late youth or early maturity.

The Valley Sinks are in a late youthful to mature stage of the Cavern Cycle of erosion. The Pennyroyal sink hole areas are in the youthful stage of a new Cavern Cycle since they are areas of many separate sinkholes with surface as well as subsurface drainage.

CHAPTER IV

GEOGRAPHY

Culture

Settlements.--Clarkson is the only corporation within the confines of the Cub Run quadrangle. It is a small agricultural center located on U. S. Highway No. 62 and the Illinois Central railroad. The population was 390 in 1940, 356 in 1930, and 413 in 1920 (16th Census of U. S., 1940). It possesses three churches and a high school. A new high school building is being erected, and a Kentucky Highway garage was erected in 1941.

Grayson Springs, a village of a few families, is located two and one-half miles south of Clarkson on Kentucky route 88. Very little exact information is available regarding the history of Grayson Springs. The following information was received from Fred Hughes, co-publisher of the Leitchfield Gazette, in a letter dated March 19, 1942. As early as 1832 a water mill was operated at Grayson Springs by a Van Meter, and several houses were then present. The Grayson Springs property, consisting of 500 acres of land and twenty-one mineralized springs, in the Rough Creek fault zone, was purchased for $2,000 by James F. Clarkson on March 23, 1836. He started the place as a health resort, and indications are that it reached its height as such in the 1860's and 1870's. It was quite popular in the south. Clarkson was the nearest station where visitors detrained on their way to the resort.

The first building was a long log structure which burned. This was followed by a still larger frame building, which later burned.

The next building erected in the early 1900's was frame and smaller. It stood until 1928 when it burned. One building, known as the recreation hall, formerly used for bowling, is all that is left. Mr. Hughes attributes the decline of the Springs as a health resort to increased knowledge of the limits of the healing power of water taken internally. As interest declined from the 1890's on, and people became more interested in other types of recreation, the resort changed hands many times.

Mrs. E. S. Killick, a former resident of Leitchfield, in her 93rd year, wrote an article for the Leitchfield Gazette which was published on February 29, 1940. She recounted some of her memories: "Then there was Mr. Noah Clarkson, the genial host at the Grayson Springs Resort, where tired business men from many cities brought their families for rest and recreation in the hot summer months. There were many varieties of sulphur water in the terraced park, and nearby a fresh water spring. There also grew the mint used in mint julep only Kentuckians seemed to know just how to mix to give the desired flavor.

"In the summer of 1867 I spent several pleasant days there with friends and relatives from Louisville, Owensboro, Lebanon and other cities. From New Orleans came cousin Abe Yates, then Mayor of New Orleans, and his family and other residents when yellow fever was epidemic there. ....

"When the old stage coach from Elizabethtown arrived about five o'clock in the afternoon with another group of visitors, we "resident" visitors were awaiting them on the long verandas and Mr. Clarkson

was at the stage coach door to greet them. He was ever alert for the comfort and pleasure of his guests. He served fine meals with vegetables and melons from his large garden; fried chicken as only Kentuckians can fry it; quail and squirrel when they could be had.

"After supper when the waiters were through with their work, they came around to the windows and sang their spirituals ...."

These excerpts from her account of life at Grayson Springs give a good picture of it as a resort. All of this is gone today, only the springs and the bowling alley remain. Some of the local residents still come to the springs for the sulphur and chalybeate water.

Cub Run is the second largest village in the area. It is located on Kentucky Highway 88 in Hart County. It possesses two churches and a consolidated High School to which children are transported in busses which collect them from the surrounding district.

On Nolin River the villages of Spurrier and Wheelers Mill still possess mills powered by water from dams across the river. Here farmers bring grain to be ground. Such old mills as these are fast disappearing. The ones at Broad Ford and Dickeys Mills have been abandoned. With the advent of gravel roads and easier access to larger trading centers such as Munfordville, Elizabethtown, Brownsville, Leitchfield, and Louisville these small communities are losing their importance as commercial centers for the surrounding regions. However, they still serve many of the smaller daily wants of the individual.

Roads.--There are two black top roads in the area: U. S. Highway 62, and Kentucky Highway 88 from Clarkson to Peonia. Kentucky Highway 226 from Peonia to Meredith; Kentucky Highway 65 from Leitchfield to Brownsville, by way of Meredith; Kentucky Highway 88 from Peonia through Iberia, Wax, Big Windy, Cub Run and Winesap; and Kentucky Highway 224 from Clarkson to one and one-half miles west of Millerstown and from Millerstown to Upton in Hart County are all crushed limestone roads which have been constructed in recent years. A narrow crushed limestone W.P.A. road extends from Grayson Springs through Skaggstown and Snap to Broad Ford. Another W.P.A. limestone road, completed in 1941, begins at Kentucky Highway 224 and extends south two miles southeast of Clarkson. It passes directly west of Oak Grove school, and Fragrant, to Rock Creek. It extends three-fourths of a mile of the latter place, then turns southwest to the Grayson Springs-Broad Ford road. Another W.P.A. limestone road extends from Big Clifty to Lacon and then to Spurrier. A spur of this road was completed in 1941 between it and Kentucky Route 224 via Little Clifty Church. In the spring and summer of 1941 a crushed limestone road was completed between Cub Run and Priceville, with the exception of bridges over Bacon Creek at Lines Mill and over Cane Run. A narrow crushed limestone road extends southwest from Kentucky route 88 through Dog Creek into Hart County. This is a short cut from Leitchfield to Mammoth Cave, and is also an outlet to Brownsville for the Hart County part of the quadrangle. This ridge top road has a branch from Sanders store in Edmonson county which heads east to the Hart-Edmonson County line southwest of Cherry Springs School.

Most of these roads have been built during the past ten years, much of the labor being furnished by local W.P.A. workmen. These roads have made a vast improvement in transportation in the region. Most of the unimproved roads are now deteriorating. In very few instances do the inhabitants get together, as in the past, to work these secondary roads, consequently, many of the roads are impassable by automobile in the drier times, and in the wet winter months some of them are impassable to wagons as well. Many of these roads are being rapidly eroded and the counties do little to keep them in good condition.

The new surfaced roads should make it possible to operate and exploit some of the natural resources in a profitable manner, and should bring social advantages to the inhabitants.

Railroads.--One railroad, the Louisville branch of the Illinois Central system, passes through Grayson County. It crosses the Grayson Springs rectangle through Clarkson in a northeast-southwest direction, and is paralleled on the south by U. S. Highway No. 62.

People.--A study of the U. S. census for 1940 in Kentucky reveals some interesting facts. The number of people of foreign birth and the number of negroes in Grayson, Hart, Hardin, and Edmonson counties was very low. The average number of persons per square mile was 34.2 for Grayson County, 47.3 for Hardin County, and 40.6 for Hart County. These averages were based on total area and total number of individuals in each county. If averages had been made on rural areas entirely they would more closely approach the population averages in the Cub Run quadrangle.

The individuals living in this region are mainly descendants of the earlier settlers, and many of them are inter-related. Names such as: Higdon, Skaggs, Meredith, Sims, Van Metre, Johnson, Craddock, Spurrier, Huffman and Wheeler are commonly encountered. All of these names may be seen on the Cub Run quadrangle map. In general, the people are friendly to strangers and are quite helpful when the nature of one's business is understood. Most of them are proud of their heritage and traditions.

The communities of Meredith, Peonia, Wax, and Spurrier are largely Catholic. Peonia has a Catholic Church, school, Priest's home, and home for the Sisters who teach at the school. South of Grayson Springs is the Ste. Augustine Catholic Church. At Wax a new Catholic Church has just been completed. Baptist, Methodist and other protestant churches are scattered over the region.

Industries

Agriculture.--The chief occupation of the inhabitants of the region is farming. Many of the people, especially in the Hilly regions, barely eke out an existence from the land. Others are more fortunate. At one time the government declared most of the land as sub-marginal and considered plans for reforesting it, but this has not been done. Mr. Faulkner[1] writes concerning the Cub Run quadrangle area: "The principal crop in this area is tobacco (Burley 31) and, for the area as a whole, the yield would be near 850 pounds per acre. Corn is grown generally and its yield would

1. Personal communication from R. T. Faulkner, County Farm Agent of Grayson Co., by letter dated March 26, 1942.

be an average of twenty bushels. Hay, mostly red top and korean lespedeza, would average about 1200 pounds per acre. Wheat, not widely grown for grain, would be about seven to nine bushels on a ten year average.

"The tobacco grows best on the rolling limestone soils or sinks land; the corn principally along banks of streams; hay on the flat or rolling lands; wheat usually following tobacco.

"The yields of crops are largest east of Clarkson and south through the Pleasant Valley and Pearman Country, and along Nolin River bottoms and down on Conoloway bottoms. The lowest yields would be perhaps through Meredith, Anneta and south on the ridge or uplands. Much erosion through this area has taken away much of the better top soils, as well as other sections of the total area. This area, as a whole, for a number of years past has been a large tobacco producing area and it still produces larger yields than it would look like. We have advocated cover crops for this area, but few yet have taken it up."

Mr. Faulkner indicates a need for fertilizers: "We have, for tobacco, advocated ten to twelve loads of stable manure per acre and from three to six hundred pounds of 20% superphosphate per acre drilled or broadcast, 100 pound of this being used under the plants for starting. Complete fertilizers such as 2-8-4, 3-8-6, 4-12-8, also have been applied to this crop alone, or in connection with manure and superphosphate. The largest yields and best quality crops would have as high as a total of 800 to 1000 pounds of fertilizer per acre. We usually use, in this area, 20% phosphate at the

rate of 125 to 250 lbs. per acre on corn, usually in the row. Some still use beef blood and bone (2-8-4) instead."

The Cub Run quadrangle possesses ample supplies of fertilizer in so called marl beds which are highly calcareous shales. The best "marl" zone occurs at the top of the Glen Dean formation. Other beds are present above the Vienna limestone of the Leitchfield formation, and in the Ste. Genevieve limestone. There are some very pure limestone beds in the Ste. Genevieve limestone which could be used as fertilizers.

An interpretation of Mr. Faulkner's facts as applied to physiographic divisions would indicate that the Oak Grove Plains and the Pearman Plains are best for crop yields. The principal crop, tobacco, probably grows best in the Pennyroyal regions. The uplands in the Hilly Country are in general poor for crops, but Conoloway Creek bottoms are good for crops.

The better class homes, outbuildings and farm equipment are in the Interior Plains and Pennyroyal regions. This would naturally be expected in regions which have the best crop yields. These are quite different from the dwellings and farm appurtenances of the Hilly Country where small frame houses or one to two room log houses with hand hewn shingled roofs are common. Some of the farms in the Hilly Country possess good bottom lands as parts of those farms, and the better crop yields are again reflected in better homes and farm equipment.

Some stock is raised in the quadrangle. The best stock farm is the Laurence Whiton farm east of Rock Creek stream and south of

Higdon in the southeast corner of the Grayson Springs rectangle. This farm, although located within the Hilly Country, is chiefly underlain by Hardinsburg sandstone and is comparable to the Interior Plains country. Mr. Whiton raises cattle, swine, and horses.

A common sight on the farms throughout the whole area is the mule. Upon them falls the burden of much of the labor.

Most of the small villages are dependent on the farmers for their existence. There are dams across Nolin River at Spurrier and Wheelers Mill to furnish water power to the mills which are still operated to grind grain furnished by the farmers. It is probable that these water powered mills will cease to function even as have those which were located at Broad Ford and Dickeys Mills. A motor powered mill is located at Iberia and operated by Henry Miller every Saturday to grind grain for the farmers.

Mammoth Cave National Park.---Mammoth Cave National Park penetrates the south central part of the Winesap rectangle. The government is slowly adding farms to the area of the Park. They are removing all signs of human habitations from the farms already acquired, and the area is being permitted to return to a natural state. Underbrush is heavy and traveling by foot off the beaten paths is difficult. A fire tower station which is located south of the Cub Run quadrangle is plainly visible from the ridge tops. This portion of the Park in the quadrangle gives no economic returns to the natives other than the original price received in payment for their land. When people realize that they can drive to the main part of Mammoth Cave from the northwest by way of Peonia, Iberia, Wax, Dog

Creek, and an Edmonson County gravel road via Sanders Store to a ferry over Green River, then the small towns mentioned should reap some economic benefits from the location of the Park.

Rock Asphalt.---Rock asphalt exists in Pottsville and Cypress sandstones in the quadrangle and has been quarried to some extent in the past. There are still minable asphalt reserves which may be utilized in the future. Mr. F. A. Lenfesty[2] furnished many of the following facts concerning the history of development of asphalt in Grayson County and this region. The first reported development of rock asphalt in the State of Kentucky was in Grayson County in 1891 at a now unknown location, but in all probability in the neighborhood of Big Clifty, possibly at Tar Hill a few miles north of Big Clifty. Sometime between 1891 and 1899 a company was located near Grayson Springs and is supposed to have extracted some 80 barrels of bitumen from the rock before abandoning the operation. Mr. Lenfesty wrote, "Since this report is quite similar to the one you got about the operations near Snap, it is quite possible that they both refer to the same operation. Snap might be considered as 'near Grayson Springs'." The Snap operations referred to were on the Hayse Williams farm two miles east of Snap at a location of NE. ¼, SW. ¼, SE. ¼ of sec. 3-K-41. Mr. Williams said that the operations were begun about thirty years ago which would be about 1910. The asphalt was distilled from the Kyrock conglomerate and transported by wagon and team to Clarkson, but the operation was not profitable.

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2. Personal Communication from F. A. Lenfesty of Seneca Oil Co., by a letter dated March 31, 1942.

Mr. Arthur Fowler opened a quarry near Meredith in 1936 and another near Peonia in 1939. He established a small processing plant at Leitchfield, but these quarries are not now being operated. The asphalt from the Meredith quarry does not cohere as it should after it has been processed and allowed to stand, even though the bitumen content of the Pottsville sand in the quarry is sufficient for commercial purposes.

Some core drill tests for asphalt have been made in the area. The Ohio Valley Rock Asphalt Company has tested near Snap and the Crown Rock Company or their successors, the Bituminous Rock Company, have also tested in the Snap region. Core tests have been made west of Huffman in the Meredith rectangle, in the Oklahoma school area, and in Hart County on the B. F. Thompson farm three-fourths of a mile northwest of Big Clifty.

Asphalt test pits have been dug af several localities in the Meredith, Snap, Big Windy, and Dog Creek areas.

Limestone Quarries.--Limestone for local road building is quarried at Snap, Grayson Springs, St. Augustine Catholic Church, and Iberia in Grayson County. Quarries in the Golconda and Glen Dean limestones are operated by the W.P.A. and the State Highway Department. A quarry in the Glen Dean limestone is situated three-fourths of a mile southeast of Big Windy in Hart County, and one in the Ste. Genevieve limestone is located about one and one-quarter miles northeast of Lines Mill west of the Cub Run-Priceville crushed limestone road.

Lumbering.--Most of the virgin timber has been removed from the Cub Run quadrangle although some lumbering is still carried on within the area. The large Branberry Higdon tract of land east of Grayson Springs was cut over several years ago, and it is reported that the operation yielded $1,000 a set. Lumbering operations were active on a small scale in the Sims Ford area in March 1941. Lumbering as an enterprise of great economic importance in this area is a thing of the past unless reforestation is practiced.

Water Resources.--Nolin River is utilized as a source of power for some mills along its course. The United States Geological Survey, Ground Water Division, has a recording station at Wax. Mr. James Moore of this Division in the Fall of 1941 supervised the construction of a concrete block tower at the northeast end of the Bridge at Wax, and the installation of an instrument to record certain desired data concerning the water in Nolin River. The instrument measures the stage of the river at any particular moment and records this information on a chart wound around a clock powered drum. Such studies are helpful in flood control projects and the utilization of water power.

Coal.--There are at least four coals in the Pottsville beds in the quadrangle, and one coal at or near the top of the Cypress formation of the Chester Series. The Cypress coal is in general non-commercial, although it has been used locally at Wax for smithing purposes and is said to be satisfactory for that use. The Main Nolin coal of the Pottsville and a higher coal near the base of the Tradewater formation have been mined locally and found satisfactory

for local consumption. These coals may never be an important economic asset.

Oil and Gas Tests.---Sixty-five oil and gas tests have been drilled in the Cub Run quadrangle since the first well was drilled in the 1860's on the Mose Paris farm in the Rock Creek bottoms east of Fragrant. Approximately one-half of these were drilled in the Winesap rectangle in the 1930's. Some yielded gas, some contained shows of oil, and three were small oil wells. Most of them were drilled to the "Corniferous" oil sand. Some were located on promising structures, others were poorly located (Structural map). There are still some untested structures in the area and future prospecting may result in wells of some economic importance.

CHAPTER V

SUBSURFACE STRATIGRAPHY

Introduction

Subsurface stratigraphic studies for the Cub Run quadrangle deal with units below the Ste. Genevieve (Mississippian) limestone, the oldest exposed formation. Sixty five oil and/or gas test holes have been drilled in the quadrangle since the 1860's. Twenty-four partial or complete drillers logs have been obtained. The F. G. Waddle No. 1 well, located near the northwest corner of the Winesap rectangle was drilled 302 feet below the Chattanooga shale probably into the Silurian system.

Microlithologic and insoluble residue studies of the Devonian and Silurian systems in Western Kentucky have been made by Louise B. Freeman (1939 and 1941); and R. P. Meacham (1933) has studied some deep wells in Kentucky which penetrated the Ordovician strata.

None of the forty wells studied by Louise Freeman (1941) or those studied by Meacham (1933) were located within the Cub Run quadrangle. The results of Louise Freeman's studies suggest the presence of Devonian and Silurian strata beneath the Chattanooga shale in the quadrangle. Meacham's study of the Perkins No. 11 well in the Le Grande pool of southeastern Hart County suggests that strata as low as the Cotter formation of the Beekmantown group of the Ordovician system may exist here. Deeper drilling may reveal lower beds.

Drillers' Well Logs

Farm: ---------- Higdon Bros.
Operator: ------ Margaret Hobson
Location: ------ Grayson County, Kentucky
C.N.L. of NW. ¼, of NW. ¼ of Sec. 19-L-40
Contractor: ---- Tim Bane
Commenced: ----- February 8, 1934
Completed: ----- May 3, 1934
Source of log: - Kentucky Geological Survey
Elevation: ----- C. H. 760
Total Depth: --- 1519 feet
Casing record: - 8¼" at 340' and 6¼" at 900'

	Depth
Soil	0- 30
Sand	30- 100
Blue mud	100- 110
Lime	110- 113
Boulders and mud, cave	113- 175
Brown sandy lime	175- 240
Mud, cave, boulders	240- 330
Brown lime	330- 550
White lime, flint	550- 615
Brown lime	615- 620
White lime, flint	620- 660
Soft blue lime	660- 665
Brown lime	665- 700
Blue lime	700- 717
Brown lime	717- 720
Black lime	720- 740
Soft blue lime	740- 775
Sandy brown lime	775- 780
Soft blue lime	780- 830
Dark lime	830- 840
Lime and flint	840- 910
Sulfur water at	875
Blue lime	910- 960
Hard dark lime, flint	960-1025
Hard black lime	1025-1050
Black lime	1050-1245
Sandy black lime	1245-1270
Black lime	1270-1325
Hard dark lime	1325-1370
White lime, flint	1370-1393
Green shale	1393-1395
Black shale (S.L.M.)	1395-1485
White lime	1485-1513
Light lime	1513-1519

	Depth
White lime	1519-1530
Light brown lime	1530-1540
Blue sandy lime	1540-1550
Brown lime	1550-1562
Blue and Brown lime	1562-1568
Blue lime	1568-1640
Brown sandy lime	1640-1651
Blue sand lime	1651-1685

This drilling record is incomplete.
One of the drillers said that the well was abandoned at approximately 1700'.
Fresh Water at 175 feet.
Sulfur Water at 875 feet.

This well was situated on or very close to the Higdon fault (Structural map). It began in the Hardinsburg sandstone, but the Chester formations cannot be recognized in the log. The black shale is ninety feet thick. It is almost impossible to differentiate the various groups and formations in the Valmeyer Series of the Mississippian System. In this well a sandy limestone between 1245 and 1270 feet may be the equivalent of the Holtsclaw sandstone of the Brodhead formation (Stockdale, 1939).

Farm: ---------- J. E. Higdon Heirs No. I
Location: ------ Near Peonia, Grayson County, Kentucky
SE. ¼, of NE. ¼, N.W. ¼, SE. ¼ of Sec. 23-L-40
Commenced: ----- February 8, 1934
Completed: ----- May 30, 1934
Source of log: - Kentucky Geological Survey
Elevation: ----- C. H. 644 feet
Total Depth: --- 1640 feet
Casing record: - 763 feet of 6¼"

	Depth
Soil	0- 5
Blue mud	5- 30
Blue lime	30- 85

	Depth
Grey shelly lime	85- 95
Hard grey lime	95- 115
Blue mud	115- 125
Hard grey lime	125- 140
Blue lime	140- 160
Soft blue lime	160- 175
Hard white lime	175- 230
White water sand	230- 275
Blue shale	275- 287
Blue lime	287- 300
Grey lime	300- 327
Hard brown lime	327- 373
Hard white lime	373- 500
Blue broken lime	500- 510
Hard brown lime	510- 540
Hard black lime	540- 575
Hard brown lime	575- 635
Brown sandy lime	635- 656
(Gas from 645 to 652)	
Brown lime	656- 665
Brown and Blue lime	665- 675
Brown lime (Sulfur Water)	675- 692
Brown lime	692- 775
Hard grey lime	775- 850
Brown lime	850- 900
Hard black lime	900-1373
Beaver sand	1373-1385
Soft black lime	1385-1395
Sandy green and brown lime	1395-1405
Green lime and shale	1405-1417
Black shale	1417-1540
Black lime	1540-1560
Broken grey lime	1560-1584
White lime	1584-1589
Grey lime	1589-1601
Light brown lime	1601-1616
Grey and brown lime	1616-1625
Oil show	1625
Grey lime	1625-1640

Total Depth: 1640

This well started in the basal Leitchfield beds probably near the Tar Springs sandstone. The Chester is somewhat better differentiated than in the other Higdon well. The interval from 230 to 275 is probably the Cypress sandstone. The interval from 1373 to

1385 is probably a partial equivalent of the Brodhead formation, and the interval from 1385-1417 would be New Providence with the Chattanooga shale commencing at 1417 and continuing to 1540 feet. Probably only lower and part of middle Devonian beds of zone IV of Louise Freeman's classification (1941, p. 699) were penetrated below the black shale.

Farm: ---------- Carl Hazlewood
Location: ------- Well at Meredith, Grayson County, Kentucky
NW. ¼, NE. ¼, NE. ¼ of Sec. 6-K-40
Source of log: - Weller 1937, p. 84; Jillson 1919, p. 324

	Thickness	Depth
Pennsylvanian System		
Soil and clay	10	10
Gray shale	28	38
Gray sand	5	43
Black shale	32	75
Black sand and asphalt	5	80
Black shale	25	105
Sand	5	110
Black shale	40	150
Coal	1	151
Black shale	5	156
Grey sand	10	166
Black rock asphalt	25	191
Shale	2	193
Grey sand	13	206
Mississippian System		
Grey shale	63	269
Brown lime	10	279
Grey shale	5	284
Red marl	16	300
Dark shale	6	306
Grey lime	10	316
Grey shale	4	320
Grey lime	46	366
Grey and white sand	46	412
Grey lime	33	445
Dark shale	5	450
Sand (Cypress?)	60	510

	Thickness	Depth
Grey lime	92	602
White shale	3	605
White lime	25	630
Lime and Sulphur Water	300	930
Black sandy lime (show of gas)	10	940
Brown and white lime	55	995
Brown shale	10	1005
Brown and white lime	140	1145
Grey sandy lime (gas)	15	1160
Grey lime	35	1195
Grey shale	12	1207
Lime and shale	13	1220
Dark grey sandy lime	25	1245
Dark shale	20	1265
Dark lime	155	1420
Grey sand	27	1447
Sand and shale	5	1452
Grey and white lime	123	1575
Light grey shale	13	1598

Devonian System

Black shale	120	1718
Black lime	20	1738
Black and white lime	5	1743
Grey lime	52	1795
Light brown lime	30	1825
Grey sandy lime	15	1840
Grey lime	10	1850
White lime	50	1900
Fine white sand (Lime?)		
Oil show and water	10	1910

The Carl Hazlewood well commenced in the Tradewater formation of the Pottsville series 156 feet above the Bee Springs sandstone member of the Caseyville formation. The Mississippian system was topped probably at the base of a thirteen foot grey sandstone at a depth of 206 feet. The Chester formations are:

Leitchfield ---------- 206 -- 300 or 306
Glen Dean limestone ---- 300 or 306 -- 366
Hardinsburg sandstone -- 366 -- 412
Golconda limestone ----- 412 -- 445 or 450
Cypress formation ------ 445 or 450 to 510

It is possible that this well penetrated the Silurian System.

Farm: ---------- John White No. I
Operator: ------ Thomas L. Barrett
Location: ------ Meredith, Kentucky, Grayson County
NE. ¼, SE. ¼, NW. ¼, SE. ¼ of Sec. 5-K-40
Source of log: - Kentucky Geological Survey
Casing record: - 528 feet of 8¼"

	Depth
Clay	0- 9
Sand	9- 85
Slate	85- 252
Lime, sand and slate	252- 461
Water sand	461- 528
Limey sandstone	528- 716
Gas sand	716- 724
Sandy lime and sandstone	724- 812
Gas sand	812- 832
Sandy limestone	832- 920
Sand	920- 976
Gas sand	976- 984
Shaly limestone	984-1027
Broken shale	1027-1075
Grey sand	1075-1081
Hard brown sand and limestone	1081-1111
Gas sand	1111-1117
Brown limestone	1117-1147
Gas sand	1147-1170
Shaly ?	1170-1181

The John White No. 1 well began in the Tradewater formation and penetrated the entire Chester series. The only recognizable unit in the Chester is the Cypress sandstone between 461 and 528 feet. The value of the remainder of the log is quite questionable.

Farm: ---------- J. Miller .... Ross et al
Operator: ------ Arrow L.Lloyd Tie Company No. I
Location: ------ 2.4 miles south of Anneta and 12 miles SE of Leitchfield of Sec. 25-K-40
Contractor: ---- Rex Pyrmid
Commenced: ----- January 11, 1939
Completed: ----- March 22, 1939
Source of log: - Eastern Gulf Oil Company at Evansville, Ind.
Elevation: ----- 723 feet
B. M. Topog.: -- 800 feet
Total Depth: --- 1818 feet

	Depth
Soil	0- 35
Sand	35- 100
Blue mud	100- 165
Sandy lime	165- 175
Mud	175- 200
Lime	200- 213
Mud	213- 220
Lime	220- 225
Mud	225- 245
Lime	245- 255
Mud	255- 260
Lime	260- 265
Mud	265- 270
Lime	270- 299
Mud, lime, shells	299- 310
Water sand	310- 325
Lime	325- 335
Lime	335- 370
Sandy shale and mud	370- 379
Sand	379- 395
Sand water	395- 413
Sand	413- 415
Mud	415- 430
Lime	430- 440
Sandy shale	440- 445
Lime	445-1470
Gas	1331-1340
Chattanooga shale	1470-1525
Shale	1525-1605
Lime	1605-1818
T. D.	1818

The Arrow Lloyd Tie Company No. 1 well started in the Pottsville series, probably in the Tradewater formation. The Mississippian was entered somewhere between 100 and 165 feet. Some of the

Chester formations are distinguishable:

Leitchfield	100 or 165 -- 245	
Glen Dean	245 -- 297	
Hardinsburg	297 -- 325	
Golconda	325 -- 370	
Cypress	370 -- 415	possibly to 430

The well probably bottomed in the Silurian.

Farm: ---------- Arch constant
Company: ------- Kyrock
Location: ------ Grayson County, Kentucky
Commenced: ----- August 1931
Completed: ----- September 1931
Source of log: - Sun Oil Company
Elevation: ----- 712 feet
Total Depth: --- 1665 feet

	Depth
Blue shale	0- 120
Lime	120- 124
Blue shale	124- 150
Lime	150- 155
Blue shale	155- 175
Lime	175- 212
Shale	212- 250
Lime	250- 256
Shale	256- 280
Lime	280- 290
Shale	290- 320
Lime	320- 325
Shale	325- 335
Sand	335- 375
Lime	375- 500
Shale	500- 510
Lime	510- 560
Shale	560- 575
Lime	575- 630
Shale	630- 640
Lime	640- 700
Shale	700- 715
Lime	715- 760
Shale	760- 765
Lime	765- 810
Shale	810- 815
Lime	815- 905
Shale	905- 910
Lime	910-1045

	Depth
Shale	1045-1065
Lime	1065-1310
Sand and lime	1310-1350
Lime and shale	1350-1405
Green shale	1405-1410
Lime	1410-1420
Green shale	1420-1458
Black shale	1458-1590
Lime	1590-1650
Lime (show of oil)	1650-1655
	1655-1665

Total Depth: 1665

The following is the same well as above, but the source of the log is different, and the record varies somewhat.

Source of log: - Carter Oil Company
Location ------- 11 N 39 E. M.

	Depth
Lime	175- 181
Blue Shale	181- 205
Lime	205- 212
Blue shale	212- 250
Grey lime	375- 445
Grey lime	445- 500
Black lime	1090-1310
Sandy lime	1310-1350
White lime	1590-1610
Brown lime	1610-1630
Grey lime	1630-1650
Oil sand	1650-1655
White lime	1655-1665

Dog Creek Well
Log: ---------- No. 347
Location:------- Grayson County, Kentucky
NW. ¼, NE. ¼, SE. ¼, SE. ¼ of Sec. 4-J-41
Source of log: - Kentucky Geological Survey

	Thickness	Depth	
Mississippian System			
Soil	12	12	
Grey lime	26	38	
Black shale	26	64	
Hard lime	10	74	
Black shale	34	108	
Grey lime	50	158	
Dark lime	70	228	
Light grey lime (salt water)	50	278	
Light grey sand	25	303	
Grey lime	71	374	
Dark grey sand	120	518	
Dark grey sand	54	572	
Light grey lime	30	602	
Red lime	40	642	
Very dark lime	93	735	
Dark bastard sand	12	747	Oil show.
Dark grey lime	178	925	
Dark bastard sand	42	967	
Very dark lime	138	1105	
Lead colored slate	5	1110	
Devonian System			
Black shale	105	1215	
Grey lime	25	1240	
Open sandy streak	18	1258	Oil show.
Dark lime	14	1272	
Dark sandy lime	8	1280	
Light sandy lime	10	1290	
Soft grey lime	40	1330	
Base of Devonian indefinite.			

Four wells have been drilled along Dog Creek in the vicinity of the town of Dog Creek. The two logs listed here as numbers 347 and 348 of the Kentucky Geological Survey files were not identified in those files as to their locations. Pat Croghan, who owns the

farm on which two of the four wells were drilled and who worked as a tool dresser on the wells furnished much of the following information which apparently locates well numbers 347 and 348. The first well in this area was drilled on Mart V. Croghan's farm, which is now owned by Pat Croghan, in the bottom of Dog Creek about 150 feet from the bridge, on the east side of the stream in the NW. ¼, NE. ¼, SE. ¼, SE. ¼ of sec. 4-J-41. This well was drilled to a depth of either 1330 or 1340 feet and began in the Golconda limestone. Log No. 347 probably is the log of this well as it begins in the Golconda limestone and ends at a total depth of 1330 feet, which none of the others do.

The Mart Croghan No. 1 was drilled about the year 1902 by a company formed at Munfordville by Paul J. Mahonney. Pat Croghan stated that there were oil and gas in this well and that it was abandoned as a paying well. Six and one-fourth inch casing still remains in it and no pump was ever placed on it. There seems to have been a tendency to confuse limestone and sandstone in this log. The identifiable Chester is probably as follows:

Golconda ----- 12 to 32
Cypress ------ 32 to 74, possibly to between 74 and 108.

The hard limestone recorded from 64-74 may be sandstone, and the thick sandstone from 374-572 is probably limestone.

Dog Creek Well
Log: ---------- No. 348
Location: ------ Grayson County, Kentucky
SW. ¼, NW. ¼, SW. ¼, NW. ¼ of Sec. 8-J-41
Source of log: - Kentucky Geological Survey

	Thickness	Depth
Mississippian System		
Soil	9	9
Grey lime	56	65
Black shale	4	69
Dark grey lime	1	70
Dark grey sand	20	90
Blue shale	12	102
Lime	28	130
Grey sand	7	137
Dark grey shale	10	147
Grey bastard sand	12	159
Dark grey shale	27	186
Grey lime	19	205
Coal	6	
Dark grey shale	4	209
Grey lime	10	219
Dark shale	3	222
Grey lime	248	470
Brownish grey lime	35	505
Hard grey sand	20	525
Grey lime	97	622
Dark bastard lime	178	800
Dark grey lime	15	815
Bastard lime and sand	25	840
Black bastard lime	80	920
Hard dark sand	30	950
Dark bastard lime	50	1000
Dark bastard slate	40	1040
Black bastard lime	173	1213
Devonian System		
Black shale	105	1318
Hard grey sand	10	1328
Black slate	6	1334
Grey hard sand (?)	2	1336
Light grey sand (?) Barren County sand	23	3597
Dark grey sand (?)	6	1365
Hard bastard sand (?)	6	1361
Hard bastard lime	25	1396
Hard grey sand (?)	24	1420
Reddish grey sand (?)	10	1430
Light open sand (?) and salt	17	1447

Water.

The "sand" given below the black shale was probably lime.

Log No. 348 is probably the John Stinson No. 1 located in SW. ¼ NW. ¼, SW. ¼, NW . ¼, sec. 8-J-41 which was drilled by Paul J. Mahonney and a Munfordville Company. The well began in the Glen Dean and bottomed at 1447 feet. According to Pat Croghan the John Stinson well, which is now a water well in the yard of Audie Dennison on the south side of the juncture of Dog Creek and Little Dog Creek, was drilled about 38 years ago (about 1903) to a depth of 1400 to 1440 feet. Log 348 can not be the Mart V. Croghan No. 2 located at NE. ¼, SE. ¼, SE. ¼, SE. ¼ of sec. 4-J-41 since that well began in the Hardinsburg whereas log 348 shows 57 feet of Glen Dean from 9 to 65 feet. The John Stinson well started near the top of the Glen Dean. The Chester formations recognizable are:

Glen Dean -------	9 --	65 feet
Hardinsburg -----	65 --	102
Golconda --------	102 --	130
Cypress ---------	130 --	186 (?)

The exact contact between the Cypress and Paint Creek cannot be picked from the well log because the nature of the shale between 157 and 186 feet is not known. This log seems to be more accurately kept than the Mart V. Croghan No. 1.

The third well was drilled in 1904 on the Dick Bradley farm in the bottoms on the east side of Dog Creek about thirty feet from the creek and about fifty feet downstream from the juncture of a ravine from Dog Creek village with Dog Creek stream. Its location is: NW. corner of NE. ¼, SW. ¼ of sec. 3-J-41. It began in the Cypress sandstone and ended at a depth of about 1400 feet, according to Pat Croghan. No oil or salt water were obtained.

The fourth and last oil and/or gas test well drilled in the Dog Creek area was the Mart V. Croghan No. 2 which was drilled the year Mart Croghan died --- "about twenty five years ago" (about 1916). It is located in NE. ¼, SE. ¼, SE. ¼, SE. ¼ of sec. 4-J-41 on a hillside back of Pat Croghan's barn about two-tenths of a mile east of Dog Creek stream at a hand level (H.L.) elevation of 555 feet. This well which had a good show of oil and gas was drilled to a depth of 1400 feet and then the casing was pulled. Contractors were A. L. Bowden and Ed Gilmore. Harry Engram and Rider drilled the holes. No logs were obtained for this well or the Bradley well.

A test well was dug on the J. A. Thompson farm in Hart County in June and July 1938 in the SW. corner of NE. ¼ of sec. 8-J-41. The log follows:

Farm: ---------- J. A. Thompson No. 1
Location: ------ Hart County, Kentucky
SW. Corner of NE. ¼ of sec. 8-J-41
Contractor: ---- H. C. Farmer, Munfordville, Kentucky
Tool dresser: -- Henry Horn and Eddie Logsdon
Drillers: ------ F. C. Farmer and W. G. Jackson
Commenced: ----- June 20, 1938
Completed: ----- July 22, 1938
Source of log: - Munfordville Oil and Gas Company
Total Depth: --- 1431 feet
Casing record: - 6-5/8" -- 730 feet

	Depth
Surface	0- 35
Slate	35- 51
Coal	51- 70
Shaly and mud water	70- 96
Sandy shale	96- 125
Sand	125- 146
Shaly sand	146- 165
Lime	165- 170
Grey lime	170- 205
Blue slate	205- 225

	Depth
Mud gumbo	225- 275
Hard grey lime	275- 278
Grey mud break	278- 281
Hard grey lime	281- 301
Grey lime	301- 417
White shale break	417- 420
Hard grey lime	420- 436
Grey lime	436- 468
Hard white lime	468- 530
White gritty lime	530- 550
Brown flaky lime	550- 575
White gritty lime	575- 591
Sulfur water	591- 595
Brown mixed lime	595- 600
White break	600- 603
Brown mixed lime	603- 624
White and blue mixed lime (break)	624- 628
Mixed lime	628- 640
Grey mixed lime (break)	640- 642
Brown lime mixed	642- 650
Grey mixed lime (break)	650- 653
Brown lime mixed	653- 737
Brown lime (hard 767-769)	737- 783
Brown lime	783- 807
Blue lime, sand	807- 827
Blue lime	827- 855
Hard gritty blue lime	855- 869
Blue lime (Hard 984-1124)	869-1174
Green lime	1174-1199
Little salt water (10 feet over tools)	1199-1205
Greyish Green shale	1205-1253
Brown shale	1253-1331
Hard black lime	1331-1347
Corniferous sand (39 feet)	1347-1386
Grey flaky lime (oil show)	1386-1408
Light grey lime	1408-1431

1247
1253
94

Total Depth: 1431

The above J. A. Thompson No. 1 well began in the Drury member of the Caseyville formation of the Pottsville series. It penetrated the Chester at 165 feet. The Chester formations recognizable are:

Golconda -------- 165 -- 205
Cypress --------- 205 -- 275 (?)

No black shale was recorded. The shale from 1205 to 1253 probably

belongs in the Osage group. This well probably was not drilled deep enough to penetrate the black shale. The topographic map elevation is approximately 780 feet.

Farm: ---------- Joe Thompson No. 1
Location: ------ Hart County, Kentucky, one mile west of Big Windy. NE. ¼, SE. ¼, SE. ¼ of sec. 2-J-41
Company: ------- McClure et al
Source: -------- Kentucky Geological Survey
Elevation ------ 781

	Depth
Black shale	1312-1390
Dark cap	1390-1400
Gray lime	1400-1410
Light lime	1410-1420
Light brown lime	1420-1430
Brown flinty lime	1430-1440
Light brown lime	1440-1450
Blue shaly lime	1450-1460
Blue shale and lime	1460-1470
Gray shelly lime	1470-1490

Total Depth: 1490

No showing of oil, gas or salt water.

The Joe Thompson No. 1 well west of Big Windy was probably drilled into the Devonian and possibly into the Silurian. The topographic map elevation is about 780 feet.

Farm: ---------- Fannie Bush No. 1
Company: ------- W. E. Hupp--Rex Pyramid Oil Company et. al.
Location: ------ Hart County, Kentucky
SW. ¼, NW. ¼, SW. ¼, SE. ¼ of sec. 21-J-42
Contractor: ---- Hupp and Duff #145 Star Drilling machine
Drillers: ------ Buell Abney and H. C. Gardenhire
Foreman: ------- Claud Salyers
Commenced: ----- May 20, 1933
Completed: ----- June 5, 1933
Source of log: - Munfordville Oil and Gas Company
Total Depth: --- 1127 feet

	Depth
Soil	0- 8
White lime crevices	82- 254
Blue lime	254- 560
Grey lime	560- 583
Blue lime	583- 737
Grey lime	737- 784
Blue lime	784- 877
Black shale	877- 951
Cap rock	951- 962
Sand (showing of oil)	962- 974
Broken sand	974- 981
Grey lime	981-1035
Green shale	1035-1060
Grey lime	1060-1127

Plugged June 6. Set first plug in top of cap rock at 951 feet; second plug at 870 feet. Shot 6¼" casing off at 300 feet. Left 130 feet of 6¼" and bottom hole packer in hole. Set 8" plug in top of 6¼". Filled with mud and rock.
June 7. Pulled 308 feet of 6¼".

The Fannie Bush No. 1 well, located in a deep hollow in the southeastern part of the Winesap rectangle, began in the Ste. Genevieve limestone at an H.L. elevation of 607 feet, and 105 feet below the top of the Paint Creek massive limestone.

Farm: ---------- Lon Craddock No. 1
Location: ------- Hart County, Kentucky
NE. ¼, SE. ¼, SE. ¼, NW. ¼, of sec. 14-J-42
Contractor: ----- H. C. Norris, Munfordville, Kentucky
Commenced: -----
Completed: ----- March 29, 1935
Source of log: --Munfordville Oil and Gas Company
Total Depth: ---- 1354 feet

	Depth
Clay and gravel	0- 57
White lime, cave	57- 100
White lime (water)	100- 135
White lime	135- 339
White lime broken	339- 414
Blue lime	414- 435

	Depth
Blue lime broken (sulfur water)	435- 460
Blue lime (Set 6¼" pipe)	460- 575
Blue lime	575- 583
Black lime	583- 605
Gas at	588
Grey lime	605- 676
Blue lime	676- 714
Grey lime	714- 784
Blue lime	784- 980
Black shale	980-1057
Cap rock	1057-1073
Brown sandy lime	1073-1084
Dark sandy lime	1084-1094
Grey lime	1094-1295
White lime	1295-1312
Mud break	1312-1316
Sandy white lime	1316-1344
Grey lime	1344-1350
Water sand	1350-1354

Total Depth: 1354

Show of Gas and Oil, one and one-half bailers of oil after standing 6 hours. Six bailers of Salt Water after standing 6 hours.

The Lon Craddock No. 1 well started twenty feet below the top of the "Productus" inflatus zone of the Paint Creek at a hand levelled elevation of 598 feet was drilled 297 feet below the New Albany black shale, and probably penetrated the Silurian.

Farm: ---------- John Day No. 1
Location: ------ North of Cub Run and west of Macon, Hart County, Kentucky
SW. ¼, NE. ¼, SW. ¼ of sec. 3-J-42
Contractor: ---- Puckett and Young
Commenced: ----- February 19, 1932
Completed: ----- March 18, 1932
Source of log: - Kentucky Geological Survey
Total Depth: --- 1385 feet
Casing record: - 8¼" 39' 9" and 6¼" 449' 2".

	Depth
Solid	0- 30

	Depth
Grey lime	30- 160
White lime	160- 230
Fresh water	230
Sulfur water	270
Brown lime	270- 435
Show of oil	435
Brown lime	435- 492
Gas Pocket	492
Black lime	492- 620
Black Sulfur Water	620
Black lime	620-1160
Green shale	1160-1201
Black shale	1201-1275
Lime	1275-1292
Cap	1292-1300
Blue sand	1300-1310
Blue sand	1310-1380
Total Depth	1380-1385

The John Day well started in the Hardinsburg sandstone at a topographic map elevation of 720 feet. The Glen Dean-Hardinsburg contact on the surface is 725 feet. None of the Chester is distinguishable. The Golconda should start at 30 feet; and the top 30 feet logged as "solid" is Hardinsburg sandstone. The drillers' term "Blue sand" as used in Hart County refers to a porous limestone or dolomitic limestone of the Silurian system which according to Russel (1934, p. 5) lies 70 to 100 feet below the base of the Chattanooga shale.

Farm: ---------- Johnie Jaggers No. 1 south of Cub Run, Ky.
Location: ------ Hart County, Kentucky
NE. ¼, SW. ¼, SE. ¼ of sec. 14-J-42
Commenced: ----- July 4, 1934
Source of log: - Munfordville Oil and Gas Company

	Depth
Soil	0- 22
Sandstone, hard	22- 32

	Depth
Sandstone, soft	32- 37
Sandstone, hard	37- 42
Lime, soft	42- 50
Sandstone, hard	50- 83
Brown lime	83- 110
Mud break and water	110- 125
Blue mud	125- 170
White soft lime	170- 215
Grey lime hard	215- 250
Brown lime hard	250- 325
Brown lime hard	325- 335
Brown and grey lime hard	335- 395
White and grey lime soft	395- 460
White lime hard	460- 475
Brown sand hard	475- 510
Grey lime hard	510- 577
Mud Break soft	577- 579
Sulfur water, black lime	579- 635
Black lime	635- 651
Black lime (Set casing and pulled)	651- 660
Blue lime (gas)	660- 665
Sulfur water	665- 670
Water sand 651-755	670- 755
Blue lime	755- 790
Gas pocket	790- 795
Blue lime	795- 815
Gas sand	815- 820
Blue lime	820-1100
Black lime break	1100-1193
Black shale	1193-1259
Corniferous sand	1259-1273
Cap (brown)	1273-1279
Corniferous white	1279-1289
Corniferous brown	1289-1294
Cap brown and hard	1294-1299
Gas sand brown	1299-1309
Corniferous sand	1309-1429
Shaly blue lime	1429-1474
Louisville lime	1474-1544
Waldon shale	1544-1549
Blue sand (sand and water)	1549

The Johnie Jaggers well began, at an H. L. elevation of 775 feet, in the Kyrock conglomerate, entered the Glen Dean limestone at 37 feet and passed through eight feet of it. The thinness of the Glen Dean limestone is due to pre-Pennsylvanian erosion in an

old river valley. The Chester formations are:

Glen Dean ----------	42	-- 50
Hardinsburg ---------	50	-- 83
Golconda ----------	83	--110
Cypress ----------	110	--170 (?)

Russell (1934, p. 5), stated: "The upper oil producing horizon of Hart County lies from one to forty feet below the base of the Chattanooga shale, and is called the "Corniferous" by operators. This term is, of course, not strictly correct, as the original "Corniferous" is of Middle Devonian age." The well bottomed in the Silurian.

Farm: ---------- Mime Hester No. 1 test well
Location: ------ Hart County, Kentucky.
NE. ¼, NE . ¼, NE. ¼, SE. ¼ of sec. 15-J-42
Contractor: ---- Oscar Benton
Commenced: -----
Completed: ----- August 17, 1934
Source of log: - Oscar Benton
Total Depth: --- 1348 feet
Casing Record: - Set 702 feet of 6¼" pipe

	Depth
Sand	0- 90
Brown lime	90- 150
Blue shale	150- 183
Blue lime	183- 203
White lime	203- 255
Sandy dark settling lime	255- 305
White settling lime	305- 492
Dark grey lime	492- 630
Blue lick water	630- 640
Blue lime	640- 670
Brown lime	670- 702
Grey lime	702- 754
Grey lime with gas	754- 760
Blue lime	760- 815
Blue lime	815-1128
Black lime	1128-1175
Mud break	1175-1177
Green shale	1177-1206
Black shale	1206-1285
Brown sandy lime	1285-1340

	Depth
Blue lime	1340-1348

Total Depth: 1348

The Mime Hester well started in the Kyrock conglomerate at an H. L. elevation of 735 feet. The determinations of the Chester formations cannot be made with any accuracy. The well probably ended in the Devonian.

Farm: ---------- Mrs. C. V. Jaggers No. 1
Operators: ----- Frost and Carpenter
Location: ------ Hart County, Kentucky, about one-half mile south of Macon, Post Office.
SW. ¼, SW. ¼, SW. ¼, NW. ¼ of sec. 1-J-42
Source of log: - Kentucky Geological Survey
Elevation: ----- 670 feet
Total Depth: --- 1239 feet

	Depth
Surface	0- 18
Blue lime	18- 120
White lime	120- 335
Brown lime	335- 375
Brown lime	375- 450
Grey lime (Sulfur Water)	450- 483
Black lime	483- 532
Grey sandy lime	532- 548
Blue lime	548- 820
Black lime	820-1050
Green shale	1050-1075
Black shale	1075-1150½
Light lime	1150½-1165
Blue shale and lime	1165-1180
Grey lime	1180-1190
White lime	1190-1195
Brown lime	1195-1220
(Gas at 1206 -- dead oil at 1210)	
Hard light lime	1220-1235
White lime	1235-1239

Total Depth: 1239

The Mrs. C. V. Jaggers No. 1 well started in the Cypress formation. Ten inch surface pipe remains in the hole. The top 18 feet were recorded only as "surface", and formations are not distinguishable between there and the black shale at 1075. The well probably bottomed in Devonian.

Farm: ---------- W. Smith No. 1
Location: ------ Wheelers Mill Area, Hart County, Kentucky
NW. ¼, NE. ¼, SE. ¼, SE. ¼ of sec. 13-K-42
Contractor: ---- Floyd Puckett
Completed: ----- June 16, 1933
Source of log: - R. E. Stouder
Casing Head
Elevation: --- 645 feet
Total Depth: --- 1184 feet

	Depth
White lime	50- 117
Grey lime	117- 162
Grey lime	162- 205
Blue lime	205- 285
Black lime	285- 416
Brown lime	416- 426
Black lime	426- 635
Brown lime	635- 688
Blue lime	688- 750
Black lime	750- 800
Brown lime	800- 850
Black lime	850- 895
Green shale	895- 915
Black shale	915- 984
Grey lime with breaks	984-1065
Shale	1065-1084
Louisville sand	1084-1099
Blue sand	1104-1142
Show of oil	1126-1138
Blue mud and red rock	1142-1160
Yellow cap	1160-1175
Total Depth:	1184

The W. Smith No. 1 well began in the Ste. Genevieve limestone and ended in the Silurian. The green shale from 895 to 916 feet

probably belongs in the New Providence formation. The New Albany is between 916 and 984 feet. The blue mud and red rock probably represents the Osgood formation of the Silurian, and the term "Yellow Cap" is a driller's term for a crystalline limestone or dolomite, in part yellowish (Russel, 1934, p. 3) and equivalent to the Brassfield of the Silurian.

Farm: ---------- N. R. Sweet Well No. 1, one mile south of Winesap, Kentucky, Hart County
Location: ------ Hart County, Kentucky
Center of NW. ¼, SW. ¼ of sec. 20-J-42
Operators: ----- Chenault, Hammond and Neurath
Contractors: --- Long and Lovejoy
Source of log: - Munfordville Oil and Gas Company
Elevation: ----- 878 feet
Completed: ----- January 29, 1931

	Depth
Sandy lime	0- 5
Red sand	5- 50
Blue sand	50- 80
Blue lime (Set 80' of 8¼" casing)	80- 109
Coal	109- 110
Blue mud	110- 120
Blue sand	120- 128
Sand and mud	128- 150
Asphalt	150- 160
Sand	160- 165
Blue lime	165- 208
Blue lime (Fresh water at 320)	208- 320
Brown lime	320- 342
White lime water 355 and 405	342- 514
Broken lime (fresh water)	514- 615
Blue lime (set 631' 4" of 6¼ casing	615- 640
Brown lime (a little show of gas and oil)	640- 655
Blue lime	655- 680
Gray lime	680- 708
Brown lime	708- 750
Blue sandy lime	750- 820
Dark lime	820-1135
Gray lime	1135-1154
Green shale	1154-1160
Black shale	1160-1241
Lime cap rock	1241-1253

	Depth
Light brown sand (Show of Oil & Gas)	1253-1260
Crystallized Brown lime	1260-1266
Crystallized Brown lime	1266-1306
Crystallized Brown lime sandy ..... (Show of Oil and Gas)	1306-1311
Crystallized Brown lime	1311-1315
Soft broken blue lime	1315-1319
Corniferous formation - 78 feet	

The N. R. Sweet No. 1 well began in the Kyrock conglomerate and penetrated the Hardinsburg sandstone at a depth of thirty feet. The Golconda is twenty-nine feet thick and is underlain by one foot of Cypress coal. The Cypress is between the depths 109 and 165 feet. The hole probably bottomed in the Devonian.

The N. R. Sweet No. 2 well, which follows, was started in the Hardinsburg but none of the Chester formations can be distinguished in the log, so it is apparently a poor record. The H. L. elevation is 792.

Farm: ---------- N. R. Sweet No. 2
Location: ------- Hart County, Kentucky
SE. ¼, NE. ¼, NW. ¼, NW. ¼, of sec. 21-J-42
Contractor: ----- H. C. Farmer, Munfordville, Kentucky
Tool dressers: - Clarence Avery and Henry Horn
Drillers: ------- Jess Crouch and Earl Crouch
Commenced: ------ May 10, 1937
Completed: ------ June 10, 1937
Source of log: - Munfordville Oil and Gas Company
Total Depth: ---- 1201 feet
Casing record: - 580 feet of 6¼"

	Depth
Blue sandy lime	0- 109
White lime	109- 251
Yellow lime	251- 310
White lime	310- 384
Yellow mud cave	384- 409
Blue lime (cave 485-498)	409- 615
Brown lime	615- 646

	Depth
Grey lime	646- 978
Black lime	978-1064
Black shale	1064-1133
Corniferous sand	1133-1158
Dark flint lime	1158-1180
Blue break	1180-1185
Dark grey lime	1185-1196
Blue lime	1196-1201

Total Depth: 1201
Well plugged at 1100 feet, 600 feet, 820 feet.

Farm: ---------- J. D. Thompson No. 1
Location: ------ 1 mile northwest of Winesap, Hart Co., Ky. SW. ¼, NE. ¼, NW. ¼ of sec. 12-J-42
Source of log: - Kentucky Geological Survey
Total Depth: --- 1387 feet

	Depth
Sandy soil	0- 5
Blue shale	5- 30
Sand	30- 55
Hard Grey lime	55- 96
Blue sand and shale breaks	96- 135
Grey lime	135- 152
Black slate	152- 162
Hard brown lime	162- 250
White lime, shale breaks	250- 510
Muck	510- 513
Water sand	513- 522
White broken lime	522- 580
Brown lime	580- 585
Hard Blue lime	585- 608
Grey sand (Sulfur water)	608- 615
Brown lime	615- 625
Blue lime	625- 655
Brown sandy lime	655- 678
Blue sandy lime	678- 688
Hard grey lime	688- 735
Blue sandy lime	735- 790
Gas, show of oil	
Grey shale	790- 800
Black lime	800-1100
Dark Grey shale	1100-1165
Green shale	1165-1170
Black shale	1170-1237
Dark Grey shale	1237-1244
Light lime	1244-1248

	Depth
Flinty Grey lime	1248-1268
Light lime (oil show)	1268-1275
Dark shale	1275-1280
Hard Blue lime	1280-1313
Yellow lime	1313-1320
Hard grey lime	1320-1325
Sandy lime and shale	1325-1387

Total Depth: 1387

The J. D. Thompson No. 1 well, located northwest of Winesap, started at an approximate H. L. elevation of 807 feet in the Hardinsburg formation. The following Chester formations are recognizable.

Hardinsburg	5 to 55 feet
Golconda	55 to 96 feet
Cypress	96 to 135 feet

The New Providence shale of the Mississippian system is probably from 1100-1170 feet. The New Albany shale is from 1170 to 1244 feet. The well probably bottoms in the Silurian.

The Joe D. Thompson No. 2 well located near Dixie school began in the Hardinsburg sandstone. The log is poor at the top. The Golconda limestone is not shown in this log but in the Fannie West No. 1 well about one-fourth of a mile to the southwest it is 50 feet thick, and in the J. D. Thompson No. 1 well about one-quarter of a mile to the northwest the Golconda is 41 feet thick. No evidence of faulting was seen at the surface, so the discrepancies are attributed to a poorly recorded log.

Farm: ---------- J. D. Thompson No. 2
Location: ------ West of Dixie School, Hart County, Kentucky
Center of SE. ¼, NW. ¼ sec. 12-J-42
Source of log: - Kentucky Geological Survey

	Depth	
Surface	0- 5	
Sand	5- 60	
Blue mud	60- 130	
White lime	130- 450	
Grey lime	450- 525	
Black sand	525- 610	
Brown sand	610- 617	
Black lime	617- 621	
Sand	621- 627	show of oil
Blue lime	627- 665	
Broken dark lime	665- 680	
Hard dark lime	680- 700	
Grey lime	700- 800	
Black lime	800- 992	
Brown and Black lime	992-1154	
Shale	1154-1160	
Grey brown lime	1160-1170	

Farm: ---------- F. G. Waddle No. 1 test well
Location: ------ Cub Run, Hart County, Kentucky
NW. ¼, NW. ¼, NE. ¼ of sec. 5-J-42
Commenced: ----- May 29, 1934
Completed: ----- August 31, 1934
Source of log: - Munfordville Oil and Gas Company

	Depth
Soil	0- 7
White lime	7- 50
White lime	50- 145
Grey lime	145- 180
Hard grey lime	180- 205
Light grey lime	205- 225
Light brown lime	225- 230
Hard grey lime	230- 233
Blue lick	233- 234
Hard grey lime	234- 260
Hard brown lime	260- 295
Hard grey lime	295- 350
Flinty brown lime	350- 370
Soft brown lime	370- 380
Water sand	380- 385
Lime	385- 400

	Depth
Water sand	400- 410
Brown lime	410- 417
Brown sand	417- 425
Brown lime	425- 436
Blue lime	436- 470
Casing set 6¼	470
Grey lime	470- 495
Black lime	495- 570
Blue lime	570- 885
Black lime	885-1049
Brown shale	1049-1129
Cap rock	1129-1140
Brown lime	1140-1146
(Rainbow show of Oil)	
Grey lime	1146-1154
Grey and white lime	1154-1177
Dark blue lime	1177-1200
Soft blue lime	1200-1355
Soft dark lime	1355-1391
Soft white lime	1391-1431

Total Depth: 1431

After standing one week it filled up 150' with Salt Water.

The Felix Waddle dry hole, drilled three-quarters of a mile southwest of Roseburg in the Cane Run bottoms, began in the Girkin limestone below the "Productus" inflatus zone. The New Albany shale is between 1049 and 1140 feet deep. The topographic map elevation is about 520 feet.

Farm: ---------- Fannie H. West No. 1
Location: ------ Hart County, Kentucky
SE. ¼, SW. ¼, SW. ¼, NW. ¼ of sec. 12-J-42
Contractor: ---- H. C. Farmer, Munfordville, Kentucky
Tool dressers: - Henry Horn and Eddie Logsdon
Drillers: ------ F. C. Farmer and W. G. Jackson
Commenced: ----- August 1, 1938
Completed: ----- August 31, 1938
Source of log: - Munfordville Oil and Gas Company
Total Depth: --- 1497 feet
Casing record: - Set 640 feet of 6¼"

	Depth
Soil	0- 8
Broken rock	8- 30

	Depth
Grey lime	30- 80
Blue mixed break	80- 98
Blue shale	98- 125
Blue lime	125- 173
White lime	173- 300
Light brown lime (gas show)	300- 325
White lime	325- 355
Water sand	355- 360
Grey lime	360- 370
Break, mud cave	370- 372
Grey lime	372- 479
Brown and white lime	479- 520
Mud, white lime	520- 527
Coarse sand	527- 567
Blue lime	567- 580
Hard brown sand	580- 590
Brown lime (Sulfur Water)	590- 625
Black lime	625- 635
Hard brown lime	635- 675
Blue lime	675- 727
Blue break	727- 732
Blue lime	732- 779
Grey lime	779- 806
Blue lime	806- 815
Blue lime	815- 862
Brown lime	862- 872
Black lime	872- 915
Black sandy lime	915- 950
Black lime	950-1147
Black shale	1147-1221
Corniferous sand	1221-1252
Blue coarse lime	1252-1269
Light brown lime	1269-1290
Grey lime	1290-1325
Blue lime (break)	1325-1415
Brown lime	1415-1450
Blue lime (break)	1450-1455
Blue sand (Show of Oil)	1455-1490
Salt Water	1490
Sand	1490-1497

Total Depth: 1497

Well plugged at 1450' 1200' 715'

The Fannie West test was started at an H. L. elevation of 816 feet in the Hardinsburg sandstone. The identifiable Chester formations are:

Hardinsburg ----- 5 to 30 feet
Golconda -------- 30 to 80 feet
Cypress ---------- 80 to 125 feet

The New Albany shale is from a depth of 1147 to 1253 feet.

A partial log of the Joe Wheeler well which started in the Hardinsburg sandstone at an H. L. elevation of 693 feet and which should have topped the Golconda limestone at a depth of 25 feet, is here recorded.

Farm: ---------- Joe Wheeler
Location: ------ Grayson County, Kentucky
NE. ¼, NW. ¼, NE. ¼, NW. ¼ sec. 8-K-42
Slightly over one mile west of Wheelers Mill
Source of log: - Kentucky Geological Survey

	Depth
Black shale	1245-1314
Corniferous	1314-1354
Broken Blue	1354-1414

Well Log in the Le Grande Oil Field

The log of the Perkins No. 11 well is included here because it penetrated the Cotter formation of the Beekmantown (Ordovician). The well is in the Le Grande pool eleven miles southeast of the southeast corner of the quadrangle.

Farm: ---------- W. B. Perkins No. 11
Location: ------ ¾ mile north of Le Grande, Hart Co., Ky.
Contractor: ---- Anna K. Wilson, Bowling Green, Ky.
Producers: ----- Hillside Oil Production Company and
Anna K. Wilson
Shut Down: ----- June 28, 1933
Resumed drilling: May 10, 1935
Source of log: - Kentucky Geological Survey
Elevation: ----- 654.9
Total Depth: --- 3244 feet (?)
Casing record: - 231' of 10" and 725' of 8¼"

	Depth
Surface	0- 25
White lime	25- 55
Brown lime	55- 60
White lime	60- 75
Lime broken, fresh water	75- 102
Hard lime	102- 127
Grey lime	127- 145
Blue lime (Sulfur Water)	145- 236
Grey lime	236- 252
Blue lime	252- 280
Grey lime, gas at 300	280- 308
Blue lime, gas at 448	308- 486
Black lime	486- 557
Black shale	557- 603
Corniferous sand, oil	603- 628
Broken sand	628- 635
Broken lime	635- 640
Mud	640- 645
Broken lime	645- 650
Blue sand, cap rock	650- 652
Blue sand, salt water	652- 679
Blue sand	679- 683
Sand water	683- 694
Sandy blue lime	694- 702
Broken lime	702- 714
Fire clay	714- 722
Blue lime	722- 725
Sandy, yellow cap	725- 731
Grey sand	731- 740
Grey lime	740- 755
Blue lime	755-1251
Sandy lime	1251-1276
Brown lime	1276-1294
Brown lime	1294-1326
Brown lime	1326-1426
Gritty lime	1426-1440
Pencil cave	1440-1442
Sand	1442-1449
Brown lime	1449-1455
Blue lime	1455-1470
Brown lime	1470-1568
Dark brown lime	1568-1573
Blue lime	1573-1825
Blue lime	1825-1839
Brown lime	1839-1884
Grey lime	1884-1896
Brown lime	1896-1910
Blue lime	1910-2076
White sandy lime	2076-2098
Top of Trenton ?	2082

	Depth
Trenton sand ?	2098-2153
Blue lime	2153-2158
Trenton sand ?	2158-2187
Water, slightly salty, Sulfur	2182-2187
Sandy lime	2187-2196
Sand	2196-2200
Sandy lime	2200-2204
Brown sandy lime	2204-2214
Blue sandy lime	2214-2218
White lime	2218-2223
Sand	2223-2227
Sandy lime	2227-2231
Brown sandy lime	2231-2238
Flinty lime	2238-2244
Water found at	2182

N.B. Dr. Meacham of the University of Kentucky notes by insoluble residue studies that there is no St. Peter which should come at 1839. Sands below are in Cotter underlying the St. Peter.

The Ste. Genevieve limestone is the oldest formation exposed in the Cub Run quadrangle, and the deepest well probably penetrates no lower than the Brassfield limestone of the Silurian. A deep well was drilled in the Le Grande oil pool of Hart County into the lower part of Cotter formation of the Beekmantown. This well, the Perkins No. 11, is located eleven miles southeast of the quadrangle.

Devonian and lower Mississippian strata crop out in Allen County and have been described by Shaw and Mather (1919). Stockdale (1939) has studied the lower Mississippian rocks of the Central Interior and published a very valuable paper on them. Mrs. Freeman's studies have added much information to the subsurface knowledge of the Devonian and Silurian systems of Western Kentucky. Many of the facts included here have been taken from these sources.

Ordovician System

The Beekmantown group is represented in Hardin County in a well near Elizabethtown by the upper Cotter formation. Meacham (1933, p. 12) has correlated the Ordovician subsurface beds of Kentucky with those of Missouri on the basis of insoluble residue similarities. According to his findings the Cotter dolomites as seen in the Perkins No. 11 well are overlain unconformably by the "Pencil Cave". The St. Peter and most of the Lowville-Stones River are missing. He (1933, p. 4) indicated "It was apparent that the Powell dolomite and other formations present in the Ozark region of Missouri, between the Powell and St. Peter were missing in the stratigraphic section in Kentucky". The residues of the Cotter dolomite are sand, dolocasts, siliceous oolites, and cherts.

The Highbridge formation of Kentucky is included in beds of Chazy and Black River age, and the Trenton is known as the Lexington formation. The Highbridge consists of the Camp Nelson limestone member which is about 285 feet thick, the Oregon member which is a fine grained magnesian limestone from 15 to 20 feet thick, and the Tyrone member at the top. The Tyrone is a fine grained limestone about 90 feet thick, which has a three foot bentonite layer about eighteen feet below the top.

The Lexington formation consists mainly of thin limestones and shales separated into the Curdsville member, 10 feet thick, Hermitage member, 40-70 feet thick, Jessamine member, 80 feet thick, and the Flanagan member, 45 to 60 feet thick.

In Central Kentucky above the Flanagan is the Perryville formation, a limestone from 0-35 feet thick, which is overlain by the Cynthiana formation, 40 to 90 feet of limestones and nodular limestones with thin shales.

The "Pencil Cave" of Central Tennessee is a driller's term for a volcanic ash lying near the boundary between the Trenton and Black River limestones. If this is the same as the "Pencil Cave" of Meacham, then the Highbridge and St. Peter formations are missing in the Perkins No. 11 well, and may be missing from the strata below the Cub Run quadrangle.

The Eden group of Central Kentucky is divided into three formations. It consists of thin limestone, green and grey shale, and siliceous limestone at the top. Its thickness is 250 feet or less. Butts (1915, p. 35) attributes to the Eden a thickness of 250 feet under Jefferson County, and a combined thickness of 400 feet for the Eden and Maysville. The latter consists of alternating thin limestone layers and shale, with some lumpy calcareous shale.

The Richmond of Jefferson County, Kentucky is composed of the Arnheim, Waynesville, Liberty, and Saluda formations which crop out in that county. The strata consist largely of thin limestones and shales. The Waynesville and Liberty are mainly shale, and the Saluda varies from sandy dolomite to sandstone and siltstone.

Silurian System

The Silurian system of Kentucky is well exposed in Jefferson County. It consists of the Brassfield limestone in the upper part of the Alexandrian, the Osgood, calcareous magnesian shales and

limestones of the Clinton; and the Laurel limestone and dolomite, Waldron blue calcareous and magnesian shale, and the Louisville limestone of the Lockport. The Laurel Limestone is of early Lockport age and the Louisville limestone is of later Lockport age. In Jefferson County (Butts, pp. 81 to 101) the Brassfield limestone is from 2½ to 7 feet thick, the Osgood from 22 to 30 feet, the Laurel dolomite from 35 to 40 feet, the Waldron shale from 8 to 12 feet, and the Louisville limestone from 42 to 100 feet thick.

The Brassfield overlies the Ordovician strata unconformably. The Girardeau and Edgewood of southern Illinois and eastern Missouri were probably deposited while land conditions existed in the Cincinnati arch region. The beds of late Silurian or Cayugan age are absent in this part of Kentucky.

Devonian System

The Louisville limestone is overlain unconformably by the Jeffersonville limestone of Onondaga (Middle Devonian) age. The contact between these two limestone is rather even and close in Jefferson County (Butts, 1915 p. 100), although a long time interval is represented by a great thickness of strata in other areas, especially in Pennsylvania.

The Jeffersonville limestone 30-40 feet thick near Ohio River wedges out to the south and is absent in the southern part of Jefferson County.

The Jeffersonville limestone is overlain by the Sellersburg limestone of Hamilton age. It consists of a lower member of fine grained siliceous limestone and calcareous shale, the Silver Creek

hydraulic limestone, and an upper member, the Beachwood, which is a light to dark grey coarsely crystalline limestone with a somewhat finer crystalline texture toward the top. The Silver Creek is from 8 to 10 feet thick and the Beachwood from 6 to 8 feet thick. The Casey limestone, a 10 foot, thin bedded, sandy to cherty, grey limestone is a later Hamilton representative which overlies the Sellersburg.

The Boyle formation, of the south and southeastern portions of the Devonian outcrop area in Kentucky, is equivalent to all of the middle Devonian limestone. The lower part is thinner and more evenly bedded than the rough cherty upper part, and carries less chert. This formation ranges from very thin to 10 to 15 feet in thickness and in some places is as much as forty feet thick.

The middle Devonian beds are overlain by the New Albany shale of late Devonian and possibly early Mississippian age. It consists of black to dark brown fissile shales in contrast to the soft, green clay shale above it, the New Providence shale. The thickness varies from 25 to 300 feet. Savage and Sutton (1931, p. 447) concluded: "The black shale in some places in Allen County, Kentucky, and probably in adjacent areas is composite in character, containing a lower unit of upper Devonian age and an upper unit of lower Mississippian age. The two are separated by an erosional unconformity with much the greater portion of the sediment in the lower division, and it is also certain that in many localities the black shale is all of Devonian age."

Subsurface Stratigraphy of Devonian and Silurian

Louise Freeman has subdivided the Silurian and Devonian of Western Kentucky into zones based on microlithologic and insoluble residue studies of well log samples. The zones are numbered from the top down; this permits new zones to be added as deeper wells are drilled. She has indicated probable correlations of these zones with the Devonian and Silurian strata which crop out in nearby areas. The zones are numbered from I to VII, the first four are in the Devonian and the last three in the Silurian system. According to her paleostratigraphic map (1941, fig. 5), only Zones IV, VI, and VII are probably present beneath the Cub Run quadrangle. The combinations of zones which would be penetrated at any one locality in the western Kentucky basin are indicated on her paleostratigraphic map. She discusses these zonal sections (p. 696), "In the deepest portion of the basin all zones of the Devonian and subjacent Silurian are present. In a semicircular area around the center, opening to the north, the three upper zones of the Silurian rest on a complete Silurian zonal section. To the east there is a narrow strip where the lowest zone of the Devonian rests on the second Silurian zone, the upper zone, the Decatur limestone having been removed. The available information indicates that the complete Silurian section continues westward. Still farther east and higher on the flank of the Cincinnati arch, another Silurian zone, the upper Brownsport or Louisville, disappears. In this area if there are any Devonian rocks present, they are only a few feet in thickness and rest on the lowest zoned part of the Silurian.

"Hence the map shows not only pre-Chattanooga areal geology but also the approximate stratigraphic section for the Devonian and upper part of the Silurian limestones. The fact that the Decatur and upper Brownsport (Zones V and VI) are present south and west but disappear towards the Cincinnati arch suggests post-Silurian uplift of the arch--a reflection of the Caledonian movement elsewhere. The evidence from these subsurface studies affords the first indication that Silurian strata younger than Louisville were ever deposited in western Kentucky. The arch probably remained a positive structure during most of Devonian time, thus accounting for the non-deposition of some of the Lower Devonian strata. Pre-Chattanooga uplift with emphasis on the Nashville dome cut off the south end of the basin and permitted erosion of the upper Middle Devonian formations from the east, south and west sides."

Two zone sections are shown on Louise Freeman's map in the Cub Run quadrangle. One combination lies west of an arcuate north-south boundary cutting across Edmonson and Grayson counties through a point about two miles east of the junction of Nolin River and the Edmonson County line. This is the combination of Devonian Zone IV over VI of the Silurian which is underlain by Zone VII. East of the above boundary, Zone VI drops out and Zone VII directly underlies Zone IV of the Devonian.

Zone VII is (p. 697) "red and gray mottled, fine-grained limestone of Bainbridge or Wayne characteristics. The red color is lost higher on the flank of the Cincinnati arch, but the texture of the limestone remains relatively constant. This results in a gray, fine-grained, magnesian limestone lithologically similar to the Louis-

ville 'high' on the side of the structure."

Zone VI was described (p. 697) as a "... dark gray, dull, shaly, fossiliferous limestone, 50-60 feet in thickness. The residue is leached gray shale, rather coarsely porous, and shows fragmentary impressions of such fossils as bryozoans, brachiopods, and crinoid stem plates. In northern Ohio County and Hancock County there is near the top considerable limonite, showing a peculiar regular pore arrangement suggestive of fossil replacement. This material occurs as irregular fragments with no indication of what fossils are represented. The pores, which are 0.01 to 0.02 millimeter in diameter, are the openings to tubes which are arranged in parallel rows through the mass of the fragments.

"A near-by well at Cloverport, Breckinridge County, at this horizon has considerable siliceous limonite in the sample. There is a small amount of blue-white chert in this zone, showing banding and in many places occurring as partial replacements of fossils. On the west side of the basin this horizon includes some glauconite. It is suggested that this argillaceous limestone, overlying typical Bainbridge and Louisville types of limestone and underlying the lithologic facies suggestive of Decatur, is equivalent to the upper Brownsport of the Tennessee section."

Devonian Zone IV.--Louise Freeman (1941, p. 698), states: "Lithologically the strata of Zone IV resemble somewhat those of Zone II. Zone IV, however, is considerably more dolomitic and ordinarily contains two or more strata rich in glauconite. The chert in the upper part, which is mottled grayish tan and in some

places dolocastic, may make up 40 per cent of the sample. There is a limestone interval about in the middle of Zone IV, which is less dolomitic and less cherty than the strata above and below, and which can be recognized in nearly every well which has been drilled deeply enough to encounter it. This limestone is white and coarsely crystalline, and the chert is white, chalky, and dolocastic. The per cent of chert and dolomite again increase in the lower part of the zone. The lower chert is mainly brown with white inclusions, some of which are undoubtedly sponge spicules, and others suggest radiolarian remains. In some cases the chert is translucent white with dull markings. Cherts of this description have been recognized in the deeper wells in the main part of the basin and in the strip surrounding this area where the Chattanooga rests on some part of Zone IV.

"The contact with the arenaceous Zone III above is sharply delineated, and the change from cherty, dolomitic limestone of the Devonian to the unmistakable Silurian limestone below is easily recognized.

"Zone IV is tentatively correlated with the Clear Creek chert, the Grassy Knob (Oriskany) chert, and the underlying Helderberg cherts. Workman (40), in his studies of the subsurface Devonian of Illinois, has been unable to differentiate between these formations and in his paper refers them all to the Grassy Knob-Bailey."

Zone IV is 300 feet thick in its greatest thickness in the Paradise well of Muhlenberg County.

Assuming Louise Freeman's correlations and paleostratigraphic map to be correct, it is probable that the Casey and Sellersburg formations are absent in the Cub Run quadrangle. The Jeffersonville formation is also probably absent, even though the Indiana Jeffersonville is a correlative of the upper part of the Grand Tower of Illinois (Savage, 1910), because it has been noted that the Jeffersonville limestone wedges out along with the Silver Creek member of the Sellersburg in southern Jefferson County, Kentucky. The subsurface Devonian strata of the Cub Run quadrangle probably belong to the oldest Devonian strata in Kentucky and are in general older than the Devonian exposed at the surface. If Zones VI and VII are present in the area, then the Osgood, Laurel, Waldron, and Louisville formations, equivalents of the Wayne and Brownsport formations of the Tennessee Silurian are probably there.

Lower Mississippian

The New Providence formation of the Osage group is present in Allen County, and consists of 40 to 50 feet of shale and shaly limestone with a predominantly bluish-green tinge (Shaw and Mather, 1919, p. 58). This formation is 350 feet thick in Jefferson County, Kentucky at the Ohio river. The lithology (Stockdale, 1939, p. 99) is most commonly clay-shale, although, in some facies there are more numerous resistant siltstone layers interbedded with the shale. This formation apparently occurs in some of the wells in the Cub Run area.

The later Osage is represented by the Fort Payne chert in Allen County. It conformably overlies the New Providence and com-

mences about fifty feet above the black shale. It is about 100 feet thick, and is composed predominantly of pure, coarsely crystalline, pinkish grey limestones. Chert occurs in layers three or four inches thick in some of the more massive beds. It is light-brown or milky white and weathers into flat slabs. Numerous geodes occur in the upper part of the formation and are less abundant in the lower beds. They are also less abundant in the lower part of this formation than in the underlying shales.

In Jefferson County, Butts (1915, pp. 148-156), named and described the Kenwood sandstone, Rosewood shale, and Holtsclaw sandstone as strata of Keokuk age. The Kenwood sandstone overlies the New Providence shale. It is forty feet thick and composed of thin sandstone layers alternating with shale. The Rosewood shale overlying the Kenwood is 190 feet thick in Jefferson County. Butts described it as "bluish gray, unevenly fissile and siliceous. .... About 30 feet above the top is a bed of soft, fine-grained sandstone 5 feet thick. About 70 feet below the top in the section west of Brooks ...., are a number of thin limestone facies with which are associated a few ferruginous nodules. .... The Rosewood is moderately fossiliferous in the 30 feet extending from 70 to 100 feet below the top"." The Holtsclaw sandstone was introduced by Butts (1915, p. 151) as the upper formation of the Osage. Its thickness varies from 15 to 20 feet with 20 feet common. Butts characterized it as "a bluish gray or buffish, rather loosely cemented, soft and easily disintegrated, very fine grained, thick to massive bedded stratum. ... It is not everywhere sharply demarcated from the underlying

shale, the passage from one to the other being commonly gradational rather than abrupt, and in such cases it is difficult to determine the position of the boundary."

Stockdale (1941, p. 79) has abandoned the terms "Rosewood shale" and "Holtsclaw sandstone" proposed by Butts, and has made the "Kenwood sandstone" a member at the top of the New Providence formation. He has proposed the formation name Brodhead for the Kentucky equivalent of "Locust Point" and "Carwood" of Indiana and discussed the "Rosewood" and "Holtsclaw" as a part of the Holtsclaw facies of the Brodhead formation of Jefferson County, Kentucky. He has extended into Kentucky the name Floyd's Knob formation for a thin unit which overlies the Carwood of Indiana and has combined the Edwardsville limestone and lower Harrodsburg of Indiana into the Muldraugh formation of Kentucky. The upper Harrodsburg limestone of Indiana is called the Harrodsburg (restricted) formation of Kentucky and as defined by Stockdale, is equivalent to the Warsaw of Kentucky.

The Warsaw formation of Jefferson County was considered by Butts (1915, p. 157) to include "the siliceous limestone with chert layers and abundant geodes, and perhaps some shale, about 80 feet thick, limited below by the Holtsclaw sandstone and above by the coarsely crystalline gray limestone of easily recognizable different character, called the Spergen ('Salem' or 'Bedford') limestone. The base of the Warsaw is marked at some exposures by a thin oolitic limestone one to two feet thick, or, where the oolitic layer is absent, by a bed of dark, green, glauconitic clay about one foot thick."

Stockdale has shown that Butts failed to realize that the apparent southward thickening of the "Warsaw" from southern Indiana is a change of facies of the Edwardsville of Indiana. The Muldraugh formation of Kentucky then is considered by Stockdale to have Keokuk affinities. He restricts the Warsaw of Kentucky as equivalent to the Upper Harrodsburg of Indiana. He indicates that the Salem formation "extends from southern Indiana into Kentucky in its normal position on top of the typical Harrodsburg (Warsaw) limestone." The Somerset shale overlying the Warsaw is made a basal member of the Salem formation. The latter persists in its normal stratigraphic position above the typical Harrodsburg limestone from southern Indiana into Kentucky.

Lower Mississippian of Cub Run Quadrangle

The drillers logs for the Cub Run quadrangle show predominantly limestone from the base of the Cypress to the top of the black shale or to the grey green shale of the New Providence formation. A thin sandstone in the J. E. Higdon Heirs No. 1 well near Peonia is probably the Kenwood member of the New Providence formation of Stockdale. This is the one record of a sandstone at this position in this area. It is twelve feet thick as contrasted to forty feet in Jefferson County. The New Providence formation as interpreted from these logs is a green shale from 5 to 39 feet thick except in the above mentioned Higdon well where the New Providence is green limey shale and sandstone with a total thickness of 44 feet.

The New Albany black shale below the New Providence ranges from 68 to 123 feet in thickness. Thicknesses of 120 feet are common in

the western tier of rectangles. The shale thickens from 105 feet in the Dog Creek wells to 120 feet at Meredith, and from there thins toward the northeast to the Branberry Higdon well. Stouder (1941, pp. 56-59) speaks of a southwest thickening of the strata between "the Golconda limestone and the base of the New Albany shale" in the Big Clifty quadrangle. Weller (1927, pp. 89 and 90) indicates a thickening of the section from the base of the Cypress to the top of the black shale in a northeast direction from a well located at Rhoda to one at Anneta and then a thinning from Anneta to Meredith. However, the interval in the Anneta well is 1007 feet instead of 1143 feet as shown by Weller; which would mean a thinning from Rhoda to Anneta and a thickening from Anneta to Meredith.

The Osage-Meramec beds in the quadrangle also thin to the south from 1075 feet thick in the Carl Hazlewood well at Meredith to 997 feet in the Dog Creek wells. This interval thickens to the east from 997 feet at Dog Creek to 1023 feet in the John Jaggers well.

The delimitation of formations between the Cypress and the base of the limestone section above the black or green shale is not feasible from these drillers logs. The Brodhead formation here is largely limestone. Its upper limits are not determinable. There is a sandstone or shale zone 32 to 48 thick in the J. A. Thompson well, the Stinson well on Dog Creek, and the Carl Hazlewood well at Meredith, which may correlate with the Holtsclaw sandstone of the Brodhead formation. It occurs 94 to 173 feet above the base of the Osage limestone. In the Holtsclaw facies of Jefferson county this

interval from the top of the Kenwood to the base of the Holtsclaw sandstone is 211 feet.

Meramec Group

The St. Louis limestone crops out in Edmonson County. About 200 feet of the formation is exposed but it is considered to have a total thickness of 300 feet. Weller (1927, p. 95) describes it as a limestone with no shale partings exposed in Edmonson County. It consists of an upper grey limestone which is chiefly finely crystalline, but ranges to coarsely crystalline. Scattered quartz grains are abundant locally, some buff lithographic beds occur, and greyish chert is locally present. The beds are non-oolitic. The lower portion of the St. Louis consists of beds ranging from light grey to black. The black limestones are finely crystalline and may be very hard and dense. The author has not differentiated this formation in the well logs.

CHAPTER VI

STRATIGRAPHY OF SURFACE STRATA

Introduction

The surface strata of the Cub Run quadrangle belong in the Mississippian and Pennsylvanian systems and are commonly classified in descending order as follows:

Pennsylvanian System

Pottsville Series

Tradewater formation

Caseyville formation

Bee Springs sandstone member

Drury member

Kyrock conglomerate member

Mississippian System

Chester Series

Elvira group

Leitchfield formation

Homberg group

Glen Dean limestone

Hardinsburg sandstone

Golconda limestone

Cypress formation

New Design group

Paint Creek limestone
Sample formation
Renault limestone
} Girkin formation

Valmeyer Series

Meramec group

Ste. Genevieve limestone

The general characteristics of these rocks is shown by the columnar section accompanying the areal maps.

The Mississippian beds consist of approximately 820 feet or less of sediments and the Pennsylvanian strata total 600 feet more or less. The Pennsylvanian beds cap the ridges in about the southwest one-third of the region and the Chester crops out in the valleys throughout. Slightly less than two-thirds of the quadrangle northeast of the Pennsylvanian area is covered by Chester beds and the Valmeyer series is limited to outcrops in parts of the eastern tier of rectangles.

The stratigraphy of these rocks presents several interesting problems. It is complicated by the Rough Creek fault zone. The Ste. Genevieve-Renault contact is difficult to determine since the Aux Vases sand of southwestern Illinois is absent here. Within the confines of the region the Sample sandstone grades into limestone and where this condition exists the Renault and overlying Paint Creek limestones cannot be separated with any degree of certainty and are known as the Girkin limestone.

The Elvira group of southeastern Illinois and western Kentucky consists of well developed sandstones, limestones and shales which are recognizable as distinct formations. This group in the Cub Run quadrangle is predominantly shale with minor amounts of sandstone and limestone. These beds can be differentiated into eight units which are probably correlatives of the Elvira formations further

southwest in the basin.

The Pennsylvanian strata overlap and succeed the Chester beds of the Mississippian with a pronounced unconformity. A pre-Pennsylvanian river channel crosses the Winesap and Dog Creek rectangles from northeast to southwest and is filled with as much as 235 feet of conglomeratic sandstone. The channel cuts as low as the top of the Cypress in places.

Description of the Exposed Mississippian Formations

Ste. Genevieve Limestone

Name:--The name Ste. Genevieve was first applied by Shumard (1859, p. 406) to limestones exposed in the bluffs along Mississippi River just south of Ste. Genevieve, Missouri.

Distribution:--The Ste. Genevieve limestone outcrop area is limited to parts of the eastern tier of rectangles and is mainly exposed east of Nolin River. A narrow strip of it is exposed along the river from the north edge of the Millerstown rectangle to Lone Oak Church fault. Akers Valley and some Valley sinks in Hardin County, and a large area around Millerstown are underlain by Ste. Genevieve beds. A narrow strip borders Nolin River from Broad Ford fault to within one-half of a mile of Big Sink fault, a short distance below the mouth of Bacon Creek. The beds border Bacon Creek to Lines Mill where the outcrop area expands to include most of the sink hole country between Broad Ford fault and a narrow strip south of Bacon Creek and the east margin of the quadrangle. The bottom and part of the sides of Cub Run hollow, Dry Run hollow, and the first hollow to the east are outlined by the Ste. Genevieve limestone.

Topography:--The Ste. Genevieve limestone forms narrow steep sided bluffs along Nolin River and other stream valleys. Gently rolling to undulating surfaces are formed by solution of this limestone in the broader expanses of its outcrop belt. Small to large, somewhat elongate, and separate to coalescing sinkholes have been formed. The larger sinks (Pl. IX, fig. 1) have gentle slopes while the smaller ones are steep sided. Immediately below the Renault-Ste. Genevieve contact, in many places, small steep sided sinks descend abruptly either to cave openings or to debris filled bottoms (Pl. IX, fig. 2). The bottoms of some of the larger sinks are under cultivation. A cave opening in the Ste. Genevieve limestone on the north side of Akers Valley in Hardin County, is about thirty feet wide and over six feet high from floor to roof (Pl. X, fig. 1).

Lithologic characters.--The limestones of the Ste. Genevieve are chiefly light gray to blue gray, although some are light tan. The texture varies from lithographic and sub-lithographic through fine to medium crystalline, and is mainly finely crystalline. Oolites are scarce in the upper 30 to 40 feet of the formation but are quite abundant below to the base. These oolites vary greatly in shape and texture. Some are discernable only on close observation while others are distinctly visible to the unaided eye. The base of the Renault is more oolitic than much of the Ste. Genevieve. The limestones are weakly resistant to weathering and outcrops of them on hill slopes and in the broader outcrop areas are discontinuous. The surfaces become undulant to rounded and are separated by vertical solution channels (Plate X, fig. 2). There are four chert

PLATE IX

Fig. 1. Ste. Genevieve Sink
A pond in an oval, gentle sided sink in the Chatten School Pennyroyal area. NE. ¼, NW. ¼, NE. ¼ of sec. 11-K-42.

Fig. 2. Ste. Genevieve Sink
Mouth of a small steep sided sink near Ste. Genevieve-Renault contact. NW. ¼, NW. ¼, SE. ¼ of sec. 10-L-42.

PLATE X

Fig. 1. Ste. Genevieve Cave Opening
Entrance to a Ste. Genevieve Cave on north side of Akers Valley in NW. ¼, SE. ¼, SE. ¼ of sec. 3-L-43.

Fig. 2. Ste. Genevieve Limestone
Discontinuous outcrops with undulant surfaces and solution channels in Ste. Genevieve limestone south of Millerstown.

zones in the formation: one near the top, and three in the bottom 140 feet. The cherts vary from tabular to rounded and nodular.

The Ste. Genevieve limestone can be divided into three members: (1) a lower zone, 140 feet thick, which is oolitic and quite comparable to Fredonia, (2) a middle member, 0 to 10 feet thick, with Rosiclaire affinities, and (3) an upper member, 0 to 30 feet thick, which is very poorly oolitic to non-oolitic and which is probably a Levias equivalent.

Fredonia member.

The lower member is a more or less oolitic limestone which contains three distinct chert zones. The texture of the limestones varies from dense and sub-lithographic to fine or medium crystalline. The oolitic texture of the limestone varies from lenses of fine oolites, which are barely discernible, to large oolites or various shapes which form the chief constituents of the rock and pull out or break across when the rock is cracked. The centers of the oolites are colored white, light brown, or grey.

About fifteen feet below the top of the Fredonia is a zone of lenticular, thin bedded cherts. These thin beds which are from 0 to 6 inches thick weather dull brown. Fresh surfaces are dark grey and possess siliceous oolites.

Another chert zone is approximately 67 feet below the top of the Fredonia. This is probably equivalent to Stouder's (1941, p. 14) chert zone 150 feet below the top of the formation. It occurs in lenses which weather into rectangular slabs with light grey to black and dull red colorations. Fresh surfaces are medium to dark

grey and somewhat mottled. This chert zone is 94 feet below the zone at the top of the formation and 45 feet below the chert which is about 15 feet below the top of the Fredonia member. The bottom 80 feet of the Fredonia, although present in Cub Run hollow, is not well exposed. Weller (1927, p. 100) mentions that cherts are "conspicuously developed in the lower part of the formation".

Rosiclaire (?) member.

A limestone zone underlain by a thin shale occurs about 24 feet below the Ste. Genevieve-Renault contact at the base of a Ste. Genevieve quarry in Hart County three-fourths of a mile northeast of Lines Mill in the SW. corner of the NE. ¼, SW. ¼ of sec. 12-K-42. The limestone is light to medium grey or light brown. It is argillaceous to sandy with some light to medium brown quartz grains and some light green grains of an unidentified mineral. It is dense to finely crystalline and hard. The Rosiclaire of Illinois contains comparable light green grains. The bottom few inches of this limestone member has black and brown elongate limestone pebbles and a few black to dark brown chert fragments scattered through it. The total thickness of this limestone is 5 feet 8 inches. Below it is 3 inches of buff to medium brown shale. The floor of the quarry is a grey limestone.

Levias Member.

The upper member (Pl. XI, fig. 2) consists of a light grey to medium grey limestone, with some light tan layers. The texture varies from sub-lithographic to finely crystalline. Chert lenses occur near the top of this zone in places. The cherts are tabular,

lenticular, and weather white, yellow-brown, and buff. The cherts have oolitic and crystalline texture. Angular, vari-sized, medium brown fragments are scattered in a pale blue siliceous matrix. In some localities such as the top edge of the large sink hole directly south of Craddock school or at the top of the above mentioned Ste. Genevieve quarry in Hart County, some dark blue to blue-black nodules of flint fill vertical joints. Some of these flints are 10 inches in diameter. They weather to chalky white surfaces.

Thickness.--The greatest exposure of Ste. Genevieve limestone is at the south end of Cub Run hollow near Green River where it is 180 feet thick. This is probably not the total thickness of the Ste. Genevieve for this region, as Stouder (1941, p. 14) indicates a thickness of approximately 220 feet in the Big Clifty quadrangle and an average thickness in Meade and Breckenridge counties of 240 feet. Weller (1927, p. 99) states that a thickness of 180 feet for the entire formation is exposed on Pilot Knob three miles southeast of Rocky Hill in Warren County. One hundred and three feet of it are exposed on the W. C. Smith farm at NW. ¼, NW. ¼, SE. ¼ of sec. 14-L-42.

Stratigraphic Relations.--The basal contact of the Ste. Genevieve limestone with the St. Louis limestone is not exposed in the quadrangle, and Weller did not see it in Edmonson County. Stouder did not indicate an exposure of this contact in Big Clifty quadrangle.

The St. Louis is overlain in places disconformably by the Ste. Genevieve at the type locality, but the relationship is conformable in this portion of the basin.

The Ste. Genevieve is unconformably overlain by the Renault formation of the Chester series. This contact is seldom exposed, however, a good contact is visible at Spurrier (Pl. XI, fig. 1) in the bluff at the west end of the bridge about two feet below the floor of the bridge. Here, slabby, lithographic to medium crystalline, light brown to medium grey and medium brownish grey limestones overlie a more massive, dense to medium crystalline and slightly oolitic limestone. The fossil Talarocrinus sp. occurs in the basal Renault bed and 6 feet 9 inches above the contact Campophyllum gasparense Butts and Talarocrinus are present.

Paleontology:--The Ste. Genevieve formation is sparingly fossiliferous. Locally Platycrinus penecillus stem plates are fairly abundant in Hart County in NW. ¼, NW. ¼, SE. ¼ of sec. 13-K-42. Lithostrotion harmodites is abundant by the side of the Wheelers Mill-Priceville road in NW. ¼, SE. ¼, SE. ¼ of sec. 9-K-42. In Hardin County in NW. ¼, SE. ¼, SE. ¼ of sec. 3-L-42 the following fossils were identified: Composita trinucleа, Triplophyllum spinulosum, and Spirifer pellaensis. These three forms and a coral Zaphrentis(?) radiocosa Ulrich were in the section on the W. C. Smith farm in NW. ¼, NW. ¼, SE. ¼ of sec. 14-L-42. The two best guide fossils for the Ste. Genevieve: Platycrinus penecillus which does not occur above the Ste. Genevieve and Lithostrotion harmodites were seldom found even on careful search. A small Pentremite probably Pentremites princetonensis occurs in the upper beds near the Ste. Genevieve-Renault contact.

PLATE XI

Fig. 1. Ste. Genevieve-Renault Contact
Slabby Renault limestone resting disconformably on massive Ste. Genevieve at Spurrier, Grayson County--2 feet below floor of bridge.

Fig. 2. Spurrier Section
Levias limestone member of Ste. Genevieve disconformably underlying slabby basal Renault (un-named limestone member).

Correlations.--The Ste. Genevieve is a widespread limestone throughout Indiana, western Kentucky, Illinois, southeastern Missouri and Iowa. It is a correlative of the Pella beds of southeastern Iowa and the middle member of the Mitchell limestone of Indiana. This member lies above the Lost River chert and below an upper member which is the Paoli of early Chester age. The Ste. Genevieve limestone of western Kentucky was considered by Ulrich to include an upper member, the Ohara. Sutton and Weller (1932, p. 437) have stated that this member as originally described by Ulrich is known to contain an unconformity below which are abundant Platycrinus penecillus stem plates which do not occur above the unconformity. A basal conglomerate is present in that section at the base of the "Upper Ohara" limestone above the unconformity. This "Upper Ohara" member is now accepted as equivalent to the Renault formation. The term Levias was proposed by Sutton and Weller (1932, p. 439) for the "Lower Ohara" or "uppermost member of the Ste. Genevieve limestone between the Rosiclaire sandstone and the Renault formation in western Kentucky and the adjacent part of southern Illinois." In 1937 the United States Geological Survey (Wilmarth, 1938, p. 1534) adopted the term "Upper Ohara" as a part of the Renault and the term Levias limestone (Lower Ohara) as the top member of the Ste. Genevieve limestone, and decided to include Ste. Genevieve limestone in the Meramec group. Stouder (1941, pp. 13, 15-16), accepts the same correlation for use in the Big Clifty quadrangle.

The term Gasper which was suggested by Butts (1917, p. 64) to

replace the name Tribune of Ulrich was abandoned by Sutton and Weller (1932, p. 441), because Butts' interpretation of the Gasper was inconsistent. The term Tribune as proposed by Ulrich was for a limestone in the Chester series of western Kentucky overlying the Bethel sandstone. The term was abandoned when Professor Weller found it to be the Menard. Butts has never described the section at Gasper River from which the term Gasper takes its name. He never clearly indicated where his type section was located, he placed the upper limit at the base of the Cypress sandstone but the lower limit is uncertain. Sutton and Weller (1932, p. 441) proposed the name Girkin "for beds of Renault and Paint Creek age in that part of western Kentucky where the Bethel (or Sample) sandstone is not developed. It will include everything from the Ste. Genevieve limestone (with Platycrinus penecillus) below to the Cypress sandstone above. This part of the section is well developed in the hills that nearly surround the village of Girkin in Warren County, Kentucky, and an excellent section may be seen in the bluff of Green River at Greencastle, 8 miles to the west".

The term Girkin is to be used in this report as equivalent to the Renault and Paint Creek limestones where the Sample sandstone is not developed, since it is within this quadrangle that the Sample sandstone intergrades into limestone.

Chester Series

Name:--The Chester series was named for the town of Chester in Randolph County, Illinois by A. H. Worthen in a manuscript.

The Chester series consists of alternating limestones and sandstones with accompanying calcareous and non-calcareous shales. In

western Kentucky the Chester is divided into the New Design, Homberg, and Elvira groups of early, middle, and late Chester age respectively.

New Design Group

The name New Design was proposed by Weller and Sutton (1940, p. 823) for the lower Chester group. It "consists of the Aux Vases, Renault, Bethel (or Yankeetown), and Paint Creek formations whose complete section occurs in outcrop only in Monroe and Randolph counties, Illinois, and the adjacent part of Missouri. The group is named from New Design township in Monroe County, Illinois, where all four formations are well developed." The Aux Vases sandstone is absent in the Cub Run quadrangle and the New Design group is represented by the Renault, Sample, and Paint Creek formations. Where the Sample is absent, the term Girkin is applied.

Renault formation

Name:--Weller (1913, p. 122) named the Renault formation from Renault Township, Monroe County, Illinois. It includes limestone, sandstone and vari-colored shales in its type locality. In the Cub Run quadrangle and adjacent areas in Kentucky, it consists of predominantly limestone with a minor amount of sandy shale. A pronounced disconformity is at its base throughout Cub Run quadrangle and other Kentucky areas where the Aux Vases is absent.

Distribution.--The areal outcrop of the Renault limestone as a recognizable unit is mainly localized in the northwest quarter of the Millerstown rectangle where the overlying Sample formation also occurs. The Renault crops out as a narrow band along the Nolin

River, Berry Run from Nolin River to about one-fourth of a mile into the Horntown rectangle, and in the bottoms and along the lower sides of the valley slopes in Dry Run and other tributary valleys. On the east side of Nolin River in Hart County on the ridge south of Spurrier and to the east and north of Spurrier are outcrops of Renault. In several scattered localities where small areas of Sample sandstone reappear, the Renault can be differentiated. One of the larger of these is in the vicinity of Craddock school in Hart County.

Topography:--The limestones of the Renault formation crops out in narrow belts along the hillsides as fairly steep slopes. Benches form on the limestones which underlie any shale breaks, and funnel shaped to rounded sinkholes may form in the limestone near the base of the Sample.

Lithologic Characters.--The Renault formation is predominantly limestone with a thin shale member about 22 to 33 feet, more or less, above the base. The thickness of the Renault varies from 29 to 55 feet. The limestone is light to medium grey, in general darker than the underlying Ste. Genevieve limestones. It may be divided into three members as far south as Broad Ford in Hart County. They are in ascending order: (1) unnamed limestone of Stouder (possibly equivalent to Paoli of Indiana, Shelterville of Illinois, and "Upper Ohara" of Kentucky), (2) Mooretown sandstone, and (3) Beaver Bend limestone.

Unnamed limestone (Shelterville-Paoli equivalent?).

The unnamed limestone (Stouder 1938, p. 261) at the base of the

Renault consists of 22 to 33 feet, more or less, of light to medium grey limestone. The texture varies from very oolitic through fine grained and medium crystalline to dense and sub-lithographic. A very pure white, oolitic limestone with fine to medium sized oolites is common in the basal part of this member. At many localities a basal limestone conglomerate overlies the Ste. Genevieve. Two general forms of the basal conglomerate occur. It may be a smooth dense limestone bed with scattered angular fragments of dense, dark grey to black and brown limestone up to 1 inch or so across; or it may be a more or less cross bedded siliceous oolitic limestone zone with black and brown limestone pellets and fine quartz grains scattered through it. The silicious oolite may rest directly on the dense basal conglomerate or on the Ste. Genevieve limestone. The top of the Ste. Genevieve in many places along Nolin River and in the Hardin County portion of the quadrangle is a light grey limestone weathered into smooth undulating surfaces. On fresh surfaces this poorly fossiliferous limestone is light dove grey, and its texture varies from dense to sub-lithographic. It is hard and breaks with a sub-conchoidal fracture. This is in sharp contrast to the darker grey conglomeratic limestone above. Where the conglomerate is absent, the beds above and below the contact may be quite similar and faunal content becomes an important means of differentiation.

The basal conglomerate is well exposed at the following locations: Hardin County SE. corner of sec. 10-L-42 north of a jog in the road; north of Spurrier in Hardin County SW. corner of SW. ¼

of sec. 8-L-42; and on the west side of Nolin River about one mile southeast of Lacon in the SW. ¼, NE. ¼, SW. ¼ of sec. 4-L-42.

The unnamed limestone often contains chert (Pl. XII, fig. 1) a few feet above the base. The chert is yellow-brown, dull medium brown to chalky white, porous and in tabular form. It is medium crystalline to very oolitic in texture and the oolites are medium to fine in size, and the crystals are medium sized. Rosettes of quartz, pale yellow to yellow brown are sometimes abundant in the basal Renault, associated with the chert. These rosettes consist of crystals radiating from a central nucleus. Weller (1927, p. 105) has very carefully described these rosettes for Edmonson County. They very commonly form a large part of the residium, but sometimes occur in place surrounded by calcite or in the limestone matrix. They were probably formed by the replacement of calcite with quartz.

Campophyllum gasparense Butts, a colonial coral not known above the Renault and a Talarocrinus fauna serve to separate the Renault from the Ste. Genevieve. Two general horizons of Campophyllum gasparense exist in the basal Renault. A lower zone occurs commonly 8 to 10 feet above the Ste. Genevieve-Renault contact, although its position may vary from 4 feet to 16 feet above the contact. A higher zone is present 25 feet above the base as at NW. ¼, NW. ¼, NW. ¼ of sec. 8-L-42, one-half mile north of Spurrier in Hardin County.

Mooretown sandstone member.

The type section for the Mooretown sandstone was described and named by Malott (1920) from a small town in Laurence County, Indiana.

He first correlated it with the Sample sandstone of Breckenridge County, Kentucky, but later called it Mooretown and assigned it a position in the section lower than the Sample.

Stouder (1941, p. 28) indicates the Mooretown as an irregular outcropping member in the southern part of the Big Clifty quadrangle. It is more regular to the north.

In the Cub Run quadrangle it is represented by a shale which is fairly well bedded, clayey to slightly silty, greenish buff in color and stained red in part with iron oxide.

It is known at two localities: (1) on the west side of the river and north of the bridge at Spurrier, and (2) in Hart County about one-fourth mile southeast of the bridge at Broad Ford north of the first jog in the road directly below an old house site. These sections are good examples of the succession of unnamed limestone(Pl. XII, fig. 2), Mooretown, and Beaver Bend limestone. The Mooretown interval is 3 feet 9 inches at Spurrier and 10 inches at Broad Ford. It was not recognized at any other localities although it may exist.

Beaver Bend limestone.

The Beaver Bend limestone was named from a bend in Beaver Creek directly east of Huron, Laurence County, Indiana.

It is recognizable at Spurrier in Grayson County and at the Broad Ford section in Hart County. One of the most distinguishing characteristics of this limestone is the occurrence of vugs partially filled with soft calcite crystals extending in toward the center. These calcite geodes vary from three-fourths of an inch to two

PLATE XII

Fig. 1. Renault cherts
Basal Renault residual cherts and quartz rosettes near Millerstown-Spurrier road. Location: SE. ¼, NE. ¼, NE. ¼ of sec. 12-L-42

Fig. 2. Renault unnamed limestone
Unnamed limestone, Campophyllum gasparense and Talarocrinus zone at head of hammer. Broad Ford section, Hart County.

inches in diameter. They occur in the top half of the member. The limestone is argillaceous to siliceous, dense to finely crystalline with some medium and large calcite crystals, and stringers of calcite vein fillings. The basal beds are more argillaceous and siliceous than the upper which are purer and sometimes quite oolitic. It is colored light to medium grey, light tan and brown, and buff, with some cream beds. The bottom part is poorly fossiliferous but the upper 20 feet contains more fossils, especially pentremites and brachiopods with Pentremites pyriformis common. The thickness of the Beaver Bend is 31 to 44 feet more or less.

Thickness of Renault.---The Renault formation varies from 29 to 55 feet. This includes those areas in which the three members have not been recognized.

Stratigraphic Relations.---The Renault limestone (Pl. XI, fig. 1) rests disconformably on the Ste. Genevieve with a local basal conglomerate. This contact is between limestones and does not have a distinct topographic expression. Often the contact is concealed by talus.

The upper contact of the Beaver Bend limestone is disconformable with the overlying Sample sandstone over wide areas according to Stouder (1941, p. 32). If such an unconformity exists in the Cub Run quadrangle it has not been observed. Where the Sample sandstone is absent, the Renault and Paint Creek have not been differentiated.

Paleontology of Renault.---Fossils in the Renault are most common in the top 20 feet of the Beaver Bend limestone member and near

the base and about 15 feet below the top of the basal or unnamed limestone member. Campophyllum gasparense Butts and a Talarocrinus fauna with associated brachiopods and Pentremites pyriformis are common in the lower member.

The Beaver Bend limestone has a greater abundance of Pentremites pyriformis, a scarcity of Talarocrinus, and a general absence of Campophyllum gasparense although it does occur in this zone at Spurrier.

Fossils from the Renault formation in the Spurrier section, Grayson County, and another collection from the Renault formation on the W. C. Smith farm, Hardin County in the bluffs and slopes above Nolin River in the NE. ¼, NW. ¼, SE. ¼ of sec. 12-L-42 are listed in the following table.

TABLE I

	1*	2*	3*
Amplexus geniculatus (?) Worthen	-	X	-
Campophyllum gasparense (Butts)	X	-	-
Cleiothyridina sublamellosa (Hall)	X	-	X
Composita trinuclea (Hall)	X	X	X
Girtyella brevilobata (Swallow)	X	-	-
Girtyella indianensis (Girty)	X	X	-
Linoproductus ovatus (Hall)	X	X	-
Pentremites godoni (Defrance)	X	-	X
Pentremites pyriformis Say	X	-	-
Productus elegans (Norwood & Pratten)	X	-	X
Spirifer increbescens Hall	X	-	X
Spirifer breckenridgensis Weller	X	-	-
Spirifer pellaensis Weller	X	-	-
Spiriferina spinosa (?) (Norwood & Pratten)	X	-	X
Talarocrinus inflatus (?) Ulrich	X	-	-
Talarocrinus planus Weller	X	-	-
Talarocrinus ovatus (?) Worthen	X	-	-
Talarocrinus trijugis	X	-	-
Triplophyllum spinulosum (Milne-Edwards, and Haine)	X	X	X

*Locations of sections from which the fossils were collected are listed above as columns:

1. Spurrier section, Grayson County
2. W. C. Smith section, Hardin County
3. Hardin County, Illinois

The Hardin County, Illinois collections are listed (Weller, 1930, p. 148) as from the Fairview bluff and at the Good Hope shaft. Talarocrinus trijugis has been collected from the Renault in Hardin County, Illinois. Pentremites with the "pyriformis" type of elongated base occurs first in the Renault. Talarocrinus with the bilobed type of base such as Talarocrinus inflatus or T. ovatus, and other forms such as Amplexus geniculatus, Talarocrinus buttsi, Girtyella indianensis, and Cleiothyridina sublamellosa are common in the Shetlerville member of the Renault formation of southeastern Illinois.

Identifications of species from the unnamed limestone and the Beaver Bend limestone members of the Renault are recorded in Table II. Amplexus geniculatus, Pentremites princetonensis, Productus cestriensis, Talarocrinus buttsi, and T. inflatus were found only in the unnamed limestone. Weller (1930, p. 142) stated that "Only four species are restricted to the Shetlerville, these being Amplexus geniculatus, Globocrinus unionensis, Talarocrinus buttsi, and Spiriferina subspinosa". This indicates that the unnamed limestone is in part equivalent to the Shetlerville.

TABLE II

Faunal list	1*	2*	3*	4*
Agassizocrinus sp.	-	-	-	X
Campophyllum gasparense Butts	X	-	-	X
Cleiothyridina sublamellosa (Hall)	-	-	-	X
Cleiothyridina sp.	-	X	-	-
Dictyoclostus parvus (Meek and Worthen)	-	-	-	X
Gastropod	X	-	-	-
Gastropod	-	-	-	X
Girtyella brevilobata (Swallow)	-	-	-	X
Girtyella indianensis (Girty)	X	-	-	X
Girtyella sp.	X	-	-	-
Linoproductus ovatus (Hall)	-	-	-	X
Pentremites godoni (Defrance)	-	-	-	X
Pentremites planus (?) Ulrich	-	-	-	X
Pentremites princetonensis Ulrich	-	X	-	-
Pentremites pyriformis Say	X	-	X	X
Productus cestriensis Worthen	X	-	-	-
Productus sp.	-	-	X	X
Spirifer sp.	-	-	-	X
Talarocrinus buttsi (?) Ulrich	X	-	-	-
Talarocrinus inflatus Ulrich	X	-	-	-
Talarocrinus sp.	X	-	-	X
Triplophyllum spinulosum (Milne-Edwards & Haine)	X	-	X	-

*Locations of sections from which the fossils were collected and names of the members are listed above as columns:

1. Unnamed limestone, Broad Ford, Hart County
2. Unnamed limestone, Spurrier, Grayson County
3. Beaver Bend limestone, Broad Ford, Hart County
4. Beaver Bend limestone, Spurrier, Grayson County

Weller and Sutton (1940, p. 829) state, "The Shetlerville member of the Renault formation in southeastern Illinois and western Kentucky is abundantly fossiliferous and three species, Spiriferina subspinosa, Talarocrinus buttsi, and Globocrinus unionensis, are restricted to it. The coral Amplexus geniculatus is also very characteristic of this member and has not been certainly recognized elsewhere, although the same or a closely related form occurs rarely as high as the Glen Dean limestone".

No fossil list was available from the Paoli limestone of Indiana for comparison with the fauna of the unnamed limestone.

Correlation of Renault.--The Renault formation is correlated with the Renault of western Kentucky and southeastern Illinois on faunal assemblage. In Indiana the Renault consists of three members named in ascending order Paoli, Mooretown, and Beaver Bend. Stouder (1938, p. 269) proposed correlations for the Renault and Paint Creek in Meade, Hardin, and Breckenridge counties, Kentucky with the Indiana and Illinois sections. His proposed Renault correlations follow:

Kentucky	Indiana	Illinois
Beaver Bend limestone	Beaver Bend limestone	Renault
Mooretown sandstone	Mooretown sandstone	
Unnamed limestone	Paoli limestone	

Stouder (1941, p. 26) discusses the unnamed limestone and states, "The basal limestone member of the Renault has not been named or described in Kentucky... . It has been called the Shetlerville limestone in the Illinois section and the Paoli limestone of Indiana. This limestone has always been included as a part of the "Upper Ohara" in Kentucky... . The rejection of the name Ohara naturally leaves the "Upper Ohara" as a member of the Lower Chester, and as the lowest unit of the Renault formation." He did not propose a name for this unit "because of the many names already assigned to the Chester formations". It would seem logical that inasmuch as he has proposed the Indiana terms Mooretown and Beaver Bend members for equivalent members of the Renault that the Paoli of Indiana

should also extend across for the unnamed limestone if they are equivalents.

The fauna of the unnamed limestone in the Cub Run quadrangle suggest that it is equivalent in part to the Shetlerville of Illinois. Weller and Sutton (1940, p. 825) state that it is possible that the Shetlerville of Illinois and Paoli of Indiana are equivalent. If they are equivalent, then it would seem logical to name the unnamed limestone of Meade, Hardin, Breckenridge, and Grayson counties Paoli. The author is not proposing the acceptance of this term but would suggest that further faunal and lithologic studies may serve to definitely correlate these units.

The Mooretown interval of the Spurrier section is considered by Stouder as equivalent to the Mooretown of the Big Clifty quadrangle.

The upper limestone member of the Renault at Spurrier and Broad Ford is the Beaver Bend of the Big Clifty quadrangle and is correlated with it.

Sample formation

Name.--The Sample sandstone was named by Butts (1917, pp. 70-71) from "its strong development and good exposures east of Sample Station in Breckenridge County on the Louisville, Henderson and St. Louis Railroad. Here, one mile east of Sample, it reaches a thickness of 40 feet of massively bedded sandstone".

Distribution:--The Sample sandstone is limited in outcrop to the same area as the Renault in the northwest quarter of the Millerstown rectangle. Small isolated areas of the Sample have been

observed as far south as Craddock school in Hart County. The Renault is also present at these localities. The major and important separate occurrences are located:

in Hardin County

1. In the road north of Akers school, in the NW. ¼, NW. ¼, NE. ¼, NW. ¼ of sec. 12-L-42.
2. Three-fourths of a mile southwest of No. 1 on the west side of the Millerstown-Akers school road is a good section. Location NE. ¼, SW. ¼, NE. ¼, SE. ¼ of sec. 13-L-42. To the west on the south side of this ridge, two other outcrops were observed. One is three-tenths of a mile west in the saddle in the road where it crosses the ridge. The other is four-tenths of a mile farther west.
3. In a road in the SE. ¼, NW. ¼, NE. ¼, NW. ¼ of sec. 11-L-42 is a ten-foot red sandy zone.

in Grayson County

4. One-half mile south of Millerstown west of the road. SE. corner of SW. ¼, NE. ¼ of sec. 17-L-42.
5. On the north side of Nolin River at Wheelers Mill in a ditch north across the road from the general store, 8 feet vertically above the bench mark. Location SW. ¼, NE. ¼, SE. ¼, NW. ¼ of sec. 9-K-42.
6. At Broad Ford.

in Hart County

7. On the south side of Nolin River from Wheelers Mill near the road at an elevation of about 575 feet.

8. About one-half mile east of Broad Ford, north of an old house site near a jog in the road.
9. Two-tenths of a mile north and one-fourth of a mile west of Craddock school are two areas of well exposed outcrops.

Topography.--The Sample sandstone forms a bench on the surface where it is overlain by shale. Where it is predominantly shale, gentle slopes exist. Steep sided sinks in the Sample exist in Hardin County one-fourth of a mile southeast of an old Catholic Church site northwest of Akers valley. The sinks are small in diameter and the sides almost perpendicular for twenty feet or more. The sink probably formed in the underlying Renault and the sandstone caved into it. Such steep sided sinks occur in the Renault at the contact of the two formations.

Lithologic character.--The Sample is variable in character. In the vicinity of Sample it varies from predominantly shale with some sandstone, to a thick massive sandstone. Its chief lithologic expression is a sandy shale.

In the Cub Run quadrangle the Sample varies considerably in lithologic character in short distances horizontally and vertically. It may grade from sandstone and shale to siltstone or clay and through calcareous clastics into sandy and argillaceous limestones. (Columnar section on Geologic map). Such gradation often can be traced in a single layer. A generalized section for the Sample in this region would consist of a lower shale, a middle sandstone, and an upper shale. The shale at the base is light grey to red, plastic,

clayey to silty, or non-calcareous to calcareous. Sometimes the clay is tan to red brown, and it is non-silty.

A sandstone may be above the shale or rest on underlying Renault limestone. It is massive (Plate III, fig. 1) to slabby and cross-bedded. It weathers medium brown to light brown, and some rust brown to white. It is fine to medium texture, with angular to sub-rounded grains, which are white or transparent, or occasionally green, all are more or less iron stained. Locally this sandstone has calcareous cement and scattered crystals of brown limestone. It may be friable and porous, with openings in the body of the sand itself away from the outside weathered zones. The cross bedding consists locally of good examples of bottomset, foreset, and topset beds. The sandstone may grade down into yellow calcareous siltstone with marine fossils, or into a hard siltstone which is greenish buff to greenish grey, and more or less calcareous. This sandstone body is known to range from 0 to 16 feet in thickness and possibly more.

There is, in places, at the top of the formation a shale which varies from calcareous to non-calcareous, and from clayey and plastic to silty. Thin bedded, light brown sandstone occurs above it in places.

Several sections are recorded to illustrate the variability of the formation and the nature of the gradational contacts. Each is described in descending order.

PLATE XIII

Fig. 1. Sample Sandstone
View of massive cross-bedded Sample sandstone in Grayson County on hill south of Berry Run in NE. ¼, SE. ¼, NE. ¼, NE. ¼ of sec. 11-L-41.

Fig. 2. Sample Sandstone
View of basal calcareous sandstone of Sample formation, Wheelers Mill, Grayson County.

Road cut section in Grayson County in road west of Spurrier

	Thickness Ft.	In.
Paint Creek		
Limestone - light grey to white, very oolitic	0	4
Sample		
Concealed	8	0
Soil zone - light brown, clayey. Probably a shale zone		
Sandstone - light brown to fresh bright medium brown; fine to medium grained, grains angular to sub-rounded, abundant iron oxide staining on quartz grains. Fairly soft to medium hard, friable, porous	15	8
Clay - light green to tan, calcareous and silty	0	4
Siltstone - yellow, calcareous, soft, contains marine fossil shell fragments ..	1	0
Clay - tan to red-brown, non-silty	0	10
Shale - marly, light tan to buff to cream colored, poorly bedded and poorly exposed	0	6
Renault		
Beaver Bend		
Limestone - weathers light cream, fresh light tan to light gray; quite oolitic, vari shaped, fine to medium, fairly pure, fossiliferous	4	0
Total	30	8

Wheelers Mill section in Grayson County
in SW. ¼, NE. ¼, SE. ¼, NW. ¼ of sec. 9-K-42

	Thickness Ft.	In.
Paint Creek		
Limestone - medium gray, fairly to very oolitic; surface weathers into sub-rounded corners and serrated ridges	2	0
Concealed	1	7
Limestone - weathers chalky to gray, fresh-yellow to medium brown; medium sized crystals scattered in a dense matrix; some more yellowish and less compact	1	7
Concealed	1	6
Sample		
Sandstone - thin bedded; chalky colored; yellowish calcareous cement; with scattered crystals of brown limestone	0	1½
Sandstone - (Pl. XIII, fig. 2) dull tan to grey, thin bedded, soft, fine-grained, calcareous	3	0
Renault		
Limestone - medium grey. Eight feet exposed above bench mark at 556	8	0
Total	19	0

Hart County Sections

Section in road south of Wheelers Mill. Location No. 7 of "Distribution" sub-heading.

	Thickness Ft.	In.
Paint Creek		
Limestone - medium to light grey, oolitic, quite hard		

	Thickness Ft.	In.
Sample		
Concealed - soil, dull rust brown	2	6
Shale - clayey toward top to silty toward base, calcareous, light yellow, tan, and buff	8	0
Sandstone - weathers medium brown, light brown to yellow brown at the top, grades down to greenish brown; very fine grained; hard; compact; slightly calcareous	4	2
Siltstone - greenish buff to greenish grey, slightly calcareous; hard; compact		
Renault limestone		
Total	10	8

The section on the south side of the river at Wheelers Mill has expanded 14 feet over the section on the north side of the river.

The following two sections, about 320 feet apart, are in Hart County one mile southeast of Broad Ford on a hillslope south of Sam Stanton's store in the NW. ¼, SE. ¼, SW. ¼, NE. ¼ of sec. 14-K-42.

Westernmost Section

	Thickness Ft.	In.
Paint Creek		
Limestone - grey		
Sample		
Concealed - (probably shale and shaly sandstone)	5	6
Limestone - buff to grey brown, sandy; grades horizontally to the east into a sandstone bed 0 feet 8 inches to 1 foot, cross-bedded to massive	3	0

	Thickness Ft.	In.
Concealed - (probably shale and sandy shale)	5	6
Renault		
Limestone		
Total	14	0

About 320 feet east of the western section the zone and individual beds grade into the following section:

	Ft.	In.
Paint Creek		
Limestone - medium grey, fresh-buff; slightly sandy, oolitic		
Sample		
Concealed	2	6
Sandstone - same weathered surface, cross bedded; fresh-light to bright medium brown, fine-grained	2	0
Limestone and sandstone - grade laterally and vertically into one another, medium brown to buff, cross bedded	4	0
Renault		
Limestone - sandy, massive; vugs filled with calcite (characteristic of Beaver Bend member of Renault); fresh-light brown		
Total	4	6

The gradation from limestone to sandstone from west to east in these two sections is readily observable in individual beds. About 1000 feet east of the last section the beds pass into a hillside of Sample sandstone float.

The field evidence for lateral and vertical gradation is best illustrated near the Millerstown-Akers School road approximately three-fourths of a mile southeast of Akers School, in Hardin County. Two sections have been studied and are here recorded. They are about 150 feet apart and grade into each other.

Section on the southwest

	Thickness Ft.	In.
Basal Paint Creek		
Limestone - weathers light grey, fresh-light grey-brown, dense with some oolites to highly oolitic; slabs weather with perpendicular faces. Some yellow brown, porous argillaceous, nodular, extremely pitted, calcareous residual material is scattered among and below the broken fragments of the above limestone	1	0
Sample		
Sandstone - weathers light tan to gray-buff; fresh-very light tan to light brown in places, quite calcareous	1	0
Shale - light tan, calcareous directly below the sandstone		
Concealed (shale float)	5	8
Shale - light tan, silty, breaks into somewhat splintery slabs about 2 to 3 inches long, fair bedding, chiefly non-calcareous (Plate XIV, fig. 1)	4	6
Concealed - rust brown, sandy zone; sandstone float, friable, porous, highly iron stained (typical Sample); also rust brown clay in the weathered zone	5	6
Renault		
Limestone - weathers medium grey, fresh surfaces--light grey; oolitic--chiefly fine to medium, some large oolites		

	Thickness Ft.	In.
scattered in it	1	0
Total	18	8

Section 150 feet northeast of section recorded directly above

	Thickness Ft.	In.
Paint Creek		
Limestone float - finely oolitic, medium grey, compact		
Limestone - weathers even medium grey, fresh-light grey, medium crystalline and oolitic, with scattered light yellow calcite crystals and crinoid columns ...	0	8
Concealed (probably shale)	2	9
Sample		
Limestone - weathers light to medium grey brown with bright medium brown specks scattered in it; also large calcite crystals 2 inches across, grades into light gray, silty limestone	3	0
Sandstone - calcareous, fine-grained, slightly porous, with white calcite crystals in it; weathers round and grey-brown; grades vertically upward into light brown silty material	3	0
Limestone - weathers medium gray, fresh light tan to light brown, coarsely crystalline; iron stained	4	2
Limestone - weathers medium grey, fresh-light tan, argillaceous, grades into finely crystalline limestone at top	2	4
Limestone - argillaceous, grades down into a thin bedded slightly calcareous siltstone (Bed shows above hammer head in figure 2, Plate XIV)	1	4
Siltstone - light tan, slightly calcareous (Plate XIV, fig. 2)	6	0

PLATE XIV

Fig. 1. Sample formation
Southwest described section on Millerstown-Akers School Road. View of 4 foot 6 inch siltstone unit.

Fig. 2. Sample formation
Portion of section 150 feet northeast of section in figure 1. View of argillaceous limestone above head of hammer showing gradation into siltstone below.

	Thickness Ft.	In.
Concealed - (medium brown, soft, fine-grained sandstone in float)	2	0
Renault		
Limestone - oolitic, light oolites have light brown centers, break around		
Total	25	3

This lower limestone is the same as the lower limestone in the section 150 feet southwest. The siltstone and limestone illustrated on Plate XIV, fig. 2 and recorded above grade horizontally and vertically into each other.

Thickness of Sample.--The Sample formation interval varies from 0-41 feet in thickness. It is best developed in the northern part of its outcrop area and pinches out to the west and south.

Stratigraphic relations.--The Sample sandstone in the Cub Run quadrangle overlies the Renault and underlies the Paint Creek conformably. Its thinning out in the area might suggest an unconformity, but the sections given above for Craddock School and Akers School areas show that the method of disappearance of the formation as a recognizable clastic unit is by lateral and vertical gradations from clastics to limestones. Vertical sections show an alternation of gradations from clastics to limestones which produces an interfingering of units indicative of fluctuations in conditions of deposition. The limestone unit in which the Sample clastic formation is not distinguishable is known as the Girkin limestone. This interval contains the Paint Creek limestone above, the Renault lime-

stone below, and a limestone zone in between which, although not recognizable as the Sample formation, represents the time interval of deposition of sandstone elsewhere. The Girkin is undifferentiated in this area.

Stouder (1941, p. 36) states: "Over the greater part of the Big Clifty quadrangle emergence was complete at the close of Renault time and the Sample sandstone unconformably overlies the Beaver Bend limestone. The erosional interval at the close of the latter period was of short duration and in some areas depositional conditions were continuous with little or no erosion upon the surface of the Beaver Bend limestone." Such a disconformity was not observed in the Cub Run quadrangle.

Correlation.--The Sample sandstone of this part of Kentucky is correlated with the Bethel sandstone of Illinois. It lies between the Renault and Paint Creek limestones which are correlated with the Illinois sections on the basis of lithology, fauna, and stratigraphic position. It is also correlated with the Sample sandstone of Indiana (Weller and Sutton, 1940, p. 827).

Paint Creek limestone

Name.--The Paint Creek limestone was named from Paint Creek in Randolph County, Illinois by Weller (1913, p. 125).

Distribution.--The area of recognizable Paint Creek outcrops is the same as that of the Renault and Sample. Although the upper limits of it can be recognized outside the area of Sample outcrop, the lower limits have not been differentiated. Therefore in those areas it is discussed as a part of the Girkin limestone.

Topography.--The Paint Creek commonly forms steep hill slopes similar to those of the Renault. A bench develops on the "Productus" inflatus zone and the shale above it forms gently rounded slopes (Plate XVI, fig. 1).

Lithology.--The Paint Creek is divisible into three members. The lowest is called Reelsville after the Reelsville of Indiana. Thicknesses from 29 to 38 feet have been measured. This member is predominantly limestone with thin local shales. The lower limestone unit of this member weathers white to light and medium grey with some light brown. Fresh surfaces are light grey to white and wet surfaces are buff. It is very oolitic with some interspersed finely crystalline limestone. The basal 2 feet, more or less, may be silty to very argillaceous, although often the basal bed resting on the Sample is very oolitic. The beds range from thin to 2 feet or more in thickness. An upper limestone unit, 7 to 9 feet thick, occurs in the Reelsville. It is medium grey and some of it weathers yellowish to chalky white. The texture varies from dense and sub-lithographic to finely crystalline, with some scattered large to medium size white calcite crystals. A thin shale and limestone occurs locally at the top.

The Elwren sandstone member consists of 2 feet or less of thin calcareous, shaly, yellow brown sandstone or sandy shale. Above this is a zone of thin limestones and shales from 4 to 9 feet thick which is included in the "Productus" inflatus zone. The shale is medium grey, weathers buff to olive and yellow green and is from 1 to 9 feet thick. The thin limestones weather yellow-brown;

fresh surfaces are medium grey to buff; the texture varies from dense to fine and medium crystalline. Individual beds are from 6 inches to 1½ feet thick. The "Productus" inflatus zone referred to by Butts (1917, pp. 87-90) in the vicinity of Sample and Stephensport, Kentucky, has never been considered as a formation but rather as a zone characterized by a particular faunal assemblage. The fossil "Productus" inflatus McChesney is now referred to Dictyclostus inflatus (McChesney) (Sutton 1938, p. 63). A massive limestone (Plate XV, fig. 1) 10 to 15 feet thick with a concentration of abundant Dictyoclostus inflatus (Plate XV, fig. 2) forms this zone and is a good datum bed for structural work. This highly ferruginous limestone is rather even bedded, weathers medium brown to buff, fresh surfaces are light and medium grey to light brown. The texture is medium to coarsely crystalline with some large red crystals, and is poorly oolitic toward the base.

In the Big Clifty quadrangle and in Breckenridge county at Sample and Stephensport, Cypress sandstone or shale rest directly on the "Productus" inflatus zone. This relation occurs in the Cub Run quadrangle in the NW. ¼, SW. ¼, SW. ¼, SW. ¼ of sec. 23-L-42 at the bend on the east side of Nolin River, but normally the Cypress rests disconformably on either a calcareous shale (Plate XVI, fig. 1) or a thin limestone (Plate XVI, fig. 2). This shale varies from 0 to 34 feet in thickness. It weathers olive green to greenish yellow; fresh surfaces are medium grey to olive grey. It is calcareous, soft and clayey, thin bedded to flaky. Occasional thin layers of limestone occur near the base and at the top of the shale.

PLATE XV

Fig. 1. "Productus" inflatus zone
View of "Productus" inflatus zone on W. C. Smith's farm Hardin County, in NW. ¼, NW. ¼, SE. ¼ of sec. 14-L-42.

Fig. 2. "Productus" inflatus zone
View of the profusely fossiliferous top of the "Productus" inflatus zone in road two-tenths of a mile northwest of Lone Oak Church.

PLATE XVI

Fig. 1. Paint Creek shale
View of upper Paint Creek calcareous shale zone in Hardin County. Location: NE. ¼, NE. ¼, of SE. ¼ of sec. 14-L-42.

Fig. 2. Paint Creek limestone
View of thin ferruginous, fossiliferous limestone at top of upper Paint Creek shale. Location: NW. ¼, NW. ¼, SW. ¼ of sec. 14-L-42, on the ridge.

At the top of this shale above the "Productus" inflatus zone a thin limestone 0 to 6 inches thick persists in the areas where the shale thickness is greatest. The limestone is very ferruginous, weathers, light grey to buff to yellow-brown. Fresh surfaces are medium brownish gray, and resinous when moist. The texture is fine to medium crystalline; oolites are numerous, vari-shaped, iron stained and some have dark brown centers.

Thickness of Paint Creek.--The Paint Creek varies in thickness from 72 feet, north of Berry Run Creek in the Horntown rectangle in the NE. ¼, SW. ¼, SE. ¼ of sec. 10-L-41, to 108 feet on the ridge about three-fourths of a mile southeast of Spurrier. This variation in thickness is the result of erosion of all or parts of the upper shale zone and is recorded by a disconformity between the Cypress and Paint Creek. This shale is thickest in the Hardin County portion of the Millerstown rectangle and thins to the west and south. In places within this area the Cypress rests directly on the "Productus" inflatus zone.

Stratigraphic Relations.--The Reelsville limestone members rests conformably on the Sample formation. This contact is gradational in places as has been mentioned in the discussion of the Sample formation sections southwest of Akers School and in the Craddock School area. The contacts between the Reelsville and Elwren or the "Productus" inflatus zone and Elwren are conformable. The contact between the top of the formation and the base of the Cypress is disconformable. At some localities non-calcareous green silty to non-silty Cypress shale rests on calcareous Paint Creek

shale, or on a thin ferruginous limestone (Plate XVII, fig. 1). In other localities Cypress sandstone rests on calcareous shale or limestone.

Paleontology.--The Paint Creek limestone contains poorly preserved fossils except for those from the "Productus" inflatus zone which yields an abundance of the species Dictyoclostus inflatus, Composita trinuclea, and Spirifer increbescens. Dictyoclostus inflatus occurs in strata above and below the zone but the great abundance of this species in the zone distinguishes it from the other strata.

Table III compares the faunas from three localities in the quadrangle with two from other places. They are quite similar.

Correlation.--On the basis of the faunal lists in Table III, the Paint Creek limestone in the quadrangle is correlated with the Paint Creek of Edmonson County, Kentucky, and that of Caldwell County, Kentucky. Stouder (1941, p. 46) correlates the "Productus" inflatus zone with the Beech Creek limestone, the Elwren sandstone (p. 42) with the Elwren, and the Reelsville (p. 42) with the Reelsville, all of Indiana. He (p. 42) stated: "The outcrop of the Reelsville has been traced and followed in detail from Indiana through Meade, Breckenridge, Hardin, Hart, Grayson and Warren Counties. Correlation with the Paint Creek is made upon the basis of stratigraphic position".

PLATE XVII

Fig. 2. Paint Creek-Cypress Contact
View of Cypress silty shales and thin bedded sandstones resting on thin ferruginous Paint Creek limestone at base of the head of the hammer. Location: SE. ¼, SE. ¼, SW. ¼ of sec. 17-L-42.

TABLE III

Genus	1*	2*	3*	4*	5*
Agassizocrinus (ovalis ?)(Miller and Gurley)	-	X	X	-	-
Archimedes proutanus Ulrich	-	-	X	-	-
Cliothyridina sublamellosa (Hall)	X	-	-	X	X
Composita subquadrata Hall	X	-	-	-	-
Composita trinuclea (Hall)	X	X	X	X	X
**Dictyoclostus inflatus (McChesney)	X	X	X	X	X
Girtyella sp. ?	-	-	X	-	-
Girtyella indianensis (Girty)	-	-	-	X	X
Linoproductus ovatus (Hall)	X	-	X?	X	X
Pelecypod	-	X	-	-	-
Pentremites gemmiformis Hambach	-	-	X	-	-
Productus cestriensis Worthen	X	X	X	X	X
Spirifer increbescens ? Hall	X	X	X	X	X
Spirifer leidyi Norwood and Pratten	X	X	X	-	-
Spirifer parvus Sutton and Wagner	-	-	X	-	-
Triplophyllum spinulosum (M. E. and H.)	X	X	X	-	X

*Location of Collections:

1. "Productus" inflatus zone in road one-fourth of a mile northwest of Lone Oak Church.
2. Hardin County - NE. ¼, NE. ¼, SE. ¼ of sec. 14-L-42. Paint Creek "Productus" inflatus zone and limestone above the upper shale.
3. Spurrier, Grayson County section. Paint Creek formation collection.
4. Fauna of "Productus" zone from Bylew Creek in Edmonson County (Weller, 1927, p. 111).
5. Paint Creek fauna from Princeton quadrangle, Caldwell County, Kentucky (Weller, 1927, p. 111).

**Formerly Productus inflatus McChesney.

Girkin limestone

Name.--The Girkin limestone is a term proposed by Sutton and Weller (1932, p. 441) "as a designation for beds of Renault and Paint Creek age in that part of western Kentucky where the Bethel (or Sample) sandstone is not developed. It will include everything from the Ste. Genevieve limestone (with Platycrinus penicillus) below to the Cypress sandstone above." It takes its name from the

town of Girkin in Warren County, Kentucky.

Distribution.---The Girkin limestone crops out on the hillsides and in valley bottoms in the eastern tier of rectangles from the south side of Akers Valley to the south margin of the Winesap rectangle. In the Horntown rectangle the bottoms of Berry Run , Nosey Creek and tributaries are Girkin. From the south side of Berry Run to Lone Oak fault it forms the hillsides on the west side of Nolin River. From Lone Oak fault along Nolin River almost to Wax, with a few exceptions, it forms the bottoms and sides of the valley. Cane Run and tributaries, Cub Run, Dry Run, Lick Creek, Roundstone Creek, and Bacon Creek bottoms and hillslopes are more or less underlain by it. One isolated outcrop area is west of Rock Creek in the fault complex, and another lies between the Grayson Springs and Higdon faults three-fourths of a mile southeast of Grayson Springs.

Topography.---The topographic forms are essentially similar to those formed by the Paint Creek or Renault formations. Hill slopes are relatively steep, elongate valley sinks either single or joined with small ridges separating them, and rounded gentle slopes in the shale at the top of the formation are all features of topography developed on the Girkin limestone.

Lithology.---The Girkin limestone has the lithology of the Renault and Paint Creek limestones. Basal Renault cherts, basal conglomerates at the Girkin-Ste. Genevieve contact, a "Productus" inflatus zone near the top overlain by a grey green shale are the main characteristics. The "Productus" inflatus zone has five or

six feet of poorly fossiliferous limestone above it in places in the Winesap and Wheelers Mill rectangles.

Thicknesses.--The disconformities at the top and base of the formation are responsible for a considerable variation in thickness of the Girkin from 120 to 170 feet. Thicknesses of 120 to 140 feet are common. Along Nolin River in the bluffs about one mile west of Craddock School the thickness is 170 feet. The south end of Cub Run hollow commonly exhibits thicknesses of 120 feet. Thicknesses of from 140 to 170 feet are common in the Millerstown rectangle. The upper Paint Creek shale at the top of the Girkin in the Winesap rectangle is usually from 18 to 23 feet thick. In a steep sided ravine about one mile southwest of Dennison in NE. ¼, SE. ¼, SW. ¼ of sec. 25-J-42 massive Cypress sandstone rests on Paint Creek limestone. Thicknesses in the Horntown rectangle vary from 0 to 14 feet more or less, and the shale thickens to the east into the Millerstown rectangle where variations of 20 to 34 feet are common. The shale on a hill about one-half of a mile southeast of Copley School is 34 feet thick.

Stratigraphic Relations.--The Cypress formation overlies the Girkin disconformably as it does the Paint Creek. In some places it cuts down into the "Productus" inflatus zone. The base of the Girkin is disconformable on the Ste. Genevieve and a basal conglomerate is in the lower part of the limestone in many areas, as for example four-tenths of a mile southeast of Riggs Ford. The contacts between the Paint Creek limestone and Sample limestone facies, and between the Sample and Renault are as yet indeterminable. Calcite geodes

such as occur in the Beaver Bend limestone of the Renault have been observed in the Girkin. A very detailed study may in time make it possible to separate these units.

Paleontology.--The fossil content of the Girkin is poor except for the "Productus" inflatus faunal zone at the top. Campophyllum gasparense and associated Talarocrinus species are in the lower beds. The faunal list in Table III, location 1 northwest of Lone Oak Church comes from the "Productus" inflatus zone.

Correlation.--The strata embraced by the Girkin are correlated with the Girkin of Edmonson County. The lower Campophyllum beds correlate with Renault and the upper "Productus" zone correlates with the Paint Creek of Caldwell County, Kentucky and southern Illinois. An undifferentiated limestone unit within the Girkin is a time equivalent of the Sample formation to the north. The Elwren sandstone and the Mooretown members of the Paint Creek and Renault were not distinguished south of Millerstown and Broad Ford respectively.

Homberg Group

Name:--Weller and Sutton (1940, p. 830) proposed the term Homberg for the middle Chester group of Cypress sandstone, Golconda limestone, Hardinsburg sandstone, and Glen Dean limestone. They derived the name from the village of Homberg in Pope County, Illinois.

Cypress formation

Name:--The Cypress sandstone was named by Engelmann (1863, p. 189) from outcrops along Cypress Creek in Union County. Engelmann used the name erroneously for Pope and Hardin Counties, Illinois sections in that he included Bethel beds and the Paint

Creek shales which underlie the Cypress. Ulrich revived the term after Engelmann had permitted it to fall into disuse only to misapply it to the Bethel in western Kentucky. Stouder (1941, p. 47) states, "The Cypress sandstone is the 'Big Clifty' of the C. J. Norwood Survey of 1870, he having supplied the name from the exposures along Big Clifty Creek in Grayson County, Kentucky."

Distribution.--The formation crops out in Cub Run quadrangle in general along the bottoms and sides of valleys. In the Dissected Interior Plains it also forms broad flat uplands especially in the northwest portion of the Millerstown rectangle and the northeast part of the Horntown rectangle north of Berry Run.

The Cypress forms part of the valley slopes of Nolin River and its tributaries from Lone Oak fault to a point slightly more than one-half mile downstream from Wax. In the Dog Creek rectangle it forms the bottom of Little Dog Creek from the eastern margin of the rectangle to one-fourth of a mile east of Pine Grove Church. Pine Branch northeast of Little Dog Creek fault and the bottoms along the headwaters of Dog Creek west of Cherry Springs School have Cypress outcrops. In the Wheelers Mill and Winesap rectangles the slopes below the uplands are outlined by a narrow band of Cypress. This is well illustrated along Cub Run, Dry Run, Cane Run, Lick Run, Round Stone Creek, Spike Laurel Run, and Bacon Creek. The Golconda limestone generally forms a narrow band above the Cypress with the Hardinsburg and higher formations on the uplands.

In the Horntown rectangle, Clifty Creek bottoms on Cypress as do the headwaters of Nosey Creek and some of the smaller creeks

to the east toward Lacon. The Cypress crops out along the valley floors and lower valley slopes of Rock Creek stream and its tributaries north of the Rough Creek fault zone, also along Grindstone Fork and its tributaries upstream from Black Rock. An isolated area of Cypress sandstone extends up Bear Creek from Grayson Springs and extends into the area between fault No. 8, No. 7, Grayson Springs fault, and Higdon fault.

Topography:--Flat topped uplands as in the Dissected Plains area, steep bluffs with waterfalls, overhanging cliffs, and reentrants, narrow flat bottomed valleys with steep slopes and cliffs rising abruptly above the valley floors, are all characteristic topographic expressions of the massive Cypress sandstone. A steep sided sinkhole is developed in massive Cypress sandstone fifty feet thick one mile southeast of Royal on the south side of the Royal-Lone Oak Church road in the NE. ¼, NW. ¼, NW. ¼ of sec. 25-L-42. The bottom of the sink is flat beneath a reentrant and a steep slope arises to the top.

The top of the massive Cypress sandstone produces a bench where it is overlain by shale and the base of the Cypress is often a more gentle slope where underlain by shale than the steep sided to precipitous bluffs above.

A predominantly shale facies forms more or less gently sloping hillsides with occasional sandstone benches.

Lithology:--The Cypress formation varies greatly in lithology in short distances horizontally. A generalized section (Section on Areal Map) indicates a basal shale member, a middle sandstone member, and a top member of sandstone, shale, thin coal, and clay.

The basal shale member is similar to the shale at the top of the Paint Creek limestone formation, but it is non-calcareous and sometimes weathers red and green, although fresh surfaces are medium grey where the middle massive sandstone above this member is thicker, and the underlying Paint Creek shale is thinner. The shale consequently varies from 0 to 20 feet thick with thicknesses of 0 to 4 feet common.

The middle member is a sandstone which varies in thickness from 5 to 62 feet. It is typically a massive, cliff forming, cross bedded sandstone (Plate XVIII). Weathered exposures are medium to light brown and fresh surfaces are white to light brown. The grain size varies from fine to medium, and the grains are angular to subrounded. A basal conglomerate of thin light to olive green, soft, clayey shale pebbles is about two feet thick and locally may be calcareous.

The top member varies from 14 to 32 feet. A light and medium grey to white clay shale or variegated shales of dull red, purple, olive green, and gray green, with occasional thin sandstones forms the top member in places; or this shale is overlain by thin bedded light to medium brown, fine grained sandstone or a green siltstone. Above it is a gray shale grading up into a medium to dark gray carbonaceous and micaceous underclay near the top. Plant stem impressions and root traces occur in it in some localities as in the Dog Creek rectangle in the NE. ¼, SE. ¼, NE. ¼, NE. ¼ of sec. 3-J-41. A thin coal, from 0 to 1 foot 2 inches thick, rather soft and shaly, rests on the underclay. Sometimes a medium gray plastic clay is above it, or a thin bedded sandstone

PLATE XVIII

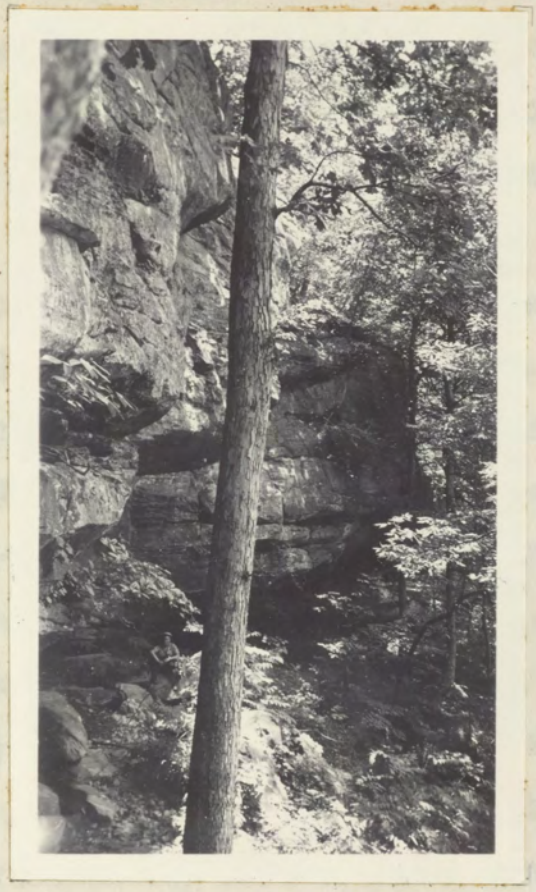

Fig. 1. Massive Cypress sandstone one-half mile north of Lacon.

Fig. 2. Cross bedded Cypress sandstone at Grayson Springs.

overlies either the clay or the coal. The coal has been used for smithing purposes from an outcrop at the base of the Golconda in Hart County across the river from Wax. Good exposures of the coal occur at many localities, as: (1) on Little Dog Creek in Hart County in the NE. ¼, NE. ¼, SE. ¼ of sec. 8-J-41, (2) in the Winesap rectangle near the road southwest of Cane Run Creek in the NW. ¼, NE. ¼, NE. ¼ of sec. 8-J-42, (3) in the Millerstown rectangle on the hillside south of Chestnut Ridge school, the headwaters of Dry Run southeast of Royal in the NW. ¼, SW. ¼, SE. ¼ of sec. 20-L-41, and (4) in the Cub Run-Priceville road cut northeast of Cane Run in the NW SW SE sec. 20-L-41.

Variation from predominantly sandstone to shale facies takes place in relatively short lateral distances. A good example of the manner in which this is accomplished is illustrated in the Pearman rectangle immediately east of the mouth of Barton Run, one-half mile east of Wax near Nolin River. A massive sandstone 14 feet thick is exposed 20 feet above the flood plain. It thins toward the southwest in thirty feet to 5 feet thick where the lower part has graded into about 7 feet of medium grey to olive green shale interbedded with occasional siltstone layers. About 100 feet further south the sandstone thins to two feet, and about one eighth of a mile further south it thickens to 5 feet. This is accomplished by lateral gradation.

A section in the Cub Run-Priceville road cut on the first hill north of Cane Run Creek along the Wax-Priceville road is predominantly shale but one mile northwest in the NW. corner of the NE. ¼, NW. ¼ of sec. 24-K-42 it is 42 feet of sandstone.

The following sections are recorded to illustrate variation in the Cypress formation in the Cub Run quadrangle:

Section in ravine and old road north of Nosey Creek in NW. ¼, NW. ¼, NE. ¼ of sec. 12-L-41 arranged in descending order:

	Thickness Feet
Golconda	
Cypress	
Sandstone and shale	4
Thin coaly horizon	
Sandstone and shale interbedded, light brown and grey	7
Shale - light and medium grey to white	14
Sandstone - tan, thin bedded	9
Sandstone - massive, cliff forming	34
Total	68

Section in Millerstown rectangle in ravine and old road one-tenth of a mile east of Lacon, Grayson County recorded in descending order:

	Thickness Ft.	In.
Covered - (slump of yellow-brown siltstone, sandstone and shale	50	0
Cypress		
Shale - well bedded, weathers dull purplish grey; fresh surfaces dull medium grey, clayey	6	0
Shale - light olive to yellow green	3	5
Shale - dull red and purple	5	0
Shale - pale green to gray green	2	0
Shale - weathers olive green, some red	2	4

	Thickness Ft.	In.
Shale - variegated dull red, purple, medium grey, intermixed.....	3	4
Concealed - (Probably siltstone and shale)...	3	0
Sandstone - very hard, fine, dull dark green.	0	2
Shale - medium grey to greenish grey silty with layers of siltstone.....	4	
Sandstone - slabby and interbedded shale.....	9	
Sandstone - massive, cross bedded forms cliff and waterfall.....	38	
Total....	105	3
Total Cypress exposed....	55	3

Section in Winesap rectangle in ravine heading on the south side of the ridge at Cub Run one-fourth of a mile east of the cross roads, recorded in descending order:

	Ft.	In.
Kyrock conglomerate slump		
Golconda - Cypress contact at a hand levelled elevation of 680 feet		
Concealed - (seeps, dark grey soil, medium grey clay soil and sandy soil. Probably zone of coal horizon).....	10	
Sandstone - light brown, thin bedded, some cross bedded, hard, fine grained, compact, iron stained.....	4	
Shale - thin bedded, purplish grey to dark grey.....	1	
Shale - dark grey to black, carbonaceous, some marcasite lenses one to one and one-half inches thick.....	1	4
Shale - medium grey, with occasional siltstone bands.....	2	6

	Ft.	In.
Shale - medium grey, thin to medium bedded, clayey.....	4	
Shale - thin bedded, carbonaceous to coaly, plant stem impressions, may be lenticular....	0	8
Shale - same as below with limestone nodules, slightly calcareous.....	4	3
Shale - light green to greenish grey with some medium grey, irregularly bedded. Some light brown iron staining.....	2	10
Sandstone - light brown to medium grey, irregular to thin bedded, ripple marked, interbedded with grey shale.....	9	
Shale - medium grey, well bedded, non-calcareous.....	1	
Paint Creek		
Shale - medium grey, calcareous, well bedded shale.....	25	
Limestone		
Total.....	65	10
Total Cypress.....	40	10

Thickness:--The Cypress formation varies in thickness from 26 to 79 feet. The greatest thicknesses are in the vicinity of Lacon and the Horntown rectangle along Clifty Creek, Berry Run, and Nosey Creek. Another area of great thicknesses, and possibly the greatest, is in Winesap rectangle south of an east west line through Center Point. The Cypress increases to the south to thicknesses of 60 to 70 feet. In a hollow one mile southwest of Denison near the south boundary of the rectangle, it is 72 feet thick. The outcrop area between the regions of great thickness in the Horntown and Millerstown rectangles on the north and the southern half of the Winesap rectangle on the south commonly has thicknesses of about 40 feet.

Stratigraphic Relations:--The Cypress rests disconformably on the Paint Creek. A green shale may rest on this Paint Creek limestone or green to grey green calcareous shale, or the massive Cypress sandstone may overlie unconformably calcareous green shale or the "Productus" inflatus zone or may even rest on beds six feet or so in the "Productus" zone.

The top of the formation is overlain conformably by the Golconda (Plate XIX, fig. 1). Golconda sandy limestone may rest directly on sandstone which grades from calcareous at the top to non-calcareous below, or it may rest on any one of the beds in the top member of the formation.

Paleontology:--A few plant fossils of a species of Lepidodendron have been observed south of Cane Run. Plant stems and root traces are present in the clay below the Cypress coal.

Correlations:--The Cypress formation of the Cub Run quadrangle on the basis of stratigraphic position is correlated with the Big Clifty sandstone of the C. J. Norwood Survey of 1870 which is exposed along Big Clifty Creek in Grayson County. It extends from Union County, Illinois to the Cub Run quadrangle, along the southern edge of the western Kentucky coal basin.

Golconda limestone

Name:--The name Golconda was used in a paper read before the Geological Society of America in December, 1915 by Ulrich (Butts, 1917, p. 91). The formation was named from Golconda, Illinois from excellent exposures in the Ohio river bluffs immediately north of Golconda in Pope County, Illinois.

PLATE XIX

Fig. 1. Conformable Cypress - Golconda contact located in a ravine one mile southwest of Millerstown in the SW. ¼, SW. ¼, SW. ¼, of sec. 17-L-42.

Distribution:--The distribution of the Golconda limestone is essentially the same as that of the Cypress with the following exceptions: It extends further up the valleys and occurs in an isolated area immediately west of Peerce ford, in some outcrops along Dog Creek, in a small area near Higdon, and in an area in the northwest part of Pearman rectangle on Grindstone Creek. Very little Golconda is associated with the area of Cypress outcrop in the northwest part of Millerstown rectangle. The bottom of Bartons Run is carved in the limestone for over one mile.

Topography:--The Golconda forms steep sided slopes, with angles of slope of 30 degrees common. It seldom occurs on the uplands except where protected by a thick Hardinsburg residual cover. The outcrops along streams are steep sided cliffs as on Barton Run, Dog Creek, and Nolin river. These bluffs may rise abruptly from the valley floor or along the side of a valley with gentler slopes immediately below. Sink holes develop on upland surfaces closely underlain by Golconda limestone. The sinks are elongated to rounded, small to medium sized, steep sided as on the upland northwest of Rock Creek or somewhat gentler sided as north of Lone Oak Church (Plate XX, fig. 1). The surfaces produced are quite rolling. Ponds form in some of the sinks.

Lithology:--The Golconda is predominantly limestone (Plate XX, fig. 2) with a few thin shale partings, and shales at the base and top. In general the Golconda is poorly fossiliferous, but locally in glade-like areas or in interbedded shales as at Grayson Springs on Kentucky Highway 88 fossils are common.

PLATE XX

Fig. 1. Golconda Sinkhole Topography. View west across the uplands two-tenths of a mile north of Lone Oak Church.

Fig. 2. Golconda quarry three-tenths of a mile east of Grayson Springs and north of Bear Creek.

The basal shale is clayey, medium grey, generally non-calcareous, although a few feet of it may be calcareous. The impervious character of the basal shale causes water to seep out along the contact between it and the limestone above. This is one of the best and most widespread spring horizons in Cub Run quadrangle. Springs have been observed flowing as steady streams of water even after long dry periods as during the summer of 1940. The overlying limestone weathers light medium to medium grey and brownish grey. Fresh surfaces are white to light brown. Although the Glen Dean and Golconda limestones weather into very similar colors, the former is generally more brownish gray. The basal Golconda weathers in bluffs with a concave profile toward the bluffs and into angular, hackly, somewhat vertically elongate rectangular fragments. Such weathering is well illustrated on the east side of Barton Run about one mile above its mouth. The basal bed may be quite massive as near the bridge over Nolin River in Hart County where it is 9 feet thick (Plate XXI, fig. 1). Here this limestone rests on about 5 inches of sandy shale which is immediately underlain by 1 foot 1 inch of black carbonaceous shale to coal.

The Golconda limestone texture varies from fine to medium crystalline to coarsely crystalline near the base. Some large white to yellow calcite crystals are scattered in it with occasional bright green grains of an unidentified mineral. The top two-thirds of the limestone is more or less oolitic, and the lower one-third is chiefly non oolitic. Locally the base grades down through sandy limestone into calcareous Cypress sandstone as in a

PLATE XXI

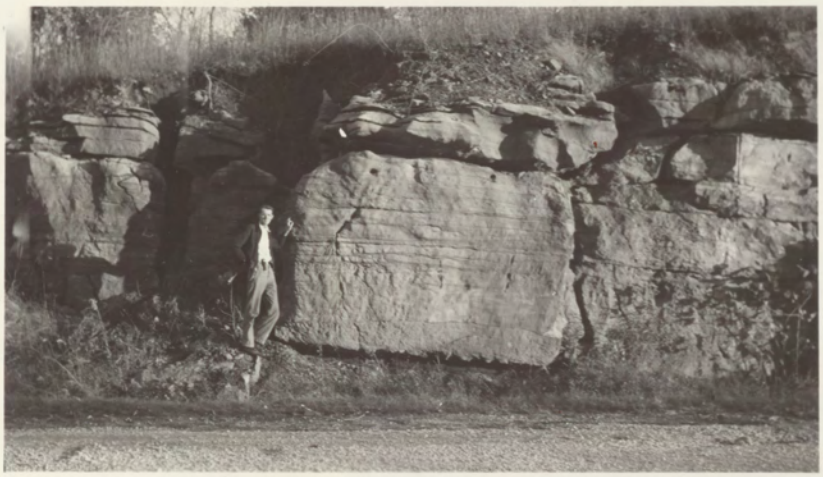

Fig. 1. Massive basal Golconda limestone. View along Kentucky Highway 88 in Hart County directly southeast of the bridge at Wax. Author stands on Cypress coal seam.

ravine one-half mile west of Dixie School in the Winesap rectangle in the NE. ¼, SE. ¼, SE. ¼ of sec. 13-J-42, or in the head of a ravine southwest of Flat Rock one mile east of Cub Run in the NW. ¼, NE. ¼ , SE. ¼, SW. ¼, of sec. 8-J-42.

The basal twenty feet often have thin irregular lenses of chert and silicified fossils (Plate XXII, fig. 1). These cherts and silicified fossils form a residuum (Plate XXII, fig. 2) rather characteristic of the lower Golconda, which associated with the spring horizon at the base of the limestone are the chief means of determining the position of the Cypress-Golconda contact. The cherts weather to a chalky to light tan color and to a porous and light weight condition. The texture is oolitic to crystalline, and follil traces are preserved. The associated silicified fossils are crinoid columnals, pentremites, and cup corals.

The topmost bed of limestone is fine to coarsely crystalline and often very argillaceous. Fresh surfaces are light tan to grey but weather dirty medium brownish grey. A vertical fluting of this bed is common.

At the top of the limestone is a medium to dark blue grey, calcareous shale from 0 to 6 feet thick. Within the body of the limestone there may be thin light grey calcareous shale zones (Plate XXIII).

Thickness:--The Golconda limestone varies from 28 to 60 feet thick with thicknesses of from 35 to 40 feet quite common. North of Cub Run in the ravine draining toward Roseburg, it is about 28 feet thick, in the vicinity of Round Stone Creek it is about 45 feet thick, and along Nolin River east of Copley school it is 46

PLATE XXII

Fig. 1. Golconda Cherts.
View of lenticular Golconda Cherts and silicified fossils in a section on Kentucky Highway 88 north of Grayson Springs.

Fig. 2. Basal Golconda Residuum.
Residual cherts and siliceous fossils. Located on a ridge between two valley sinks in Millerstown rectangle in the SW. ¼, SW. ¼, NW. ¼ of sec. 25-L-42.

PLATE XXIII

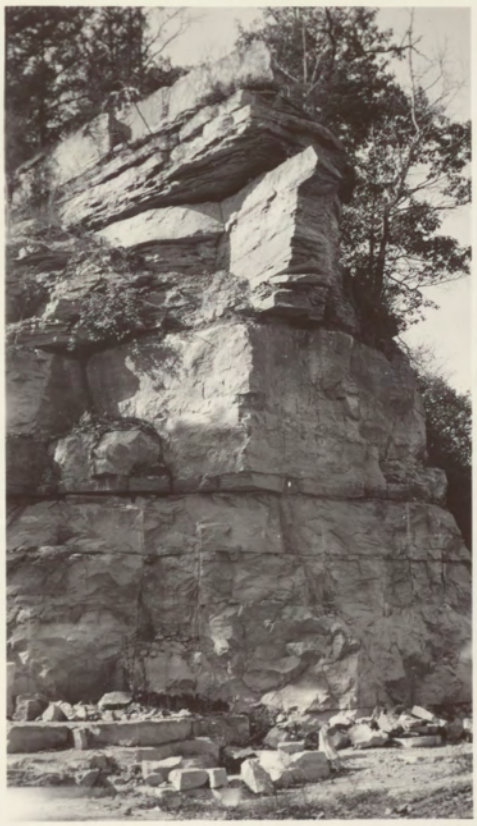

Fig. 1. Golconda - Hardinsburg.
View of quarry near Dog Creek stream showing thin shale partings and the Hardinsburg sandstone resting on a 6 inch dark grey shale of the Golconda. Location: NW. ¼, SE. ¼, SE. ¼, NE. ¼ sec. 4-J-41.

feet thick. Fifty feet was recorded in the Fannie West well in the Winesap rectangle.

Stratigraphic Relations:--The Golconda overlies the Cypress conformably (Plate XIX). Limestone may grade downward from sandy limestone into calcareous sandstone; or basal shale or limestone may rest on Cypress sandstone or sandy shale or on coal or carbonaceous clay. The Hardinsburg rests disconformably on the Golconda (Plate XXIV, figs. 1 and 2). The time interval represented by the disconformity is not great. In many localities Hardinsburg sandstone rests on shale above the limestone (Plate XIX), a maximum of 6 feet of shale has been observed, and the variation in thickness of the limestone is not great.

Paleontology:--The Golconda is not highly fossiliferous except in some of the few shale zones. The lower part carries some silicified pentremites, crinoid columns, Agassizocrinus, and fossil corals. No Pterotocrinus capitalis (Lyon) were observed in the area although it is a common guide fossil in western Kentucky and southern Illinois. Fossil collections from three localities are listed in table IV.

TABLE IV

Golconda Fauna	1*	2*	3*	4*
Agassizocrinus sp.	-	X	X	-
Archimedes distans Ulrich	-	-	X	-
Archimedes laxus Hall	-	-	X	-
Archimedes meekanus Hall	X	-	-	-
Archimedes proutanus (?) Ulrich	-	X	-	-
Archimedes swallovanus Hall	X	-	X	X
Cliothyridina sublamellosa (Hall)	X	-	-	X
Crinoid ?	X	X	-	-
Crinoid stems	X	X	X	-
Pentremites okawensis Weller	X	X	X	-
Pentremites platybasis ? Weller	-	X	X	X
Pentremites pyramidatus (Ulrich)	-	X	X	-
Prismopera serrulata Ulrich	-	-	X	-
Spiriferina transversa ? (McChesney)	-	X	-	X
Spiriferina spinosa (Norwood & Pratten)	-	X	-	X
Tabulipora ramosa (Ulrich)	-	-	X	-
Triplophyllum spinulosum (M. E. and H.)	X	X	X	X

*Locations of sections from which fossils were collected.

1. Millerstown rectangle in SW. ¼, SW. ¼, NW. ¼ of sec. 25-L-42.
2. Kentucky highway 88 road cut two-tenths of a mile northwest of Grayson Springs.
3. Winesap rectangle one mile southwest of Winesap in the SW. ¼, NW. ¼, NE. ¼, NE. ¼ of sec. 18-J-42.
4. Hardin County, Illinois, SE. ¼ sec. 9, T.12 S., R.10 E. (Weller, 1920, p. 182).

Correlation:--The Golconda of the Cub Run quadrangle is correlated with the Golconda of the Big Clifty quadrangle and of Edmonson County. It can be traced to the west around the western Kentucky coal basin. Pentremites platybasis and an abundance of Archimedes suggest Golconda affinities. Weller (1927, p. 124) listed Prismopera serrulata Lyon as a Golconda fossil in Edmonson County. The Edmonson County Golconda was correlated with southern Illinois and western Kentucky Golconda.

PLATE XXIV

Fig. 1. Hardinsburg - Golconda Disconformity. Location: Grayson County SW. corner of NE. ¼ of NW. ¼ of sec. 25-K-42.

Fig. 2. Disconformable contact. Hardinsburg sandstone rests disconformably on Golconda limestone. Head of hammer at contact. Location: near Fig. 1.

Hardinsburg sandstone

Name:--The name Hardinsburg was proposed by Butts (1917, p. 96) for a "persistent sandstone stratum" near Hardinsburg, Breckenridge County, Kentucky. A thickness of about thirty feet is exposed at Hardinsburg.

Distribution:--The Hardinsburg is widely distributed throughout the Cub Run quadrangle. It forms the flat uplands of the Interior Plains and Dissected Interior Plains. Some scattered to outcrop areas are along stream bottoms or small local upland areas, such as the bottom of Lizard Run in the Grayson Springs rectangle, a narrow strip along the east side of Higdon fault from Higdon to Snap, the bottom of Rock Creek from Iberia to fault No. 34 near Sims Ford (Structural map), a narrow strip along Nolin River from three-fourths of a mile upstream from Peerce Ford to a mile or so downstream, along Little Dog Creek from the Little Dog Creek fault to the headwaters in Winesap rectangle, and along the hollows southwest of Dennison.

Topography:--Broad flat uplands or narrow dissected uplands are characteristic of the Hardinsburg. Sinkholes into which the Hardinsburg sandstone has collapsed are common in both types of uplands. Some massive Hardinsburg forms perpendicular cliffs and waterfalls in cirque-like canyon heads, (Plate XXV fig. 1). Such perpendicular cliffs are well developed along Nolin River upstream from Wax. Valleys eroded in the Hardinsburg are gentle sloped such as along tributary to Little Dog Creek west of Pine Grove School in the Dog Creek rectangle. On uplands the Hardinsburg flats are being dissected into rounded gullies in which the ledges of

mealy sandstone stand out boldly (Plate XXV, fig. 2). Slopes formed on the Hardinsburg are rather steep, but usually less than the slope of the Golconda. Angles as high as 24 degrees have been measured on Hardinsburg slopes.

Lithology:--The Hardinsburg formation is predominantly a massive cliff forming (Plate XXV, fig. 2) to slabby, evenly bedded sandstone (Plate XXVI, fig. 1). Then bedded shaly sandstones and sandy shales are at the top or scattered in the body of the formation.

The basal beds comprise a shale zone 0 to 14 feet thick which grades into sandstone. This shale is light to dark grey and locally green, clayey, and non-calcareous. Locally a thin sandstone may occur below it. In places instead of this shale there is a thin coaly clay 4 inches thick with 2 feet of brown clay below it.

The massive sandstone member, which overlies this shale or grades into it is in places calcareous in the bottom few feet and grades downward into Golconda limestone. This is the condition in a ravine below a road about one-half of a mile northeast of Black Rock in the NW. ¼, NE. ¼, SE. ¼ of sec. 23-L-41. There the basal bed is between a white to light brown clean sandstone above and a limestone below. The bed is from 0 to 1 foot 6 inches thick, and light brown, clean and calcareous. The basal beds are conglomeratic. Light green clayey shale pebbles, which vary from small to three-fourths of an inch in diameter and average one-eighth of an inch, are scattered in the base of the sandstone, and in places are dispersed through the massive sandstone together with thin stringers of green shale. This is well exemplified in

PLATE XXV

Fig. 1. Massive Hardinsburg sandstone.
View of Hardinsburg cliff in a valley sink one mile southwest of Lone Oak Church, in the Horntown rectangle.

Fig. 2. Gullied Hardinsburg sandstone.
View of gullies and Hardinsburg sandstone formed by erosion. Located in Millerstown rectangle directly south of Lone Oak fault at the NW. ¼, SW. ¼, NW. ¼ of sec. 23-L-42.

PLATE XXVI

Fig. 1. Hardinsburg slabby sandstone. Millerstown rectangle. NW. ¼, NE. ¼, SW. ¼ of sec. 25-L-42.

the road cut on the Cub Run - Lines Mill road about four-tenths of a mile north of the cross roads at Cub Run and on the north side of the Cub Run fault and ravine crossing the road.

The sandstone which forms the greater part of the Hardinsburg formation is massive to slabby and cliff forming, even-bedded to cross-bedded, ripple marked, and in places thin bedded and shaly. It weathers medium grey brown to light brown, light tan, and light yellow. Fresh surfaces are white to light brown. The texture is chiefly fine grained to very fine grained, with angular to sub-angular grains. Cementation varies from tight to loose. Much of the Hardinsburg is hard, although some is soft, mealy, and friable. The sands are clean to somewhat iron stained with ironstone concretions and small light brown iron stains scattered throughout. Locally these beds are micaceous as in the road cut section in Hart County at Wax, or in Little Dog Creek tributary bottoms about one and one-eighth miles west of Pine Grove school. This massive sandstone may grade upward throuch calcareous sandstone into siliceous limestone of the Glen Dean as in a ravine about one and one-eighth miles southwest of Lone Oak Church in the SE. ¼, NW. ¼, SW. ¼ of sec. 25-L-42. In places a shale overlies the massive sandstone and underlies the Glen Dean. It varies from 0 to 15 feet thick with 6 feet common, is light and medium grey to olive green, and non-calcareous and clayey. In some localities a light tan to buff or red clay is in this upper zone. In other localities white shaly sandstone and sandy shale exist. The shales become silty to sandy toward their bases.

In those places where the Golconda limestone lies close beneath a surface capped with Hardinsburg and sinkholes develop in the Golconda, the Hardinsburg may collapse into the sinks giving an appearance of false structures (Plate XXVII, figs. 1 and 2).

The Hardinsburg is easily eroded and weathered, but the residual material forms a protective covering where it accumulates. This is well exemplified in the Dissected Interior Plains areas. It consists of a red soft sandy mass from which the cementing materials have been leached and has the original bedded structure preserved. It slumps down into joints in the underlying sandstone. The red residuum intermixed with the sand is red clay produced from the weathering of the overlying Glen Dean.

Thickness:--Exact thicknesses of the Hardinsburg are difficult to obtain except where steep bluffs are exposed as along Nolin River. The thickness varies from 34 to 57 feet. About one mile north of Big Windy on the Nolin River bluffs it is 54 feet thick. One mile south of Nebo School it is 53 feet thick. In the vicinity of Wax it is about 45 to 46 feet thick. The Hardinsburg is rather uniform in its thickness.

Stratigraphic Relations:--The Hardinsburg sandstone overlies the Golconda disconformably. The disconformity has been observed at many localities and is well illustrated in Plate XXIV. In the discussion of Hardinsburg lithology the nature of the basal and upper contacts was indicated. The upper contact is conformable and gradational, transitional beds occurring between the Hardinsburg and Glen Dean. Good exposures of this contact are in a

PLATE XXVII

Fig. 1. Hardinsburg sandstone.
View of "false" structure produced by slumping of Hardinsburg sandstone probably into an underlying Golconda sinkhole. Location: Kentucky Highway 224, SE. ¼, SE. ¼, NW. ¼ sec. 16-L-42.

Fig. 2. Hardinsburg sandstone.
Slumped Hardinsburg sandstone and residuum. Hammer on Golconda limestone. Location: SW. ¼, SE. ¼, NE. ¼ of sec. 23-L-42.

ravine one-eighth of a mile southeast of Lone Oak Church and between a Y in two roads one-fourth of a mile southwest of Lone Oak.

Correlation:--The Hardinsburg sandstone is correlated with the Hardinsburg sandstone of Breckenridge County, Kentucky. Weller and Sutton (1940, p. 832) state: "it thins westward in northern Union and southern Jackson counties, Illinois, and is absent from the Chester section in southeastern Perry County, Missouri. It is probably represented in Randolph County, Illinois, by the chert horizon in the middle of the Okaw formation."

Glen Dean limestone

Name:--The top formation of the Homberg group was named from the section near the village of Glen Dean, Breckenridge County, Kentucky by Butts (1917, p. 97).

Distribution:--The Glen Dean limestone is exposed as outliers on the Hardinsburg plains or Interior and Dissected Interior Plains. These isolated hills were discussed previously in the chapter on Physiography. The outcrops are discontinuously exposed as a boundary between the outer margin of the Hilly Country and the Interior Plains Country. It is characteristically exposed on hill slopes between the flat Hardinsburg uplands and the flat uplands developed on Pennsylvanian strata. The Glen Dean crops out in some valley bottoms such as the headwaters of Lizard Branch, southwest along Bear Creek for one and one-quarter miles from Fault No. 5, the lower reaches of Conoloway Creek from two miles above its mouth to Nolin River, and up Nolin River from the vicinity of Dickies Mill to the hill slopes near Peerce Ford and to

the mouth of Dog Creek, the bottom of Dog Creek from fault No. 39 one-half mile upstream above its mouth to Little Dog Creek fault, along Nolin River from Wax Fault to the Sims Ford fault complex, most of Grindstone Fork bottom between Black Rock and the Higdon fault, and separated strips along Hunting Fork Creek from the Snap fault one-half mile west of Black Rock fault, and from it into the headwaters in the vicinity of Buzzard Ridge. It also outlines some of the hillsides west of Cub Run hollow and along Little Dog Creek and its headwaters.

Topography:--The Glen Dean forms gently sloping hills (Plate XXVIII, fig. 1) rising above the Hardinsburg surfaces or gentle hill slopes of about 14 degree angles in the upper shales, about 18 to 20 degrees on the limestone slopes and about 7 degrees on the basal shales. Small sinks, funnel shaped to elongate and oval (Plate XXVIII, fig. 2) are formed in the Glen Dean. Benches form on the top of the massive limestone.

Lithology:--The Glen Dean is divisible into three lithologic units, namely, a lower shale member, a middle massive limestone divisible into a lower and upper limestone with a shale between, and an upper calcareous shale and thin bedded limestone unit. The top of the upper division of the middle massive limestone member is quite useful as a structural contour datum bed as it persists throughout most of the Glen Dean area in the Cub Run quadrangle.

The various units are here discussed in ascending order. A non-calcareous silty to sandy shale may occur in the top of the

PLATE XXVIII

Fig. 1. Glen Dean - Leitchfield Capped Hill. View from the northeast of a hill in the background rising above the Oak Grove Plains. One mile east of Oak Grove School, Grayson County.

Fig. 2. Sink Hole in Glen Dean limestone. View of a pond in the Glen Dean limestone on Anthony Sims farm in the SW. ¼, NE. ¼, SE. ¼, of sec. 24-K-41.

Hardinsburg and it is generally this shale which forms the white to light yellow, clayey, "crawfishy" soil below the base of the Glen Dean limestone. Butts (1917, p. 97) included lower shales in the Glen Dean but the author has preferred to place it with the Hardinsburg because of its silty and sandy character. In a section one-eighth of a mile southeast of Lone Oak Church this shale is overlain by a calcareous sandstone or a sandy, fossiliferous, marine limestone 2 feet 8 inches thick, which is basal Glen Dean. Above this is a shale zone (basal shale of the Glen Dean limestone) about six feet thick.

Above this and grading horizontally into it is a massive limestone which may form a zone 50 to 65 feet thick with or without a 0 to 16 foot shale break from 3 to 12 feet below the top of the zone. The lower part of this massive limestone (Plate XXIX, figs. 1 and 2) is from 30 to 34 feet thick. It is even bedded, locally cross bedded, and possesses local disconformities. It is poorly fossiliferous but has a coral zone in the bottom 22 feet in which the corals are associated with gastropods and bryozoa. The limestone is medium grey to grey brown, argillaceous to sandy, fine to medium crystalline. The shale unit overlying the lower massive limestone varies from 0 to 16 feet. It weathers buff, is medium gray on fresh surfaces, and contains some interbedded limestone. Its fauna consists of some corals, bryozoa, Spirifers, and Pterotocrinus acutus and P. bifurcatus. This zone is thickest in northwest Grayson County and thinnest in southeast Hart County. The upper part of the massive limestone varies from three to twelve feet thick. Small rounded ironstone concretions are characteristic

PLATE XXIX

Fig. 1. Glen Dean Limestone.
View of Iberia quarry lower massive limestone.

Fig. 2. Solution in Lower Glen Dean Limestone.
View in ravine one-fourth of a mile southeast of Lone Oak Church in the SE. ¼, NW. ¼, NE. ¼, SE. ¼ of sec. 25-L-42.

of the top of this unit. They weather a medium dark brown and leave a circular iron stained hole from which, due to weathering, a thin film of medium brown iron oxide may trail across the surface of the limestone for a few inches. The limestone is dull medium grey to grey brown, argillaceous to sandy, fine to medium crystalline, and contains some oolites. Similar ironstone concretions appear in the Tar Springs sandstone.

An upper shale and limestone member is commonly present at the top of the Glen Dean. It is predominantly a calcareous to "marly" shale, very fossiliferous carrying a pronounced bryozoa fauna. The associated limestones are very thin, and often quite fossiliferous, although some are poorly fossiliferous. The top limestone in the Lone Oak Church Area is a hard, smooth, sandy to argillaceous, laminated limestone dark brown when fresh, but brownish gray on weathered exposures. A peculiarly wavy laminated structure is characteristic of this bed. It fractures subconchoidally. This bed, although separate from the Tar Springs in this area, grades into it further west. On the north side of Grindstone fork in Grayson County in the Pearman rectangle in the SW. ¼, NW. ¼, NW. ¼, NW. ¼ of sec. 4-K-41, the Tar Springs sandstone grades down from highly ferruginous wavy sandstone into a sandy limestone at the base. The bottom 2 feet contains fossils, Spirifers and palecypods of the Allorisma type. It contains yellow and green shale pebbles. Below this in a cave is 2 feet of thin bedded conglomeratic calcareous sandstone. This suggests that these beds belong to the Leitchfield and are separated from the Glen Dean by a disconformity. Ten feet below is the massive Glen Dean limestone. These basal Leitchfield

beds may be equivalent in part to the wavy limestone in the Lone Oak Church area. About three-fourths to one-half a mile northwest of Iberia there are similar transitional beds between the Glen Dean and Tar Springs. Similar beds occur in an old road near the junction of the Snap fault and fault No. 20 near Rock Creek and north of Snap. They are noticeably absent in the vicinity of Sims Ford along Nolin River.

Most of the thin limestones in the upper shale zone of the Glen Dean are thin, light to medium grey limestones. One in particular is very fossiliferous with an abundance of bryozoa and broken fragments of other fossils. It is generally the highest distinct Glen Dean limestone. This limestone is the top of the Glen Dean in a road cut section up an old road on the hill southeast of Dog Creek. The shales in this upper zone become marly in many localities where the fossils are very abundant and contain scattered small yellow calcareous nodules and a soft white calcareous clay. The "marl" beds are generally 6 to 10 feet thick.

Thickness:--The Glen Dean varies in thickness from 40 to 71 feet, but thicknesses of 52 feet for the massive limestone and 62 feet for the formation are common over the area. The 40 foot thickness is in the Grayson Springs rectangle on the Oak Grove Plains. The 71 foot thickness is in the road southeast of Dog Creek, Hart County in the SW. ¼, SE. ¼ of sec. 3-J-41.

Stratigraphic relations:--The Glen Dean rests conformably on the Hardinsburg (Plate XXX, fig. 1) which grades into it through transition beds of calcareous sandstones or shales and sandy limestone. It is overlain by the Leitchfield formation apparently with

PLATE XXX

Fig. 1. Glen Dean - Hardinsburg Contact. View of sandy, fossiliferous Glen Dean limestone resting conformably over Hardinsburg shale. Located in ravine one-fourth of a mile southeast of Lone Oak Church in the SE. ¼, NW. ¼, NE. ¼, SE. ¼ of sec. 35-L-42.

transitional conformable relations in some places although a slight disconformity is suggested by a basal conglomerate at the above mentioned locality in the Pearman rectangle on Grindstone Creek. In some places Tar Springs sandstone rests directly on Glen Dean thin limestone, in places green or grey green shale rests on thin limestones, and in some localities the Glen Dean massive limestone is overlain by non-calcareous green shale. All these are suggestive of a disconformable relationship. The variation in thickness of the Glen Dean also suggests a disconformity at the top.

Paleontology:--The Glen Dean is especially fossiliferous in the upper shale zone, and the lower zones are poorly fossiliferous. The faunal collections from the Glen Dean are listed in Table V and are compared with a collection from Brownsville in Edmonson Co.

TABLE V

Glen Dean Fossils	1*	2*	3*	4*	5*	6*
Agassizocrinus conicus Owen & Shumard	X	X	-	-	-	-
Anisotrypa solida Ulrich	-	X	-	-	-	X
Archimedes communis Ulrich	-	-	-	X	-	-
Archimedes proutanus ? Ulrich	-	-	X	-	-	X
Archimedes swallovanus Hall	-	-	X	-	-	X
Archimedes terebriformis Ulrich	-	X	-	-	-	-
Cliothyridina sublamellosa (Hall)	X	-	X	X	X	X
Composita (laevis) Weller	-	-	-	-	X	-
Crinoid columnals	X	X	X	X	X	-
Cystodictya sp.	-	-	-	-	X	-
Dictyoclostus inflatus ? (McChesney)	-	X	-	-	-	-
Eupachycrinus sp. ?	-	-	X	-	-	-
Eupachycrinus sp. ?	X	-	-	-	-	-
Fenestella cestriensis Ulrich	-	-	-	X	sp.-	Xsp.
Girtyella increbescens Hall	-	-	-	X	-	-
Linoproductus ovatus (Hall)	-	X	-	-	-	X
Lyropora quincuncialis Hall	-	-	X	-	-	Xsp.
Meekopora	-	-	-	X	-	-
Nucula randolphensis Weller	-	-	X	-	-	-
Orthotetes Kaskakiensis (McChesney)	-	-	X	-	-	X
Pentremites (Godoni of Ulrich)	X	-	-	-	-	-
Pentremites okawensis Weller	-	-	X	-	-	X
Pentremites spicatus Ulrich	-	-	X	-	-	-

TABLE V (Continued)

Glen Dean Fossils	1*	2*	3*	4*	5*	6*
Prismopera serrulata Ulrich	-	-	-	-	-	X
Productus cestriensis Worthen	-	-	X	X	-	-
Pterotocrinus acutus Wetherby	-	-	X	-	-	-
Pterotocrinus bifurcatus ? Wetherby	-	-	X	-	-	-
Pterotocrinus depressus Lyon & Casseday	X	-	-	-	-	-
Pterotocrinus serratus Weller	-	-	-	-	X	-
Pterotocrinus spatulatus Wetherby	X	-	-	-	-	-
Reticularia setigera (Hall)	-	-	X	-	-	-
Rhombopora sp.	-	-	X	X	-	X
Rhombopora tabulata Ulrich	-	X	-	-	X	-
Spiriferina increbescens Hall	-	X	-	X	-	-
Spiriferina spinosa Norwood & Pratten	-	-	X	-	X	X
Spiriferina subspinosa Weller	-	X	-	-	-	-
Spiriferina transversa (McChesney)	-	-	X	-	X	-
Tabulipora ramosa (Ulrich)	-	-	X	-	-	-
Tabulipora sp.	-	X	-	-	-	-
Tabulipora tuberculata (Prout)	-	-	-	X	-	-
Triplophyllum spinulosum (M. E. and H.)	X	-	X	X	X	X

*Locations of sections from which fossils were collected:

1. Kentucky Highway 88 road cut at Wax, Grayson County.
2. On south side of Little Dog Creek one-half way between Pine Grove Church and school Hart County. Location: NE. ¼, NE. ¼, SW. ¼ of sec. 9-J-41.
3. Quarry at Iberia, Grayson County
4. SE. ¼, NW. ¼, SW. ¼ of sec. 25-L-42.
5. NW. ¼, SE. ¼, SE. ¼, SW. ¼ sec. 19-L-40
6. Glen Dean limestone at Brownsville, Edmonson County, Kentucky, road back of jail. (Weller, 1927, p. 135).

The faunal assemblage is typical Glen Dean.

Correlation:--The Glen Dean is correlated with the Glen Dean of Breckenridge County and Edmonson County.

Elvira Group

Name:--The name Elvira was proposed by Weller and Sutton (1940, p. 35) for the upper Chester group: "This group consists of eight alternating sandstone and limestone-shale formations, namely, the Tar Springs sandstone, the Vienna limestone, the Waltersburg

sandstone, the Menard limestone, the Palestine sandstone, the Clore limestone - shale, the Degonia sandstone, and the Kinkaid limestone."

Distribution:--Regionally the sandstones are best developed in southern Illinois and nearby western Kentucky. They become thin and shaly to the southeast as do also the limestones. In Edmonson, Warren, Meade, Hardin, Breckenridge, and Grayson counties, Kentucky, the Elvira group is predominantly shales with minor amounts of limestone and sandstone.

Leitchfield formation

Name:--Shaler (1877, pp. 46, 106 and 391) applied the term Leitchfield marls to beds of the Upper Chester in the vicinity of Leitchfield, Grayson County, Kentucky. Later Butts (1917, p. 112) applied the name Buffalo Wallow to the Upper Chester beds above the Tar Springs sandstone in Breckenridge County, Kentucky "on the highway 2 miles west of Cloverport." This term is in current use by the United States Geological Survey. The term Leitchfield is used in this report to include all of the upper Chester, Buffalo Wallow of Butts and the Tar Springs.

Distribution:--The Leitchfield formation is localized mainly in the Hilly Country, and some outliers of it exist in hills on the Interior Plains. Most of the exposures occur on hill slopes and in valleys in the Dog Creek, Pearman, Meredith, and Grayson Springs rectangles with some in the Horntown rectangle.

Topography:--The Leitchfield shales form steep slopes between the overlying Pennsylvanian beds and the underlying Glen Dean, but these slopes are generally more gentle than the Pennsylvanian slopes.

The more resistant beds form benches of narrow width. Especially true this is of the persistent lower limestone bed. Denuded hill sides in the red and green shales are common.

Lithologic Character:--The Leitchfield formation in the Cub Run quadrangle is predominantly shale. The shales are medium grey to red and green, with some yellow and purple beds. They vary from calcareous to non-calcareous, clayey to silty or sandy, and thin to poorly bedded. The clayey shales become very slippery after rains, and some roads over such shales are impassable to wagons in the long wet seasons and winter months (Plate XXXI, fig. 1).

Two prominent limestone strata crop out persistently in the area. The top of a lower chert bearing limestone (Plate XXXII, figs. 1 and 2) occurs from 43 to 45 feet above the top of the massive Glen Dean limestone, and the top of an upper grey crystalline limestone about 3 feet 6 inches thick consisting of two beds (Plate XXXIII, fig. 1) is about 92 feet above the top of the lower limestone. Both of these limestones are good datum beds for structural mapping. Zones of sandy to silty shale and associated sandstones are interbedded with zones of calcareous, clayey shales and thin, yellow to yellow brown, dense, argillaceous limestones. On the basis of lithology these zones have been separated into members to which names of the various formations of the Elvira group in western Kentucky and southeastern Illinois have been applied. Micro-paleontological studies by Paul Sims of the Illinois State Geological Survey are now in progress on several collections made from this area. The results which were to be included for this report have not been completed due to the pressing demands of defense

PLATE XXXI

Fig. 1. Sims Ford Road.
View of typical road on clayey Leitchfield shales, in Hart County in the SE. ¼, NE. ¼ of sec. 25-K-41. It is impassable in wet seasons.

PLATE XXXII

Fig. 1. Vienna limestone.
Chert lenses below head of hammer. Along Kentucky highway 88 one-fourth mile southeast of Iberia.

Fig. 2. Vienna limestone.
Location: NE. ¼, NE. ¼, SE. ¼ of sec. 25-K-40.

PLATE XXXIII

Fig. 1. Clore limestone.
View of two beds of upper massive, grey Leitchfield limestone. One mile southeast of Rock Creek.

Fig. 2. Clore Shale.
View of red and green Leitchfield shales below upper limestone in same locality as Fig. 1.

work on his time. He has informed the author personally that collections from the following localities yielded no guide fossils:

1. Pearman rectangle N. ½, SE. ¼, NW. ¼ of sec. 10-K-41.

2. Horntown rectangle in the S. ½, SE. ¼, NE. ¼ of sec. 25-L-41, eight-tenths of a mile southeast of Rock Creek along the Rock Creek - Snap crushed limestone road. This is one of the most complete sections for the area; it includes from the Glen Dean to 35 feet above the upper grey limestone.

3. A section in the highest Leitchfield limestone beds exposed in the quadrangle is located on the headwaters of Conoloway Creek about one mile northeast of Huffman in the Meredith rectangle in the NW. ¼, SW. ¼, SW. ¼ of sec. 3-K-40.

The following localities were sampled by the author for Paul Sims but no results have been received from him at this time.

4. On the west side of Conoloway Creek about 20 feet above the bottoms, about one mile northeast of Van Metre School in the SW. ¼, SE. ¼, NE. ¼ of sec. 17-K-40. Here the lower chert bearing limestone is overlain by 8 foot thick calcareous shale which contains abundant macro-fossils. A collection was taken from this zone.

5. A section southeast of Dog Creek of Hart County along an old abandoned road in the NW. ¼, SW. ¼, SE. ¼ of sec. 3-J-41.

Mr. Sims reported that the microfauna from the lower chert bearing zone in the Sims Ford area has a Vienna form associated with it.

The following detailed sections show the variability of the Leitchfield in the Cub Run quadrangle.

Section in Pearman rectangle, No. 1 above. Described in descending order from crest of hill at 800 feet.

	Thickness Ft.	In.
Kyrock conglomerate of Pottsville.....	7	0
Concealed.....41		0

	Thickness Ft.	In.
Leitchfield formation		
Shale - red and green clayey.....	2	6
Concealed to road.....	4	6
Concealed--(sandy zone).....	3	0
Concealed--(olive to yellow green shaly soil).	3	0
Sandstone--very fine, yellow brown, non-calcareous.....	0	1
Sandstone to siltstone--very fine, light green, calcareous.....	0	3
Shale - olive green.....	4	6
Shale--olive green to yellow green, fresh blue grey, slightly calcareous.....	2	0
Sandstone--shaly, very thin bedded, fine grained, light brown to grey brown.....	0	10
Mudstone to limestone--yellow brown, calcareous, thin bedded.....	2	9
Sandstone--dull green with some medium to dark brown iron stained surfaces, hard very fine grained.....	0	4
Shale--weathers yellow green to olive green...	3	8
Concealed.....	1	6
Limestone--argillaceous, dense, weathers smooth, light brown and tan, to brownish yellow.....	1	0
Shale--yellow brown, clayey to silty calcareous	0	7
Siltstone--clayey to hard, calcareous, yellow brown.....	0	2
Shale--olive green, non-calcareous, clayey to grey green in top 6 inches.....	3	0
Concealed--(limestone residuum 10 feet above base).....	45	0

	Thickness Ft.	In.
Clay--light grey, non-calcareous, plastic.....	3	9
Clay--silty, tan, non-calcareous.....	1	6
Shale--medium grey, clayey, well bedded, non-calcareous.....	2	0
Shale--olive green, non-calcareous, poorly bedded, clayey.....	1	4
Limestone--very argillaceous, weathers yellow to yellow brown.....	1	0
Concealed.....	0	9
Limestone--very argillaceous, fresh yellow brown, sandy, with black magnesian stains scattered in it.....	2	2
Concealed.....	5	0
Probable top of Glen Dean		
Concealed.....	15	0
Top of massive Glen Dean limestone		
Total thickness...	158	11
Total Leitchfield.	95	11

Section No. 2 of above list, about one mile southeast of Rock Creek. Begins 72 feet below top of hill to southeast at an approximate elevation of 740 feet.

	Thickness Ft.	In.
Leitchfield formation		
Degonia member		
Shale--thin bedded, grey.....	11	0
Clore member		
Limestone--"Upper grey," fossiliferous, crystalline, dark grey, two massive beds (Plate XXXIII, fig. 1).....	3	6
Shale--green (PlateXXXIII, fig. 2).....	5	0

PLATE XXXIV

Fig. 1. Palestine sandstone.
View of Palestine interval in Leitchfield section one mile southeast of Rock Creek.

Fig. 2. Sandstone in Menard.
In same locality as Fig. 1 and 5 feet lower.

	Thickness Ft.	In.
Limestone--yellow, peculiar fret-work weathering.....	1	6
Shale--green.....	1	3
Shale--yellow, calcareous.....	0	4
Palestine member (Plate XXXIV, fig. 1)		
Shale--red and green.....	1	0
Shale--sandy.....	5	4
Sandstone--thick bedded.....	2	6
Concealed.....	8	0
Shale--medium grey; sandstone--thin bedded and sheety.....	10	0
Sandstone--olive green to tan, weathers light brown with light red-brown cast....	0	10
Shale and interbedded siltstone, well bedded, weathers olive green with tinges of light red brown.....	4	0
Menard member		
Claystone--yellow, calcareous.....	2	3
Shale--light grey-green, silty very well snd thin bedded.....	0	8
Limestone or calcareous mudstone inter-bedded with yellow and red clay shale--(1 foot 2 inches to 1 foot 8 inches).....	1	8
Shale--grey green, well bedded, calcareous	0	7
Siltstone--grades down into sandstone (Plate XXIV, fig. 2).....	2	0
Shale--thin, medium grey, top 1 foot weathers purplish.....	2	6
Claystone--dull tan to yellowish.....	0	3
Shale--grey green to olive green.....	1	9
Limestone band, yellow.....	0	4

	Thickness Ft.	In.
Shale--same.....	0	11
Limestone--nodules.....	0	2
Shale--dull grey green, thin bedded.....	1	0
Limestone--weathers light yellow tan, fresh-same, with dark magnesian traces, dense, 0 foot 3 inches to 1 foot 8 inches.....	1	8
Waltersburg member		
Shale--green.....	1	2
Concealed (apparently grey and green shale interval. Studies of other sections suggest base of Waltersburg in here).....	22	8
Vienna member (includes part of above shale zone, probably basal 8 feet)		
Limestone--(lower limestone 43 feet above massive Glen Dean beds.) dull even medium grey, weathers light brown to light and medium brownish grey, finely crystalline compact, fossil traces.....	2 exposed	
Tar Springs member		
Shale--red and green, clayey.....	12	0
Concealed.....	5	0
Sandstone (Tar Springs) thin bedded, light greenish-grey to white, some dark brown iron stains on joints and beds.....	5	0
Shale--medium grey.....	11	0
Glen Dean limestone--top thin bed.		
Total Leitchfield	128	10

The above section is one of the best exposures in the quadrangle. Division into members is on the basis of lithology. The Leitchfield section above the Clore is well exposed in the following section about one mile northeast of Huffman in the

Meredith rectangle or No. 3 of the above list.

	Thickness Ft.	In.
Base of Kyrock conglomerate		
Leitchfield formation		
Kinkaid member		
Shale--grey green.....	11	0
Limestone--yellow.....	0	7
Shale--grey.....	1	9
Limestone--yellow.....	0	4
Shale--grey green.....	0	7
Limestone--yellow.....	0	6
Shale--green gray.....	1	10
Limestone--yellow.....	1	0
Shale--grey.....	1	0
Limestone--yellow, argillaceous, slightly massive.....	0	9
Shale--grey.....	1	7
Limestone--yellow, thin bedded, argillaceous, weathered.....	3	3
Concealed.....	29	0
Upper grey crystalline (Clore) limestone		
Concealed to top of Vienna in bottom of Conoloway Creek.....	92	0
Total Leitchfield	148	4

The lower beds of the Leitchfield are well exposed in the following section from the abandoned road southeast of Dog Creek in Hart County. Section No. 5 listed above.

Pennsylvanian - Chester contact at 745 feet where 0'4" of carbonaceous clay overlies thin shale.

	Thickness Ft.	In.
Leitchfield formation		
Waltersburg member		
Shale--very thin, flaky, calcareous, medium grey.....	4	7
Shale--dull green, slightly silty, non-calcareous.....	2	0
Concealed--(with light brown sandstone float).....	8	4
Shale to bright green non-calcareous clay.....	5	4
Shale--weathered green, fresh-medium grey, clayey, non-calcareous.....	3	0
Sandstone to siltstone--dull olive green to greenish tan, beds 6 inches thick, hard, angular slabs.....	1	0
Sandstone--weathers with straight angular perpendicular faces; fresh, bright light green, fine grained rather homogeneous, slightly micaceous, weathers dull medium grey brown, with some slabs.	1	6
Shale--medium grey, well bedded non-calcareous, weathers dull green.....	6	9
Vienna member		
Shale--same as above, but calcareous, and fossiliferous (Collection).....	13	0
Limestone--light brown weathers smooth with black magnesian traces.....	1	7
Concealed.....	0	10
Limestone--crinoidal, fine to medium sized columnals, weathers medium grey with a tinge of brown, medium crystalline, white calcite crystals and cross sections of crinoid columnals, and scattered bright		

	Thickness Ft.	In.
green grains; some thin tabular cherts in the top. (Plate XXXV, figs. 1 and 2)....	4	0
Limestone--weathers light brown to buff, beds 2 feet thick, fresh medium brown with some medium grey, considerable iron staining, very finely crystalline.....	6	0
Tar Springs		
Shale--thin bedded, slightly silty, soft, light grey to greenish grey, weathers tan, non-calcareous. Top 3 to 8 inches is calcareous.....	12	0
Limestone--yellow, argillaceous.....	2	0
Shale to siltstone--well bedded, olive green to light tan, non-calcareous, silty.....	2	5
Shale.....	0	2
Limestone--yellow, argillaceous, interbedded with thin green shale.....	0	10
Shale--green, poorly bedded, non-calcareous.....	4	0
Sandstone (Tar Springs) Plate XXXVI, figs. 1 and 2)--medium brown, thin bedded, wavy.	2	8
Shale--medium grey, clayey, well bedded, non calcareous.....	3	0
Total Leitchfield....	85	0
Glen Dean		
Limestone--thin bedded, medium grey, very fossiliferous thin limestone.....	1	0
Thin limestones and shale--calcareous, "marly".....	5	0
Limestone--massive dull grey, argillaceous, finely crystalline.		

PLATE XXXV

Fig. 1. View of Vienna Chert and Limestone. Along Kentucky Highway 88 one-fourth mile southeast of Iberia.

Fig. 2. Top View of Same Chert and Limestone.

PLATE XXXVI

Fig. 1. Tar Springs sandstone.
Along Kentucky Highway 88, one-fourth mile southeast of Iberia.

Fig. 2. Tar Springs sandstone.
View of top of bed of Tar Springs showing typical hatchured surface with small ironstone concretions. One mile southeast of Ste. Augustine Church in ravine in the SW. ¼, NW. ¼, SW. ¼, NE. ¼ of sec. 17-L-40.

Stratigraphic Relations:--The Tar Springs sandstone overlies the Glen Dean with apparent conformity in some places although there is some evidence for disconformity, such as the previously mentioned basal conglomerate on Grindstone Creek and the thinning of the Glen Dean limestone in the Grayson Springs rectangle. The unconformity at the top of the Leitchfield and below the Pennsylvanian represents a time of marked erosion. Relief as great as 235 feet exists between the bottom of the pre-Pennsylvanian river channel and the old Chester uplands on either side in the Winesap and Dog Creek rectangles. The basal Pottsville conglomerate fills an old channel out as low in the section as the Cypress west of Cherry Springs School.

The unconformity between the Leitchfield and Pennsylvanian beds is slightly angular. The thickest Leitchfield section contains the youngest Leitchfield beds which are overlain by younger Pennsylvanian beds, and the thinner sections are composed of older Leitchfield beds overlain by Pennsylvanian beds older than those in the areas of thickest Leitchfield. Progressive overlap of Pennsylvanian beds on Leitchfield from the southeast toward the northwest is evinced in the area.

Paleontology:--Table VI gives some of the more common fossils found in the Leitchfield. Orthotetes kaskaskiensis is common in the "marly" shale overlying the lower limestone. The red and green shales are non-fossiliferous.

TABLE VI

Leitchfield fauna.	1*	2*	3*	4*	5*
Agassizocrinus sp.	-	-	-	X	-
Archimedes swallovanus Hall	X	-	-	-	X
Chaetetes sp. Fischer	-	-	-	-	X
Composita subquadrata (Hall)	-	-	X	-	-
Composita trinuclea (Hall)	-	-	-	-	X
Dictyoclostus inflatus (McChesney)	X	X	-	-	X
Fenestella sp.	-	-	X	X	-
Linoproductus ovatus (Hall)	X	-	-	-	X
Meekopora	X	-	-	-	-
Orthotetes kaskaskiensis (McChesney)	-	-	X	-	-
Platycrinus sp.	-	-	-	-	X
Productus cestriensis Worthen	-	-	X	-	-
Rhombopera tabulata Ulrich	X	-	-	-	-
Spirifer increbescens Hall	X	-	X	X	X
Spiriferina transversa ? (McChesney)	-	-	X	-	-
Tabulapora ramosa Ulrich	-	-	-	X	-

*Location of sections from which fossils were collected are numbered

1. Three-fourths of a mile southeast of Rock Creek SE. ¼, SE. ¼, NE. ¼ of sec. 25-L-41, from the upper grey limestone.
2. In road one mile northeast of John son Cross Roads. SW. ¼, NW. ¼, NE. ¼ SE. ¼ of sec. 2-K-40.
3. On the west side of Conoloway Creek bottoms about 20 feet above the follow plain SW.¼, SE. ¼, NE. ¼ of sec. 17-K-40. In the Vienna or lower limestone.
4. Along the Skaggstown - Snap road one-eighth mile south of Skaggstown in the lower limestone.
5. General Collection.

Correlation:--The Leitchfield is correlated with the Buffalo Wallow of Butts and the underlying Tar Springs sandstone. The eight individual members proposed here may be correlatives of the more distinct divisions of the Elvira group of western Kentucky and Illinois, but much detailed work is yet to be done before such correlations can be definitely established.

Pennsylvanian System

All the Pennsylvanian strata in the Cub Run quadrangle belong

to the Caseyville and Tradewater formations of the Pottsville series.

Caseyville formation

Name:--In 1856 D. D. Owen named the Caseyville and L. C. Glenn redefined it in 1912 as a "coarse, cross-bedded, conglomeratic, cliff-forming sandstone in 20 to 60 foot beds alternating with thin beds of shale up to 20 feet thick containing thin coal seams. It unconformably overlies the Mississippian and underlies the Tradewater," Wilmarth (1938, p. 361). It was named for Caseyville in Union County, Kentucky.

In the Cub Run quadrangle the formation is divisible into a basal member, the Kyrock conglomerate, a middle member, the Drury, and an upper member, the Bee Spring sandstone.

Kyrock Conglomerate:--The Kyrock conglomerate is "a massive conglomeratic sandstone impregnated with asphalt, exposed on Nolin River at Kyrock, Edmonson County (Wanless, 1939, p. 89).

Distribution:--The Kyrock conglomerate forms the basal beds of the Pottsville series throughout most of the area of Pottsville outcrops in Winesap and Dog Creek rectangles. It also crops out in the Rough Creek fault zone south of Fault No. 26, east of the Iberia fault, along Hunting Fork and southwest of it in the Hilly Country to Wax. Some conglomerate occurs west of the Iberia fault in an old road about three-fourths of a mile northwest of Iberia. In general it is absent from the Meredith rectangle west of the faults and from Grayson Springs rectangle. The Kyrock conglomerate is west of Little Dog Creek fault and north of fault No. 39 near the mouth of Dog Creek.

Topography of Kyrock Conglomerate:--The Kyrock conglomerate generally forms a steep to precipitous slope or cliff (Plate XXXVII, fig. 1) rising abruptly above the Leitchfield formation. Where overlain by the Drury shales, a bench is formed on the top of the sandstone and the slopes in the Drury are gentler. V-shaped ravines and valleys with cirque-like heads are common in the regions of greater thicknesses of the conglomerate. Talus slopes with massive sandstone float blocks on the hillsides below are characteristic (Plate II, fig. 1). Precipitous cliffs and high waterfalls with stream beds at the top etched in narrow gorges are common. Names such as "Indian Bluffs or Cliffs" and "Pirates Cave" as applied to the Kyrock conglomerate are quite suggestive. Re-entrants and overhangs are formed in many of the cliffs, especially in the Dog Creek and Winesap rectangles. Indians used these somewhat protected places as shelters, and consequently, the floors of these re-entrants have yielded a wealth of archaeological specimens. U-shaped stream valleys have developed in the more massive and friable phases of the conglomerate in the Winesap and Dog Creek rectangles. Much of the valley bottoms and slopes have been mantled by the loose sand as it has been eroded from the cliffs.

Lithology of Kyrock conglomerate:--The Kyrock conglomerate is a thin to massive, cross bedded conglomeratic sandstone which weathers light to medium brown, sometimes honey combed (Plate XXXVII, fig. 2). Fresh road cut surfaces are generally light brown and freshly broken surfaces are white to light brown. Grain size varies from fine through medium to coarse. Toward the top of the formation fine grained rock which varies from sandstone to siltstone

PLATE XXXVII

Fig. 1. Massive Kyrock Conglomerate.
View of Indian Cliffs in Hart County, in the SW. corner of NW. ¼, SE. ¼ of sec. 20-J-40.

Fig. 2. Kyrock Conglomerate.
View of cross bedded Kyrock conglomerate across Kentucky Highway 88 from Blue Spring School southeast of Iberia.

occurs. Grains are angular to subangular. The conglomerate is in lenses more or less localized. Outside the pre-Pennsylvanian river channel this conglomerate is more common in the lower beds. It consists of white, yellow, and pink rounded quartz pebbles varying in size from small to one to two inches in diameter. Rounded to elongate oval iron cemented concretions are common in the channel phase of the Conglomerate. They are filled with loose quartz sand, more or less stained with dark brown to black iron oxide coatings and cement (Plate XXXVIII, fig. 1).

In the pre-Pennsylvanian river channel fillings, the conglomerate lenses are quite pronounced in places and are scattered from the bottom to the top of the member.

Stratigraphic Relations of Kyrock conglomerate:--The base of this member rests unconformably on the Chester. Several small channel fillings as well as the major channel fill are discussed later.

Thickness:--The Kyrock conglomerate varies in thickness from 235 feet in the channel to 0 outside it. Thinning of this member is the result of wedging out of the sand and the unconformable relations below it. Along Dog Creek and Little Dog Creek near the mouth of the latter, bluffs of massive Kyrock 80 feet or more high decrease to a thickness of a few feet in less than one-half mile. Outside the channels thicknesses are commonly 40 feet or less.

Correlation:--The Kyrock conglomerate is, according to Wanless (1939, p. 89) "equivalent to Lower conglomerate of Caseyville, and part of a channel which connected Eastern Interior and Appalachian Coal Fields."

PLATE XXXVIII

Fig. 1. Kyrock conglomerate Residual Material. View of loose quartz pebbles and ironstone concretions in Kyrock Conglomerate, Hart County, in the SW. ¼, SW. ¼, SE. ¼ of sec. 16-J-42.

Fig. 2. Topographic expression of Caseyville formation. Terraced hill on south side of Hunting Fork creek six-tenths of a mile southeast of Snap. Bee Spring forms crest of ridge.

Drury member of Caseyville.

The Kyrock conglomerate and the Bee Spring sandstone are separated by a zone consisting of shale with minor thin sandstones, siltstones, coals, and clays. This is the Drury member which was named by Lamar (1925, p. 23 and pp. 91-95) from excellent exposures along Drury Creek especially in bluffs south of Makanda, Jackson County, Illinois.

Distribution of Drury:--The Drury is commonly exposed in the Pearman and Horntown rectangles in the Hilly Country above the Kyrock conglomerate. There are some in the vicinity of Dog Creek and Sims Ford areas of Hart County, but it gradually disappears to the east in the Dog Creek rectangle, between Dog Creek and Big Windy. Between Peerce School and St. James Church, in the southern part of the Meredith rectangle, the beds exposed are chiefly representatives of the upper part of this member, and to the north they disappear, so that in the vicinity of Huffman, Bee Spring sandstone rests on Leitchfield.

Topography:--The slopes developed on the Drury are more gentle than those on the sandstones above and below. Thin sandstone beds within the Drury produces benches on the hill slopes (Plate XXXVIII, fig. 2). (The house in the picture is on the Drury slope about the horizon of the top of the Main Nolin Coal, fifteen feet above the Kyrock conglomerate.)

Lithology of Drury member:--Some of the shales in this member vary from clayey to silty and from light brown to buff in color; others are dark grey and clayey. The thin sandstone beds are light to medium brown, very fine grained to silty, more or less

thin bedded, and iron stained. The upper part of the Drury grades into the Bee Spring sandstone through siltstones and thin sandstones. The Drury contains two coals. The lower, the Main Nolin coal, occurs about fifteen to twenty feet above the base of the Drury. It varies in thickness from a blossom to four feet as in Dug Hill south of Iberia in the NE. ¼, NW. ¼, NE. ¼ sec. 16-K-41. It is a rather persistent coal, underlain by clay and clayey shale. It crops out along the south side of Hunting Fork Creek and some of its tributaries where diggings have been made into it. It is overlain by shales and thin sandstones. A second, but lenticular coal, about one foot thick with a thin underclay below it, occurs in shales in the upper Drury beds 20 feet more or less below the Bee Spring sandstone and 35 feet or more above the Main Nolin Coal.

Thickness of the Drury:--The Drury is generally about 100 feet thick. Although no lesser thicknesses have been observed in the Cub Run quadrangle, Weller notes a thickness of 50 feet in parts of Edmonson County.

Stratigraphic Relations of Drury:--The basal and upper beds of the Drury are apparently conformable with the beds which they contact.

Correlation:--The Drury is probably equivalent to the Drury of Illinois between the Lower Conglomerate or Lick Creek and the Upper Conglomerate or Makanda. The Main Nolin coal is considered the equivalent of the Battery Rock coal of Illinois.

Bee Spring sandstone

Name:--The Bee Spring sandstone was named by P. N. Moore (1884, pp. 8 and 38) for exposures near Bee Spring, Edmonson County,

Kentucky.

Distribution:--The Bee Spring sandstone is exposed in the Meredith, Pearman, Grayson Springs, and northwestern part of Dog Creek rectangles, also a part of the Horntown rectangle. It caps the ridges in much of the area, forms steep bluffs along Conoloway Creek, and parts of Miller Fork. The Tradewater formation caps the ridges, underlain by Bee Spring, in the Meredith and Peonia areas.

Topography:--The Bee Spring sandstone forms precipitous cliffs, flat uplands, (Plate XXXVIII, fig. 2), steep sided valleys, and benches.

Lithology of Bee Spring sandstone:--The Bee Spring is a massive, cross bedded, cliff forming, medium brown to pink and light brown glistening sandstone. Locally, shale pebbles are present in the basal layers. In the vicinity of Dug Hill this zone has graded into thin bedded micaceous sandstones and siltstones, (Plate XXXIX, fig. 1), light brown to medium grey, with dark brown to black iron staining. The massive sandstone facies of the Bee Spring locally contains a thin shale or clay parting with a lenticular thin coal at the top, as in the road west of Huffman.

Thickness:--The Bee Spring sandstone member is 40 to 60 feet thick in Edmonson County. It thickens in Grayson County to 100 feet or more. It is 60 feet plus at Van Metre school in the Meredith rectangle, about 70 feet thick west of Huffman, 40 feet at Peonia, and less to the north. The thinning between Meredith and Peonia is due to pre-Pennsylvanian arching of the strata and a greater thickness of Leitchfield between the Clore member and the base of the Bee Spring sandstone which unconformably overlaps

PLATE XXXIX

Fig. 1. Bee Spring sandstone.
View of thin bedded sandstones and siltstones of Dug Hill, Bee Spring sandstone. On Kentucky Route 88 one-half mile east of Blue Spring School.

Fig. 2. Tradewater formation.
View of thin coal in lower Tradewater beds. Dug Hill section.

the Leitchfield there. This interval is 48 feet thick north of Peonia in SW. ¼, SE. ¼, NE. ¼ of sec. 24-L-40 and 1 foot in the road west of Huffman.

Stratigraphic Relations:--Normally the Bee Spring sandstone rests conformably on the underlying Drury beds, but where the pre-Pennsylvanian relief was sufficient it overlapped onto this pre-Pennsylvanian surface and is unconformable with the Leitchfield formation.

Correlation:--The Bee Spring sandstone is correlated with the Makanda sandstone member of the upper Caseyville formation of Southern Illinois.

Tradewater formation

Name:--The Tradewater was named for exposures along Tradewater River east of Battery Rock, Kentucky by L. C. Glenn (1912, p. 27). It includes beds from the base of the Sebree sandstone above to the top of the Caseyville below.

Distribution:--The Tradewater formation caps some of the ridges in the vicinity of Meredith, Peonia, and Dug Hill. The upper beds in the Pennsylvanian of the Grayson Springs rectangle probably belong to this formation.

Topography:--The topography produced on these beds is rolling on the uplands, with V-shaped ravines. Locally benches are formed on resistant sandstones.

Lithology and Thickness:--The beds above the Bee Spring consists of a series of thin sandstones, clays, clayey shales with red brown interlocking ironstone concretions, and a thin, local coal near the base (Plate XXXIX, fig. 2). Local stream channel

sandstones (Plate XL, fig. 1) and occasional ironstone beds about a foot thick (Plate XL, fig. 2) occur in this formation. The Tradewater formation is from 0 to 200 feet thick in the Cub Run quadrangle.

The Tradewater seems to overlie the Bee Spring sandstone conformably.

Pottsville Unconformity and Pre-Pennsylvanian River Valley:-- The pronounced unconformity at the base of the Pottsville series has been discussed on previous pages. In summary it is pointed out that Pennsylvanian beds from the Kyrock conglomerate into the Bee Spring sandstone overlap various strata of the Leitchfield. The overlap is the result of an irregular Chester surface and the angular relation between Chester and Pennsylvanian strata. A pre-Pennsylvanian channel crosses the Winesap and Dog Creek rectangles from northeast to southwest. It is filled with massive Kyrock conglomerate with the greatest thicknesses in the vicinities of Cub Run and Cherry Spring School, in about the middle of the channel. The northwest edge of the channel is one-half mile north of Cub Run, and the southeastern border is about one and one-fourth miles southeast of Cub Run. This Pottsville channel filling extends southwest into Edmonson County, and northeast and east across Hart County and along the Larue - Green and Marion - Taylor County lines (Weller 1927, p. 158) for a distance of at least forty miles. Drainage was toward the southwest.

Smaller channels are in the Cub Run quadrangle. One is visible near the juncture of Dog Creek and Nolin River and probably trended from northwest to southeast. Slightly less than one mile northeast

PLATE XL

Fig. 1. Disconformity in Tradewater formation. View of channel deposit in Dug Hill section along Kentucky Route 88.

Fig. 2. Ironstone bed in Tradewater formation. View along Kentucky Highway 65 west of Meredith.

of Blue Spring school another pre-Pottsville channel is exposed in a ravine east of the Snap fault. It is narrow and steep sided.

CHAPTER VII

STRUCTURAL GEOLOGY

Regional Relationships

The Cub Run quadrangle is located on the axis of the southeastern extension of the Western Kentucky Coal Basin, on the southwestern flank of the Cincinnati arch and north of the Nashville dome. The regional dip of the strata is to the southwest north of the syncline axis and to the northwest in the region south of the axis. Weller (1927, p. 173) indicates a northwest dip of about thirty feet to the mile for Edmonson County and Stouder (1941, p.56) indicates an average regional dip of S 60 W in the Big Clifty quadrangle.

The complex fault system which crosses the Cub Run quadrangle in a northwest - southeast direction is a part of the Shawneetown - Rough Creek fault zone which crosses the Southern Illinois and Western Kentucky Coal Basin in an east - west direction. It begins in Saline County, Illinois, about eighteen miles northwest of Hicks dome, extends east through Gallatin County, crosses the Ohio river just south of Shawneetown, and then continues eastward in Kentucky across central Union, northern Webster, northern McClean, north-central Ohio, and north-central Grayson counties to a point about five miles northwest of Leitchfield in Grayson County where it swings to the southeast and extends across the Cub Run quadrangle into Hart County. Stouder (1941, p. 57) has shown five faults trending northeast - southwest across the Big Clifty quadrangle, and Weller (1927, p. 175) has indicated a northeast - southwest trend for four separated faults in Edmonson County, and for several in Warren

County. About 6 miles southwest of the Edmonson - Warren County line, these faults intersect faults of an east - west system which continues with some interruptions across Butler, Muhlenberg, and Christian counties into the highly faulted areas of Caldwell, Lyon, Livingston, and Crittenden counties.

Structural Contour Map

A map of the structural geology of the Cub Run quadrangle accompanies this report. The map shows 53 faults, 65 oil and/or gas test well locations, and structural contours drawn on two datum surfaces. The datum used in the Millerstown rectangle is the top of the "Productus" inflatus limestone, and in the remainder of the area the base of the Golconda limestone. Some 1600 or more different elevations were used in preparation of the map. In the Meredith, Grayson Springs, and Pearman rectangles where the Golconda is subsurface, elevation readings were taken on the Vienna and Clore limestones of the Leitchfield, and on the top and base of the massive Glen Dean limestone, whose intervals above the base of the Golconda are fairly constant for each individual bed. These elevations were then keyed down to the Golconda horizon.

Elevations were taken with a hand level and locations were plotted on the topographic map as a base. The contour interval chosen is twenty feet, since this is the smallest unit which can be used with accuracy. In the fault zone where Pennsylvanian beds crop out sufficient data were not available for coutouring, so such areas were left blank.

Strike and dip readings were made with a Brunton compass, and the more important of these readings have been plotted on the map.

Faults

Representation on Map.--The faults are represented on the structural geology map by heavy black lines and thin inferred positions are indicated by dashed lines. Names are applied to the more important ones where it is possible to indicate such on the map and serial numbers 1 through 39 are used to indicate all other faults except number 18 which refers to a complex of faults near the juncture of faults numbered 16 and 17 in the Pearman rectangle.

The two small, closely spaced, faults which border a graben in the Horntown rectangle in the NE. ¼, SE. ¼, SE. ¼, NE. ¼ of sec. 25-L-41 (Plate XLI, fig. 1) northeast of fault number 15 are not numbered; and a northeast southwest trending pre-Pennsylvanian fault (Plate XLI, fig. 2) in the southwestern part of the Pearman rectangle between faults numbered 36 and 37 is represented by two short lines on opposite sides of the bend in Nolin River one-tenth of a mile south of Sims Ford. These two lines are not numbered.

The downthrown and upthrown sides of the faults are indicated by the capital letters D and U respectively. The amount of displacement between beds on opposite sides of the fault is indicated by small figures and symbols in this manner: 25 feet ± .

General Character of Faults.--The faults form a faulted zone from the Horntown rectangle through the Dog Creek and Winesap rectangles. They have an en echelon arrangement, with some diverging from the main zone such as the Broad Ford, Big Sink, Fragrant, Mulberry, Lizard Branch, and number 1 faults.

PLATE XLI

Fig. 1. Grabem in Hardinsburg sandstone. View of two small faults in NE. ¼, SE. ¼, SE. ¼ NE. ¼ of sec. 25-L-41, in a road cut northeast of fault No. 15.

Fig. 2. Pre-Pennsylvanian Fault. View of horizontal Pottsville overlying with angular unconformity high angled Hardinsburg beds. Board rests on relatively flat Golconda limestone.

The throw of strata along the faults varies from place to place from as little as 10 feet to as much as 160 feet. Cub Run fault, Higdon fault, fault No. 5, and No. 8 are pivotal types. Big Sink fault exemplified a hinge type. All faults in the Cub Run quadrangle are normal except the westernmost one of the complex represented by No. 18 which is a small thrust of 15 feet upthrow on the west. The top of the massive Glen Dean is shoved over massive Glen Dean to the east. This was probably the result of compressional forces exerted as the juncture of the two major faults, number 16 and the Cub Run fault, was accomplished.

It is common for a small area in the vicinity of the juncture of two faults to fracture along several small faults. This is well exhibited by the complex of number 18, at Rock Creek where six small faults were formed at the juncture of Lizard fault and Grayson Springs fault, and also in the Sims Ford area.

The fault planes are predominantly at high angles. This is observable at Snap on fault 24 next to the road where Glen Dean on the downthrow side abuts Hardinsburg on the upthrow, and on fault number 34 where it crosses Nolin River 250 feet or so northwest of Sims Ford. The curvatures in the trends of the faults are more the result of the character of the bed rock and nature of the forces exerted than the topographic expression of surface traces of fault planes of low angles on topography of considerable variation in elevations. The trace of a fault across the surface of the region is not always definitely exposed. Certain topographic features such as elongate valley sinks, step-like sinks, elongated

ridges, and sub trellis drainage patterns are indicative of faults in the region. Careful analyses of soil changes, mineralization, bed rock relations, and residual materials all may suggest the presence of a fault.

In areas of relatively low regional dip, increases in the dip of the strata to angles of 4 or 5 degrees are indicative of possible faults nearby. The zone of influence of any one fault on the angle of dip of nearby strata is limited to a narrow belt about one-half a mile or less in width, paralleling the trend of the fault. The angle of dip of the strata within such a zone increases toward the fault, the beds generally rising toward the fault plane on the downthrow sides, and remaining essentially low angled or suddenly dropping rapidly toward the fault on the upthrow side. The angle of dip on the downthrow side of the Lone Oak fault on the west side of Nolin River increases from 4 degrees about 500 feet from the fault to 32 degrees next the fault plane.

There seems to be no relationship between the vertical component of displacement or throw of these faults and the angle of dip of strata adjacent to them. For example, fault number 24 at Snap with a throw of 50 feet has strata next to it with dips of from 3 to 5 degrees, in contrast to the Broad Ford fault at Broad Ford with a throw of about 30 feet and an angle of dip of 18 degrees in strata next to it. It is possible that the angle of dip of the strata depends on the nature of the beds themselves, or on the recurrence of faulting or renewed distortion along any particular zone. It is known that in the Cub Run quadrangle both pre-Pennsylvanian faulting and post-Pottsville faulting have

occurred. Some renewed displacement along these zones may have taken place at the time of the New Madrid earthquake in 1812.

The regional trend of the fault zone across the Cub Run quadrangle and in the regions to the south and west suggests that the location of this region with reference to the Cincinnati arch, the Nashville dome, and the western Kentucky structural basin has influenced the trend of the fault zone.

Pre-Pennsylvanian faulting and deformation.--A pre-Pennsylvanian fault in which the Hardinsburg sandstone is dropped against the Golconda limestone (Plate XLI, fig. 2) is exposed along Nolin River in Hart County on both sides of a meander in Nolin River in the Sims Ford area between faults 36 and 37. The Hardinsburg beds on the south dip at an angle of 60 degrees in a direction S. 5 degrees E. The Golconda chert bearing limestone is exposed about nine feet below the base of the Pottsville beds which rest with angular unconformity on the Golconda and Hardinsburg formation.

Another evidence for pre-Pottsville faulting is fault No. 26 which has massive Kyrock conglomerate next to it at the base of the Pennsylvanian on the downthrow side and basal Tradewater as the oldest Pennsylvanian on the north or upthrow side with the Kyrock conglomerate absent. This indicates that fault number 26 probably formed prior to Pottsville time and that while Kyrock conglomerate was deposited in the area south of the present fault it was not deposited to the north because that area had sufficient relief due to faulting to prevent deposition until Tradewater times. Similar conditions existed along the Iberia fault, where very little conglomerate occurs west of that fault,

but is present in the northwestward tilted fault block between Iberia and Snap faults.

Pre-Pottsville and post-Leitchfield deformation is indicated in the Meredith area. Elevations on the Clore limestone in a northeast-southwest direction from a road cut section slightly over one mile north of Peonia to an elevation in the road west of Huffman indicate an arching of the strata from an elevation of 644 feet on the southwest to 665 feet in the middle in the NE. ¼, NW. ¼, SW. ¼, SW. ¼ of Sec. 3-K-40, and 655 feet north of Peonia. The Leitchfield beds above the Clore over this arch increased the thickness from 1 foot thick on the southwest to 51 feet in the middle and then declined to 48 feet to the north. The Pennsylvanian beds have a different structure.

Age of faulting and deformation.--The faults in the Cub Run quadrangle were formed predominantly in the post-Pottsville beds. Fault No. 26 and the Iberia fault, although post-Pennsylvanian in age apparently had pre-Pottsville-post-Chester deformation. The fault south of Sims Ford indicates similar pre-Pottsville faulting.

Evidence of pre-Pennsylvanian tilting is indicated by the Chester arch near Meredith and the angular relationship between the Pennsylvanian and Chester beds.

FOLDS

The Cub Run quadrangle is on the eastern extension of the western Kentucky Coal basin; the axis of which crosses the center of the quadrangle through the Meredith, Pearman, and Wheelers Mill rectangles. The regional dip toward this axis from the northeast

and southeast has been considerably modified by folding which accompanied the formation of the Rough Creek fault zone.

Conoloway syncline in the Meredith rectangle and Round Stone syncline in the Wheelers Mill and Millerstown rectangles have similar axial trends and seem to be continuations of each other, interrupted by the fault zone.

Miller Fork syncline is northeast of a southwest-northeast trending nose from Peonia to Meredith. Conoloway syncline lies to the south of the nose. The closure on this nose is at least 120 feet. It has been drilled and has two capped gas wells on its crest.

A fault trough, which rises on all sides toward the faults, lies between the Sims Ford complex, Iberia fault, fault No. 26, and the Snap fault.

A small syncline with a northeast-southwest trend occurs near Fragrant.

A terrace strikes northwest-southeast in the Horntown rectangle from the west end of Lone Oak fault toward Horntown. This is apparently the end of a fault from the Big Clifty quadrangle.

A small basin occurs near Spurrier. Beds rise from the northeast side of the basin toward the northeast corner of the Millerstown rectangle. Some gas wells were obtained off the quadrangle a mile or so to the north.

Another large syncline is in the vicinity of Roseburg in the Wheelers Mill rectangle. A nose lies to the north of it and its axis parallels the trend of the Broad Ford fault. It has been tested and has produced gas and a showing of oil. The Roseburg

syncline has a northeast-southwest trending axis which cuts the Big Sink fault at an angle of about 30 degrees. It extends into the area between Big Sink fault and Cub Run fault where a small depression occurs next to the Cub Run fault. This syncline seems to decrease in magnitude westward toward Wax fault.

The Winesap rectangle has two northwest-southeast trending noses in the vicinity of Winesap. Both have been drilled and the one which extends northwest from Winesap has produced some gas.

Another nose trends west from the west side of Cub Run fault about one and one-half miles due west of Winesap. It extends west to Little Dog Creek fault and is paralleled on the south by a narrow syncline.

In summary, the folds, noses, and synclines have received their present trends as a result of the folding which accompanied the faulting. Small synclines and folds closely parallel the faults where the beds have been bent down or pulled up toward them. This type of structure is localized within one-half mile of the faults. Larger structural features such as synclines and noses are more regional in character and generally cross the faults at acute angles suggestive of strain ellipsoid relationships. The areas in which an abundance of test holes have been drilled coincide with the structural highs determined by this survey.

CHAPTER VIII

ECONOMIC GEOLOGY

General Remarks

The Cub Run quadrangle contains some resources of economic value such as rock asphalt, "marl", coal, limestone, and possibly oil and gas reserves under untested structures.

Rock Asphalt

Asphalt impregnated sandstones occur in the Cypress sandstone of the Chester and in the Bee Spring and Kyrock members of the Pottsville. The Cypress deposits are located in bluffs in a north-south hollow three-fourths of a mile west of Rock Creek. Ignition tests of the Cypress one and one-fourth miles southwest of Fragrant on the Will Paris farm showed an asphaltic content of 3.05%. It is non-commercial as the content should range from a minimum of 6.2% to a maximum of 8.5%, and be preferably 7%.

The Bee Spring sandstone is intermittently asphaltic in the ridges from Peerce school to Peonia on the east side of Conoloway creek and from Peonia to about one and one-quarter miles south of Meredith. An outcrop occurs on the Richard Stinson farm west of Dickeys Mills.

Asphalt impregnated Kyrock conglomerate occurs near Snap back of Meredith's store, along Hunting Fork on the farms of S. C. Camms, Mrs. Florence Williams, Hayse Williams and others. It is in both the Kyrock conglomerate and Bee Spring sandstone in these areas. Samples were collected from the Kyrock conglomerate on the farms of Hayse Williams, S. C. Camm, Florence Williams, and Henry Hardin Kerr.

The Hayse Williams 6 foot sample tested 7.56% on ignition. This was from a pit from which asphalt was mined and distilled years ago. This sandstone has too much conglomerate in it to be commercial.

The four feet of black rock from the remainder of the farms mentioned above tested too low to be of commercial importance.

Samples collected from the Kyrock conglomerate on the Frank Stinson and R. R. Childress farms along Little Dog Creek above its junction with the mouth of Dog Creek, were tested. The Frank Stinson ignition tests from top down ran:

0 - 3 feet 9 inches ---------- 3.11%
3 feet 9 inches - 5 feet 3 inches - 9.86
5 feet 3 inches - 9 feet 3 inches - 5.17

This is in the base of the Kyrock conglomerate. The 9.86 test is too high and the 5.17 per cent sample has too low a content. They might be mixed and used commercially.

The R. R. Childress sample from the south side of Little Dog Creek tested 2.37 per cent and is too low for commercial value.

The areas which may have some commercial importance for asphalt are: (1) the Meredith area between Fowler's quarry and the C. J. Huffman farm, (2) the Oscar Constant and Claude Constant farms on the east side of Conoloway Creek on the ridge top about one-half mile west of Oklahoma school, and (3) an area on the Claude Constant farm west of Fowler's quarry and one-half mile west of St. James Church.

Ignition tests were run on samples from all these localities and the good zones of the black rock tested from 6.2 to 9.0 per cent.

The following asphalt core test records were furnished the author by C. J. Huffman for test holes drilled on his farm in the Meredith rectangle located in the NE. ¼, SE. ¼, SE. ¼, NW. ¼ of sec.-J-40. These tests were drilled during April and May 1939.

TABLE VII

Core Test No. 1.

Surface	to	Thickness	Ignition	Remarks
0	11	11		Over burden Red
11	13½	2½	6.18	sandstone streaks
13½	16	2½	5.03	
16	18½	2½	6.65	
18.5	21	2½	6.18	
21	23.5	2½	3.86	
23.5	26	2½	4.31	
26	31	5	5.03	Extraction 4.63
31	33	2	3.50	
33	35	2	2.86	
35	39	4	S.S	
39	41	2	2.78	
41	43	2	S.S.	
Average		26	4.77%	

Core Test No. 2.

0	15	15		
15	18	3	4.55	
18	20	2	3.68	
20	21½	1½	6.60	
21.5	24	2½	5.83	
24	25.5	1½	6.73	
25.5	29	3½	3.55	
29	31.5	2½	4.83	
31.5	33	1½	3.71	
33	36	3	5.35	
36	39	3	3.46	
Average		24	4.67%	

(Table VII continued)

Core Test No. 3.

Surface	to	Thickness	Ignition	Remarks
0	26	26		Overburdened
26	29	3	4.85	
29	32	3	5.51	
32	35.5	3½	3.03	
35.5	39	3½	3.92	
29	42	12	4.08	
42	45	3	3.90	
45	46.5	1½	3.72	Sandstone streaks
46	49	3	3.84	
49	51	2	Trace of asphalt	
Average		23	4.07	

Core Test No. 4.

0	26	26		Overburden
26	28.5	2½	5.51	
28.5	31	2½	5.99	
31	33.5	2½	4.71	
33.2	36	2.8	5.75	
36	38.5	2½	3.41	
38.5	41	2½	4.00	
41	43.5	2½	3.65	
43.5	46	2½	3.74	
46	49	3	3.17	
Average		23	4.41	

Core Test No. 5.

0	46	46		Overburden
46	47.5	1½	5.01	
47.5	49	1½	5.24	
49	49.5	½	8.52	
49.5	54.5	5	3.84	
54.5	56.5	2	3.70	
56.5	58.5	2	3.74	
Average		12.5	4.15	

Core Test No. 6.

BLANK

Core Test No. 7.

0	33	33		Over burdened streaked with slate and sandstone.
33	35	2	3.25	

(Table VII continued)

Core Test No. 9.

Surface	to	Thickness	Ignition	Remarks
0	43	43		Overburdened
43	46	3	4.32	
46	48	2	5.92	
48	51	3	3.02	S.S. streaked
51	53.5	2½	3.76	
53.5	55.5	2	4.11	
55.5	57.5	2	3.48	
57.5	58.5	1	S.S.	
58.5	60.5	2	2.64	S.S. streaked
6.05	63.5	2	2.26	S.S. streaked
Average		18.5	3.60	

Core Test No. 10

0	29	29		Overburdened
29	31	2	4.30	
31	32	1	3.40	
Average		3.5	3.91	

The following asphalt core test records were furnished by B. F. Thompson for tests drilled on the B. F. Thompson and George Thompson farms three-fourths of a mile northwest of Big Windy, Hart County in the NW. ¼, SW. ¼ of sec. 1-J-41.

TABLE VIII

Core Test No. 2.

Surface	to	Thickness	Ignition	Remarks
14	15½	1½	3.15	
15½	18½	3	4.03	
18½	19½	1	3.64	
Average		5½	3.72	

Core Test No. 3.

				Extraction
23	24½	1½	5.51	4.75
24½	26	1½	6.27	5.62
26	29	3	8.69	7.95
32	32.3	¼	9.12	
Average			7.39	6.57

Core Test No. 4.

8	10½	2½	2.42

Core Test No. 7.

0	2	2			
2	18½	16½			Overburden
18½	19½	1	3.99	3.45	sandstone
19½	20½	1	6.31	5.35	
20½	23	2½	7.22	6.33	
23	24	1	9.91	8.62	
Average		5½	6.94	6.04	

Core Test No. 13.

48	53	5	2.60

(Table VIII continued)

Core Test No. 10.

Surface	to	Thickness	Ignition	Extraction	Remarks
0	7				Over-
7	11	4			burden
11	16	5	2.09	1.62	very
16	22	6	2.79		lean
22	26	4	3.14		rock
26	29	3	3.16		
29	30	1	2.36		S.S.
Averages		19	2.72		streaks

Core Test No. 11.

0	19	19			Over
19	21	2			burden
21	25	4			trace of
25	31	6	1.72	1.03	asphalt
31	41	10	2.73	2.01	sandstone
Average		16	2.35	1.64	

Core Test No. 14.

19	21	2		Mixed L.R.-ss. & slate
21	26	5	2.43	
26	31	5	3.07	
31	32	1		L.R. with S-S. streaks
Average		10	2.76	

Samples were taken from a pit on the B. F. Thompson farm in Hart County beginning at 15 feet 4 inches below the top of core hole No. 7. The results of ignition tests are:

From		To		Ignition Test
Ft.	In.	Ft.	In.	Per cent
15	4	18	6	3.18
18	6	19	4	4.73
Covered				
20	10	23	0	3.64
23	0	24	0	7.28
24	0	26	0	7.68

The analyses of asphaltic sandstones show that the percentage of asphalt in the rock increases from top to bottom, that samples taken from outcrops are fairly reliable for determination of approximate asphalt content of impregnated sandstones a short distance back from the outcrop as recorded in core tests, and that most of the Cub Run quadrangle, with the exception of the areas previously mentioned, has rock which is too lean for commercial purposes.

Marl

The calcareous shale zone above the massive limestone of the Glen Dean is high enough in calcareous content to be used for agricultural purposes. Good "marl" beds in this formation are exposed northwest of the school in the Skaggstown area, on Ed Hill's farm in the Pearman Plains country in the SE. ¼, SW. ¼, NW. ¼ of sec. 10-K-41, and in the quarrys at Iberia and Ste. Augustine Catholic Church.

Another "marl" zone occurs in the shale above the Vienna. It generally has a high calcareous content and an abundance of fossil shells.

Mr. Faulkner, County Agent of Grayson County, has recommended that marl of no lower than 30 per cent of calcium carbonate be used as so many beds of good material are available. Most of the marls used in Grayson County will run from 60 to 80 per cent calcium carbonate.

Coal

There are only two coals in the area which are minable, the Main Nolin coal and a coal below a massive sandstone not far above the Bee Spring sandstone in the Drury formation. They are mainly in the Hilly Country of the Meridith and Pearman rectangles, and are utilized chiefly for local consumption.

Oil and Gas Test Holes

Sixty five oil and gas test holes have been drilled in the Cub Run quadrangle. None of these were commercial holes although most of the wells penetrated the Devonian and Silurian strata. There are yet some structures in the area which could be tested. Because the sands penetrated depend upon porosity as well as structure for their productivity, good structures may yield poor results due to a lack of porosity. It is recommended that any future tests should be made on the basis of geology but it should be recognized that lack of porosity may make even the most promising structure unproductive.

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VITA

Wallace Woodrow Hagan was born at Griggsville, Illinois, on February 3, 1913. After being graduated from Urbana High School, Urbana, Illinois, he attended the University of Illinois where he received the degrees of Bachelor of Science in Geology with High Honors in the year 1935, and Master of Science in Geology in 1936. He was awarded a University of Illinois scholarship for graduate study in the school years 1935-1936, and fellowships for the years 1936-1937 and 1940-1941. In the summer of 1935 he was Student Geological Technician for Mesa Verde National Park, Colorado. He was an assistant to Dr. Harold R. Wanless under a Geological Society of America grant in the summer of 1936.

From September, 1937 to June, 1939 he was assistant to the chief geologist of the J. V. Wicklund Development Company of Detroit, Michigan. He was a consulting petroleum geologist from June, 1939 to September, 1940.

He is a member of Sigma Xi, Phi Kappa Phi, Phi Beta Kappa, American Association for the Advancement of Science, Paleontological Society, and Associate Member of the American Association of Petroleum Geologists.

He is a co-author with A. H. Sutton, Department of Geology, University of Illinois, of "Inadunate Crinoids of the Mississippian-Zeacrinus" Journal of Paleontology, vol. 13, no. 1, pp. 82-96, 1939.

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

STATE OF KENTUCKY
REPRESENTED BY THE
DEPARTMENT OF MINES AND MINERALS

KENTUCKY
CUB RUN QUADRANGLE

Topography by C.W. Goodlove, W.R. Chenoweth,
S.E. Clement, and H.L. Turner.
Surveyed in 1922-1924.

APPROXIMATE MEAN DECLINATION 1925

Scale $\frac{1}{62500}$

1 ½ 0 1 2 3 4 Miles

5000 0 5000 10000 15000 20000 Feet

1 ½ 0 1 2 3 4 5 Kilometers

Contour interval 20 feet
Datum is mean sea level

Map of Mammoth Cave National Park, scale 1:31,680, contour interval 10 feet, from a later and more detailed survey, is available

Polyconic projection
5000 yard grid based upon U.S. zone system C

ROUTES USUALLY TRAVELED
HARD IMPERVIOUS SURFACES
OTHER SURFACE IMPROVEMENTS
1941
U. S. ROUTE
STATE ROUTE

CUB RUN, KY.
Edition of 1925
reprinted 1941

STRUCTURAL GEOLOGY

KENTUCKY
CUB RUN QUADRANGLE

LEGEND

STRUCTURAL DATA

KNOWN FAULTS

PROBABLE FAULTS

DOWN THROWN SIDE OF FAULTS
D

UPHEAVED SIDE OF FAULTS
U

AMOUNT OF DISPLACEMENT
D 50' a
U

DIP OF STRATA
25°

STRUCTURE CONTOURS ON BASE OF GOLCONDA LIMESTONE
700

DEPRESSION CONTOURS

STRUCTURE CONTOURS ON TOP OF "PRODUCTUS" INFLATUS LIMESTONE OF PAINT CREEK

PROBABLE CONTOURS

DEPRESSION CONTOURS

ECONOMIC DATA

- DRY HOLE
- DRY HOLE WITH SHOW OF OIL
- DRY HOLE WITH SHOW OF GAS
- DRY HOLE WITH SHOW OF OIL AND GAS
- ABANDONED OIL WELL
- ABANDONED OIL WELL WITH SHOW OF GAS
- GAS WELL
- T.D. 1000' TOTAL DEPTH OF WELL

CROSS HATCHED AREA CONTOURED ON TOP OF "PRODUCTUS" INFLATUS LIMESTONE OF PAINT CREEK IS. OTHERS ON BASE OF GOLCONDA LIMESTONE

SCALE 1/62500

0 1 2 3 4 Miles

CONTOUR INTERVAL 20'

GEOLOGY BY WALLACE W. HAGAN
OCT. 1940 - NOV. 1941

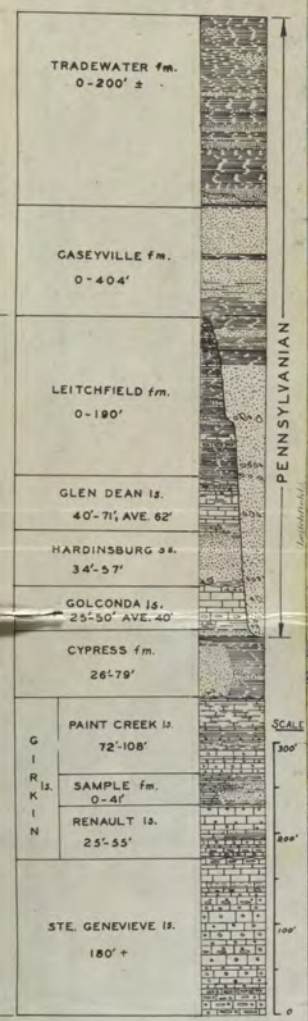
AREAL GEOLOGY

DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

KENTUCKY GEOLOGICAL SURVEY
WILLARD ROUSE JILLSON
DIRECTOR AND STATE GEOLOGIST

KENTUCKY
CUMBERLAND QUADRANGLE

GENERALIZED STRATIGRAPHIC SECTION



GEOLOGICAL LEGEND

PENNSYLVANIAN

POTTSVILLE SERIES

Pp — TRADEWATER fm.
CASEYVILLE fm.

UNCONFORMITY

MISSISSIPPIAN

CHESTER SERIES

ELVIRA GROUP

Ml — LEITCHFIELD fm.

HOMBERG GROUP

Mgd — GLEN DEAN ls.
Mh — HARDINSBURG ss.

DISCONFORMITY

Mg — GOLCONDA ls.
Mc — CYPRESS fm.

DISCONFORMITY

NEW DESIGN GROUP

Mpc — PAINT CREEK ls.
Ms — SAMPLE fm.
Mgr — GIRKIN ls.
Mr — RENAULT ls.

UNCONFORMITY

VALMEYER SERIES

MERAMEC GROUP

Msg — Ste. GENEVIEVE ls.

Geology by Wallace W. Hagan
Oct. 1940 - Nov. 1941