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THE GEOLOGY OF HENDERSON COUNTY, KENTUCKY.

A dissertation submitted in partial
fulfillment of the requirements of the degree of

Doctor of Philosophy

to the Graduate School of the

University of Cincinnati

1929

by

Charles Vernon Theis

C. E., University of Cincinnati, 1922.

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LIST OF ILLUSTRATIONS

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CHAPTER I

GEOGRAPHY

LOCATION

Latitude and Longitude. Henderson County, the region covered by this report, is an irregular area included between the meridians 86° 30' and 87° 55' west longitude, and between the parallels 37° 35' and 38° 00' north latitude.

Boundaries. It is bounded on the north by the "north shore" of the Ohio River, which separates it from Vanderburg and Posey Counties, Indiana. All of the islands of the Ohio River on the north side of the county are included in it, as is also Green River "Island", which is now an island only at high water, and lies to the north of the low water course of the Ohio. On the west it abuts Union County and on the south, Webster County. Green River forms most of its eastern boundary, beyond which, in the latitude of Henderson, lie Daviess County to the northeast and McLean County to the southeast.

Relative Location. The Wabash River, forming the boundary line between Indiana and Illinois, joins the Ohio a few miles west of the western boundary of the county. Henderson, the county seat, lies ten miles south of Evansville, Indiana, and not quite half way between Louisville and St. Louis. The area is in the north-western quarter of the Western Kentucky Coal Field. These features are shown on the sketch map, Figure I, p. 1A.

CULTURE

Population

The county has a population of 27,609, of which the greater part is rural, while some 12,169 persons live in Henderson, the one city (census of 1920). In addition to this one city, there

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are several villages, numbering up to several hundred inhabitants. These are scattered around the outskirts of the county and include, travelling clockwise from Henderson, Spottsville, Bluff City, Hebbardsville, Robard, Corydon and Smith Mills. One large village, Zion, lies in the interior of the county. These villages are all primarily country villages, with mines at Robard and until lately in Corydon, giving a touch of industrial life. Henderson, however, has rather varied industries because of its happy situation, immediately on the shores of the Ohio yet entirely floodless. The industries and other features of Henderson are treated below.

Occupations

Agriculture. The chief occupation in Henderson County is agriculture. There are many types of soil and of topography, to be discussed later, giving rise to a variety of farm products, but by far the most important are corn and tobacco. About 70,000 acres of corn are grown per year at an average value of twenty dollars per acre. In 1924, some 10,000 acres of tobacco were raised at an average price of sixty dollars an acre. The tobacco acreage is being decreased so that now there are perhaps only 8,000 acres in tobacco.* Some stock is raised- cattle and hogs, in the level or gently rolling country around Henderson, and fewer sheep in the rougher areas between Hebbardsville and Robards. In the last decade horticulture has risen in importance until now successful commercial orchards of apples and peaches are found on the higher portions of the gently rolling part of the county.

*Statements of Donald Martin, former county agent of Henderson Co.

Mining. Next to agriculture, mining is by far the most important industry. The mines in Henderson alone have a payroll probably greater than all other industries in the county.

There are four large railroad shipping mines in the county:

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the Southland Coal Company, operating two shafts at Henderson, the Pittsburg Coal Company at Baskett, the Panama Coal Company at Robards, and one at Jennings Switch. In addition there is the Cash Creek Coal Company at Riv 'side, four miles west of Curdsville, shipping via Green River. The L. H. & W. Coal Company has just opened a shaft at Lee's Switch. Many well equipped wagon mines cover the county, there being eight in operation at the present time.

The drop in the price of coal, poor methods of mining, and insufficient capital have caused the abandonment of numerous shafts. There are nine or ten such shafts in the county which have been abandoned within the last ten years. Some of these are waiting until the price of coal rises, while others have been entirely ruined by mismanagement.

All the coal mined commercially now or formerly within the county comes from the No. 9 seam, with the exception of that mined at Smith Mills and that at Corydon, which comes from a higher seam correlating with the No. 14 coal of Webster County. No. 9 coal lies within working distance of the surface throughout the county, and is probably present everywhere within it except under some of the alluvial flats of the eastern part, where it has been eroded, and in a restricted area near Wilson Station, where it probably was never deposited.

Other Industries. The other industries of the county are all concentrated in Henderson. The most important of these is the cotton textile, using about 8,000 bales of cotton per year.

Henderson is the chief market for dark tobacco, inasmuch as so much of it is raised in the close vicinity. Something like thirteen million pounds are handled per year. As an outgrowth of

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the usual tobacco trade, one of the few nicotine plants of the country is established here.

A meat packing plant handling some five million pounds per year is partly the result of the number of hogs raised in the county, while a canning and pickling plant is fed here by the garden produce, chiefly tomatoes, of the surrounding region.

Transportation

Rivers. The Ohio River furnishes sixty-one miles of waterway to Henderson County, while Green River flows for forty miles along the eastern border. Both are navigable throughout the year.

The Ohio River is kept at a 9-foot pool stage by the series of dams lately erected by the War Department. Two of these dams, No. 47 opposite Newburg, Indiana, and No. 48, about six miles below Henderson, are in the county, while No. 49 is only a few miles below the western county line.

Green River requires much less engineering skill to be made continually navigable than does the Ohio. It is a very deep river and the two lower dams in it are some sixty miles apart. One dam is located within the county, that at Spottsville, some eight miles above the mouth of the river. Green River furnishes an excellent ice harbor for river craft, never having been known to carry an inconvenient amount of ice.

At present, neither of these streams is being used to any extent for produce from this county. No large shipments are made on the Ohio and only two mines are at present shipping via Green River. During the World War, Green River was lined throughout its portion contiguous to this county with coal mines using it for an outlet. Seven mines were in operation at that time.

Railroads. Henderson County is well equipped with railroads

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because the Henderson railroad bridge furnishes one of the few crossings of the Ohio below Louisville and because its gentle topography makes railroad location easy. Practically the only railroad cut in the county is the ten or fifteen foot cut of the L. H. & St. L. near Spottsville. Radiating out from Henderson are three lines: the Illinois Central running southwesterly through Corydon, the Louisville, Henderson and St. Louis running easterly through Spottsville, and the Louisville and Nashville, coursing southerly through Robards. To the north, Henderson is furnished an outlet through Evansville, Indiana, by the L. & N., I. C., and by the Evansville Electric.

Highways. Two national highways are routed through Henderson County, the "Dixie-B Line", coming through Evansville and running southerly to leave the county at Poole, and the Ohio River Route, from Owensboro, through Spottsville, Henderson and Corydon to Morganfield, Union County and beyond. Besides these two national highways, there are other better class highways radiating from Henderson like the spokes of a wheel, one bearing south of east to Hebbardsville and beyond, two running southeast, one to Robards and one west to Smith Mills.

These roads are all gravelled roads, wide and with easy grades. Outside of Henderson there is not a mile of permanent hard surface in the county. However, the gravel, when well drained and constantly tended, gives a very good riding surface. The county has just embarked on a large road building program and a few years will no doubt see great improvement in these main arteries.

Branching off from the main arteries is the checker-work of dirt roads, removed from each other in both directions in the upland portion of the county by distances generally of about a

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mile or a mile and a half. In the rougher eastern portion of the county these roads tend to follow ridges but do not do so consistently. Throughout the remainder of the county, the roads follow property lines in general, without regard to topography, and are the relics of horse-and-buggy days. Generally cut in the loose, loess-like dirt that blankets the uplands, they wash very badly, especially on the grades, and make automobile traffic precarious in places. The continual and rapid wearing and washing of the road, accentuated by the necessary continual grading, is sharply pointed out by such sights as old gate steps standing two feet or more above the present road, and by the ten or fifteen foot chasm-like road cuts (all unconsolidated material), seen in the western part of the county.

CLIMATE

Available reports on Henderson County are not many, but there are considerable data on Owensboro, Daviess County, just east of Henderson. Inasmuch as both are river stations, without marked differences in topography, it may be assumed that conditions are sufficiently similar to warrant comparison.

The mean annual temperature recorded at Owensboro, covering a period of 26 years, is 56.8°. The mean maximum for the same period is 66.6°, the mean minimum 47°. The coldest month is January, which has a mean of 34.9° and a mean minimum of 26°. The hottest month is July, with a mean of 77.8° and a mean maximum of 88.3°. Extremes of temperature recorded for this station for the same period are 103° in July and -21° in February.

Prevailing winds are from the south from April to September inclusive, from the southeast during October, and from the northwest during the remaining months. The wind velocity is not recorded

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for either Henderson or Owensboro, but at Evansville, Indiana, just north of Henderson, the record for 25 years shows an average yearly velocity of 8.3 miles per hour. The maximum velocity recorded for this station is 77 miles per hour on August 26, 1916. Average monthly velocity ranges from 10.2 miles per hour during March to 6.2 miles per hour during August.

The precipitation record for Henderson, from 1894 to 1903 and from 1917 to 1922 inclusive, is as follows:

Lowest annual rainfall	34.32 inches	(1918)
Highest annual rainfall	49.73 inches	(1897)
Average annual rainfall	43.22 inches	
Average monthly rainfall- lowest	2.52 inches	(February)
Average monthly rainfall- highest	5.37 inches	(March)

Periods of exceptional rainfall occurred in March, 1897, which shows an average for the month of 11.64 inches, and in June, 1900, with an average for the month of 11.01 inches. Periods of exceptional drought occurred in February, 1895 and in September, 1897, both of which show an average for the month of 0.08 inches.

The record for Owensboro for the period of 26 years shows an annual average of 104 days with 0.01 inch or more of precipitation. Monthly averages range from 11 days during the months of March, April and May to 6 days in October. The average annual snowfall is 11.3 inches.

The frost data recorded for Henderson from 1894 to 1902 show the length of the growing season varying from 159 days in 1895 to 221 days in 1894, with an average for the nine years of 198 days. Other data are as follows:

Earliest date of first killing frost	September 30	(1899)
Latest date of first killing frost	November 11	(1897)
Latest date of last killing frost	May 14	(1895)
Earliest date of last killing frost	March 30	(1894)

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The frost data for Owensboro for the period from 1896 to 1922 are a follows:

Average date of first killing frost	October 23
Average date of last killing frost	April 12
Average length of growing season	194 days
Latest date of killing frost in Spring	May 2
Earliest date of killing frost in Fall	September 30

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CHAPTER II

TOPOGRAPHY

INTRODUCTION

Under the title "Topography", the surface of the county will be discussed; its altitude, its shape, its drainage and other features that can be seen on a topographic, as contrasted with a geologic, map. In this chapter certain processes causing some of the features will be indicated; but a full account of the development of the topographic surface will be postponed to Chapter VI, after a discussion of the materials underlying this surface.

Technically, the county may be described physiographically as a region peneplained and now standing at an elevation of 560 to 580 feet; eroded to early old age by streams flowing at an elevation of 300 feet or less; alluviated to an elevation of 390 feet, approximately, with present streams developing broad flood-plains about 20 feet lower, and the whole upland covered and bed rock features generally obscured and over large areas concealed by a deposit of wind blown, fine sand and loess, forming modified dunes near the river and mantling the uplands. This concise statement will now be elaborated.

DRAINAGE

General Plan of Drainage

All drainage of the county is, as one would expect, eventually to the Ohio, via a multitude of sloughs in the flood-plain and three main streams in the uplands. These three streams are Highland Creek, entering the Ohio at Uniontown, (Union County), draining perhaps the southwestern fifth but forming in large part the western boundary of Henderson County; Canoe Creek, joining the Ohio just below the city of Henderson and draining approxi-

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mately the central two-fifths of the uplands; and Green River, with its mouth seven miles northeast of Henderson, although twenty miles by river above that town, and carrying the run-off of the eastern two-fifths of the uplands. The two former are meandering, tortuous creeks intrenched in broad flood-plains and falling some six inches to the mile. Green River is a deep, generally placid stream falling, in the lower 60 miles of its course, at an average rate of about 4.5 inches per mile.

The Ohio River

The Ohio River flows for about sixty-one miles along the northern border of the county, although the air line distance is only about thirty-three miles. Its characteristics may be studied from the chart, Fig. 8. In this distance its low water fall was, before the introduction of the government dams, 18.2 feet, an average fall of a little over 3½ inches per mile. The gradient is not regular. In a distance of six miles, from the Daviess County line to the location of the Newburg Dam, (No. 47) it falls about 3½ feet, an average of seven inches to the mile; for the next fourteen miles, to just above the bend at Evansville, it falls only 2½ feet, averaging two and one-eighth inches per mile; in the mile and a half at the bend it drops over a foot, and then to Henderson Bridge, a distance of eleven and a half miles, drops 1.2 feet, an average of 1¼ inches per mile, after which it descends fairly uniformly in a distance of twenty-eight miles to the Union County line, at an average rate of 4.3 inches per mile, or a total of ten feet.

The channel bottom is very irregular, ranging, previous to the construction of the dams, from a low water depth of about three feet, two miles below Henderson, to 34 feet just above the Union County line. 33 feet at West Franklin and 36 feet just below

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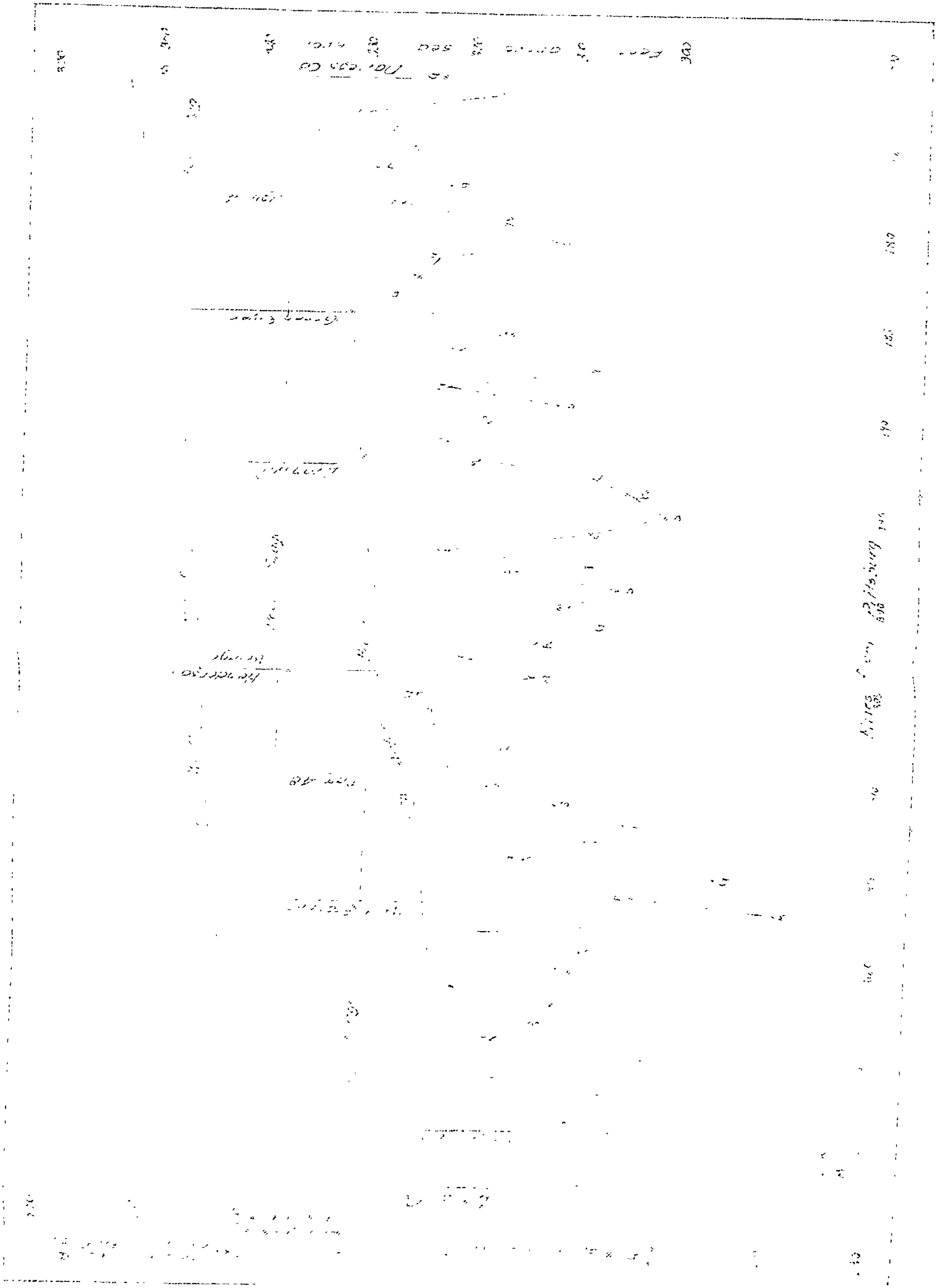

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ig. 3. Characteristics of the Ohio River in Henderson County.

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Evansville. These deep holes have different causes. That below Evansville seems to be the result of a rock bar at Howell, the down-river portion of Evansville, which deflects the river and by narrowing the channel, increases the current. This rock bar is also the cause of the peculiar and uncommon reentrant of the river at this place, at what should be the apex of the meander. The deep portion at West Franklin is the result of the concentration of the current at the outside of a sharp reversal in the meanders; and that below Mt. Vernon (Indiana) has the same origin.

It will be seen from the chart that the bed of the river is made up of all possible types of material. The unconsolidated material ranges from mud through sand to gravel, while solid rock is not uncommon in its channel and occurs even more frequently near the shore. The solid rock is uncovered only at the outer curves of the meanders. The reason for this seems to be that here the river encroaches upon a rock shelf, which, it is believed, is present in the river valley throughout the county at an elevation of about 300 feet A. T.

TOPOGRAPHIC TYPES

Henderson County may be divided for purposes of topographic description into five sections: the flood-plains of the Ohio and Green Rivers, the alluvial terraces of these two rivers, the Smith Mills dune section, the Canoe Creek plain, and the Green River section. Boundary lines between these sections are hard to draw, because one type of topography merges into another. The flood-plain and terrace sections are continued up all the creeks far within the other sections. Perhaps one half the county lies at or below the level of the terrace. The modified dunes of the Smith Mills section grade insensibly into the loess-covered low

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hills of the Canoe Creek Section. The rough topography of the Green River Section becomes more gentle going westward, so that the westernmost portion of this section is like in character to the easternmost portion of the Canoe Creek territory. Despite, however, these transitional phases, these sections remain, as types, different in aspect and in origin.

The Flood-plain

Description. The flood-plain section of the county will be defined as that portion which is at present subject to annual floods. It includes approximately one fourth of the county. On Green River there is very little of this flood-plain developed. There is a strip near Cash Creek and a strip one-half to one mile wide from Curdsville to the point where the county line departs from the river. The area between Green River and the Ohio belongs almost entirely to this division, although there are included patches of the terrace somewhat reduced in elevation. The next large portion and the most typically developed part of the flood plain is that included in the narrow peninsula of Kentucky, running from just above Henderson to Evansville (Indiana), and its associated portion north of the river, Green River Island (Ky.) In the western part of the county, that portion known as "Coon Country" and bounded by the Ohio River and Pond Creek, comprises the largest unit of this topographic division.

This flood-plain has an elevation of 370 to 375 feet at the natural levees, where it enters the county; near Henderson the corresponding elevations are from 365 to 370 feet and where the river leaves the county, the elevations are from 355 to 360 feet. The flood-plain has therefore approximately the same slope as the river in high water.

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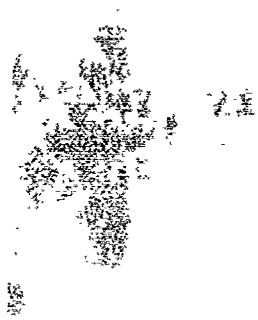

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The drainage of the plain is all away from the river because of the natural levees which everywhere rim the riverward part of it. This gives rise to some surprising examples of drainage such as that at the mounds near Dam 48, where run-off originating within 500 feet of the river pursues its course by way of Pond and Highland Creeks for some twenty miles before entering the river. In a few places such as the peninsula of Kentucky, opposite Evansville, the sloughs run directly into the river, but over the larger portion of the plain they are tributary to permanent or intermittent streams which run along the innermost part of the plain at the foot of the scarps of the uplands. The surface is monotonous in the extreme; the eye does not discern the low, elongated swells and depressions which rise or fall at the rate of about five or ten feet per mile, and deeper sloughs lie only ten or fifteen feet below the neighboring country.

Processes at work on flood plain. The quantity and size of material which a stream can carry varies with its velocity. When, therefore, a stream overflows its banks and covers a large area with its muddy waters, the silt particles rapidly settle out of the comparatively quiet slack water and cover the area with an alluvial coating. Near the channel the rushing waters of the main stream come in contact with the backwater. Along this zone where the velocity is first checked, more material is dropped than in any other equal area in the flooded district and so a low ridge, or natural levee, is built here. The material in the remainder of the flooded district is so distributed that the resulting built-up surface slopes gently back from this levee.

As the riverward portion of the flood-plain is kept continually higher than the rest of the flood-plain, the drainage in

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low-water seasons naturally flows backward to the bluffs and any streams running longitudinally on this plain are pushed back against the bluff. One of the most note-worthy examples of this is Pond Creek, previously mentioned. This stream starts near Dam 48 (50,41) and flows westward, northward, then south-westward, skirting the terraces and bluffs for some twelve miles.

The drainage into these master streams is by means of shallow troughs, or sloughs. These sloughs may apparently originate in two ways, one constructional, the other destructional.

When a river flows over a broad flood-plain, it continues to increase the width of its meanders by undercutting the outside of the curve, where the current is concentrated, and the filling up of the inside of the curve, where the current is comparatively slight. Under ideal conditions the river would probably cut uniformly into the banks at the outside of the curve and uniformly deposit on the inside, leaving a perfectly flat flood-plain behind it.

However, this simple process is complicated by the imposition upon it of factors making for non-uniform action. These factors may be the inequalities in resistance to wear of the bed of the stream, which may be of bed-rock, gravel, sand, or silt; conflicting currents at the mouths of tributaries; or accumulations of unconsolidated material, such as sand dunes, near the bank of the stream, which furnish additional material to be undercut into the stream at some points. In addition, it is the habit of a stream to swing its current from one side to the other, producing bars more or less alternately on opposite sides of the channel, with "cross-overs" of the current between them. Whatever be the cause, it is evident that the habit of heavily loaded streams

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is to form bars and islands in its bed.

It seems that in the bars and islands in the river in Henderson County, we can see different stages in the formation of a slough. In Figure 5, there are given three examples which may illustrate steps in this process.

In part "A" of this figure, there is reproduced a map of Diamond Island, about 15 miles below Henderson. The current of the river is now to the south of Diamond Island, and a sand bar is being built out from the north side of the island. If the present process continues, Diamond Island will in time be connected with the north bank of the river by this sand bar. It will then have the appearance of the island and bar figured in part "B".

Part "B" represents a bar forming on the Kentucky shore just above Mt. Vernon, Indiana. It seems probable that, with the extension of the meander at this point, the bar will continue to grow until finally it is a part of the Kentucky mainland. Should this occur, the new land will have the appearance of the politically famous Green River "Island".

Green River "Island" is shown in part "C" of the figure. It lies just above Evansville, Indiana, is separated from the Indiana mainland only by a slough, but is politically a part of Kentucky. At the time of a suit for its possession between the two states, geological and hearsay evidence was given little weight. However, it was shown that in the early days of settlement both Indiana and Kentucky considered it a part of Kentucky under the definition of the Indiana-Kentucky boundary as the north shore of the Ohio. A copy of the map of the original Henderson Grant, pre-

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served in the courthouse at Henderson, shows this land as a true island. Two rare old small-scale maps* in the offices of the Kentucky Geological Survey also show this as an island. It seems probable that in the last 150 years this land has first been united at low water with the north shore of the Ohio and so furnishes the final example of the constructional formation of a slough.

Examples of such sloughs seem to be found preeminently within the big bend of the Ohio opposite Henderson, in Indiana. Here the sloughs run straight across at the neck of the meander and become more and more curved as the present channel of the Ohio is approached, suggesting that they represent old courses of the river in the progressive extension of its meander. Other such sloughs are apparently those across the bend of the river just above Diamond Island, in Kentucky.

It would seem, however, that not all the sloughs are developed in this manner. Some seem to be true consequent streams developed on the original slope of the flood-plain, through the usual forces of erosion.

The clearest examples of this type of slough are found in the drainage of that portion of the flood-plain near and extending into Union County, on the Uniontown topographic sheet. Here Powell Lake and Grassy Pond, bayous trending north-south, occupy the center of the flood-plain inside the meander at this point. Sloughs branch back from these bayous on both sides, giving the drainage a centipede shape. It seems evident that these represent true consequent streams following the slope of

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*(1) "Map of the State of Kentucky, from Actual Survey, by Elihu Barker of Philadelphia", published by J. Debrell (?), London, 1795. (2) "Map of the State of Kentucky, with the Adjoining Territories, by J. Russell, 1794", published by H. D. Symonds, London, 1794.

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the flood plain from the natural levees on both sides to the low sag in the center, and then following this sag downstream with the general fall of the flood-plain.

Terrace section

Two alluvial terraces skirt the flood-plain in several portions of the county.

The upper terrace. The upper terrace is best developed in this county in a strip a little over a mile wide, extending from Henderson westward through Geneva almost to Smith Mills. Another small area is preserved above Atkinson Park at Henderson. On Green River this terrace is well seen about Bluff City. On the Indiana side of the river it is preserved in the broad lowland between Evansville and Newburg, and in a wide stretch extending from Mt. Vernon some eight miles east.

This surface has apparently a slightly greater fall than the river. It is about 395 feet above sea level at Bluff City, about 390 feet at Henderson, and a little over 380 feet above the sea near Mt. Vernon.

This terrace runs an indeterminate distance up the creeks. It generally merges in a gentle curve with the upland areas due to wash of the loess from the uplands. It merges with the flood-plains of the creeks by an actual decrease in altitude; that is, the terrace slope as continued up the creeks is backward and away from the river.

This terrace is drained by meandering intermittent or permanent streams. In the sections preserved on the Kentucky side, the streams are pushed back against the bounding bluffs, like the streams on the flood-plain, as well shown on the strip around Geneva and near Bluff City. In the wider stretches in

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Indiana the streams pursue more irregular courses.

The topography of this terrace away from its edge is even more monotonous than that of the flood plain. The ridge-like swells and sags do not occur here, and the eye discerns nothing but a flat plain. Near the edge of the terrace there are in some places low ridges of sand and silt, and at Henderson and near Dam 48 there are accumulations of fine sand and loess rising some 75 feet above the level of the terrace.

The lower terrace. The lower terrace forms the second bottoms of the western part of the county, from Smith Mills southwestward. This land is overflowed, but only at periods of extreme high water. It has an elevation of about 370 feet above sea level whereas the flood plain of this section has an elevation of not quite 360 feet above sea level. East of Mt. Vernon, in Indiana, another portion of this terrace is preserved. It lies here between the flood-plain of the river and the portion of the upper terrace previously described.

This lower terrace has many of the characteristics of the upper. In the broad area preserved in Indiana some of the streams are displaced against the bluffs and others are not. The surface of this terrace, like that of the upper, is much flatter than that of the present flood-plain.

Smith Mills Dune Section

That upland portion of the county encircling Smith Mills (48-45)[1], extending south to Highland Creek and east to just beyond

1. For the purpose of ready reference, the area discussed is considered to be cut into sections by lines of latitude and longitude at intervals of one minute. The first reference number given refers to the minutes of latitude in excess of 37°, and the second to minutes of longitude in excess of 87°. The point to be located lies near the intersection of these two lines.

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the meridian 87° 45', will be designated the Smith Mills dune section. Here we find thick accumulations of unconsolidated sediments as revealed in bluffs and in wells. The portion from Smith Mills north is very much dissected; deep washes occur in the tilled lands but solid rock is never exposed. The region south and west of Smith Mills is lower and more gently rolling.

In the bluffs forming the northern edge of this section, the Madisonville limestone occurs in its maximum development in the county. As a result of this thickness of limestone underlying the porous materials above it, the only sinkhole in the county has developed here. The water seeping through the loess above has found an outlet along the cracks in the limestone, and enlarged these cracks by dissolving portions of the rock until now a large stream issues from the "Rock Spring" at the base of the bluff. The underground drainage has in the course of time carried away a portion of the overlying loess until now a depression or sinkhole occurs there.

The eastern boundary of the section has been set arbitrarily. The topography in the section is considered essentially due to the accumulation of wind blown dust and sand; that to the east is considered essentially due to the erosion of the underlying bed rock which was later simply mantled or blanketed with loess. With a gradual decrease in the amount of wind blown material, the latter type becomes more prominent, but there is no sharp transition from one type to another.

(Henderson) Canoe Creek Plain

The drainage area of Canoe Creek and of Highland Creek within the confines of this county and excluding the Smith Mills section just considered, forms a natural topographic unit. This

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is the topographic type to which Dr. Glenn in his publication on Webster County*, refers as the Henderson Plain. Inasmuch as

*Glenn, L. C., Geology & Coals of Webster Co.- Kentucky Geological Survey, Series VI, vol. 5, 1922.

Henderson is located on a different type of topography, it is thought better to dispense in the report with that name for this section. By naming it Canoe Creek, we designate the chief area in which it is developed.

This area is one of low ridges covered by loess in decreasing thickness from north and west to southeast, and of wide alluviated valleys. Bed rock is seldom seen and when it is seen, occurs in exposures from one to five feet in height, where a creek happens to be cutting against bed rock or where a resistant ledge is high in the hills, as the Madisonville limestone in the hills northeast of Poole, or where such a ledge is washed clean in the road bed, as a few exposures of the coarse basal sandstone of the Lisman formation. The drainage is of dendritic, or irregularly branching, type. The country is gently rolling, with a total relief of 200 feet and a local relief, excepting in the Poole hills and a few other isolated hills, of 100 feet. Such isolated hills are found in the Graham Hills section (50-31), rising to 540 feet elevation; a few hills (42-30) near Robards rising to 560 feet and in the Poole hills previously mentioned, rising to 560 feet. These last two localities are on the divide between the Green River and Canoe Creek drainage.

Green River Section

The Green River section is defined as that territory drained by Green River and including also the range of hills along the Ohio for two or three miles below the mouth of Green River.

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While this territory is not everywhere rough, it is as a whole much rougher than the Canoe Creek section, because of the greater dissection due to its proximity to Green River and to the presence above drainage of the resistant Anvil Rock sandstone through most of the area. The total relief is the same as that of the Canoe Creek section but the local relief, while comparable in the western part to that of the Canoe Creek section, in the eastern part near Green River amounts to the full 200 feet. Filled valleys are as prominent in this section as in the preceding.

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CHAPTER III

S T R A T I G R A P H Y

INTRODUCTION

The bedded rocks of the earth's crust are divided by geologists into certain standard groups, named commonly after a locality in which the group was first studied and which has been taken as the type locality for it. For the convenience of the general reader the groups of rocks which are considered in this report are named below, beginning with the highest, and therefore the youngest, ones.

Cenozoic Rocks	
Recent System	Mud deposited on flood plain.
Pleistocene System ("Glacial Age")	Silt and sand of terrace and loess covering hard rock of county.
Tertiary System	
Pliocene Series	Hill top gravels.
Miocene Series	Not represented in this area.
Oligocene Series	Not represented in this area.
Eocene Series	Not represented in this area.
Mesozoic Rocks	Not represented in this area.
Paleozoic Rocks	
Permian System	Not represented in this area.
Pennsylvanian System	Coal bearing rocks of county.
Lisman Formation	
Carbondale Formation	
Tradewater Formation	
Caseyville Formation	
Mississippian System	
Chester Series	Probably strata at bottom of oil tests in eastern part of county.

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MISSISSIPPIAN SERIES

The strata of the Mississippian series do not outcrop in this county. They are included in this discussion only because of their interest in connection with oil and gas prospecting.

The nearest outcrops of the Mississippian strata lie some 35 miles to the west of this area and some 55 miles to the south and east. The only wells in this county which have entered this series are the Gregory well at locality 36 (50,26)*, near Spotts-

*The locality numbers refer to numbers on the map of the county. For meaning of numbers in parentheses, see footnote, page 18. The well records are tabulated in Chapter VIII, and are given graphically in Plates 1 and 2, inserted at back of this volume.

ville, the Rolland well at locality 41 (46,21), near Hebbardsville, and the Fred Williams well at locality 41 (47,28), near Zion, and perhaps the diamond drilled coal test at the Southland mine in Henderson (locality 20).

A comparison of sections in the Mississippian bordering the coal field in Kentucky* and in Illinois** and Indiana***

*Butts, Chas., The Mississippian series of western Kentucky, Ky. Geological Survey, Series VI, Vol. 7, 1922.

**(1) Butts, Chas. Geology of the Equality-Shawneetown area, Ill. Geol. Survey, Bull. 47, 1925.
(2) Weller, Sturat, Geology of Hardin County, Ill. Geol. Survey, Bull. 41, 1920.

***Malott, Clyde A., The upper Chester of Indiana, Proceedings, Indiana Academy of Science, Vol. 34, 1924; p. 103.

shows that the upper Chester consists largely of shales and limestones, that the members are variable, but that some limestone occurs in all the sections in the upper 200 feet. The limestone apparently decreases in amount from west to east.

A well in McLean County*, about 15 miles southeast of

*Jillson, W. R., Oil field stratigraphy of Kentucky, Ky. Geol. Survey, Series VI, Vol. 3, 1922; p. 504.

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Robard, shows the upper 150 feet of Mississippian to be about half limestone, and the top of the Mississippian to be about 1420 feet below Coal No. 9. A well at New Haven, Ill., about 30 miles west of Henderson, shows the upper 150 feet of Mississippian there to be about half limestone, and the top to be about 1000 feet below Coal No. 9.

Going northward the Chester formations drop out and in central Indiana the basal Pottsville rests upon the St. Genevieve group, the Chester being entirely non-existent.* In the wells

*Logan, W. N., Handbook of Indiana Geology, Indiana Dept. of Conservation, Publication No. 21; p. 528; 1922.

drilled for oil in the southwestern corner of Indiana the records are confusing, either due to a change in character of the Chester sediments or to poor interpretation of the cuttings by the driller.

In this county the only data available are furnished by the four wells mentioned above. The three oil wells in the eastern part of the county surely entered the Mississippian but their records cannot be made to harmonize with each other nor with the diamond drilling at Henderson. So little confidence can be placed in the accuracy of these three oil records that an attempt to draw even tentative conclusions from them can only be made on the basis of a study of the Henderson well record (locality 20).

This well penetrated to a depth of 1282 feet below No. 9 coal. At a depth of 896 feet below this coal there begins a 146-foot sandstone, succeeded by 125 feet of predominantly shaly strata, and this, in turn, by 115 feet of sandstone. The stratigraphic correlation of these last two groups raised the question of the Mississippian-Pennsylvanian contact.

It is possible that the base of the 146-foot sandstone

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marks the base of the Pennsylvanian and that the remaining 240 feet represent Chester strata. Such a correlation would make these strata probably equivalent to the Buffalo Wallow group of shales underlain by the Tar Springs sandstone, as shown where these strata come to the surface 50 miles east, or to the shaly group of upper Chester with the underlying Palestine sandstone found in outcrop an equal distance to the west.

The obvious objection to this interpretation is that it means that in 240 feet of upper Chester strata, there is not present a foot of limestone, whereas in every obtainable section surrounding this territory, some lime is found in these strata, and in many of them, as in the Equality, Illinois, section and in the New Haven record, it forms the preponderant part. In accepting this interpretation, one is forced to the conclusion that the sediments in this area in upper Chester time were coarser than anywhere else in the three states, so far as known.

To interpret the entire Southland well as Pennsylvanian means that at least 1300 feet of Pennsylvanian strata lie beneath Coal No. 9. This thickness equals that of the section in the Webster County syncline* and is 250 feet greater than that found in the New Haven well. It is some 600 to 800 feet greater than that found in Indiana wells a few miles north, as interpreted by the Indiana Geological Survey. We shall see later, however, that this interpretation is probably in error (page 74). A thickness of 1300 feet of Pennsylvanian strata below Coal No. 9 also means that the Caseyville (basal Pottsville) would be about 600 feet thick at this point, that is, it would be as much as 100 feet thicker at this point than it is in the center of the Webster County syncline,

*L. C. Glenn, Op. Cit., General section.

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where the strata would be expected to reach their maximum thickness.

However, at Sebree Springs, between the center of the Webster County syncline and the Henderson well, some 20 miles from the latter, a thickness of 575 feet of Caseyville was recorded.*

*L. C. Glenn, Op. Cit.; p. 170

This agrees well with the thickness observed in the Henderson record and favors the view that the Caseyville here is actually thicker than expected. Unfortunately, there is again a possibility of an error in the interpretation of the Sebree Springs well because of the faulting near this point.

On the whole, we may say that the interpretation of all of the 1300 feet of strata below No. 9 as Pennsylvanian is entirely possible. In the McLean County well, also on the same side of the Webster County syncline, though nearer, an even greater thickness of Pennsylvanian below Coal No. 9, namely about 1420 feet, was recorded. We may well accept, for the present, this interpretation as the more probable.

The three oil prospects in the eastern part of the county are, as mentioned before, almost valueless in fixing the lower limit of the Pennsylvanian. It is certain that many of the "limestones", especially in the Gregory well (locality 39), are sandstones. The top of the Mississippian is placed in this well at a depth of 1240 feet on the basis that the 120 feet of sandy sediments above this are the only possible representative of the Caseyville in the log. This gives a thickness of 1160 feet of Pennsylvanian below Coal No. 9. In the Williams well (locality 36), it is placed at 1330 feet on the basis of the sands and sandy limes(?) above this depth, and in order to give a thickness of the Pennsylvanian

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in agreement with that in the Gregory well four miles away. This gives a thickness of 1190 feet of Pennsylvanian below Coal No. 9. In the Rolland well (locality 41), it is placed at 1165 feet, 1030 feet below Coal No. 9, at the base of the last of a series of sandstones. The coal show at about 1190 feet is interpreted as being one of the thin Chester coals, known principally from the Tar Springs sandstone. It is impossible to attempt to recognize any other horizons in these wells.

It may be noted that the interpretation here placed on these records makes the thickness of strata between Coal No. 9 and the base of the Pennsylvania 1190 feet in the most western, and 1030 in the most eastern of these three wells. All three lie, in turn, east of the Henderson well. If we accept a thickness of about 1300 feet for the same interval in the Henderson well, a thinning of the Pennsylvanian toward the east is indicated. It should always be remembered, however, that the three eastern records are untrustworthy and that the thinning is not definitely established.

In conclusion it may be said that we know practically nothing about the character of the Mississippian in this section because of the inadequacy of the oil well records.

PENNSYLVANIAN

The Pennsylvanian formations occurring in this county and their correlations with the similar formations of Indiana and Illinois are shown in the following table. The names given for Kentucky are those which will be used in this report, having been adopted by Glenn in his report on Webster County.

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	Illinois*	Kentucky**	Indiana***	Ditney and Patoka quadrangles****
Conemaugh	McLEANSBORO FORM.			
	---	LISMAN FORM.		
	---	---	SHELBURN FORM.	
	---	---	---	
	---	Madisonville Ls.	Somerville Ls.	SOMERVILLE FORM.
	---	---	---	MILLERSBURG FORM.
	Anvil Rock Ss.	Anvil Rock Ss.	Busseron ? Ss.	---
	---	CARBONDALE FORM	---	---
			PETERSBURG FORM.	
		Coal No. 12	Coal No. 7	Millersburg Coal
				PETERSBURG FORM.
	Unnamed Ls.	Providence Ls.	Unnamed Ls.	Unnamed Ls.
Allegheny	CARBONDALE FORM.			
	Herrin-Coal No.6	Coal No. 11		
	---	---	---	---
	Harrisburg - Coal No.5	Coal No. 9	Coal No. 5	Petersburg Coal
		---	---	BRAZIL FORM.
	---	---	STAUNTON FORM.	
			Coal No. 4	
		Sebree Ss.	---	
		TRADEWATER FORM.		

			BRAZIL FORM.	
	Lower Murphysboro-Coal No.2	Coal No. 6	Upper Minshall Coal ?	
Pottsville	POTTSVILLE FORM.	---	---	
	---	---	---	
	Curlew Ss.	Curlew Ss.		
	---	---		
		Coal No. 1A	Lower Block Coal?	
		CASEYVILLE FORM.	MANSFIELD FORM.	
	---	---	---	---

Mississippian Series.

*Cady, G. H., Coal resources of District V, Ill, Geol. Survey, Coal mining investigations, Bull. 19, 1919.

**Glenn, L. C., Geology and Coals of Webster Co., Kentucky Geological Survey, Ser. VI, Vol. 5; 1922

***Logan, W. N., Handbook of Indiana geology, Indiana Dept. Conservation, Publication No. 21, 1922; p. 519 et seq.

****Fuller, M. L., and Clapp, F. G., Geologic Atlas of United States, Patoka folio No. 105 and Ditney folio No. 84, U. S. G. S.

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In this table all stratigraphic intervals larger than a few feet are indicated by lines of dashes. Members in any one column not separated by these dashes may be considered superimposed. Member names are given in lower case, names of formations in UPPER CASE type. When a member name stands immediately below a formation name, that member is defined as the top of the formation; if the name of the member is immediately above a formation name, that member is defined as the base of the overlying formation. Names of members lying on the same line, in different columns are correlative.

It will be seen that similar names are used for different sections of strata and that the limits of the standard major time divisions of the Pennsylvanian are placed at slightly different horizons in the three states. For a controversial discussion of this question, the reader is referred to the publications of Glenn* and Logan**.

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* Glenn, L. C., Op. Cit., p. 51 et seq.
**Logan, W. N., Op. Cit., Chap. V.

Caseyville

The Caseyville formation is defined by Glenn*** as the

***Op. Cit., p. 64

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section of strata extending from the top of the massive conglomerate sandstone a few feet beneath Owen's Coal No. 1A downward to the top of the limestones of the Mississippian.

This formation is not exposed in this county and has been penetrated only in the Smith Mills, the Henderson, and the historic Holloway wells, and the three previously discussed oil wells. These last three wells show large amounts of sandy material in this por-

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tion of their logs but are otherwise of no value in determining the character of the Caseyville. The Smith Mills well (locality 2), which did not reach the base of the Caseyville, gives a thickness of at least 365 feet of this formation. The upper part is described as a coarse sandstone while the lower part shown by this log is an undescribed sandstone. In the center occur sandy shale layers and one 2-inch coal, possibly at the horizon of the Battery Rock coal of the Shawneetown area.

The Henderson well record (locality 20), according to the interpretation given above, shows a thickness of at least 625 feet of sandstones, sandy shales, and blue and dark shales in this formation. This thickness is as great as any known for the Caseyville in the western Kentucky field. The upper boundary is not well defined, but if it is lowered, an abnormal thickness is given to the overlying Tradewater.

In the Holloway boring (locality 25) there are 156 feet of sandstone from the base of Owens No. 1 B coal to the bottom of the hole. This is probably all Caseyville, No. 1 never having been deposited.

The Newman boring at Newman, Daviess County (50,18) reported going through 280 feet of predominantly sandy materials before entering twenty feet of black slate where the record ends. The sandstone, if the record is accurate, represents the Caseyville in whole or part, while the slate may perhaps be Mississippian.

Since the boundaries of the Caseyville in none of the wells noted are definitely fixed, nothing can be said about changes in thickness.

Tradewater Formation

Glenn defines the Tradewater* as extending from the top

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*Op. Cit. p. 70

of the Caseyville upward to the base of a prominent sandstone in Webster County, which he calls the Sebree sandstone. In his general section this is the first thick sandstone above Coal No. 6 (Owen No. 5) and occurs about 75 feet above that coal.

This formation outcrops nowhere in the county, but many wells have penetrated it. It consists predominantly of shales in contrast to the Caseyville, which is predominantly sandstone or conglomerate. Interbedded with these shales is quite a little sand, some limestone and several coals, a few workable.

Its thickness in this section can be determined in only three wells- at Smith Mills, at Henderson and on the Holloway farm. The Smith Mills record (locality 2) gives a thickness of 485 feet for this division of strata, that at Henderson (locality 20) makes it 450 feet and in the Holloway log (locality 25) it is 420 feet. In the latter log, the 182 feet of sandstone coming in shortly above Coal No. 6, the base of which has been taken as the top of the Tradewater, probably would show shaly members of this sandstone if the record were more detailed. This might raise the top of the Tradewater. Taken according to the interpretation given, a slight thickening westward of the Tradewater is indicated, as found by Glenn in the Webster County region.

Members of this formation which may be distinguished over some distance are Coals 1 B of Owen, with a thickness of three and a half feet in the Smith Mills well and of six and a half feet (?) in the Holloway well; Coal 4, found in the Smith Mills, Henderson and Holloway holes; and Coal 6, (Owen 5), found in nearly every well, often four to five feet in thickness. Coal 6 ranks only next

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to number 9 in persistence and continuity. Besides these coals, the sandstone forming the oil sand of the Corydon section should be mentioned. This sandstone, with its top in the neighborhood of 100 feet below coal No. 6, shows in thicknesses of 18 to 40 feet in nearly all the logs.

Another interesting sandstone is that found about 700 feet below coal No. 6 at locality 20 in Henderson. This has all the characteristics of Owen's Curlew sandstone*, the base of which,

*Owen, D. D., Third Report, Ky. Geol. Survey, Vol. III, 1857; p. 23.

according to Glenn**, approximately marks the base of the Allegheny.

**Op. Cit., p. 53.

Carbondale Formation

The Carbondale, according to Glenn***, extends from the

***Op. Cit. p. 81.

base of the Sebree sandstone upward to the base of the Anvil Rock sandstone, or in case that sandstone is absent, to the lowest of a series of marls and limestones that lie close above No. 12 Coal if present, or close below No. 14 Coal if present.

This formation outcrops in the eastern part of the county near Green River practically throughout the course of the river in this county. It is predominantly the coal-bearing formation of this county and for all of the Western Kentucky Coal Field and adjacent parts of Indiana and Illinois, containing coals 9, 11 and 12 in Kentucky and their equivalents, the Springfield and Herrin coals of Illinois and the No. 5 of Indiana. Its character is in general more shaly and calcareous than the lower formations, altho thick lenses of sandstone are indicated in many of the well logs.

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Its base is seen nowhere in the county but its upper limit throughout the eastern part of the county is plainly marked by the base of the coarse, feldspathic, Anvil Rock sandstone. In the western part of the county, as revealed in shafts and well logs, its upper boundary becomes less distinct. Its thickness is irregular, most of the irregularity coming in the upper portion from the top to Coal No. 9. However, it is possible that the lower portion would show like irregularity if there were as much detail known about it. There is an indication of a slight tendency to thicken southwestward, but the irregularities in thickness make it impossible to say that this change is significant.

Several members of this formation show continuity throughout the county. In fact, the strata in the Carbondale are probably more persistent than those of any other of the Pennsylvanian sediments in the three-state coal field.

The lowest of the recognizably continuous strata is the Sebree sandstone which can be identified in nearly all of the wells penetrating it.

Above this, the next persistent guiding bed is Coal No. 7 according to Owen's designation in the Holloway well. It seems to run regularly at an interval of 90 to 120 feet below No. 9. The interval is 100 feet at Henderson (locality 20), 95 feet at Smith Mills (locality 2) and 120 feet in the Corydon region, indicating a thickening to the south. It is sometimes associated with a limestone, as in the Smith Mills well, a characteristic of most of the persistent coals in this region.

No. 9 coal comes somewhat above the center of the formation. This coal is one of the most remarkable elements in

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Pennsylvanian stratigraphy because of its persistence. It underlies an area of 25,000 square miles in Indiana, Illinois and Kentucky. It is the most persistent coal in the eastern United States, the Pittsburg seam, the "runner-up" in this respect, covering but 6,000 square miles#. In this county it has an average thickness of about four feet, somewhat less than it has to the south and west in Webster County. It apparently thins northward. Some unusual features in the stratigraphy about No. 9 are present in this county, which will be discussed in a subsequent section.

#Quoted from Glenn, op. cit. p. 113, quoting from Ashley, G. H., Ind. Dep. Geol. & Nat. Res., 33rd Annual Report, 1909, p. 93.

No. 9 Coal forms perhaps the best key-bed in the Eastern Interior coal field, because of its persistence and because of its readily recognizable roof and immediately overlying strata. This roof always bespeaks marine conditions. In this county the roof is generally a black, fissile shale of varying thickness, overlain by a blue sandy shale, the "penniwinkle" rock of the coal miners. In this roof, or in the "penniwinkle" rock, fossils are nearly always found. In the L. H. & W. mine (53,30) the fossils are found as impressions in this fissile shale, sometimes preserving a calcareous or pyritic or marcasitic coating and are mostly forms of Productus. In the Graham Hill shaft (49,32) they occur as calcareous or pyritic casts in the "penniwinkle" rock, and are chiefly gastropods. In the Sunnyside shaft in Evansville, a multitude of crinoid joints and portions of stems are found. In the mines at Yabkeetown, Indiana (55,18) forms of Productus are found in abundance, in impure irregular limestone flags occurring in the roof.

No collection of fossils was made for this report but

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Glenn collected some from the roof of the coal at Robard (41,33) which Dr. George H. Girty identified as follows:*

*Glenn, op. cit. p. 58.

Eupachycrinus tuberculatus Meek and Worthen
Derbya crassa (Meek and Hayden)
Chonetes mesolobus Norwood and Pratten
Lingula umbonata Cox
Productus cora d'Orbingy
Marginifera muricata (Norwood and Pratten)
Composita subtilita (Hall)
Astartella gurleyi White
Aviculopecten rectilateratius (Cox)
Pteria acosta (Cox)
Euphemus carbonarius (Cox)
Bellerophon percarinatus Conrad
Phanerotrema grayvillense Norwood and Pratten
Naticopsis altonensis McChesney
Soleniscus gracilis (Cox)
Soleniscus sp.
Orthoceras Knoxense McChesney
Fragments of large nautiloid

At a distance varying from 80 to 100 feet above No. 9 occurs No. 11 Coal with its overlying Providence limestone, the Jolly limestone of Hutchinson**.

**Hutchinson, F. M., Coals of Central City, Madisonville, Calhoun, and Newburg Quadrangles, Ky. Geol. Survey, Bull. 19, 1912.

No. 11 Coal maintains itself rather constantly as a horizon throughout the county, but is very inconstant in its thickness, as are all the coals near the horizon of the Providence limestone. Near the Shiver mine at locality 44 (45,20) it is reported four feet thick, but this thickness may be abnormal, due to the swelling of the coals here caused by folding, as in the case of No. 9 Coal at the same locality (see page 149). In the Southland hole at Henderson (locality 20) it is not present, although in a hole about one mile away it is reported four and a half feet thick. In the Graham Hill shaft (locality 23) it is either not present or is the coal once worked there, the second one down, with a thickness

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of about three feet. At the Robard shaft (locality 60) it is reported to vary from two feet to seven feet in the width of the shaft and in some of the Kleidered holes (locality 12) it is six feet thick. At Uniontown in Union County it is reported to be six feet and to maintain that thickness in the mine.

The Providence limestone is an impure, fossiliferous limestone and furnishes an excellent key bed, which was used in working out the structure in the eastern part of the county. It is very seldom well exposed but measures from three to four feet where seen in outcrop and from two feet in the L. H. & W. shaft to about fourteen feet in the Smith Mills well where it appears divided into two members separated by five feet of shale.

It frequently takes on a "flint rock" phase, when it becomes an irregularly-breaking, gnarly, very hard rock. This is a more siliceous phase of the rock and is frequently found in association with the more pure limestone, as in the L. H. & W. and Graham Hill shafts. At other times its horizon is represented by a concretionary limestone, as probably a mile east of the Shiver mine at locality 44 (45,20) and near Robards (locality 60), where the limestone was found in boulders when the shaft was dug here.

No collection of fossils from it have been made in this county but Glenn* publishes a collection determined by Girty, made

*Op. Cit. p. 59.

just south of the line in Webster County. The collection gave

<u>Fusulina cylindrica</u> Fischer
<u>Marginifera splendens</u> (Norwood and Pratten)
<u>Squamularia perplexa</u> (McChesney)

No. 12 coal occurs almost immediately above the limestone

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in the eastern part of the county. It is reported by Hutchinson*

*Hutchinson, F. M., op. cit., p. 108, 112.

to average one foot four inches in the eastern part of the county and never to exceed two feet. No exposures are at present to be seen in this section. In the shafts in the western part of the county it is equally unimportant where typically developed. The question of its correlation in certain regions will be deferred to the discussion of the relations of No. 12 and No. 14 coals and the Anvil Rock sandstone.

No. 9 Coal and the "Kleiderer Fault". It is very important at this place to discuss in as much detail as possible the stratigraphic conditions in the Carbondale in a territory lying between Henderson and Wilson Station on the Illinois Central railroad and northward to the river. The solution of the problems arising here is important, not only insofar as it affects purely stratigraphic questions but also because it indicates the presence here of a prominent structure.

Several years ago Mr. Kleiderer projected the installation of a mine in this area and made, for this section of the coal field, a rather thorough inspection of his property by means of drill holes. Although these showed the strata to be somewhat abnormal, Coal No. 9 was found to be present in normal thickness in every hole. When, however, he sank a shaft within a few yards of one of these holes down to what was considered Coal No. 9, he found it to pinch out very rapidly in all directions. His company was disrupted by the expense of trying to break through the surrounding rock to the coal. Later some diamond drill holes were put down to further examine this property. In addition, there was some diamond drilling done independently on an adjoining farm. In

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all there are eleven fairly accurate records in this section. It was thought that the conditions met here had to be interpreted as due to faulting. The writer has come to the conclusion that the evidence requires another interpretation.

This problem involves a question as to the structure of the entire Carbondale in this section. (See charts, Plates 1 and 2). We will accordingly consider first this formation as revealed in the record of the original Kleiderer well No. 2 (locality 18). This well reaches to Coal No. 6 and hence goes through all the Carbondale and into the Tradewater.

The following members are conspicuous in this section:

Providence limestone (70 feet above the base of Coal No. 9)
A series of lower irregular limestones
Coal No. 9
Coal No. 7 (95 feet below Coal No. 9)
Coal No. 6A* (144 feet below Coal No. 9)
Coal No. 6 (265 feet below Coal No. 9)

*The coal called No. 6A in this report is identical with the coal called No. 6 in Owen's classification. This change in nomenclature is made necessary because Owen's Coal No. 5 corresponds to Coal No. 6 of current usage.

In the following discussion we shall make use of these intervals between the various key beds.

Going southwestward about one mile from this well to locality 15, where another well was put down, we find a three-foot limestone overlain by one and a half feet of coal and underlain by one and a half feet of coal, evidently the Providence limestone with its normally associated coals Nos. 11 and 12. Here we find an interval of about 80 feet between the base of the Providence limestone and the base of No. 9, here four feet thick, with the same irregular limestone in this interval as reported in the previous well.

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Going three-fourths of a mile further west, to the diamond drill hole at locality 12, we find a limestone one foot three inches thick, overlain by a coal one foot five inches thick, and underlain by a seven foot coal,- again the Providence with its associated coals. Here we get the first evidence as to what are the true conditions in the Kleiderer shaft. A two inch coal shows at a distance of 80 feet below the limestone, which it will be remembered is the interval from the Providence limestone to No. 9 coal in its normal development in the well just considered. In addition, there are eight feet of "dark shale with thin coal seams" in the interval registering the horizon of No. 10 coal, always thin in this county. About 215 feet below the limestone is a coal of a thickness of one foot eight inches. This interval is within a few feet of the interval from the limestone to the No. 6A Coal in the Kleiderer well first considered.

We therefore come to the conclusion that at this place Coal No. 11 attains the development it has at Uniontown and Waverly, where it is worked, and in another of these holes on the Kleiderer property; that Coal No. 9 is practically non-existent but its horizon recognizable; and that No. 6A is the bottom coal in this well.

Proceeding to the shaft (locality 13), there are first of all two wells to be considered (logs 10 and 11), both of which were by report within 100 feet of the shaft. They could not be located more accurately. The Kleiderer well put down before the shaft was sunk is represented by log 11. This well is practically a duplicate of the well at locality 15, except that at locality 15 the limestone beds below the Providence limestone occur at a higher level than in this well. The limestone - Coal No. 9 interval is 81 feet.

The Peabody well (log 10, locality 13) was put down after

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the shaft was sunk. It shows Coal No. 11 practically removed by erosion. No coal occurs for a distance of 146 feet below this, where a coal 1 foot 1 inch thick appears. At a depth of 187 feet below Coal No. 11, there is another coal, of a thickness of 2 feet 1 inch. It seems probable that these coals represent Nos. 8 and 7, respectively. If this interpretation is correct, Coal No. 9 must be absent, with the "brown, limy, shale" marking its horizon. Such local gaps in Coal No. 9 occur in other places.

We now turn to the shaft itself. According to Mr. W. S. Kleiderer, brother of the owner, a two-foot limestone underlain by a seven-foot vein of coal was found immediately beneath the alluvial fill at the top of the shaft. This seems to indicate that the Providence limestone with its associated Coal No. 11 was found at its normal level. At about the place where No. 9 was expected from its depth in a nearby mine and the drill hole close by (log 11), a vein of coal, about one-foot in thickness, was found. It was not believed that this thin bed could be No. 9, and so the shaft was sunk deeper until a 4 to 5-foot bed of coal was struck. This was the bed which was worked and which gave the trouble. The depth to the bottom of this coal is given as 208 feet, which, in view of the uncertain accuracy of this measurement, puts it near enough to the horizon of the coal called No. 8 in log 10 to be correlated with it.

This interpretation seems entirely natural and does away with the necessity of assuming any faulting. Unfortunately the shaft is now inaccessible, being flooded almost to the top. None of the men with first hand information on the conditions in the shaft have had any geological training. The reports of strong dips seen in the shaft should, therefore, be received with caution. All

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observers agree that the coal worked thickened and thinned rapidly and that on one side at least it pinched out in a very short distance. Such conditions, however, are known to occur locally in large seams in unfaulted regions and are to be expected in a coal which is as local in its development as Coal No. 8. The difficulties encountered by an hypothesis of faulting here are discussed under "Structure", page 70.

The drill hole at locality 16 presents a problem of its own, which, however, does not seem to affect the question of faulting in the Kleiderer shaft. Here the Providence limestone with its Coals Nos. 11 and 12, the former 6-feet 6-inches thick with its characteristic blue band near the bottom, occurs immediately below the alluvial filling. The next prominent coal, 3-feet 8-inches thick, is 108 feet below the limestone, while the thin coal underlain by limestone has risen in the section from its position in log 11. If this thicker coal is No. 9, it has dropped some 30 feet in the section to its position in the southern part of the county; if it is No. 8, it has risen about 40 feet.

The diamond drill records on the Barrett farm, at localities 7, 8, and 9, remain to be considered, as they are of great importance in determining the structure of this region. They show the Providence limestone from one to two and a half feet thick, with Coal No. 12, less than a foot thick, a short distance above it. No. 11 Coal shows in only one record, at locality 8, where it is five feet eight inches thick and 25 feet below the limestone. There is no such interval between the coal and limestone elsewhere in the county or, to the writer's knowledge, in western Kentucky. Yet it is near enough to its proper horizon to be correlated with No. 11 in this region of exceptional behavior of the coals. It should be

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noted that at locality 9, only 200 yards distant, this coal is absent. In all three wells a four- to four-and-a-half-foot coal is found at an interval varying from 193 feet at locality 7 to 175 feet at locality 9, below the limestone. In addition, at locality 7, there is found 53 feet above this coal, another coal only five inches thick. By comparison of these three logs with the well at locality 18, this lowest coal is assigned to the horizon of No. 7. This implies that No. 9 is absent in this territory and No. 8 is present as the five inch coal at locality 7.

The analysis of these logs therefore brings us to the conclusion that No. 9 is absent over an area embracing localities 7, 8, 9 and 13 and of undetermined extent south and west of that territory. The nearest places where No. 9 is known to be present in these directions are Corydon and Smith Mills. It further confirms the view, that the coal worked in the Kleiderer shaft and which gave so much trouble was not No. 9 but probably No. 8, and that the exceptional conditions here are due not to faulting, but to abnormal conditions of deposition of the strata, abnormalities which extend through the whole Carbondale in this section. These conclusions will be of great importance in discussing the structure in the area.

Top of Carbondale. In the eastern section of the county the top of the Carbondale is easily recognized, due to the immediately overlying, typically developed, Anvil Rock sandstone. Frequent sections could not be obtained, due to the loess covering, but No. 12 Coal in this section is always reported to have a sandstone roof and it seems probable that at no place is there more than about ten feet of shale between No. 12 Coal and the base of the Anvil Rock. In the shaft records to the west, however, as shown at

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Graham Hill at locality 23 (49, 32) and the L. H. & W. shaft at locality 26 (53, 30) the base of the Lisman is not so clearly defined.

In the Graham Hill shaft (locality 23), about 90 feet above No. 9 Coal there occur ten feet of "bastard limestone" and then above this a three foot coal with its fire clay. A purer limestone overlies this and then eight feet of sandstone and sandy shale are recorded. Next comes a two foot coal with 70 feet of overlying shale, then 45 feet of shaly limestone. Inasmuch as there is an erosional unconformity between the base of the Lisman and the top of the Carbondale, the 70 feet of concretionary shale might be referred to the Carbondale, with the 45 feet of sandy sediments being referred to the Anvil Rock basal member of the Lisman. However, in view of the fact that the Anvil Rock is not well developed at other places it seems best to correlate the four feet of sand below the upper coal with the Anvil Rock and place the top of the Carbondale here at the top of the limestone. Similarly, the top of the Carbondale is placed at the top of the highest coal in the L. H. & W. shaft (locality 26).

Lisman Formation

The Lisman formation is found in every section of the county. Its lowest member, the Anvil Rock sandstone, caps the high hills in the eastern part of the county and ~~its~~ upper members lie concealed beneath the loess in the remainder of the county, except where a few feet have been washed clean in a road ditch or are exposed where a stream happens to run against bed rock in its bed. There are no measurable sections of the Lisman in the county but fortunately the Smith Mills drill hole went through practically all the strata of this formation which occur in this county and gives

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a good section of these strata in its western part. It is probable that a score of feet more than are reported here occur in the high hill near the mouth of Green River but the exact position of these strata can not be determined with certainty from the fragmentary exposures. It is sufficient to say that wherever seen, the Lisman presents a characteristic characterless succession of shales and sandy shales, with the exception of the Anvil Rock and Madisonville members.

Anvil Rock Sandstone. The Anvil Rock sandstone, where exposed in the eastern section of the county, is a feldspathic sandstone of coarse angular grains, poorly cemented. It is strongly cross-bedded and in some places includes flattened pellets of clay. It is exposed only in road cuts or high on the hills bordering Green River. In most of these exposures, only a few feet of the formation may be seen, but in the "Rockhouse" hill at locality 63 (40, 29) it is seen in good development and good exposures.

Its base cannot be seen at this point, but a spring about ten feet below the lowest exposure probably derives its water from the Providence limestone, indicating that the sandstones seen above this spring are very near to the base of the Anvil Rock. If so, the member is about 125 feet thick at this point, which is far greater than it has been revealed in any drilling or other exposure in the county. The exposures here show twenty feet of coarse, soft sandstone, above which the strata are partially concealed for 40 feet. Part of this interval is also soft, coarse sandstone and the rest is probably shale. Above this covered portion, the "Rockhouse" extends upward for 65 feet, composed entirely of soft, cross-bedded sandstone. The strata above this are partially concealed but include more shaly sandstone.

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The sandstone in the "Rockhouse", by weathering, has developed the honeycombed, pockety appearance of many of the Pennsylvanian sandstones. Overhanging ledges are left, giving one large rockhouse and several smaller ones. The cross-bedding has been beautifully exposed by the action of the weather.

West and north of the Green River section, the exposures are very poor and where its horizon is penetrated by the drill ten or twelve miles away, it has lost its identity and is seemingly represented by a few sandstones overlying the Providence limestone. As will be explained below, the writer has reason to believe that in this county the Anvil Rock sandstone is a transgressing member extending transversely across the No. 12-14 Coal. It is thought that the sands were poured out as an irregularly branching fan into the shallow embayment where the Providence limestone and its associated coals were forming; in places such as the eastern part of the country, after both limestone and No. 12 Coal had formed; in other places, such as the region around Corydon, sometimes after part of the limestones had formed, after which the distributaries of its delta shifted and the limestone and coal formation continued.

No. 14 Coal. The coal worked at Smith Mills and Corydon has been correlated by Dr. Glenn* with the Baker or No. 14 coal of Webster County. This conclusion was based upon the very close similarity of this coal to the Baker coal where typically developed. The coal at Smith Mills was examined by Dr. Glenn, who remarks that the roof is here very weak, that it contains "bells" or flattened tree stumps, that the coal carries much mother of coal, does not slack readily, is in very thin, alternating bright and dull layers, has no dirt or sulphur apparent, and that the analysis shows low sulphur, all of

*Op. Cit. p. 111.

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which features are present in the No. 14 coal in its type locality in Webster County*.

*Personal communication.

The evidence that the two seams are the same seems incontrovertible, as each seam is distinctive in the region in which it exists. The writer accepts the view that the coal at Smith Mills is the same seam as that at the Baker mine in Webster County, but believes also that No. 12 in this county represents essentially the same horizon. In other words, he believes that the Anvil Rock sandstone which is supposed to separate the two coals, is a transgressing member and sometimes lies above the coal, sometimes below it, and sometimes separates it into two seams.

This conclusion is based upon a study of the two diamond drill records near the Smith Mills mine, one at locality 2, a mile north of the mine and the other at locality 6, about two miles southeast of the mine. Unfortunately, the shaft of the mine is timbered and the mine is not now operating, so that the strata overlying the coal could not be examined. The well at locality 2 shows the Providence limestone to be fourteen feet thick and in two benches separated by five feet of shale. A six foot-three inch coal lies above this limestone and is separated from it by only five feet of fire clay and fossiliferous shale. This thick coal is without doubt No. 12. An 11-inch coal is found about thirty feet higher in the section, separated from the main coal by shale and sandstone. Above this there are more than 100 feet of shales before sandy sediments are reached. The sandstone overlying the thick coal therefore represents the Anvil Rock.

The well at locality 6 shows this same coal less than four feet thick and in two equal benches separated by three feet

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of shale. No sandy sediments overlie it. Evidently the Anvil Rock is not well developed in this section, and the coal shows a tendency to split.

If, then, the thick coal in the mine is the same as the thick coal in these two wells, the Smith Mills coal is definitely No. 12. There remains, however, a possibility that the coal worked in the mine is equivalent to the thin bed in the locality 2 well. Although this is not probable, it deserves investigation.

The information about the shaft was all furnished by Mr. W. W. Cooper, who sank the shaft and acted as superintendent of the mine for 21 years, until a few years ago. Mr. Cooper states that a 7-foot sandstone, immediately overlying the coal in the shaft and separated from it in other parts of the mine by the thin weak shales of its typical roof, is soft, rather coarse and non-resistant. Blocks of this sandstone, taken out of the mine for use as steps, were not serviceable because of their softness. A piece of medium-coarse, incoherent sandstone picked up in the dump was identified by Mr. Cooper as the sandstone of the roof. This piece of sandstone enclosed a pellet of hardened clay, thus bespeaking a torrential origin. The features of this sandstone, as seen and described by Mr. Cooper, are suggestive of the Anvil Rock. It also bears approximately the same relation to this coal as the sandstone in locality 2 well bears to the thick coal there.

Dr. Glenn* was told at the mine that No. 11 coal lay fifty feet below the coal worked. However, no drilling or shafting to this depth has been done to the knowledge of Mr. Cooper or the writer. A water well a quarter mile distant is reported to have stopped in limestone, thirty feet below the thick coal. By making the assump-

*Personal communication.

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tion that the water was obtained at the base of the limestone, this report agrees as closely as could be expected with the same interval in the locality 2 well, which is 23 feet.

The evidence which has led the writer to correlate the Smith Mills coal with Coal No. 12 may be summarized as follows: (1) all evidence obtainable concerning the stratigraphic position of the coal in the mine refers that coal to the same horizon as the thick coal in the locality 2 well; (2) it is not probable that the thick coal both north and south of the shaft should disappear in this region while coals only slightly or not at all developed in the wells should thicken to eight feet in the shaft; (3) the sandstone overlying the coal in the shaft is suggestive of the torrential character of the Anvil Rock.

It thus appears that the Smith Mills coal is both No. 12 and No. 14 of Dr. Glenn's report. The writer believes, as stated above, that the Anvil Rock sandstone transgresses the horizon of essentially one coal; that No. 12 coal represents this coal or part of the coal where it was formed prior to the deposition of the Anvil Rock sediments; and that No. 14 represents the same coal where the Anvil Rock was deposited before coal formation had begun.

Lisman above Anvil Rock. The only member above the Anvil Rock which can be distinguished in this county is the limestone which has been referred to the Madisonville horizon. At Madisonville, the type locality, there are two or more ledges of limestone near the same horizon, only one of which has been named the Madisonville. At this distance from the type locality, the limestone seen here cannot, of course, be identified certainly with the original limestone. It is, in all of Hutchinson's sections*, the first limestone above the

*Hutchinson, F. M., Geology and coals of Central City (and other) Quadrangles. Ky. Geol. Survey, Bull. 19, 1912.

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Providence limestone, (his Jolly limestone); is 180 to 190 feet above the Providence, and is the most persistent of the limestones in the lower Lisman. In Glenn's general section for Webster County (op. cit), the Madisonville is placed about 275 feet above the Providence and there are two more limestones within fifty feet below. This section, however, is probably in the thickest part of the Pennsylvanian and it has been shown already that in this county the interval decreases from west to east and probably also from south to north. Since this limestone is the only one named in the Webster County report, it is implied that it is the most persistent. It is thought best not to multiply names by giving the limestone in Henderson County a new name and hence this limestone is referred provisionally to the Madisonville horizon. It is excellently exposed at Smith Mills. A comparison with a similar development at West Franklin, Indiana (54, 43) which can be traced northward to Evansville, shows that it is the same as the Somerville formation of the Indiana Survey and the Patoka and Ditney folios.

There are only three areas in this county where the Madisonville is exposed. The most western and best exposure is that near Smith Mills, at Rock Springs (locality 1) (Distinguish from Rock Springs near Corydon and Cairo) and westward. A section here gave:

limestone	6 feet
concealed	10 feet 8 inches
(apparently shale and sandstone)	
limestone	11 feet

A section three-fourths of a mile southeast gave:

limestone	4 feet
shale	6 feet
solid limestone	2 feet 6 inches
shaly limestone	4 feet
limestone	1 foot

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Both ledges are fossiliferous and impure. The upper frequently appears much brecciated. Crinoids, brachiopods and gastropods abound in both ledges.

A southward thinning of the limestone is indicated by these two sections and hence the three-foot limestone in the Smith Mills log very probably represents its entire thickness here. The interval given in the log from the base of Madisonville to the base of the Providence is 206 feet and that to the base of No. 9 Coal is 313 feet.

The second area in which this limestone occurs is in the hills close to Poole (39, 38) on the Webster County line. It is apparently only three to four feet thick in this vicinity and its interval to other key beds can not be determined.

The third place of outcrop is in the Wolf Hills north-east of Henderson (53, 32). Here it is three to four feet thick and has some shaly layers. It occurs, among other places, at a spring on the Wolf farm. About 100 yards from this spring a well (locality 27) drilled many years ago, showed No. 9 coal to be only 255 feet below the limestone at the spring. Traced eastward along these bluffs, the limestone fails to reappear where exposures of the bed rock can again be seen, but calcareous sandstones are found at the suspected elevation and fragments of shaly sandstone carrying gastropod impressions, found in the float, suggest that here the limestone has been replaced by a more sandy phase.

The Madisonville limestone should be present in the Graham Hills (49, 32) but is probably too thickly covered with loess to be exposed. Two wells drilled on the Stites orchard struck a two-foot limestone immediately below the loess. This is probably the Madisonville, suggesting an interval to No. 9 coal as found in the Graham

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Hills mine, a half mile away, of only 235 feet. Whether or not this limestone in this record may not be merely residual boulders left at the time of the pre-loess erosion of the country cannot be determined and hence this interval cannot be regarded as accurate.

The difference in interval from the Madisonville limestone to Coal No. 9 found at those places in Henderson County, the interval to the south as given by Hutchinson and the greater interval given by Glenn for Webster County, indicate a southwestward thickening of the lower part of the Lisman.

TERTIARY

The gravels found in the eastern part of the county in the vicinity of Green River are obviously much younger than the Coal Measures strata just considered. Before their deposition it is evident that the strata were warped and uplifted and underwent a long period of erosion.

There are several deposits of gravel worth noting. The one at the highest elevation is at Ridgewood hill (51, 26), a mile west of Spottsville. Here the base is at approximately 550 feet A. T. or about twenty feet lower than the highest bed rock elevation in the county. In the road passing through this deposit, the gravel appears to be about seven feet thick but it is reported that several test holes in this locality showed only about eight inches. It is probable that these did not touch the deepest part of the gravel.

Here, as elsewhere in the county, the gravel consists mainly of chert pebbles of irregularly rounded shapes, often tabular, ranging from a half inch in diameter up to several inches. Quartz pebbles are also found. The gravels are all deeply colored in red and brown shades and are imbedded in a red, sticky clay or

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are associated with a sharp sand. There are frequently seen tabular masses of gravel up to eight inches in long dimension and two or three inches thick, cemented with a dense limonitic and manganiferous material. Slabs of much greater size are frequently found in other deposits. An interesting feature shown in the side of the road here is a boulder of sandstone with Pennsylvanian characteristics. This boulder measures in horizontal direction about eleven inches and vertically about eight inches. It is at least "case-hardened" with hematitic material. Surrounding it on all sides is loose gravel and to its base one of the limonitic masses of gravel is cemented with more limonite. This is the largest boulder seen in any of the deposits in this county. It is surprising that it should consist of Pennsylvanian sandstone impregnated with hematite, the least resistant rock.

The deposits southeast of Hebbardsville are much alike in their characteristics. They occur at elevations of 480 to 490 feet and are from six to eight feet thick as far as could be seen in exposures. A typical section is that at locality 43 (46, 19) where nine feet of gravel are overlain by ten or twelve feet of loess. Here the gravel is, as in most places seen, horizontally stratified.

The thickest deposit known in the county is that north of Spottsville at locality 32 (53, 25). One section at this place gave nine feet of gravel overlain by seventeen feet of loess. Another gave

gravel	5 feet	
limonitic clay		6 inches
gravel	5 feet	

In one instance, some poorly defined cross-bending was seen dipping south. This gravel is reported here to cover about five acres and to be twenty feet thick in some places. At various

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points in the county where the chert gravels were not found, thin layers of sandstone fragments, indurated with red iron oxides, were seen. One such locality near the "Rockhouse" (Locality 63) gave the section

soil	2 feet 6 inches
indurated sandstone fragments	6 to 8 inches
incoherent sandstone	2 feet

(elevation of the base section 460 feet)

Further east near the top of the Rockhouse hill these gravels were found again. Float in the region of the Wolf Hills northeast of Henderson also carries them.

In some of the exposures, the gravels plainly follow the slope of the hills in a blanket that may have a thickness of one to eight or ten inches. Such gravels seem to be the result of creep from some higher deposit down the slope of the hill. However, thick deposits of gravel occur at widely varying altitudes, considering the relief of the county. Of two deposits about two miles apart near Spottsville, the one is at 550 feet elevation, the other, the thicker of the two, at 440 feet or only about fifty feet above the river terrace. Near Hebbardsville, there are other thick deposits midway between these two elevations. In other places on the ridges where the gravels can not be seen, the red sticky clay is found. It is almost possible, by riding over the ridge roads, to tell where the clay underlies the soil on account of the roughness of the road due to the hardness of the clay after it has been cut by wheels and then dried.

It would be well to mention here the existence of still another deposit only slightly above the flood plain. This is at locality 29 (53, 28) just northwest of Baskett and underlies, at least in part, the loess hill at this point. As seen in the road

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up the riverward side of the hill, it appears to be about five feet thick. Its altitude is about 390 feet or about the level of the terrace in this section, although none of that terrace is preserved here. This deposit would be referred to a later reworking of the older gravels if it were not for the range in elevations shown by the other gravel deposits. It is here doubtfully assumed to owe its present position to the same process which caused the present distribution of all these gravels. A discussion of the probable nature of this process will be found in Chapter VI, dealing with the Tertiary history of this region.

PLEISTOCENE

Terrace materials

Description. The materials underlying the terraces along the Ohio River and filling the tributary creeks range from gravel to clay, including silt of the appearance of loess.

The lowest material seen in exposures along the river is sand in medium size of grain, in beds 2 inches to 8 inches thick and strongly cross-bedded. Along the planes of cross-bedding, pebbles of crystalline rock are frequently found. Above the sand, there generally occurs a deposit of clay, often interlaminated with sand, and frequently with a silt resembling loess. Frequently the upper 10 feet of the deposit is composed of a silt indistinguishable in the field from loess.

The following sections illustrate the kind of material found under the highest terrace.

Locality 65

	feet
Residual clayey soil	5
Loess-like silt	5
Silt and clay	8
Sand, usually medium grained, but e.so coarse and fine, strongly cross-bedded, ca.rying pebbles of crystalline rock	16
(In other sections nearby clay is found at all elevations, lying in large lenses in the sand).	
Concealed to water level	10

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feet	inches
5	
5	
5	
2	
	1
	4
	2
	4
2	
	½
1	
	2
2	
1	
	6
1	6
2	
3	
12	

ality 67, 20 feet of
terrace. This loess-
to the usual air-breath-
ow that at least part of

several exposures under
ifications have been made

ted to be yellow clay,
ne different materials
the order named, but
ypes of material are
ve been found near the

ces of at least two differ-
ent ages are present in this county, no distinct difference in the materials underlying these two terraces has been noted. The lower

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terrace appears to differ stratigraphically from the upper terrace only in the absence of the thick loess-like silt layer at the top. The lower materials seem to be the same under both terraces. It would appear that erosion of the upper terrace had not proceeded far up to the time that the second terrace was built. However, the lower materials under the upper terrace vary so much laterally that it is impossible to regard any sequence as typical; therefore, it may be that two distinct series of deposits are present but indistinguishable. No actual contact between the materials under the two terraces could be found.

Name. These terrace deposits are the same as those to which Glenn*

*Op. cit., p. 122.

gives the name "Graves Creek formation" in Webster County. In this county (Henderson) they are shown to be divisable into two parts along the Ohio River. These are designated on the map of the county as Early and Late Wisconsin fillings, respectively. Sufficient time has not been available to distinguish between these two deposits, and between these deposits and those of the present flood-plain in all sections of the county. Accordingly, in many places in the county the three deposits appear on the map as "Quaternary alluvium".

Age and origin. The terraces with the continuation of the higher one in the creek valleys are of Pleistocene age. The upper one is thought to be of Early Wisconsin and the lower of Late Wisconsin age. Some of the material found at depth under the terraces is probably of pre-Wisconsin age. Both of the terraces are the result of the overloading of the Ohio River with glacial debris during times of glacial occupancy of the region. The evidence for these views is presented at length in Chapter VI (page 121 et. seq.)

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Loess

Description. The loess of Henderson County is a fine silt of buff or grayish color mantling the entire county. When dry it is soft and almost unctuous to the touch and crumbles in the hand. When wet it does not become plastic like a clay, but still possesses much more cohesion than a sand. Despite its smooth feel, under the microscope it is seen to consist entirely of very small and sharply angular grains, mostly quartz.

The grain size of the loess varies both horizontally and vertically. In the western part of the county the loess is coarser than in the eastern and southern portions, away from the Ohio. In many exposures lenses of fine sand, and in a few cases even medium sand, are intercalated in the loess. Bands of such sand over ten feet thick are found in the thick loess accumulations in Atkinson Park above Henderson, and below Smith Mills at locality 62. In no case could a sharp boundary between the two materials be observed and in many cases the transition in grain size extended over several inches.

Chemically, the loess is calcareous, especially so near the Ohio. One sample from near Smith Mills yielded twenty per cent of calcium and magnesium carbonates. It carries both the calcareous "loess kindel", or irregular concretionary masses, and the ferruginous tubes that form around plant rootlets. The "marls" of the county are in part locally enriched portions of the loess, the enriching material having been derived from the leaching of the loess above.

In structure, the loess is massive. No stratification has been observed in any of the material above the level of the terraces. However, some suggestion of a very vague horizontal stratification may be found in the calcareous concretions. Tabular concretions,

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which may be up to a foot in long dimension and from one to three inches thick, are always found lying horizontally in the loess.

The loess is expressed topographically by gullied hill-sides and, in the region where it is thick, by vertical walls in road cuts and facing the flood-plain.

In the western part of the county it is very thick, completely covering all rock outcrops excepting along the river bluffs. A diamond drill record at locality 2 gives 45 feet of "sandy clay", which is probably all loess. Even greater thicknesses, up to 80 feet, are suggested by discontinuous outcrops along roads on hill sides. It cannot be certain however, that a vertical section at any one place would show such a thickness. South of Smith Mills, at locality 62, loess, together with fine sand, rises in one exposure some 80 feet above the flood-plain. Some of the material in the lower part of this exposure may, however, be of aquatic origin.

In the eastern part of the county the loess is thinner, and in the southeastern part, away from the broad valleys of the Ohio and Green rivers, is between 5 and 10 feet in thickness.

The relationship of the loess to the terrace materials is intimate but obscure. Several deposits below the level of the terraces present problems. Just west of Smith Mills, at locality 68, loess rises from the level of the lower terrace, or second bottom, to an elevation of about 450 feet A. T., a height above the terrace of about 65 feet. Although the lower part of this deposit lies below the level of the higher of the terraces, it seems to be continuous with that above and carri s, even in its lowest portion, only the typical air breathing loess fauna. On the other hand, an exposure of the terrace materials at locality 67, near

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Mt. Vernon, shows a material which has the characteristics of typical loess. The material is fine, pulverent, and carries a great number of typical loess fossils. However, there are also present a few pelecypods, thus bespeaking aquatic conditions at the time of deposition of this material.

Fossils. Collections of fossils taken from several localities have been identified by Dr. F. C. Baker. The writer wishes here to express to Dr. Baker his sincere appreciation of this kindly service. These fossils are listed below. The collections made from terrace materials are also given here for the purpose of comparison.

List of Pleistocene fossils from Henderson County

Collection:	A	B	C	D	E	F	G	H	J	K	L	M	N	O	P
Polygyra multilineata wanlessi F. C. Baker	x	x	x				x								
Polygyra hirsuta yarmouthensis F. C. Baker	x	x				x				x			?		
Polygyra monodon (Rackett)	x											x	x	x	x
Polygyra monodon cf. peoriensis F. C. Baker		x													
Polygyra fraterna (Say)									x				x		
Polygyra sp.											x				
Hendersonia occulta (Say)	x	x			x	x	x		x						
Vallonia gracilicosta Reinh.	x		x				x	x							
Gonyodiscus anthonyi (Pilsbry)		x	x				x	x	x						
Retinella hammonis (Strom)		x				x			x						
Columnella alticola (Ingersoll)		x	x												
Vertigo modesta (Say)		x	x				x								
Vertigo ventricosa (Morse)		x													
Vertigo loessensis F. C. Baker			x				x								
Strobilops virgo (Pilsbry)		x													
Euconulus fulvus (Muller)		x							x		x				
Succinea grosvenori gelida F. C. Baker		x	x				x	x				x			
Succinea ovalis pleistocenica F. C. Baker			x	x	x		x			x					
Succinea retusa fultonensis F. C. Baker														x	
Succinea cf. ovalis											x				
Gastrocopta armifera similis Sterki			x												
Gastrocopta armifera										x					
Punctum pygmaeum (Drap.)			x												
Carychium exile canadensis Clapp			x												
Helicodiscus paralellus (Say)						x									
Anguispira alternata (Say)									x						
Pomatiopsis lapidaria (Say)											x				
Pomatiopsis scalaris (Baker)												x			
Circinnaria concava (Say)									x				x		
Stagnicola caperata (Say)													x	x	x
Stagnicola umbrosa (Say)														x	
Stagnicola sp.															x

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	ABCDEFG	H	J	K	L	M	N	O	P
Cincinnatia cincinnatiensis (Anthony)					x				
Cincinnatia emarginata (Kuster)					x				
Amnicola limosa (Say)					x				
Valvata tricarinata (Say)					x				
Fossaria parva (Lea)								x	
Helisoma trivolvis (Say)								x	
Gyraulus altissimus (F. C. Baker)								x	
Physella gyrina hildrethiana (Lea)								x	
Planorbula new species								x	
Pisidium sp.					x		x	x	
Sphaerium sp.					x				

The localities from which the collections were taken are described below.

ABCDEFG: From locality 68, about 2 miles northwest of Smith Mills. The hill, in which the road cut exposure shows nothing but loess, excepting as noted below, rises from an elevation of 375 feet A. T. to 440 feet A. T. The lower elevation is the elevation of the probably Late Wisconsin terrace, but the loess is probably older than this terrace. At an elevation of 400 feet A. T., a clay band, 2 to 8 inches thick, runs horizontally for the length of the exposure, about 100 feet. No difference in character between the loess above and that below this band was noted. The collections were taken from the following elevations: A, 380 feet; B, 395 feet; C, 400 feet (fossils from perhaps both above and below the clay band); D, 410 feet; E, 415 feet; F, from 1 foot below the clay band; G, from 1 foot above the clay band.

H: From a mound about 1/2 mile below Dam 48 at locality 66. The loess occurs in a curving band about 4 feet thick, underlain and overlain by fine sand. The mound apparently represents a dune upon the Early Wisconsin terrace.

J: From the base of a loess deposit about 20 feet thick capping a Tertiary gravel deposit at locality 32 (52, 25).

K: At locality 69, in river bluff about three miles below Mt. Vernon, on the Indiana side of the river. The material was taken

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from an 8-foot loess-like band of silt at an elevation of 385 feet, underlying horizontally bedded sand in a hillock rising to about 405 feet A. T. The fossils indicate that it is a true loess.

L: From the material underlying the Early Wisconsin terrace at locality 65, about 5 miles below Henderson. This material ranges here from a heavy, dark blue, clay to a coarse sand with pebbles of crystalline rock.

M: From the Early Wisconsin fill in Sellers Ditch at locality 70, 2 miles south of Henderson. The material associated with the fossils is a heavy, dark blue, clay.

N: From locality 67, on the Ohio River Bank, about 3 miles below Mt. Vernon. The material appears in the field to be a typical loess but lies below the level of the Early Wisconsin terrace.

O: From the bank of a small drain, where crossed by the Uniontown road about 2 miles southwest of Mt. Vernon, in NE $\frac{1}{4}$ of SW $\frac{1}{4}$ of Sec. 13, T 7 S, R 14 W, Uniontown quadrangle. The material underlies what appears to be the Early Wisconsin terrace although not typically developed here. Dr. Baker is inclined to consider the fauna as of Sangamon or Peorian age.

P: From loess-like material at locality 71, about two miles below Mt. Vernon. The collection was made from about 10 feet below the level of what is probably the Early Wisconsin terrace.

Origin of the loess. A somewhat thorough discussion of the origin of the loess is given in Chapter VI. The writer's viewpoint may be indicated here. The loess that rises above the terrace level, together with the intercalated sand, has had an eolian origin. This material was probably derived from the materials of the old flood-plains as they were building up to form the present terraces, and older terraces since removed by erosion or masked by the later ones.

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If this eolian action was taking place while the rivers still occasionally flooded their alluvial flats, the origin of some of the loess-like materials under the terrace would be explained.

Age of the loess. The loess of Henderson County probably represents many stages in the Pleistocene. Loess of probably Early Wisconsin age is found at locality 66, in the mounds below Dam 48. Most of the loess is pre-Wisconsin, as shown by the topographic relationships between it and the Wisconsin terraces. This question is also further discussed in Chapter VI (page 128).

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CHAPTER IV

STRUCTURE

GENERAL

By reference to the geologic map of Kentucky*, it will

*Jillson, Willard Rouse, Geologic Map of Kentucky. Colored, areal and structural. Scale 1 inch = 10 miles. Ky. Geol Survey, 1927.

be seen that the Henderson County region is bounded on the south and southeast by faults. The Shawneetown-Rough Creek fault extends from the Ozark Mountains of Missouri through southern Illinois and crosses into Kentucky at Shawneetown, Illinois. It runs east from there, south of Morganfield, (Union County) and then follows the line of hills from Morganfield to Sebree (Webster County) and thence eastward into McLean County. Its course in Webster County roughly parallels the southern line of Henderson County, remaining at a distance of about four miles from it. This fault represents a major disturbance, for it brings to the surface in Webster County, Mississippian limestones,- rocks which are at a depth of more than a thousand feet in Henderson County. Glenn** states that the fault

**Op. Cit. p. 129

in Webster County is in part a simple overthrust, complicated in other places by block faulting. In some of these blocks he places the displacement at 1500 to 2500 feet or perhaps more.

In the neighborhood of Sebree (Webster County) a subsidiary fault branches off this main one and follows the Green River flood-plain from this point to Hambleton's Ferry and probably beyond. This fault is nowhere exposed and nowhere approaches close enough to the bluffs on either side to render itself apparent by steep dips in

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the rocks. Its location and character have not been determined by the writer as no work was done by him on the southeast side of Green River, but is taken from the work of F. M. Hutchinson. Its course is plotted on the map accompanying this report just as it is plotted on Mr. Hutchinson's map of this region.

Mr. Hutchinson describes the fault as follows:

> "The Curdsville Fault apparently begins near Eastwood Ferry, thence faithfully follows the general course of Green River northeastward for a distance of nearly twenty miles before departing from the river and disappearing under Ohio River sediments. The line of fracture, which appears to be confined wholly to Green River Valley, is completely hidden from view; but the fault is clearly a normal fault with a downthrow to the east. The amount of the displacement varies from a few feet, near Eastwood Ferry, to more than 180 feet at Hamilton Ferry, its most northernly defined limit.
>
> Evidence showing the occurrence of the fault is as follows: The dip of the rocks lying east of Green River is in a generally northwestern direction, and such, with but little variance, is the general dip west of the river. Just west of the river, however, the beds are found suddenly elevated a maximum distance of more than 180 feet above their corresponding position on the opposite side of the river; whereas, if the same rate of dip were maintained they would be at least 40 ft. lower. Such a fact cannot be explained by any process of natural folding, and can only be explained by assuming that a fault accompanied by the required displacement, has occurred."*

*Hutchinson, F. M., Geology and Coals of the Central City ... (and other) quadrangles, Kentucky Geological Survey, Bull. 19, 1912; p 6.

The general dip in the county is westward to the amount of 350 feet in the distance of 25 miles from the bluffs near Hambleton's Ferry to the drill holes south and west of Corydon, or an average of 14 feet to the mile. The structure map, however, shows that this dip is not a regular and uninterrupted one.

It will be observed that the axes of folding parallel the faults from Hambleton's Ferry to the Webster County line fault and thence for an indeterminate distance along the Webster County line. The folding paralleling the Curdsville fault throws doubt upon

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Hutchinson's interpretation of this as a normal fault. It might indicate faulting due to thrusting, in which case the faulting would be of the reverse type. Mr. Hutchinson does not make clear the evidence upon which he bases his interpretation of this as a normal fault. Without definite evidence either way, both possibilities should be kept in mind.

DETAILED STRUCTURE

Data On Which Structure Is Based

The structure as represented on the map is recognized as generalized and in parts doubtful. The doubtful portions are represented by contours drawn in broken lines.

The data on which this structural map is based are taken from observations of rock outcrops, coal mine shafts, coal test drillings, oil wells, and a few water wells. Except in the Green River drainage area, the Ohio River bluffs, and the Poole Hills, there are no outcrops which could be used as points to determine the structure. In the Green River section, the Providence limestone is above drainage and because of the water it carries, frequently causes washes in the loess which expose it in gullies. Most of the structure in this section is based upon observations made on this bed. In addition, several coal shafts furnished data.

In the remainder of the county, well records and coal shafts furnished the only data. Diamond-drilled coal tests, mine shafts, and to a smaller extent, churn-drilled coal tests, furnished data which could be considered accurate and interpreted with a sense of certainty. Some of the oil well records showed great inconsistencies and could be interpreted only by careful comparisons among themselves and with more accurate well records. The records of four water wells have also been used in drawing the structure and

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in each case doubt is felt as to the interpretation put upon these logs. As in some cases the structure is important, it will be well to discuss in detail the evidence upon which it is based in the areas outside of the Providence limestone outcrops.

The following discussion of structure deals with the contours as drawn on the map of the county, for which Coal No. 9 was used as a base. When reference is made to the structure developed on the Providence limestone as a base, this fact is specified.

Poole Anticline

One anticline has its crest near the Webster County line from Green River to Poole. The evidence for this fold consists of a reversal of dip shown by outcrops of the Providence limestone southeast of Robard and of a tendency toward a similar reversal shown in the vicinity of Poole by scattered outcrops of the Madisonville limestone. An interval of 300 feet from the Madisonville limestone to No. 9 coal has been assumed, because this is a little less than the interval in Webster County to the southwest and in the Smith Mills region to the northwest in which directions the members are believed to thicken. The interval has not been determined nearer at hand and hence the structure is doubtful in this area.

The Geneva Dome

The dome centering about a mile north of Wilson Station on the Illinois Central Railroad is the most interesting structure in the region from the standpoint of economic geology. It must be emphasized here that this structure is based upon an interpretation of the stratigraphy of this region, an abnormal stratigraphic sequence fully discussed in the chapter on stratigraphy. It will be recalled that Coal No. 9 apparently is missing at several of the

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localities tested and in reappearing suddenly, is found at a different distance from the Providence limestone. In cases where No. 9 Coal is absent, the structure represents the structure of the overlying Providence limestone; in such cases a constant interval was assumed between the limestone and the place of No. 9 coal. This would seem the best assumption, for the limestone probably was more nearly level at the time of its deposition than was the coal bed, as coal beds are known at times to split widely in short distances. The data from which some of the contours bounding this dome are drawn are capable of different interpretation; therefore it will be well to review the data.

The slope of the Providence limestone is well shown between localities 7, 8, 9, and 12 by its position in those wells.

The structural drop from the center of the dome to Smith Mills is certain, since the record of the well at locality 2 is excellent. In detail, however, the actual position of the contours between these two points is subject to some doubt. The evidence upon which the structure in this region is drawn is as follows.

The dip of the beds between Smith Mills and West Franklin, Indiana, is northwestward, as shown by outcrops of the Madisonville limestone at both places, although dips south of Smith Mills are westward and southwestward, indicating a circumferential strike between these points.

A water well at Geneva (locality 10) shows a four foot coal at an elevation of 230 feet above sea level. This coal is not reported to have the limestone roof of No. 11 coal. Assuming that its thickness has been reported approximately correctly, it must be No. 9 coal, as this is the only thick coal ordinarily found

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at the horizon indicated approximately by the general dip from the center of the dome to Smith Mills.

A water well drilled on the Horace Bagley farm struck a "hard, flinty rock that came up in little sharp pieces" at an elevation of 290 feet. Beneath this rock a flow of water was struck which carried up little rounded gravel into the casing. This would suggest a boulder of the Providence limestone and has been considered slump from a nearby ledge or perhaps even an overhanging ledge in place. Its position has been taken to indicate roughly the position of the Providence here because it is in about the position where it would be expected from the other data. It does not seriously affect the structure.

The closure of the dome toward Corydon is clearly indicated by the relatively lower elevation of the coals in the numerous wells southwest of that place. The detail of the dip in this direction cannot be determined.

Unfortunately, the closure in a southeast direction - the direction most important from an economic standpoint in this region of generally westerly dip - cannot be so definitely shown. The Providence limestone is only ten feet higher at Robard in the southeast corner of the county than it is at the crest of the dome, while No. 9 coal is lower at Robard than it is in the region of the dome, contrary to the dip indicated in the Robard region; this fact suggests a reversal somewhere between Robard and the dome crest. However, it cannot be asserted that there is not an anticlinal axis running from some place north of Robard to the Wilson dome, thus preventing a complete closure.

In drawing the structural map, use was made of a water well drilled at locality 22. The record of this well was not

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wholly clear and it is interpreted with much misgiving. A 40-foot limestone in the upper part of the record shows that the strata were in all probability very poorly interpreted, as no such thickness of limestone is known in this vicinity.

In drawing the structure through localities 13, 16, and 22, some assumptions had to be made, due to the change in the stratigraphy between these points. The interval between Coal No. 9 and the Providence limestone at locality 13 is 81 feet; in the drill hole at locality 16, the interval between the Providence limestone and the coal doubtfully interpreted as No. 9 is 110 feet. Inasmuch as the remainder of the structure in this area is essentially that of the Providence limestone, the structure between those two points is so drawn. At locality 22, the 4-foot coal reported in the log is assumed to be Coal No. 9. This interpretation carries the inference that the 40-foot "limestone" is a mistake in the driller's identification of the rocks passed through.

It must be emphasized that this closure to the southeast is largely a matter of conjecture, because of the vagueness of the record of the well at locality 22 and because of the nature of the Carbondale stratigraphy in this area. It is possible actually to refer the lower part of the 40 feet of "limestone" in the locality 22 well to the Providence limestone, the two feet of "shale and coal" below it representing Coal No. 11. On this assumption, Coal No. 9 would be cut out and the 4-foot coal found in the well would probably represent Coal No. 8. The 230-foot contour would be drawn from locality 20 in Henderson southward and westward between localities 16 and 22, thence connecting with the 230-foot contour around the dome. From this point it would come back again southeastward, crowding the contours around Cairo further southwest, and connect with

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the 230-foot contour near Robard. An anticline would be shown running northwestward from north of Robard through the Geneva dome and pointing from there toward Mt. Vernon, in a direction which would roughly bisect the angle between the Rough Creek and Curdsville faults; this would give a fan-shaped aspect to the structure of the county with the folds radiating approximately from the point of intersection of the two faults.

The structure between Henderson and Geneva, using the base of the Providence limestone as a key horizon, and assuming that the base of the thick limestone in the locality 22 well is the base of the Providence, is shown in Fig. 4. The scale of this map is one inch to the mile and the locality numbers are the same as those shown on the large map of the county.

Implications of a Hypothesis of Faulting

Inasmuch as some privately prepared geological reports have interpreted the conditions around the Kleiderer property as due to faulting, it may be advisable to consider some of the implications of an hypothesis of faulting in this region.

In the first place it should be noted that the maximum vertical range shown by the Providence limestone is only 50 feet in a distance of a mile, whereas the increase of interval between the limestone and No. 9 coal, on the assumption that No. 9 coal is one of the coals found in the irregular wells, ranges from 50 to over 100 feet. To explain this discrepancy it is necessary to assume a complex folding accompanying the faulting, so that, although the fault has a vertical displacement of 100 feet, the folding has compensated for this displacement with the result that a smaller vertical range of the limestone is observed between drill holes.

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Making this arbitrary assumption, let us consider how we could get the increased intervals. The first possibility is illustrated diagrammatically by A, Fig. 12. If the beds are tilted, a vertical drill hole will penetrate them diagonally and so give abnormal thicknesses to the strata. However, individual known beds should also be abnormally thick, whereas none of the beds, not even the limestone, are thicker than usual.

If, then, the thickening of intervals is not due to tilting, it must, under the assumption, be due to the cutting of the fault plane by the wells. If the fault were a normal fault, that is, one in which the strata on the upper side of the fault plane have slipped down, the intervals would be decreased instead of increased, as illustrated in B, Fig. 12. Hence no normal fault occurs here.

If the fault were of the reverse type, that is, one in which the strata above the fault plane have been pushed up (C, Fig. 12), the strata would be repeated in the same vertical line. Thus wells at 1 and 2 in the figure would repeat known beds. Only wells in the general position of 3 in the figure would show increased intervals between the limestone and the coal. It should be noted that it is impossible in this way to increase the interval from the limestone to No. 9 coal from 80 to 160 feet or more without repeating either the lime or the coal.

Assuming the minimum displacement- about 40 feet- required to explain the irregularities of any of the wells under the faulting hypothesis, the probability of hitting the fault plane with a well can be computed. If we assume that the fault plane is at the very low angle of about 27° (a slope of one foot vertical to two horizontal), the limit of movement of such a well as No. 3 in the figure

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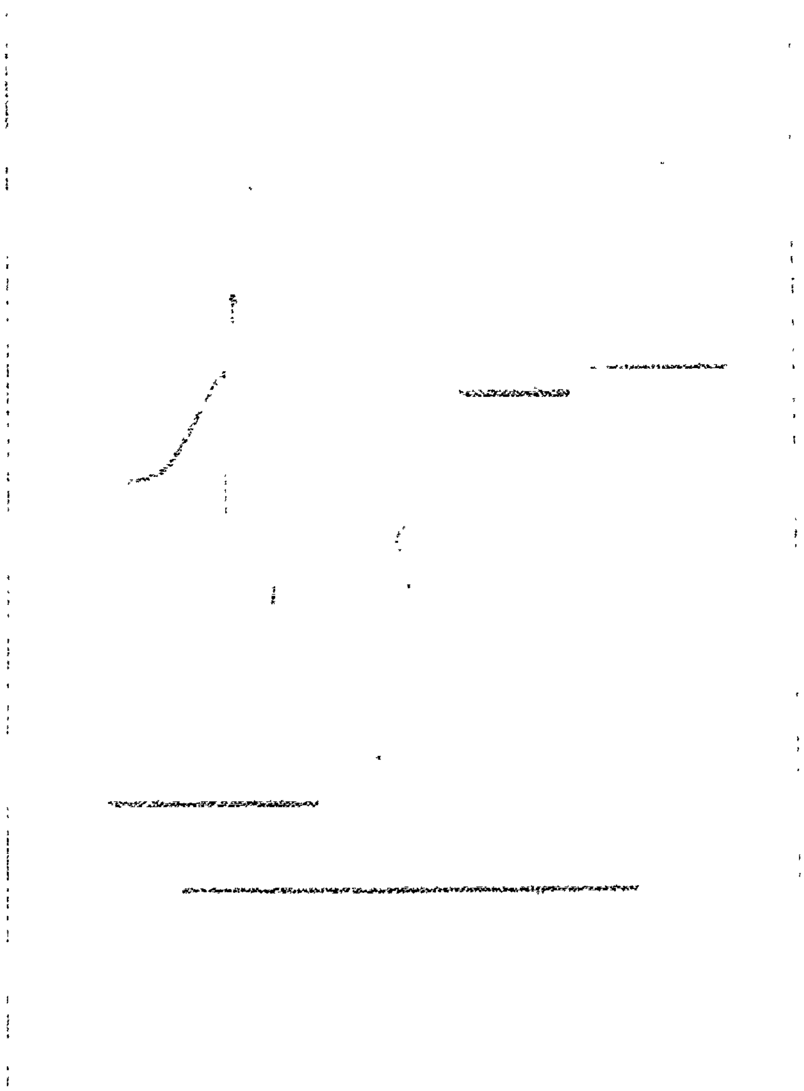

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will be 80 feet from side to side. The section bounded by the wells showing irregularities to be explained by faulting is about a square mile in area and about one and one-quarter miles long. If we assume as many as four faults running the length of the section, the chance of one well hitting a fault plane is about 1 in 13. Seven holes were put down in this area since development was started and all showed irregularities. The chance of all seven hitting the fault plane, the necessary assumption under the faulting hypothesis, is about 1 in 70,000,000. If only one fault is assumed the chance lies close to one in one trillion. Assuming that the displacement was 80 feet instead of 40 feet, and that the coal was kept from repeating by being squeezed out in the section above the fault plane, the chance is still only one in 500,000. Further, if the diamond drill crossed the fault plane, it would seem probable that the driller would have recognized it in the core.

It is impossible to state that no very minor faulting has occurred in this area. Many mines throughout this coal field find such minor faults during their operation which could not be foretold by drilling. However, as far as this section is concerned, there is no reason to postulate any faulting at all, and the chance that the conditions met here are due primarily to faulting is negligibly small.

Structure in Smith Mills Bottoms

No structure is shown in the river bottoms to the west and north of Smith Mills. The reason for this is obvious. Water is obtained in the alluvial filling of this bottom and consequently no wells touch bed rock. There was, however, a diamond drill coal test located just across the point of the meander in Mt. Vernon,

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Indiana, which is of great interest in this connection. The record of this well is given in the Indiana publication* and is copied

*Logan, W. N. Geology of the Deep Wells of Indiana; Ind. Dept. Cons. Pub. #55, p. 474, 1926.

among the logs printed in this book, because of its bearing on the structure of Henderson County. The correlations of the members as given in this log are the work of the Indiana Survey.

The interpretation of the Indiana Survey places their No. 5 coal (Kentucky No. 9) at an elevation of about 150 feet below sea level, an elevation which agrees very well with the elevations five miles north, as roughly given by estimating the depth to Indiana No. 5 from the outcropping seams plotted on the map of the Patoka quadrangle by Fuller and Clapp*. By comparison with the Smith Mills log

*Fuller, M. L., and Clapp, F. G., Geologic Atlas of U. S., Patoka folio, No. 105.

some 10 miles southeast and with the log of a diamond drilled coal test well at New Haven, Illinois, some 15 miles west, striking discrepancies are noted between the strata as given according to the Indiana correlations and the strata shown in both of the other wells. All three records give evidence of accuracy and reliability. It is deemed best to discuss this question of stratigraphy under the heading of structure because its answer affects only the question of structure so far as Henderson County is concerned.

In this discussion it must be remembered that Indiana and Illinois coal No. 5 is Kentucky No. 9 and the No. 6 coal of those two states is No. 11 of Kentucky. The Somerville limestone of Indiana is equivalent to that called Madisonville in this report. The Kentucky nomenclature will be used in discussing the Indiana and Illinois wells as well as those of Kentucky, although in the

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log published herewith the nomenclature as given in the reports of Indiana will be retained.

The following inconsistencies between the Mt. Vernon log according to its published interpretation and the Smith Mills and New Haven logs should be noted.

(1) The interval between Nos. 9 and 11 coals in the Smith Mills log is 105 feet and in the New Haven log is 100 feet, while the same interval in the Mt. Vernon log is made slightly over 200 feet.

(2) Thick coals appear above the No. 11 coal in the Mt. Vernon log in what is a barren series in both the other logs. This series is barren throughout Henderson and Webster counties.

(3) The interval from No. 9 coal to the Mansfield sandstone (basal Pennsylvanian of Indiana) is given in the Mt. Vernon log as 400 feet. To the corresponding Caseyville of Kentucky it is 675 feet in the Smith Mills log. The lower part of the New Haven record is much sandier than the others so that the correlation of the Mansfield and Caseyville cannot be determined. However, the interval from No. 9 to the top of the Mississippian is 1050 feet in the New Haven record. The Mansfield sandstone does not, in the knowledge of the writer, approach any thickness comparable to this difference of 650 feet in any portion of Indiana. In the wells nearest to this locality whose records are published in the work cited, its thickness is given as only 200 feet. While it is possible that such a great thickening of this member does occur in the Mt. Vernon region, it cannot be assumed without further data.

Minor irregularities in the members as compared with the other logs also occur, but they cannot be considered as critical inasmuch as they are to be expected in Pennsylvanian stratigraphy.

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A black fossil shale roof occurs over the coal considered No. 9 in the Indiana correlation. This suggests that this coal is indeed No. 9 and would be strong evidence for the correctness of the correlation if the other evidence supported it and if No. 6 coal did not also have a fossil shale roof in Webster County where it is opened*. The suggestion that this coal at Mt. Vernon may not be No. 9 but No. 6 leads to the attempt to so correlate it.

*Glenn, L. C., Op. Cit. p. 79.

If this coal be placed opposite No. 6 of the Smith Mills record, several other members at the same time can be correlated between the two logs without material change in their intervals. They follow.

(1) The coal called No. 8 in the Mt. Vernon log, with limestone immediately above and below it stands within 5 feet of the place of No. 9, with limestone similarly related in the Smith Mills log.

(2) A coal with limestone close above and below it, 200 feet above this hypothecated No. 6 in the Mt. Vernon log, stands within five feet of a coal with similarly placed limestones in the Smith Mills log.

(3) A 2.4-foot fossil limestone occurs 51 feet below the hypothetical No. 6 coal at Mt. Vernon and a 2-foot fossil limestone occurs 55 feet below No. 6 at Smith Mills.

(4) The base of a limestone in the Mt. Vernon log is within five feet of the base of the Providence limestone in the Smith Mills well. If the limestone in the Mt. Vernon well is the Providence, No. 11 coal is absent but it may be said that No. 11 is a variable coal and is absent in some Henderson County records. The

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sequence in the 40 feet of rock above this limestone varies from that shown at Smith Mills but is very similar to that at Hitesville (locality 4) and also to that section of the New Haven log. The conglomeratic sandstone above the upper limestone in the Mt. Vernon log is probably the Anvil Rock.

(5) Finally, perhaps the major objection to the Indiana interpretation, the great thickness of the Mansfield, or alternative little thickness of the Pennsylvanian below No. 9, is eliminated in this interpretation because the top of the Mansfield in the Mt. Vernon log coincides within five feet with the top of the Caseyville in the Smith Mills log.

It would seem that the only real discrepancies between the Smith Mills log and the Mt. Vernon log as thus interpreted are the absence of No. 11 coal at Mt. Vernon, previously considered, and the presence of the 2.2 foot coal, called No. 7 in the Indiana correlation, lying 55 feet below No. 9 as here considered. This is here regarded as a local development of coal No. 8. Another record from Mt. Vernon, given in the same report, shows only a four-inch coal near this horizon. This latter record is, however, apparently not so accurate as the other.

The detailed correspondence of the Mt. Vernon with the New Haven log is not so close as that with the Smith Mills no matter which interpretation is put upon the Mt. Vernon log. It can only be said that the general aspect of the Mt. Vernon log agrees more closely with the New Haven log under the interpretation here suggested than under the interpretation previously put upon it and published by the Indiana Survey.

There is a possibility that the interval from No. 6 to No. 9 coal has shrunk from 290 to 200 feet in going from Smith

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Mills to Mt. Vernon and that the 4-foot coal about 200 feet above the No. 6 coal in the interpretation here suggested is really No. 9; in that case the 2.2 foot coal about 30 feet above this hypothetical No. 9 (considered No. 8 in the above) would be No. 10 and the 6-foot coal about 55 feet above that and capped by limestone would be No. 11. This would give a somewhat better correspondence between the two logs for the hundred feet above No. 9. Considering the log as a whole, however, the first interpretation here suggested is probably the correct one.

The elevation of No. 11 coal at Uniontown is about 200 feet. The elevation of this coal, assuming normal intervals, is 60 feet above sea level on the southern edge of the Patoka quadrangle about four miles north of the Mt. Vernon well, as estimated from the outcrop of the Aldrich coal plotted on the maps of the publication cited. At Smith Mills and at West Franklin, Indiana, it is about 170 feet A. T. At Mt. Vernon, according to the interpretation urged here, it is at an elevation of 245 feet above sea level, or according to the alternative correlation mentioned, at 145 feet above sea level. The general dip at Smith Mills and West Franklin is westerly.

If the interpretation made here is correct, the Geneva structure, which has a northwesterly trend, probably continues through the Ohio River bottoms past the lower end of Diamond Island as an anticline upon which, in the vicinity of Mt. Vernon, a dome is raised. This interpretation implies a sharp northerly dip at Mt. Vernon or perhaps a fault somewhere north of it. This suggestion is radical but it must be remembered that major structures could be concealed under the thick loess and alluvium north of Mt. Vernon without being suspected; that the region is only about 20 miles

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removed from the Shawneetown fault; and that comparable faulting and folding, though of a different trend, occurs in the Illinois coal fields about 25 miles west.* It may well be that there is

*Cady, G. H., Coal resources of District V, Ill. Geol. Survey, Co-op. Mining Series, Bull. 19; Map. ; 1919

a structural reason for the great widening of the valley at the junction of the Wabash and Ohio Rivers.

Green River Flats

The structure as drawn in the flats east of the Green River is exceedingly generalized. It is not intended to indicate more than the most probable dip of the rocks. There are no data in these flats upon which the structure can be based. The contours as drawn simply connect the loose ends of the contours in the highland portion of this county, with known elevations of the No. 9 coal in Indiana at Newburg and Yankeetown and at two intermediate points. They are intended to indicate roughly only what coals may be expected under these flats.

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CHAPTER V

HISTORY OF BED-ROCKS

MISSISSIPPIAN

The account of the geological history of this county should properly begin with Mississippian time, because the rocks laid down at that time have been penetrated by drilling in this county. However, as mentioned previously, the records of this drilling were so poorly kept that we can say nothing about the history of this time from data obtained within the county. It is probable that here, as in most surrounding regions, shallow seas covered the territory, into which were poured sands and silts, which later became the sandstones and shales of the Chester group. In the clearer portions of these seas limestones accumulated from calcium carbonate precipitated in various ways from the sea water. At the close of this period the sea bottom was uplifted and made land and began to wear away.

PENNSYLVANIAN

Caseyville

When the land was once again lowered, the rivers, carrying their debris toward the shifting arms of the shallow sea, formed a thick deposit of coarse sands and pebbles, which later became the Caseyville sandstone. Such a coarse sandstone and conglomerate froms the basal member of the coal measures in practically all parts of the world. At times finer material was brought to this area, which later formed the shale members of this formation.

Tradewater

During the time in which the Tradewater formation was deposited, the land which was furnishing the sediments evidently stood lower than before so that over long periods relatively little

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material was brought to the sea and most of it mud rather than sand or gravel. The coasts of the very shallow arms of the sea must have been low marshy areas scores of miles in extent. Here flourished the great coal forests, continually pushing the marsh belt out into the sea and filling up the shallow embayments with decomposing vegetation. This vegetation, preserved from decay by being covered with water, thus excluding air, decomposed into peat, which under the pressure of sediments piled upon it later, was changed into coal. The relatively high sulphur content of many of these coals indicates that the coal was formed in the salty or brackish water of marshes and not in fresh water swamps. The marine fossils found in the roof of Coal No. 6 and in the limestones associated with some of the other coals shows that from time to time the sea encroached far across the swampy lowlands, killing off this vegetation and depositing muds of calcium carbonate or of clay. In time these changed to the limestones and shales rich in remnants of marine organisms.

Carbondale

The general conditions of sedimentation which prevailed during the time when the Tradewater formation was formed remaine the same throughout the time when the Carbondale formation and the Lisman formation above were deposited.

During Carbondale time, one of the most unusual events of Pennsylvanian time occurred. This was the deposition of Coal No. 9. A shallow embayment must have covered most of the area of the whole coal field in western Kentucky, southern Illinois, and Indiana; an embayment not so deep as to prevent the growth of forest out into it and yet deep enough to retain its marshy charac-

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ter and hold enough water to protect the dead vegetable matter from oxidation. After the deposition of a very thick bed of peat, the forest growth stopped, obviously by an advance of the sea which left the remains of its teeming life as the fossils or "penniwinkles" now found in the roof of the coal.

The position of the Kleiderer shaft probably represents the location of a delta which was being built out into the sea at this time. To the north the marshy embayment seems to have been more shallow than it was to the south of this location, while evidently near this place one of the distributaries of the stream flowed. Thus the coal formed to the north at a higher elevation than to the south while just at this point conditions were such as to allow but a thin bed to form, or, what is just as probable, the coal formed to an unknown thickness but was later cut out to its present thickness by the waters in the channel which passed nearby. After the deposition of the peat which formed the coal, the region to the south was filled in by sediment more rapidly than that to the north where limestone was accumulating, thus making the interval between Coals No. 9 and No. 11 less on the north side than on the south side of the shaft.

At the close of the Carbondale there came another period when the lands were low and vegetation covered large marshy regions flooded again by an advance of the sea. This was the time when Coals No. 11 and No. 12 with the intermediate Providence limestone were deposited.

Lisman

With the inauguration of Lisman time came the deposition of the coarse, crossbedded, Anvil Rock sandstone by torrential waters. These sands were spread over the entire county with the exception

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of the region between Henderson, the Graham Hill mine (locality 23), and the L. H. & W. mine (locality 26), the logs of whose shafts do not show this sandstone or else show it as a very thin one.

After this period of torrential outpouring of coarse sands, certain sections of the western part of the county were left free from incoming sediment and in these sections grew the forests which were to form the Baker or No. 14 coal. As pointed out in the chapter on stratigraphy, it is believed that No. 12 coal and the No. 14 coal of Webster County, Corydon, and Smith Mills are essentially the same and that the Anvil Rock is really a transgressing member; that is, that its sands were poured out in fans into the embayment on the shores of which the vegetation was growing. It is conceived that these sands were spread in a general way from southwest to east so that in the southwestern portion the sands were deposited directly or almost directly upon the Providence limestone before the forests which were to form No. 12 coal could grow to appreciable extent, and that after the delta had shifted eastward, coal formation was resumed, giving the No. 14 coal around Corydon. In the eastern part of the county, No. 12 would have been forming during the earlier part of this time, while by the time the deltaic fans had reached and covered these deposits conditions for coal formation would have ceased.

After the passing of the time of the Anvil Rock and No. 14 coal there is nothing more significant recorded in the Lisman formation in this county until the deposition of the Madisonville limestone. A long series of shales and sandy shales were deposited, indicating a low land that was furnishing the sediments. The streams became progressively more and more sluggish and brought less and

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less sediment to the embayment until, in Madisonville time, 5 to 10 feet of rather massive limestone had time to accumulate. With the passing of this episode more muds and sandy silts were deposited in this area although a few miles north in Indiana a massive sandstone was deposited.

Soon after the close of Pennsylvanian time the American continent was greatly uplifted. It was at this time that the Appalachian mountains were formed. Probably at this time, possibly long after this, the rocks in this county were subjected to the gentle folding and localized faulting discussed in the chapter on the structure of Henderson County. Nothing has been left to indicate the history of the county during the very long span of time from the end of the Pennsylvanian to near the close of the Tertiary period. It is probable that in this interval great thicknesses of sediments overlying those now seen were removed by erosion.

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CHAPTER VI

PHYSIOGRAPHIC AND MANTLE-ROCK HISTORY

INTRODUCTION

In this chapter the history of the present surface will be traced. This discussion will involve both the manner in which the bed-rock was cut and the means by which the unconsolidated deposits lying upon the surface of the bed-rock were deposited. Inasmuch as the points arising in this discussion pertain not only to Henderson County but, in a general way, to much of the surrounding country, this chapter will have a more general scientific interest than the other chapters in this report. Because many of the questions arising in connection with the subject are controversial ones, the treatment of the material must be of a more technical nature in some places.

The history of the present surface divides naturally into four parts on the basis of the effects produced. These are as follows:

(A) The erosion of the bed-rock surface of the county in probably late Tertiary time, in the early stages accompanied by the deposition of the high-level gravels upon this surface.

(B) The filling of the valleys, or the work of the river during Pleistocene time.

(C) The spreading of the loess, or the work of wind in Pleistocene time.

(D) The latest events in the history of the Ohio River in this territory during Recent time.

The major points which will be urged in this chapter

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are grouped below for the convenience of the reader. Fig. 18, which portrays an ideal cross-section of Henderson County, expressed some of these points diagrammatically. The views held by the writer are as follows:

(1) A peneplain was established, probably in late Tertiary time, at a level which is now 550 feet above the sea.

(2) The territory was intermittently uplifted and the rivers cut terraces which now stand approximately 500, 440, 390, and 300 feet above the sea; after which the river degraded to a level now about 200 feet above tide. This cutting took place entirely, or almost entirely, in late Tertiary time.

(3) Accompanying the formation of these terraces, gravels - the "Lafayette" - were deposited over the old flood-plains. The materials of the "Lafayette" were derived from the Mississipian and Pennsylvanian strata up atream.

(4) These gravel-covered terraces probably correlate in a general way with similar terraces on the lower Mississippi River.

(5) Hypotheses of a differential depression of the southern part of the Eastern Interior Coal Field, in order to explain the wide filled valleys, are unnecessary and, in some respects, untenable. The wide valleys are merely an expression of the less resistant lithology of this region.

(6) A hypothesis of general depression of the lower Ohio Valley to explain the deep filling is probably unnecessary.

(7) The filling of the valleys was due probably only to the overloading of the Ohio River with glacial debris.

(8) Two dominant fillings, represented by two terraces, which seem to be assignable to Early and late Wisconsin stages are present.

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(9) An earlier, much eroded, probably Illinoian, fill may be present.

(10) The loess of Henderson County was deposited mainly through aeolian action; the "marl-loess" hypothesis, as propounded for the lower Wabash valley, is not applicable to Henderson County, although the loess here lies below the critical elevation given for the "marl-loess".

(11) The Ohio River is at present aggrading its flood-plain in the coal field, although degrading its channel. This may be the result of either the normal growth of the stream or a climatic variation.

PART A - TERTIARY HISTORY

EROSION

Peneplanation at 550-foot level

The first recorded event in the development of the surface of Henderson County was the formation of a peneplain, now represented by the summits of all the high hills of Henderson County. These hills rise to elevations of slightly over 560 feet above sea level.

These hills all lie on ..e divide between Green River and the smaller streams to the west. Those with summits reaching from 560 to 580 feet above the sea are: several peaks in the Wolf Hills (53, 29 to 33), Ridgewood Hill, west of Spottsville, (51, 26), those between Robard and Niagara (42, 30), Rockhouse Hill (40, 28), and the Poole Hills (39, 37). The highest point in the county, in the Wolf Hills, is only a few feet above 580 feet above the sea. In neighboring counties in Kentucky and Indiana, many divides rise to the same 560 to 580-foot level.

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Inasmuch as these hills are so widely spaced, dominating as they do the entire eastern part of the county, there can be little doubt that their summits represent the remnants of a surface of little relief at one time continuous over this county and vicinity. Since these hills are capped by different stratigraphic units, the surface does not represent a stripped plain. It must have been produced through the reduction of the entire region to base-level. The presence of chert gravels- the "Lafayette" - upon Ridgewood Hill shows that the surface was in part produced by the lateral planation of Green River. These gravels are discussed on page 90.

<u>Correlation.</u> A peneplain in Hardin County, Illinois, represented by remnants varying in elevation from 500 to 540 feet above sea level has been described by Salisbury*. The higher points may

*Weller, Stuart, and others, The geology of Hardin County, Ill. Geol. Survey, Bull. 41, p. 50; 1920.

represent this same surface.

<u>Geologic Age.</u> There are no data from within the county which would indicate even an approximate date at which this peneplain was perfected, and no probable correlation of it has been described elsewhere.

It apparently abuts to the east against the Crawford Upland of the Indiana Geological Survey, which rises some 300 feet higher, and has been correlated by Malott** as probably a part of

**Logan, W. N., and others, Handbook of Indiana Geology, Indiana Department of Conservation, Pub. No. 21, P. 131; 1922.

the "Early Tertiary" or Highland Rim peneplain. Higher hills to the south of the coal field in Kentucky rise to about the same level as this higher surface in Indiana and perhaps represent

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the same surface. The 560-foot level is therefore probably younger than the Highland Rim.

The age of the Highland Rim peneplain is in doubt. If its age is considered Early Tertiary, following Malott*,

*Logan, W. N., Idem.

the age of the 560-foot level is probably Late Tertiary. If, as suggested by Shaw**, the Highland Rim peneplain was

**Shaw, E. W., The Pliocene history of northern and central Mississippi., U. S. G.S., Prof. Paper 108, p. 162; 1918.

perfected in early Pliocene or not earlier than Miocene time, the age of the lower level is probably Pliocene. In the lower Mississippi valley, according to Shaw***, the terrace "Lafayette"

***Idem. p. 139.

gravels such as are found capping the 560-foot level in one place in Henderson County, are all Pliocene. Following this interpretation the age of this level in Henderson County would be Pliocene.

Inasmuch as there is no evidence contrary to this assumption, and some in favor of it, the 560-foot level in Henderson County is considered of Pliocene age.

Degradation of peneplain.

Since the formation of this peneplain, the region must have been uplifted at least 350 feet as the bed-rock bottom of the Ohio River is that distance below the plain.

This uplift was probably not of the nature of a continuous rise, either gradual or comparatively sudden, but seems to have taken place as an intermittent series of rises, interrupted by periods of quiet. The evidence for the intermittent character

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of this uplift lies in an apparent series of levels capped by the "Lafayette" gravels.

Explanation of Figure 14. An attempt has been made to give the evidence for two of these intermediate terrace in the map of Figure 14 .

The working principle underlying the construction of this map is as follows. A series of terraces long exposed to erosion would lose its identity due to dissection, especially when, as in the present case, the terraces are close together in vertical range. A way must therefore be sought to mask the effects of later erosion. This may be done by considering each peak as dominating a certain area, or as representing the height from which the surrounding area was cut down, the lower elevations in that area being given no consideration. If contours are then drawn on these peak elevations, correctly located, the resulting map should have the appearance of a map of a terraced area in which erosion has not yet destroyed the terrace surface.

In constructing the map of Figure 14, the highest elevation in each small quadrangle $2\frac{1}{2}$ minutes square was plotted. In a few instances two points were chosen from only one of these small quadrangles when two distinctly different peak elevations happened to fall near the opposite edges of the quadrangle. In general, however, each area $2\frac{1}{2}$ minutes square (about $6\frac{1}{2}$ square miles) is represented by only the highest peak in the area. Contours of twenty-foot interval were then drawn upon the plotted data. The areas falling within the elevations at which "Lafayette" gravels were found in Henderson County are hachured and the areas of Pleistocene alluvial filling are stippled. Figures on the map

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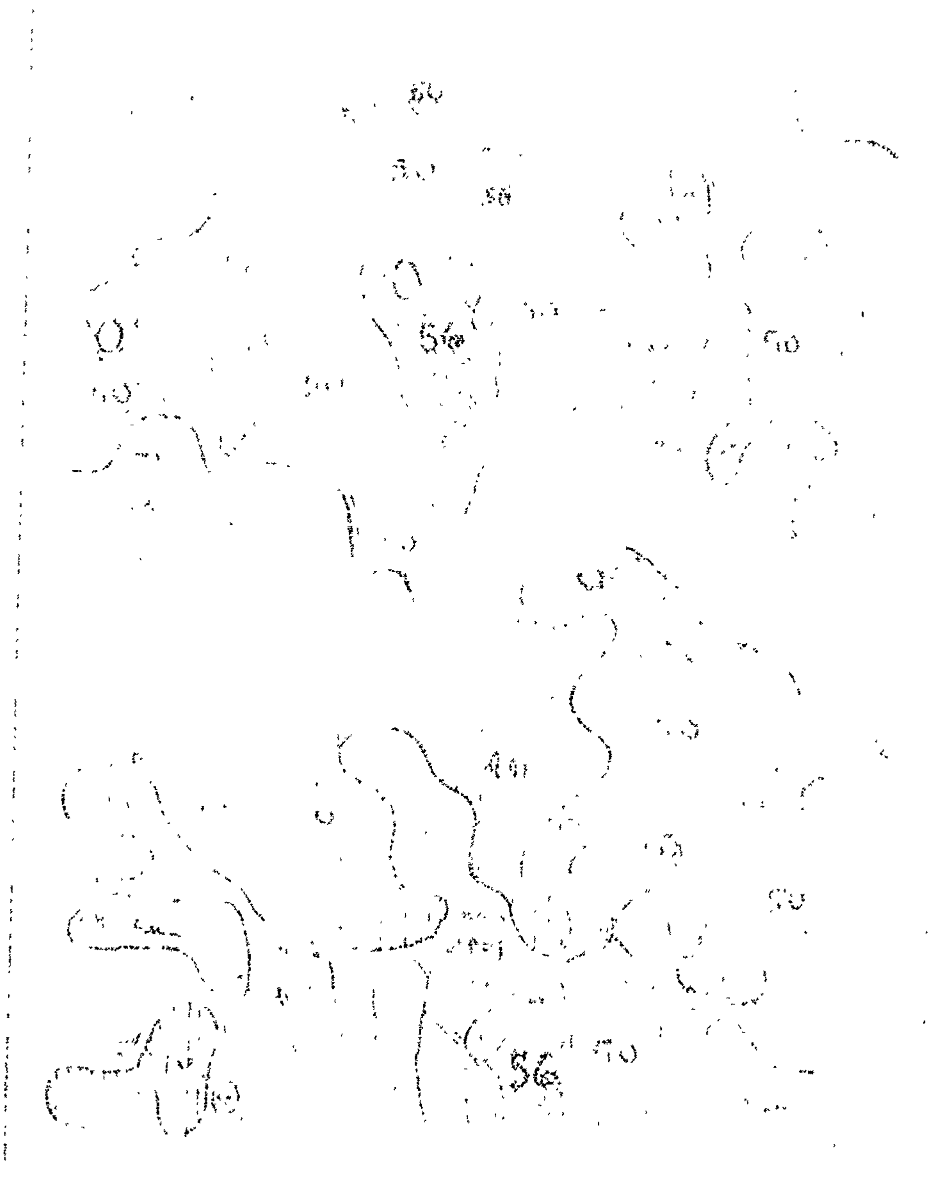

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give the elevations of the areas in tens of feet above sea level.

Objections to this map as evidence of terrace formation at the levels indicated may easily be raised. Especially in the portion of the map including Indiana territory there are large areas lying at elevations intermediate to the 500 and 560-foot levels. It is probable however that such areas are to be expected as indicating areas which were not entirely reduced. In this connection it is worthy of note that the largest area of these intermediate levels is farthest removed from the major streams. It shows its monadnock character in that it contains within it the highest elevation (660 feet above tide) of the mapped area. On the other hand, the reduction to the hypothetical terrace levels is very marked along Green and Ohio rivers.

Perhaps the most convincing point to be made about this map is the abrupt drop shown in most places from residual elevations above the 560-foot level down to this level, and from the 560-foot level down to the 500-foot level. Such a condition obtains in almost all portions of the Kentucky part of the map and is very marked north of a line joining Evansville and Mt. Vernon, Indiana. A like step is found at most points between the 500-foot and higher levels and the 460-foot level. Inasmuch as the construction of the map was a mechanical procedure, in which the opinions of the writer could take little part, the erosion steps displayed on the map appear very significant of an intermittent uplift of the land.

Some additional evidence of the terraced character of the area is given in the following.

Description of intermediate terraces. The first pause in the uplift is thought to have resulted in the cutting of a terrace

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at a level standing now about 500 feet above the sea. In Henderson County this surface is represented by many ridges and knolls near Green River, which rise slightly above the 500-foot elevation. Most of these remnants have Tertiary gravel caps. Such remnants may be seen between Hebbardsville and Robard, near the southeastern boundary of the county.

This 500-foot level is also well represented in southwestern Indiana, where Fuller and Clapp have postulated a period of local peneplanation to explain it*.

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*Fuller, M. L., and Clapp, F.G., Geol. Atlas of the U. S. , Patoka Folio, No. 105, p. 6; 1904.

A second pause in the down-cutting apparently resulted in the planing of a level at 440 feet above the sea. This surface is represented in Figure 14, by the area lying above the 460-foot contour, the difference of twenty feet representing approximately the average thickness of the loess in the western part of the mapped area. The loess in this area effectually conceals the bed-rock and it is possible that the accordance in level of the loess-capped hills does not correspond to an accordance of the concealed bed-rock hills. In the region around Smith Mills it is known that the 460-foot level is the result of a loess deposit more than 45 feet thick. This area is shown by dashed contours and hachures on the map. It is believed however that most of the 460-foot surface is the result of loess deposition upon hillocks of accordant heights. The hillocks back from the river in all cases represent bed-rock mounds under their loess covers, as shown by the records of wells, and by outcrops of bed-rock in a few placed along the sides of stream valleys. If the eolian hypothesis for the origin of the loess is accepted, it is easier to account for the accordant levels by the assumption that a sub-

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uniform thickness of loess caps hills of about the same elevation than by an assumption that a deposit of loess of varying thickness has been so distributed over an uneven surface as to bring nearly all summits to the same elevation. Evidence sustaining the view that the loess has an eolian origin will be given later, on page 123.

The presence of a thick deposit of chert gravel upon a shelf extending out from Ridgewood Hill at locality 32 (53, 25) gives additional evidence for the conception of terracing at this level. Figure 15 gives a cross-section of the topography and the profile of the divide in this vicinity and shows the abrupt drop of the topography from the 560-foot level to the wide gravel-covered bench at 440 feet above the sea.

In Hardin County, Illinois, Salisbury describes a plain (the Elizabethtown plain), varying from 400 to 420 feet above tide*, or 100 to 120 feet above low water in the Ohio. This level is in fair agreement with that postulated in Henderson County, which is 110 feet above low water.

*Weller, Stuart, and others, The geology of Hardin County, Illinois Geol. Survey, Bull. 41, p. 50; 1920.

A third pause, when the rivers were at a level which is now about 390 feet above the sea, is suggested by a thick deposit of chert gravel at that elevation at locality 29 (53, 28). Several wells put down on low loess-covered hills near the Ohio found bed-rock at about that elevation. Bed-rock covered by thin chert gravels is found at this elevation under the thick loess in the bluffs north of Smith Mills, and near Green River, where the road crosses the creek about 2 miles northwest of Bluff City. This terrace is not represented on Figure 14, because its level is ap-

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proximately that of a Pleistocene terrace in this section.

In Webster County, Glenn* postulates a pause in the down-

*Glenn, L. C., Geology and coals of Webster County, Kentucky Geol. Survey, Series VI, Vol. 5, p. 33; 1922.

cutting of the streams when they were at approximately their present levels because of the frequency of bed-rock outcrops in the flood-plains of the present streams. This level would correlate with the one suggested for Henderson County.

A fourth pause in the uplift, resulting in the formation of a rock terrace now about 300 feet above the sea, is strongly suggested by the elevations of the bed-rock surface under the valley filling, as given by wells which penetrate this filling. Figure 18 (page 102A) shows the location of wells in Henderson County and vicinity which have struck the bed-rock floor beneath the filling. The black dots represent wells which have found bed rock at an elevation of within 10 feet of 300 feet above sea level. The crosses represent wells which first found bed-rock at a lower elevation, and the figures give the elevations at which rock was found. All wells located on this map are so far removed from the valley sides that they do not intersect the projected slopes. The elevation of bed-rock in Henderson County is given in many places on the geological map of the county with the caption "El. Rock".

On Highland Creek, in the vicinity of the mouth of Beaverdam Creek (43, 45), southwest of Corydon, several oil tests, rather scattered, gave elevations of the bed-rock floor, ranging, with one exception, from 290 to 320 feet above sea level. The one exception, the Onan well, almost at the mouth of Beaverdam, gave an elevation of only 240 feet for the rock floor.

Elevations of the rock floor under the terrace are shown by wells there to be comparable to those in the creeks just mentioned.

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Thus at Geneva (49, 41) one well places it a 285 feet, the coal tests about three miles southwest of Henderson place it at 290 to 312 feet, while at the other end of the county, at Bluff City on Green River, bed-rock was found in a water well at 295 feet above sea level. In the flats between the Ohio and Green rivers, just east of the county line, at Newman (Daviess County) (50, 17), an oil test reported the first bed-rock at an elevation of 255 feet above the sea*.

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*Hutchinson, H. M., Coals of Newburg (and other) quadrangles, Kentucky Geol. Survey, Bull. 19, p. 126; 1912.

Outside this area, the records at hand indicate the same preponderance of the 300-foot elevation of the rock floor beneath the fill. This condition obtains just west of Wabash River, in Illinois, and in Webster County, on the drainage of Tradewater River. Dam No. 49, on the Ohio River just below Uniontown, is built upon a rock bar extending entirely across the river. A series of 19 drill holes at this dam showed bed-rock elevations to vary only from 310 feet to 295 feet above tide. This bar may be in part due to the cutting of the Ohio at the present time, but in view of the fact that the Ohio is cutting rock at lower elevations above this point, it would seem to be an inherited feature.

The preponderance of 300-foot elevations strongly suggests that rivers cut wide valleys at this elevation before the country was again uplifted. After the uplift, the major streams seem to have cut inner trenches about 100 feet lower, as shown by the records of one or two wells near the mouth of Wabash River, which first found bed-rock at an elevation of 200 feet above tide.

Unfortunately, no actual cross-section of the bed-rock floor of the Ohio in this section is available. However, such a cross-section is available for the Mississippi River below

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St. Louis. This cross-section, given in Figure 16, shows that the bed-rock floor of the Mississippi consists of a platform ranging in elevation from 280 to 300 feet above tide, in which is cut an inner trench some 50 feet deeper. It seems safe to assume in the light of the data above that the Ohio River near Henderson County has a rock floor similar in shape.

It may therefore, be concluded that since the cutting of the 560-foot level the drainage has cut down in an intermittent manner to an elevation of about 200 feet above sea level, producing terraces at elevations of approximately 500, 440, 390, and 300 feet above the sea. The levels from 560 to 390 feet, inclusive, are capped in placed by the "Lafayette" gravels.

Geologic ages of these levels. No attempt to assign geologic ages to any of these levels, excepting that at 500 feet has heretofore been made. Malott* is inclined to regard this 500-foot

*Logan, W. N. (and others), Handbook of Indiana geology, Indiana Dept. of Conservation, Pub. No. 21, p. 252; 1922.

level as Pleistocene. This view does not accord with that of the present writer.

The writer regards all of this cutting, with the possible exception of a slight deepening of the trenches of the major streams, as Pliocene. The upper Mississippi drainage had cut to its lowest elevation in pre-Glacial time, before the Nebraskan glaciation*. The bed-rock profile of the Mississippi River shows

*Leverett, Frank, Outline of the Pleistocene history of the Mississippi River, Jour. Geol., Vol. 29, p. 620; 1921.

no great inconsistencies between its northern and central parts, according to data at hand**, presented in Figure 17.

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**Leverett, Frank, The Illinois glacial lobe, U. S.G. S. Monograph 38, p. 475; 1899.

The elevation of the bed-rock floor of the Mississippi at St. Louis is in agreement with that of the Ohio in the vicinity of Henderson County. The burden of proof rests upon any hypothesis which would imply that the Ohio continued to degrade after the upper Mississippi had begun to aggrade. The gravels at the 390-foot elevation contain no crystalline pebbles, excepting quartzite and hence indicate a pre-glacial origin. The evidence favors the view that the Ohio had completed its cutting at the time the Mississippi had completed its degradation, and hence before Pleistocene time.

SEDIMENTATION - THE "LAFAYETTE" GRAVELS.

Introduction

The origin of the "Lafayette" gravels in this county is intimately connected with the origin of the bed-rock surfaces upon which they lie. They are here discussed separately because of the great divergence of opinion as to the manner in which these deposits originated.

In the neighborhood of Henderson County, gravels referred to as "Lafayette", "Pliocene", or "late Tertiary" are described from the following localities: (1) in Webster County[1], adjoining Henderson County to the south, occuring at an elevation of about 500 feet above the sea; (2) opposite Owensboro, Kentucky, on the Ohio River about 30 miles east of Henderson County, at an elevation of approximately 390 feet above sea level[2]; (3) in Martin County, Indiana, about 70 miles northeast of Henderson County, at an elevation of 700 feet[3]; (4) in the Shawneetown Hills just west

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of the Wabash River, at an elevation of 500 feet A. T.[4]; (5) in Union County, Kentucky, about 20 miles southwest of Henderson, at an elevation of about 550 feet A. T.[5] In addition, gravels of about the same characteristics are described at elevations of from 500 to 700 feet A. T. in southwestern Indiana[6], which have been suggested to be early Tertiary by Fuller and Clapp, but which are regarded as probably late Tertiary by Malott[7].

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1 Glenn, L.C., Op. cit., p. 122 and map

2 Veatch, A.C., Notes on the Ohio Valley in southern Indiana, Journal of Geology, Vol. 6, p. 264; 1898.

3 Logan, W. N., Handbook of Indiana Geology, Indiana Dept. of Conservation, Publication No. 21, p. 229; 1922.

4 Butts, Charles, Geology and mineral resources of the Equality-Shawneetown area, Illinois Geol. Survey, Bull. 47, p. 52; 1925.

5 Lee, Wallace, Geology of the Kentucky part of the Shawneetown quadrangle, Kentucky Geol. Survey, p. 43; 1916.

6 Fuller, M. L., and Clapp, F. G., Geological Atlas of U. S., Patoka folio, No. 105, p. 6; 1904.

7 Logan, W. N., Idem, p. 136.

The gravels in most of these deposits have been described without discussion of their origin. Veatch, in his discussion of the low-level gravels near Owensboro, has urged that they were deposited in an arm of the Gulf Embayment, extending up the Ohio River in Pliocene time. It appears that the other observers have regarded the gravels in other localities as having been deposited in a single sheet, apparently inferring that some late crustal movement would explain their difference in elevation, or postulating that any gravels found at lower elevations are slumped, or redeposited, or reworked, portions of a higher deposit. The working distinction between a "reworked" and an "original" surficial deposit has not been made clear.

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The most critical and thorough work on the "Lafayette" in recent years is probably that of Shaw*. His conception is

*Shaw, E.W., The Pliocene history of northern and central Mississippi, U. S. G. S. Prof. Paper No. 108, p. 152 et seq.; 1918.

briefly that the material previously called "Lafayette" is of two kinds; (1) residual materials in interstream areas, including that in the type locality, and (2) terrace gravels along the Mississippi and nearby streams which are to be correlated with the Pliocene Citronelle formation of the Gulf coast. It is evident from the photographs and descriptions of these terrace deposits that they represent the kind of "Lafayette" to which the Henderson County deposits are to be referred.

Characteristics of "Lafayette" in Henderson County

Character. It will be recalled from the description of the "Lafayette" of this county, previously given on page 51, that these deposits are composed predominantly of sub-angular, deeply stained, orange-red, chert gravel, in some cases containing silicified Paleozoic fossils, partially cemented by iron oxide. A large number of veinquartz pebbles are also found.

The material, while designated "gravel" according to general usage, is not all gravel. A large proportion of sharp sand and clay also occur intermixed with the gravel, without assortment. The deposits are generally horizontally bedded, and the contact with the overlying loess is usually horizontal and distinct.

Distribution. The deposits in this county are closely confined to the vicinity of Green and Ohio rivers. Hills away from the rivers, rising to the same elevation as gravel-capped hills near the rivers, carry no gravel deposits.

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The extent of their vertical distribution has been indicated in the discussion of the formation of the terraces. One deposit is found at 550 feet A. T. at locality 33 (51, 26); several at about 500 feet A.T. near Green River; one, apparently the largest and only a mile distant from the highest deposit, at 440 feet A. T., at locality 32, (53, 25); and one thick deposit, at locality 29 (53, 28), and several thin deposits at 390 feet above sea level.

Origin.

The materials making up these deposits are all such as could be derived from the upper courses of the streams upon which they lie. Given a series of pauses in the uplift of the region, such as here postulated, whereby corrasion was checked and the processes of chemical erosion relatively accelerated, the thick, siliceous, limestones of Mississippian and earlier ages, lying on the upper course of Green River, would be expected to weather to a thick mantle of clay and chert. At the same time the lower Pennsylvanian conglomerates and sandstones, which are sometimes poorly cemented, would disintegrate to the sharp sand and vein quartz pebbles found in the "Lafayette" deposits. This material carried by streams nearing baselevel would be deposited as an alluvial mantle over the floodplains in the lower courses of the streams.

It has been suggested that the clay found in the deposits is the result of disintegration in place of limestone fragments originally deposited with the chert. If this had been the case the deposits would not have retained their horizontal bedding after the extensive leaching necessary to carry away the calcium carbonate and leave only the impurities behind.

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As the deposits are still horizontally bedded, and show no evidence of slumping, the probability is that the material was reduced to its clay and gravel components before it was transported.

The hypothesis that the lower gravels represent a reworking of the highest deposit is untenable excepting to explain a minor part of the deposits. The lower deposits cannot represent slump from higher ones, because they are apparently found at definite elevations, they are horizontally stratified, their upper contacts are approximately flat and level, and they are apparently of not much greater age than the upper ones, judging from the amount of cementation shown. The deposit at locality 32, at the 440-foot level, shows horizontal cementation bands thruout the length of the exposures and up to 6 or 8 inches thick. While a conception of "reworking", involving the erosion by water of the upper deposits and redeposition at lower levels, is, in a nature of the case, necessarily somewhat true, it has no significance. It is scarcely to be expected that the entire mantle of residual gravel, sand, and clay was entirely removed from the upper courses of the streams during the first period of uplift. If the lower deposits had been deposited at a much later date then the upper deposits, it would be expected that the lower ones would carry in places a shingle deposit of cemented gravel slabs, derived from the cemented layers of higher deposits. No such shingle deposits were observed, but instead, as noted above, the lower deposits as well as the upper were cemented along horizontal planes.

Probable correlation of these terraces with those on Lower Mississippi River.

All data point to the conclusion that the Pliocene history of Henderson County is analagous to part of that given by Shaw* for

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*Idem.

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northern Mississippi. Here, as in Mississippi, the region was raised by intermittent uplift and wide plains in part due to lateral planation of the rivers were formed at various levels. This intermittent character of the uplift is attested to in Hardin County, Illinois, by Salisbury*, although he makes no attempt

*Weller, Stuart, and others, Geology of Hardin County, Illinois Geological Survey, Bull. 41, p. 48, 1920.

to date the uplift. During the times when the rivers were approaching grade, they meandered widely over areas near their present courses, planed off their beds, and deposited their loads of detritus. These deposits form the "Lafayette" of Henderson County.

Shaw** describes four gravel covered bed-rock terraces

**Idem.

in northern Mississippi. The elevations of these terraces do not differ greatly from those of the similar terraces in Henderson County. It is not expected that the four levels described in Henderson County will correlate individually with those of Mississippi, because those here described cannot be regarded as established beyond question, due to a lack of data in some cases, and because other "Lafayette" gravel deposits are known in the vicinity at higher elevations. It is believed however, that these terraces are comparable in origin and in age, and that it is possible that further work in the intervening areas may establish the continuity of these levels with some of those of Mississippi. This suggestion has previously been made by Shaw***. It is further possible that the discordance in eleva-

***Idem. p. 126.

tion of some of these "Lafayette" deposits of the Ohio valley-but not within Henderson County, may be proved to be due to Pliocene or Pleistocene warping.

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PART B - THE FILLED VALLEYS.

GENERAL DESCRIPTION.

Areal setting

The detritus-filled valleys of Henderson County are only a part of the system of wide and deeply filled valleys extending thruout the southern part of the Eastern Interior Coal Field in Kentucky, the southern part of Illinois, and the southwestern part of Indiana. In Kentucky the filled area makes up from one-fourth to one-third of the total area underlain by Pennsylvanian strata, as estimated from the Geological map of Kentucky*. In Indiana and Illinois a comparable area is present.

*Jillson, W. R., Geological map of Kentucky, Scale 1"/10 miles, Kentucky Geological Survey, 1927.

Figure 18 shows a sketch map of the filled valleys in Kentucky.

Description

The topography and stratigraphy of those valley fillings have already been discussed on pages 17 and 54. Some of the important features are recalled here for convenience of the reader.

The filling in the tributary creeks is continuous with a terrace along the Ohio River. The terrace along the Ohio was originally 10 miles wide below Henderson. Highland Creek has a valley floor two miles wide, while that of Canoe Creek is one mile wide. Green River has a terraced valley about three miles wide in the southern part of Henderson County. These widths are comparable to those of streams of similar size throughout the valley-filled section of the coal field.

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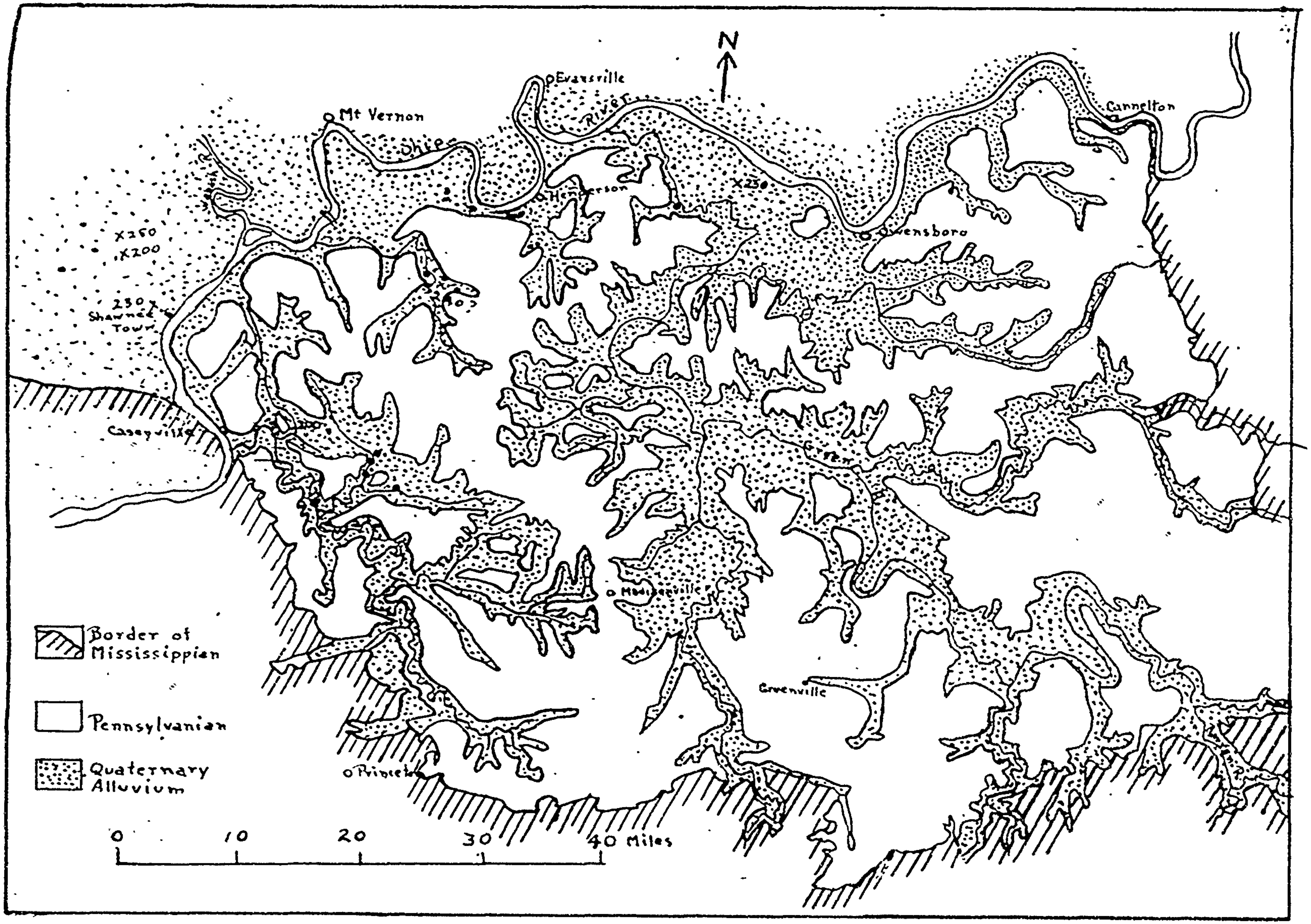

Fig. 18. Sketch Map of the Filled Valleys of Western Kentucky

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In the vicinity of Henderson County the filling along the river probably averages 100 feet thick, and is about 200 feet thick at its maximum. From this maximum the thickness decreases to zero in the upper courses of the creeks where the rising bed-rock floor intersects the surface of the fill.

The elevation of the highest terrace and most prominent valley fill is about 390 feet above the sea at Henderson. Going up stream the elevation of the fill rises, being about 420 feet A. T. in the Tell City quadrangle about 65 miles up the Ohio. Conversely its elevation decreases down the Ohio, being about 370 feet A. T. in the Shawneetown quadrangle about 50 miles below Henderson*.

*Lee, Wallace, Geology of the Kentucky part of the Shawneetown Quadrangle, Kentucky Geological Survey, P. 44; 1916.

Along the Ohio two terraces are well represented, a lower being about 10 to 15 feet below the elevation given above. In addition there are indications of another older and higher terrace which has been greatly eroded.

A unique feature of this valley filling is that its surface slopes upstream in creeks tributary to the Ohio River. This is well shown in Henderson County by Canoe Creek. For a distance of about three miles in a straight line from the mouth of the creek, the 380-foot contour is close to the stream, or, in other words, the general level of the valley floor is above 380 feet A. T. At this point the 380-foot contour swings gradually away from the creek; the general level of the valley floor is below 380 feet A. T. This level holds for about three miles; in the upper course of the creek the valley floor again rises above 380 feet. This condition is typical of many middle-sized

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creeks coming into the Ohio from both sides in the coal field. In large streams, such as Green River, the surface is nearly flat. For a distance of 75 miles or more the level of the valley floor of Green River lies between 380 and 400 feet above the sea.

Another feature is the spit-like bars developed below practically every large accumulation of loess and sand near the river. Such bars may be found in Henderson County extending downstream from the high loess and sand hills at Henderson, and downstream from similar accumulations near the Union County line. They are more definitely shown on the map of the Owensboro quadrangle, north of Owensboro, in Indiana.

The materials and structure of the valley filling are varied. Near the river the materials are frequently coarse, often being made up of torrentially crossbedded sand, with igneous pebbles scattered along the planes of crossbedding. Along with these coarser materials is an abundance of blue, sticky, clay. In many places a material which seems to be a typical loess, from 10 to 20 feet thick, is found near the surface of the fill. This material generally shows its aquatic, or at least partially aquatic nature, by the presence of aquatic fossils or pebble-bands.

In the valleys of the tributaries, the material is finer, being most frequently blue clay, horizontally bedded. In a few cases loess-like silt carrying an aquatic fauna was observed. Sections of this material and fossil lists have previously been given, on pages 57-59.

Previous work

The wide filled valleys of this region have been variously interpreted as the result of subsidence of this area, or of ponding

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of the streams due to some damming mechanism uniformly affecting the whole area in which they occur, or as due to ponding resulting from backwater in the main streams, the Ohio and Mississippi. This last explanation is accepted here.

This conception of the history of the fillings was apparently first urged by Shaw*, basing his conclusions chiefly on observations in southern Illinois. Later Butts** and Wallace Lee***

*Shaw, E.W., Newly discovered beds of extinct lakes in southern and western Illinois and adjacent states, Illinois Geol. Survey, Bull. 20, p. 139 et. seq.; 1915.

**Butts, Charles, Geology of Equality - Shawneetown area, Illinois Geological Survey, Illinois Geological Survey, Bull. 47, p. 55; 1925.

***Lee, Wallace, Geology of Kentucky part of the Shawneetown quadrangle, Kentucky Geological Survey, p. 46; 1916.

have carried this interpretation onto Ohio River drainage, the former in southeastern Illinois, and the latter near the western border of the coal field in Kentucky.

QUESTIONS CONCERNING THE CUTTING OF THE VALLEYS.

Although the manner of cutting of these valleys has already been described in the previous section of this chapter, it will be well to discuss here some questions regarding the course of the drainage and the altitude of the territory at the time the valleys were cut. This is necessary because the peculiar width of the valleys in this section has given rise to hypothesis of Pleistocene subsidence of the region and to suggestions of major drainage changes. The conception held by the writer is that the territory stands today at no significantly different elevation than it had when the valleys were cut, and that the streams now have essentially the same courses they had then. We shall first discuss the effect of the lithology in the formation of these wide

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valleys and then shall consider the hypotheses of drainage changes and crustal depression.

Lithology the governing factor in forming the wide valleys

The distribution of the wide filled valleys gives strong evidence for the conception that the lithology of the region was the determining factor in the formation of these wide valleys. Everywhere the wide valleys are confined to the Pennsylvanian strata above the basal Pottsville. The Ohio River enters the area of Pennsylvanian outcrop through a narrow valley and leaves through a gorge, at Caseyville, while in Henderson County, near the center of outcrop, the valley is 5 to 10 miles wide. The tributary creeks have broad valleys in the interior of the coal field while as soon as the Mississippian contact is passed the valleys are found to be immediately narrowed. The same conditions are found in the adjoining states.

A striking expression of the effects of lithology in this section upon the size of valley is found in the Tradewater River valley. This stream, which flows northwestward just inside the western border of the coal field in Kentucky, has a valley which is alternately gorge-like and very wide. In every case the gorge-like valley corresponds to the outcrop of a more resistant sandstone and the open valley to the outcrop of a more shaley member*.

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*Glenn, L. C., Geological map of Webster County, Scale 1: 62500, Kentucky Geol. Survey, 1922.

Both geologists who have worked in this vicinity are agreed that the stream has throughout its history held its present course**.

**Glenn, L. C., Geology of Webster County, Kentucky Geol. Survey, Series VI, Vol. 5, p. 12; 1922.
Lee, Wallace, op. cit. p. 48.

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The confinement of the wide valleys to one group of strata, and the demonstration in the Tradewater valley that the lithology controls the size of that valley are strong presumptive evidence that all these wide valleys are only an expression of the lithology of the region. We shall, however, now examine the evidence concerning alternative hypotheses.

Improbability of major drainage changes having occurred

At the first sight the appearance of a map of the wide filled valleys strongly suggests drainage changes. The extremely broad valley of the Ohio above the mouth of the Wabash, trending east-west, is continued in the same direction to the west of the Wabash, by the broad valley of Saline River. Beyond the head of Saline River, across a very low divide, the broad valley system is continued by the valley of Muddy River, flowing west to the Mississippi. On the other hand, the valley of the Ohio, which bends sharply to the south immediately below the mouth of the Wabash, rapidly constricts to a narrow throat at Casyville. When it is remembered that the Illinoian glacier at one time did pond the drainage of Saline and Muddy rivers, and hence might have caused major drainage adjustments, the supposition that the Saline-Muddy systems might have been at one time the continuation of the Ohio does not seem idle.

However, this supposition is entirely negated by less obtrusive evidence. The divide between Saline and Muddy rivers is a bed-rock divide* and represents the low point of a divide of some length separating the Mississippi and Ohio River drainages. Muddy River empties into the Mississippi through a gorge, in the basal Pennsylvanian and Mississippian rocks, much narrower than that of

*Leverett, Frank, The Illinois glacial lobe, U. S. G. S. Monograph 38, p. 527; 1899.

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the Ohio at Caseyville, and there is no larger breach through these rocks nearby. Therefore no through stream ever flowed westward from the mouth of the Wabash.

On the other hand, Pliocene gravels are found at an elevation of 545 feet A. T. within 6 miles of the Caseyville gorge*,

*Lee, Wallace, Op. Cit. p. 44

in a position in which they could not have been deposited by any present west or north flowing stream, excepting Tradewater River. This stream has so little drainage from the area of Mississippian rocks that it is improbable that it could have been the agent that carried the "Lafayette" cherts to this point. The presence of these cherts at this point argues strongly for the conception that the Ohio River took its present course through the Caseyville gorge sometime in the Pliocene. This argument also militates against the hypothesis, lately propounded**, that Green River once flowed north-

**Fowke, Gerard, The genesis of the Ohio River, Proc. Indiana Acad. of Science, Vol. 34, p. 98; 1924.

ward through the present Wabash valley to the Great Lakes.

Improbability of differential depression of the coal field having occurred.

It has been frequently suggested that the prominence of the filled valleys in this region is due to a subsidence of the region relative to the surrounding territory in which none of these wide valleys occur. This hypothesis is based on the tacit assumption that the depth of the valleys both inside and outside the coal field is a sub-constant function of their width. Specifically, it is assumed that the wide valleys in the coal field correspond to a great depth, and the narrow valleys outside to a less depth, and that, therefore, the bed-rock channels of the streams are at a

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lower elevation inside the coal field than outside, so indicating subsidence.

This assumption, however, is unfounded. As shown in the preceding section of this chapter (page 93), the river widened these valleys at a time it was cutting, near Henderson County, at a level which now stands approximately 300 feet above the sea, or about 100 feet above the bottom of its deep, bed-rock trench. The width of these valleys therefore bears no relation to their depth.

If the river had never reached a lower level than it has today, the filled valleys would still be present. The Ohio River is at present cutting below the level of the 300-foot shelf which underlies most of the filled area. At Mt. Vernon, Indiana, the river is on rock at 285 feet A. T., and at West Franklin, Indiana, at 290 feet A. T. There has therefore been no depression of this region relative to its altitude at the time the wide valleys were cut.

There is therefore no evidence showing that the Western Kentucky coal field, and adjacent areas to the north, have been depressed relatively to the surrounding areas, since the wide filled valleys cannot be so interpreted. Positive evidence showing that it had not been relatively depressed could be found only in well records striking the channel bottom of the Ohio below the coal field. Unfortunately no records which would give such evidence are available. One well near the Ohio River at Golconda, Illinois, about 30 miles below the filled valley area, penetrated to an elevation of but 230 feet A. T. without reaching bed-rock*. This lone

*Leverett, Frank, The Illinois glacial lobe, U. S. G.S. Monograph 38, p. 787; 1899.

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inaccurate record is entirely in accord with the view that the region of wide valleys has not been relatively depressed.

Lack of evidence of widespread depression

It has been demonstrated above that the width of the valleys in this section affords no evidence of depression and that there is no evidence for a depression of the wide filled valley area relative to surrounding areas. However, the question still remains whether or not the depth of the filled valleys does not indicate a wide spread depression involving not only the coal fields but part or all of the lower Mississippi-Ohio valley. Although a definite answer to this question is apparently beyond our present knowledge, the writer is inclined to believe that no such depression has occurred and that Henderson County and the surrounding area stands today at substantially the same elevation it had when the lowest cutting of the valleys occurred.

It has been shown above that the elevations of the bed-rock valley bottom is close to 200 feet A. T. in this vicinity. This figure is probably fairly accurate for it is the lowest elevation given for the bed-rock surface by several wells, all of which were evidently in the trench rather than on the 300-foot shelf. This would make the thickness of filling about 180 feet, a value which agrees well with the thickness of fill known elsewhere on the Ohio and Mississippi drainage.

The point where the 200-foot elevation is found is about 1200 miles from the sea, if the distance is measured along the meanders of the Ohio and Mississippi rivers. Near this point the Ohio River is at present cutting bed-rock at an elevation of 285 feet above the sea, as shown by soundings given on the maps of the Ohio River Survey. This corresponds to a gradient over the 1200

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miles of 2.85 inches per mile.

If we assume that the old Ohio River at the time it was cutting its bed at the 200-foot level had the same gradient, it, with its continuation in the Mississippi, would have been 840 miles long and would have reached about the vicinity of Natchez, Mississippi. This is under the assumption that the old river flowed in as tortuous a course as the present Mississippi.

There is ground to believe that the mouth of the Mississippi, at the time the bed-rock trench of the Ohio was cut, was as far from its present mouth as Natchez or even farther. Humphrey and Abbot, in 1861, estimated that in the past 4400 years the Mississippi had advanced its mouth a distance of 200 miles*.

*Upham, Warren, Growth of the Mississippi delta, American Geologist, Vol. 30, p. 110; 1902.

This estimate was based upon the present rate of advance of the delta. Natchez is only about 360 miles by river from the mouth of the Mississippi. Therefore the mouth of the Mississippi may very well have been at Natchez only 8000 years ago. This date long postdates the beginning of the Pleistocene, when the bed-rock trench was probably cut. Leverett**, using Upham's data,

**Leverett, Frank, Outline of the Pleistocene history of the Mississippi River, Journal of Geology, Vol. 29, p. 619; 1921.

has suggested that the mouth of the Mississippi at the beginning of Pleistocene time was near the site of Vicksburg, or perhaps farther up. Vicksburg is located 460 miles from the sea by water. Shaw*** on the evidence of a probable terrace in Mississippi is in-

***Shaw, E. W., The Pliocene history of northern and central Mississippi, U. S. G. S. Prof. Paper 108, p. 157;1918.

clined to believe that the mouth of the Mississippi River was in the

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vicinity of Natchez in Pliocene time.

Two factors, both favorable to the conception that the land at the time the trench was cut was no higher than at present, have not been considered. In the first place, the elevation of 285 feet A. T. used in figuring the present gradient of the Ohio-Mississippi system represents only a somewhat deeper hole in the channel of the river as revealed by soundings at a time of normal flow. In times of flood the river probably scours much deeper than the 35 feet below low water stage, represented by the 285-foot elevation. This would indicate that the gradient along the bed-rock channel could be significantly less than the 2.85 inches per mile, used in the calculations above. In the second place, it has been assumed that the channel at the time the trench was cut was as tortuous as is the present Mississippi from Cairo to Natchez. It is conceivable that it was much less tortuous and that much of the meandering of the river has been developed because of the much greater load of material delivered to it in Pleistocene time. If the channel had been less tortuous, the distance by water to the mouth would have been considerably shortened.

It appears therefore, that the old Ohio and Mississippi rivers, maintaining no lower gradients than they have at present, could have cut their valleys when the region stood at its present elevation. The converse of this statement is that there is no necessity for postulating a depression of the region in Pleistocene time in order to explain the filled valleys.

THE FILLING OF THE VALLEYS

Manner of filling

General statement. The filling of the valleys in the section under discussion was immediately due to the overloading of the

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Ohio River by debris-laden glacial waters. This is clearly demonstrated by (1) the character of the materials in the terraces, (2) by the attitude of the surface of the filling in small tributaries, and (3) by the continuity of the terraces along the Ohio with known glacial terraces upstream.

The character of the material under the terraces has been discussed in Chapter III (page 54). It will be recalled that pebbles of igneous rocks occur in placed under the terraces. Such pebbles could not be brought to Henderson County excepting through the intermediate agency of glaciers.

Significance of backward slope of valley floor in tributaries. The backward sloping valley floors in the tributary creeks in the coal field can only be explained as parts of the backward sloping terrace along the master stream. This backward slope cannot be due to late tilting of the region for it occurs thruout the coal field and on both sides of the Ohio River. It means that at the time of filling, the overloaded Ohio flooded the creek valleys with backwater. In these backwater ponds more material was dropped near the source of supply than farther from the river, and hence the surface near the river rose more rapidly than it did farther from the river.

Continuity of the Henderson County terraces with known glacial terraces. It has already been noted that the terraces level rises up the Ohio. Its elevation in the Tell City quadrangle is slightly over 420 feet A. T., or about 30 feet higher than in Henderson County 65 miles below. Unfortunately, none of the topography along the Ohio River, between this point and Cincinnati has been mapped, with the exception of two quadrangles near Louisville. There are available, however, the charts of the Ohio River Board of Engineers, which reproduce the topography of a strip ex-

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tending a quarter-mile back on each side of the river*. A great

*The Ohio River, Pittsburgh to mouth, Ohio River Board of Engineers, 280 charts, scale 1"/600 feet, contour interval 5 feet, U. S. War Department; 1911-14.

disadvantage of these maps for our purpose is, of course, that the area covered by them is so narrow that it does not often include high terrace remnants.

Figure 19 has been plotted from these maps, and from the U. S. G. S. topographic sheets where available. A low water and a high water profile from Cincinnati to Cairo are given, and all terraces or what appear to be terrace remnants in this distance are shown by inverted T's.

If the limitations of the maps from which the data were taken are remembered, we have in this figure nearly conclusive evidence of the continuity of the terraces of Henderson County and vicinity with the known glacial terraces near Cincinnati. It will be noted that all the high terrace remnants from Lewisport to Cincinnati lie close to a straight line joining the terraces at the two extremes. The justification for assuming that the profile of the terrace would be practically straight is found in the present practically straight high water profile between the same points. Below Owensboro the profile of the terrace flattens out in a manner analagous to that of the present high water profile over the same distance.

Conditions at time of filling. It would appear that at the time the valleys were filled the streams were not essentially different from those of today in this vicinity. Probably in spring and early summer, at the time of increased melting of the ice, great floods came down the Ohio River, rising, in Henderson County, some 20 feet higher than they do to-day, and ponding all the tributaries

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Figure 19. Profile of Ohio River from Cincinnati to mouth. ⊥ represents terrace remnant. The present high water and low water profiles are also given.

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to a commensurate depth. These floods differed from those of today probably only in being higher, lasting longer, and carrying more material. (Also much aggradation)

The comparatively slowly moving waters over the flood-plain, coming in contact with pre-existing mounds of loess and sand, undercut these mounds and carried the materials a short distance downstream, depositing them in spit-like forms extending downstream from these mounds. Such spit-like low ridges are those found below Henderson and Smith Mills and in many other places outside the county.

Geologic age of fillings

Age of the two prominent terraces. It has been noted above that the filling of the Ohio River and tributary streams gave rise to two terraces from 10 to 15 feet apart in Henderson County. Both of these terraces are well preserved and neither shows evidence in this vicinity of extensive erosion by tributary streams. The upper is evidently to be correlated with most of the valley filling in the tributaries. The upper terrace is tentatively assigned to the Early Wisconsin stage of glaciation and the lower to the Late Wisconsin.

This conclusion rests largely upon the data given in Figure 19. A series of terrace remnants apparently connects the upper terrace of Henderson County with known Wisconsin terraces at Cincinnati. Judging by the amount of each terrace preserved in the vicinity of Henderson County, the lower terrace was formed in the first half of the interval between the time of formation of the upper terrace to the present. In the vicinity of Dam. 48, the level of the upper terrace declines gradually to that of the lower

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and the only stratigraphic difference between the two seems to be the presence of a loess-like silt layer just below the surface of the upper and its absence on the lower terrace. This indicates that the erosion of the upper terrace had not proceeded far before the building of the lower, and suggests that the times of their formation were not far apart, geologically. As it is known that the Wisconsin advance was at least double, it would seem most probable that the upper terrace was the result of the Early Wisconsin advance of the ice, and the lower terrace the result of the Late Wisconsin advance.

The evidence is not, however, complete enough to prove beyond doubt the continuity of the upper terrace with the Wisconsin at Cincinnati. Is is possible, without doing violence to the data, to connect the lower terrace in Henderson County with the terrace at Cincinnati; in this case the higher terrace found in this county and near Tell City would represent some earlier, most probably Illinoisan, terrace. However, although this alternative correlation must be admitted to be possible, it does not fit the data assembled in Figure 19 so well as the one first given.

Moreover, contributory evidence seems to favor the first interpretation. The well preserved nature of the upper terrace and the fact that the drainage generally still follows the original slope backward to the bluffs indicates that it was completed very recently in geologic time. As the streams on this terrace are frequently displaced against loess bluffs, it would appear that the formation of the upper terrace post-dated the deposition of much of the loess. As the major period of loess deposition seems, in regions within the glaciated limits, to have immediately preceded the Wisconsin glacial stage, this

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would indicate that the terrace is of Wisconsin age.

The fact that a loess-like silt, or perhaps in places and at some horizons a true loess, forms the capping layer of the upper terrace would at first suggest that this terrace might be of an earlier age than the major, or pre-Wisconsin, loess deposit of the United States. But elsewhere, in glaciated regions, the major loess deposit rests upon a weathered Illinoian till, and its age seems to be immediately pre-Wisconsin rather than immediately post-Illinoian; while in Henderson County the loess or loess-like silt seems to be an integral part of the main terrace deposit. It seems to be continuous with the underlying stratified deposits and no evidence of a weathered zone or of erosion upon the surface underlying the loess was noted. In fact, in most exposures, silts approximately loess in appearance are found interbedded with the clay and sand beds in the lower part of the terrace materials and increasing in importance upward. Granting that the origin of this material is to be correlated in some way with the origin of the main loess of the United States, it would yet appear to have Wisconsin rather than Illinoian affinities.

Moreover, valley trains of Illinoian age seem not to be well preserved along the central Ohio River; and hence reference of the well preserved terrace in Henderson County to any earlier glaciation would be very dubious. The relation shown in the preservation of the two terraces, cited above, would also suggest the ages assigned rather than ages of Illinoian and Wisconsin, respectively.

Finally the weight of authority as given for neighboring regions apparently favors the interpretation here made. Leverett*

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*Leverett, Frank, Unpublished manuscript, to carry title of The Pleistocene of northern Kentucky, Kentucky Geol. Survey, Series VI, Vol. 31.

has described terrace remnants from Cincinnati to Owensboro and assigned most of them to the Wisconsin. The elevations of these Wisconsin terrace remnants of Leverett agree with the hypothetical Wisconsin terrace slope given in Figure 19.

In the Patoka quadrangle**, a score of miles northwest

**Fuller, M. L., and Clapp, F. G., Geol. Atlas of the U. S., Patoka Folio, No. 105; 1904.

of Henderson County, on the Wabash River, a Wisconsin terrace stands at the same height above the present flood-plain of the Wabash as does the upper terrace in Henderson County above the flood-plain of the Ohio. Below this terrace in the Patoka quadrangle, stands an "upper, perfected, flood-plain", overflowed only at periods of extreme high-water***, which is assigned to a transitional stage

***Idem. p. 5.

between Wisconsin and Recent time. The same description would apply to the lower terrace in the western part of Henderson County, to which a Later Wisconsin age is tentatively assigned here.

Possibility of an earlier fill. The existence of a fill earlier than those described in the preceding seems very probable. This fill, if such is to be, is, however, very much eroded and so extensively covered with loess that its terrace character is very much obscured.

Suggestions of this terrace in Henderson County are found in several broad areas developed at an elevation between 400 and 420 feet above sea level, or about 20 feet above the Early Wiscon-

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sin terrace. Such areas are found in and just east of Henderson and in Indiana just below Mt. Vernon. At Atkinson Park, just above Henderson, a small terrace of about three acres extent stands at an elevation of about 410 feet A. T., as shown on the large scale charts of the Ohio River Survey. The positive identification of these forms as being due to a pre-Wisconsin fill is made difficult by the fact that the waters of the Early Wisconsin floods rose to about the same level, as shown by the spit-like forms previously discussed, altho the terrace of this stage was built up only to an elevation about 15 feet below this.

Additional evidence is found in the fact that definitely water-laid, stratified, sand is found up to an elevation of 405 feet A. T. in the river bluffs just above Henderson. Unfortunately, none of the exposures seen were high enough to include any overlying loess at these points. However, the exposures were located at the base of steeply rising loess-topped hills, so that there can be little doubt but that the water-laid material antedates the thick loess. Again, however, an alternative interpretation that the stratified material represents a bar built up above the general level of the Wisconsin terrace and that the loess and sand hills above represent Wisconsin and Recent dunes, such as are found in other regions in Mississippi River drainage, cannot be disproven.

Finally, there is one record of an old soil, although none has been seen by the writer. This is in the record of the old "Peoples's Mine" shaft at Henderson*. The shaft starts at

*Collett, John, Geological Survey of Indiana, 7th Annual Report, p. 271; 1876.

about the elevation of 395 feet A. T., or about the elevation of

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the Wisconsin terrace. The record is as follows:

Yellow Clay and sand	10 feet
Black Peaty soil	4 feet
Blue clay	3 feet
Yellow clay and quicksand	10 feet
Clay and sand with boulders and aquatic pelecypod and gastropod shells	10 feet
Limestone; bed-rock	

Again the value of this evidence is in doubt. The identification of the "black peaty soil" was not the work of a trained geologist but of the men who sunk the shaft, who later reported it to Collett. The shaft has long been in disuse and cannot now be entered. An examination of the creek bank nearby revealed no old black soil.

In conclusion, it can only be said that the balance of evidence indicates the probable existence of this old valley filling but does not prove it. If it is present it is most probably of Illinoian age, inasmuch as the Illinoian glacier seems to have been the only pre-Wisconsin glacier to have had major effects upon the Ohio River.

Shaw* has described a terrace in southern Illinois, which

*Shaw, E. W., Newly discovered beds of extinct lakes, Illinois Geol. Survey, Bull. 20, p. 139 et seq.; 1915
Shaw, E. W., and Savage. T. E., Geologic Atlas of U. S., Murphysboro-Herrin Folio, No. 185, p. 8; 1912.

he refers to a pre-Wisconsin, probably Illinoian age. Whether this terrace is to be correlated with that called Illinoian or that called Early Wisconsin in Henderson County is not certain. Wallace Lee**

**Lee, Wallace, Geology of the Kentucky part of the Shawneetown Quadrangle, Kentucky Geol. Survey, p. 45; 1916.

has suggested the possible existence of a probably Illinoian terrace on the Ohio River in Union County at an elevation which would insure

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its correlation with the one suggested here in Henderson County. Shaw*** has discussed a deposit of sand in the Patoka quadrangle,

***Shaw, E. W., On the origin of the loess of southwestern Indiana, Sciene, n. s., Vol. 41, No. 1046, p. 104; 1915.

rising a distance above the Wisconsin terrace there about equal to the vertical distance between the Early Wisconsin and the higher terrace noted in Henderson County; he is inclined to consider this deposit a part of the valley filling of this region.

PART C - ORIGIN OF THE LOESS OF HENDERSON COUNTY.

Introductory

Previous work. The origin of the loess of the Mississippi Valley has been one of the most discussed questions of American geology. David Dale Owen, who apparently first described the loess of Western Kentucky, joined with other early geologists in considering it a water-laid deposit*. After the description of the great areas

*Owen, D.D., Kentucky Geological Survey, Vol. I, pp. 21, 24, 28; 1856.

in China thickly overlain by primarily wind-laid loess had been published, the concept of an eolian origin of the loess of the Mississippi Valley gained steadily in favor. During the last thirty years, geologists generally have come to believe that the loess had its ultimate origin in the rocks ground up and pulverized by the glaciers. This material is thought to have been carried out from the glaciers and deposited over valley flats, whence it has been blown in dry seasons over the surrounding country.

During their work in the Patoka quadrangle, only a score of miles north of Henderson County, Fuller and Clapp** divided the

**Fuller, M. L., and Clapp, F. G., (1) Geologic Atlas of U. S., Patoka Folio, No. 105; 1904.

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(2) The marl-loess of the lower Wabash Valley, Bull. Geol. Soc. of America, Vol. 14, pp. 153-176; 1903.

fine silts resembling loess into two parts, as follows: (1) the common loess, in general covering the uplands as a blanket deposit, and (2) the "marl-loess", the calcareous, coarser, loess found in great thickness on the east side of the Wabash and forming bluffs there up to an elevation of 500 feet above sea level. To the common loess they assigned an eolian origin, and to the "Marl-loess", an aqueous origin. Among the reasons cited for this latter conclusions are : (1) the "marl-loess" includes small pebbles in places, (2) it is stratified in places, (3) the deposits are unoxidized, suggesting the exclusion of air during their deposition, and (4) the deposits are limited upward by the elevation of 500 feet above the sea. This evidence would appear to conclusively show the aqueous origin of the "marl-loess".

However, the evidence used has been questioned by E. W. Shaw*, who finds no pebbles nor stratification above 440 feet A. T., and no change in the character of the loess at the 500 foot contour. He is inclined to consider the stratified deposits as a part of the valley fillings, and contends that all material above this level is windlaid.

*Shaw, E.W., On the origin of the loess of southwestern Indiana, Science, n. s., Vol. 41, No. 1046, p. 104; 1915.

Although no other deposits of loess have, to the writer's knowledge, lately been assigned to an aqueous origin, the "marl-loess" hypothesis for the Wabash Valley has lately been quoted without comment.***

***Handbook of Indiana Geology, Indiana Dept. of Conservation, Publication No. 21, p. 149; 1922.

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Inasmuch as the loess deposits of much of Henderson County conform to the description of the "marl-loess" of the Wabash Valley, the question of their origin has been given some study.

Description. Although the loess has been described already (page 57 et seq.), it may be well to recall here its chief characteristics in the vicinity of the Ohio River. These deposits of loess are coarser than those farther from the river, and carry intercalated beds of fine sand. They have a grayish to buff color and are high in calcium content. They rise to a rather uniform elevation of 470 to 480 feet A. T. These features are especially well seen in the vicinity of Smith Mills. They are also said to be characteristics of the Patoka deposits, excepting that the upper elevation there is given as 500 feet above tide.

The following discussion is concerned only with the true loess, which rises above the level of the terraces. Certain loess-like materials found beneath the terrace level, which have at least in part, an aquatic origin, will be discussed subsequently.

Eolian origin of Henderson County loess.

All of the loess in Henderson County above the level of the terrace is thought by the writer to have had an eolian origin. The evidence for this belief is as follows:

(1) The thick deposits occur on easterly sides of large river flats.

(2) The intercalated sand lenses are present only near these flats.

(3) The deposits carry only land fossils.

(4) The flood waters of known glacial stages deposited material different from the loess.

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(5) There has occurred no derangement of the drainage. These points will be discussed serially.

<u>The deposits are best developed on the eastern sides of extensive flats.</u> The loess deposits at Smith Mills are over 45 feet thick as shown by road cuts and by the diamond drill record at locality. 2. The loess and sand deposits at locality 62, just below Smith Mills, are 70 feet thick as shown in one vertical exposure. These localities are just east of the great flats at the mouth of the Wabash and in the great bend of the Ohio between Diamond Island and Uniontown. Similar deposits occur just above Henderson, east of what is practically a continuation of this flat. On the other hand, no such thick deposits are found elsewhere in the county; there are none on Green River, for instance, nor at Evansville.

The fact that the thick deposits of loess are found to the east of the river flats points strongly to the conclusion that the dominant westerly winds were involved in their formation. In any one locality, the conditions might be explained by chance erosion, but this condition seems to be general. In the Wabash Valley, for instance, Fuller and Clapp (Op. cit.) find the "marl-loess" thickest and best developed on the east side of the river. This condition is explained under the "marl-loess" hypothesis by a postulate that the current in the water body hugged the western shore. Under the eolian hypothesis, it is self-explanatory.

<u>The intercalated sand lenses are present only near the flats.</u> In the deposit at locality 61, there is a sand lens over 10 feet thick. In the deposits above Henderson one lens is 12 foot thick. Back from the river flats no sand was noted. To explain this circumstance under the "marl-loess" hypothesis it is necessary to assume that the current in the water body depositing the loess follow-

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ed approximately the present course of the river. Under the eolian hypothesis it would be expected that the winds dropped the coarsest material first.

The loess deposits apparently carry only land fossils. The fauna of the loess deposits has already been described (page 59). Collections from near Smith Mills, from locality 32 in the eastern part of the county, and from a curving band of loess in the high mound below Dam 48 furnished abundant shells of land snails but none of aquatic species. On the other hand, collections made from deposits which plainly are terrace deposits furnished many pelecypods and aquatic gastropods.

The flood waters of known glacial stages deposited materials other than loess. The nature of the materials under the terraces has been previously discussed (page 54). The major part of the terrace materials is stratified sand and clay. Only the upper 10 to 15 feet of this material resembles the loess, and this generally shows its fluviatile character by the inclusion of aquatic fossils or pebble bands. On the other hand the vertical range of the very calcareous loess in the western part of the county is about 100 feet. In order to hold to a theory of an aquatic origin of the loess, it would be necessary to prove that some glacial stage was capable of bringing a material -the loess- to this region, which is very different from that deposited during other, known, glacial stages.

There is no derangement of the drainage.

If these loess deposits had been formed from material brought directly by water from a glacier, the Wabash and Ohio Rivers would have been the only streams capable of furnishing it. This would mean that the material dropped here was essentially a backwater deposit. If such material had built up the land to an elevation of 460 or 470 feet

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above the sea, as it is necessary to assume, there would have been left only a few isolated points of older rock projecting above the silt cover. During deposition, nearly all of the Canoe Creek and Highland Creek drainage basins would have formed an immense lake, and no drainage area would have been left for these streams. Under such conditions these streams could not have maintained their channels. When the water had again subsided, they should have flowed over this silt surface without regard to their old courses. They should now be out of harmony with their old drainage lines.

Especially the smaller tributaries should here and there flow in young rock gorges such as are universally present where glacial deposits have partially filled drainage basins. Such displacement of the streams, for instance, was accomplished by the Wisconsin filling in this county. Just west of the Union County line, at Robinsville, Highland creek flows in a trench cut thru the Wisconsin terrace into the bed-rock below. Just south of the county line, in Webster County, where the Sebree road crosses Graves Creek about two miles above its mouth, the creek is again flowing in a rock trench under a Wisconsin terrace.

There is not an instance of such a trench above the level of the Wisconsin fill in the county. Moreover, the low hills in all portions of the county, excepting near the river, seem to correspond to bed-rock hills, and the valleys in all instances, excepting those noted above, seem to be overlying their old deep valleys. Wells on the Kleiderer and adjacent property near the mouth of Wilson Creek show bed-rock under the hills at elevations of about 380 feet A. T., while short distances away, under the valley flat, the elevation of bed-rock is uniformly

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about 300 feet A. T. Wells near the mouth of Beaverdam Creek, near Corydon, exhibit the same conditon.

If the loess had been deposited by wind, it would have naturally accumulated on the hills. If it had been deposited by water, it would have covered hill and valley to a common level. The streams in sinking their channels when degradation began again should have cut channels regardless of the buried topography. The fact that no such channels are found is strong evidence for the correctness of the eolian theory of its origin.

Loess-like materials under terrace.

The loess or loess-like silt found just beneath the surface of the terrace ascribed to Early Wisconsin time, presents a problem. In places and at certain horizons it appears to be a typical loess and yields an abundance of the typical loess fauna. However, it seems to be conformable upon the underlying stratified materials and some of the most typical exposures yield aquatic fossils as well as the more numerous land fossils. Pebble bands have also been noted in the lower portion.

Some of this loess-like material is undoubtedly reworked loess. The spit-like bars extending down-stream from Henderson and near Smith Mills can scarcely be ascribed to any process other than the undercutting of the loess and sand mounds at these two places and the redeposition of this material immediately down-stream. This suggests that a large part of the material underlying the terrace flat may have the same origin.

Further, it appears that the deposition of some of this material may be due to the combined action of wind and water. The floods at the time the terraces were being built were probably variable in intensity, as they are today. In the concluding stages

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of terrace formation it is probable that only one flood in a considerable number of years topped the flood plain of that day. In the intervals between these greater floods, the winds would have been at work reworking the material dropped by the floods, carrying away the very fine material and depositing typical loess. In these intervals the terrestrial fauna would live and die and be entombed. The next great flood would rework this material, perhaps distributing it more evenly, and leaving the aquatic shells which are found in the loess-like material beneath the surface of the terrace.

Geologic age of the loess.

Evidence as to the age of the loess in Henderson County is scanty. Inasmuch as loess seems to have accumulated in the Mississippi Valley in all interglacial periods of the Pleistocene, it is probable that the loess of Henderson County may range in age throughout the Pleistocene.

Much or most of the loess of this county is apparently pre-Wisconsin in age. Below Henderson the streams on the Early Wisconsin terrace have been displaced against loess hills. These loess hills rise rather sharply from the terrace, indicating that original loess-covered hills have been buried by the fill rather than that later loess had mantled bed-rock mounds rising above the terrace. The uniformity with which spit-like forms are developed on the Early Wisconsin terrace below large loess accumulations, for instance at Henderson and Smith Mills, indicates that those loess mounds antedated the building of the Early Wisconsin terrace.

Some of the loess is probably early Pleistocene. This is suggested by the fact that where it caps Pliocene gravels, the

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contact between the two shows no evidence of extensive erosion of the upper surface of the gravel. In the deposits at Smith Mills, a 4 to 8 inch horizontal band of clay is found at an elevation of about 400 feet A. T. This is the elevation of the possible terrace of Illinoian age. The clay may represent a thin layer of alluvium spread over pre-existing loess mounds. If so, that below would probably be pre-Illinoian and that above post-Illinoian. No difference between the two deposits was noted. Dr. F. C. Baker* remarks that a collection taken at

*Personal communication.

the horizon of the clay layer has a Peorian aspect, while another collection of shells from below the layer contains species abundant in both Peorian and Yarmouth time; the collections, however, do not admit of positive correlation. Pre-Illinoian loess has been identified in southern Illinois**.

**Lamar, J. E., Geology and mineral resources of the Carbondale quadrangle, Illinois Geol. Survey, Bull. No. 48, p. 111; 1925.

Finally some of the loess is post-Early Wisconsin. A layer of loess about 4 feet thick curves over a mound which has been built on the Early Wisconsin terrace, near Dam 48.

An attempt was made to establish the ages of some of the loess deposits paleontologically. Fossil collections made from several different localities were submitted to Dr. F. C. Baker for identification. Dr. Baker has very kindly indicated the ages which might apply to these collections. However, these collections were not extensive enough to assure that all species present have been collected and, moreover, the fauna from this general region, beyond the edge of the glaciers, is not known in

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detail, because of a lack of material for paleontological study. Dr. Baker is of the opinion, therefore, that comparisons with the more abundant material from within the glaciated region are not conclusive and that the paleontologic correlations must be regarded as only tentative. The lists of loess-fossils from within the county have been given on page 59.

PART D - RECENT HISTORY OF THE OHIO RIVER IN THIS SECTION.

INTRODUCTORY

Since Wisconsin time, the Ohio River has cut down its flood-plain some 10 or 15 feet in Henderson County. This is shown by the relation of the late Wisconsin terrace to the flood-plain, as seen for instance, above Mt. Vernon, Indiana. At present, however, the river is aggrading its flood-plain, as shown by the presence of well developed natural levees upon it. At the same time, it is degrading its channel in this section and for a distance of about 100 miles below, as shown by numerous outcrops of solid rock in its bed.

It is a recognized fact that some rivers are scouring their channels at the same time they are loading their beds with so much unconsolidated material that islands and bars are formed in them. The Missouri River near Omaha is a classic example of this action. Here the river in flood cuts down through some 45 feet of sediments and scours the solid limestone beneath. During the waning stages of the flood the river again fills up its bed with sediment to approximately the same level. Thus in time of flood the aggradation of the flood-plain and the degradation of the channel of the stream go on practically simultaneously.

The ultimate result of the river's work at Omaha is open to doubt. Chamberlin and Salisbury, in their "Geology", cite this

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example* and draw from it the conclusion that an <u>aggrading</u> stream

*Chamberlin, T. C., and Salisbury, R.D., Geology, Henry Holt and Co., Second edition, p. 195; 1909.

may temporarily degrade its channel, because, in the long run, more material is added here than is taken away. N. M. Fenneman, in an unpublished manuscript, uses the same example, but draws from it the inference that the Missouri River at this point is a <u>degrading</u> stream. He maintains that bars in a river bed are not a criterion which proves that the river is aggrading. If the river is degrading, more material is removed from the river bed in the long run than is deposited. In the absence of quantitative data as to whether the Missouri River at Omaha and similar streams are actually raising their beds or are lowering them, no decision between those two views can be reached.

In Henderson County, we have apparently incontrovertible evidence that the flood plain is rising while the channel is being degraded simultaneously. This evidence lies in the presence of natural levees on the flood-plain and of rock bottom in places in the channel. It is conceivable that a wasting flood-plain may go with bars in the channel if the stream is heavily loaded. But it is hardly conceivable that a wasting flood-plain should have natural levees. If the level of the highwater flow of the river is lowered gradually, the levees formed must become correspondingly lower; for a meandering stream continually destroys its old levees, building new ones. Naturally, successive levees will be lower and lower, and such a wasting flood-plain must slope toward the river. The strongly sloping natural levees along the Ohio River in Henderson County prove, therefore, that the flood-plain is being actively built up. The frequent presence of rock bottom, on the other hand,

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can only mean a constant active scouring and deepening of the river bed.

It seems, therefore, that here we have a clear case of an aggrading flood-plain and a degrading channel. The question arises, is this a normal condition in the history of a stream or is this condition caused by a larger flow of water in time of flood at present?

OBSERVATIONS

Present aggradation of flood-plain of the Ohio

As stated above, the opinion that the flood-plain of the Ohio in this vicinity is being aggraded at present rests on the presence of natural levees which everwhere rim it. These levees may be clearly discerned on the Uniontown topographic sheet in the big bend of the river above Uniontown. Farther upstream the flood-plain rises so that the contours do not again, in Henderson County, catch the slightly greater height of the levees. They may be inferred, however, from the location of houses along the river-ward edge of the flood-plain and from the location of roads in the same placed. The large-scale maps of the Ohio River Survey consistently show higher ground near the river.

It might, perhaps, be suggested that these natural levees are the result of the overloading of the streams by the wash of the exceptionally loose loess soil since deforestation. However, the levees are shown to be more ancient than the white man's occupancy of this region by the fact that the oldest dwellings on the flood-plain were located upon them.

Minor results of aggradation on the other hand, such as fillings around trees and fences in some places, notably in the big bend of the river opposite Evansville, may be due to deforestation.

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Unlike the natural levees, they do not demonstrate that the Ohio in this section is aggrading its flood-plain regardless of man's activities.

Character of flood-plain below the coal field. The Ohio River, after passing the western boundary of Henderson County, flows for about 35 miles thru terranes of Pennsylvanian age, which it leaves at Caseyville, Ky. Its valley for the next 50 miles of its course is cut in rocks of Mississippian age, the western boundary of which is at Smithland, Ky., at the mouth of the Cumberland River. From here, the river flows thru Tertiary deposits to its mouth at Cairo, Ill., a distance of 60 miles.

That portion of the course of the Ohio River which lies within the Mississippian rocks presents the same aspects as does the Missouri River near Omaha, cited above. Here, as will be developed more fully in the succeeding pages, the channel is being scoured, while the bed of the river is cluttered with bars and islands. As stated above, these cannot be held as proof of aggradation. On the other hand levees are not well developed, and several tributaries run along the flood-plain in an upstream direction, a circumstance rather difficult to explain if the flood-plain is aggrading. But this lack of distinct evidence that the flood-plain is aggrading may be due merely to the narrowness of the valley in this section, which prohibits the development of a wide area of slack water in times of flood.

Along the course of the Ohio within the Tertiary outcrop, the levees again become prominent. In view of the fact that the flood-plain is certainly aggrading here below the Mississippian portion of the river, and again in the coal field above this portion, it is probable that in this Mississippian area, too, the

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flood-plain is aggrading.

Character of flood-plain in other contiguous regions. Going up-stream from Henderson County, the levees become less marked on the charts of the Ohio River Survey and at about the upper limit of the coal field become indistinguishable. At Cincinnati, the flood-plain is certainly degrading, for it slopes toward the river.*

*Fenneman, N. M., The geology of Cincinnati and vicinity, Ohio Geological Survey, Ser. 4, Bull, 19, p. 148; 1916.

The tributaries of the Ohio near Henderson County show signs only of degradation. The same is true of Webster County, immediately south of Henderson County.** This degradation, has,

**Glenn, L. C., The geology and coals of Webster County, Kentucky. Geological Survey, Ser. VI, Vol. 5, p. 34; 1921.

of course, nothing to do with the question of the status of the Ohio River channel. It is merely an expression of the less advanced state of erosion along the tributaries, where the Pleistocene fill is still being cut away.

Degradation of the channel of the Ohio.

Degradation within the coal field. Rock ledges extending entirely across the channel of the Ohio show that the bottom is undergoing erosion. Such rock bottoms are found below Evansville, Indiana, (Mile 802 below Pittsburgh), at West Franklin, Indiana, (Mile 815), at Mount Vernon, Indiana, (Mile 830) at Uniontown, Kentucky, (Mile 841), and at Dam No. 50 (Mile 875). At Evansville, the river is cutting on rock for only a short distance; at West Franklin, for about a mile,; at Mount Vernon, for over a mile; at Uniontown, for about three miles. The river has cut its channel into the solid rock underlying the Pleistocene fill about 30 feet at Evansville,

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about the same distance at West Franklin, and about 40 feet at Mount Vernon. It should be noted that it is at this last locality that the natural levees are best developed.

Degradation below the coal field. Rock bottom is found just as frequently in the channel of the river in the area of Mississippian rocks as it is found above. The river has a rock bottom near Rosiclare, Illinois, at Miles 891, 892, and 894; near Carrsville, Kentucky, at Miles 897 to 899, at Miles 901, 914, and 917; and, as it leaves the Mississippian rocks at Smithland, Kentucky, at Mile 921. Thus for a distance of 120 miles, from Evansville to Smithland, the river is frequently cutting solid rock.

It is, of course, not implied in the foregoing, that the Ohio is now cutting down its channel below the level of the Tertiary or Early Pleistocene cutting. These rock channels are found here because the river has been superimposed upon rock shelves in the old valley by the Pleistocene fill. Somewhere under the flood-plain or terraces, lies the old channel, with a bottom elevation of about 200 feet A. T. However, these rock channels bear clear proof that, at present, the Ohio is degrading its channel.

INTERPRETATION

Introduction

The processes which may cause streams to aggrade their flood-plains may be classified as (1) diastrophic, (2) a change in the amount or character of the load of debris carried by the stream, (3) the normal growth of the stream, and (4) a climatic change, causing greater runoff and hence higher flood stages.

The aggradation of the flood-plain in this vicinity cannot with any degree of probability be ascribed to diastrophic

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movements. If the region had lately been depressed, the Wisconsin terraces would have been involved in the movement and should be therefore nearer the flood-plain here than they are elsewhere. While this is actually true, the smaller height of the Wisconsin terraces appears to be solely the result of the conditions of deposition. In fact, the terraces are not so near the flood-plain as would be expected from the convergence downstream between flood-plain and terraces in the upper section of the river (Fig. 19). Uplift farther down the river would cause aggradation, but any assumption of diastrophic movement encounters the same difficulties as that of normal growth, as will be shown later. Any diastrophic hypothesis is less simple and therefore less probable than one of normal growth. It seems, therefore, impossible to call on diastrophic movements for an explanation of the widespread aggradation along the Ohio River in western Kentucky.

Neither does it seem possible to account for this aggradation by assuming a change in the amount or character of the load carried by the Ohio River. Certainly there was as much glacial debris available immediately after the retreat of the glacier as there is now. Nor have any important drainage changes occurred on the Ohio River in post-glacial time, which might have changed appreciably the amount or character of the load.

Either of the two remaining factors, on the other hand, may have been responsible for the growth of the flood-plain of the Ohio in this region. The rise of the natural levees may be part of the normal growth of the Ohio River as a member of the Mississippi River system. Or it may be the result of a recent change of climate. These two possibilities will be discussed more fully in the suc-

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ceeding pages.

<u>Possibility that effect produced here are caused</u>

<u>by mouthward extension of the Mississippi</u>

The mouthward growth of the Mississippi River has been involved in the development of the flood-plain in Henderson County and vicinity. The natural levees extend continuously from the mouth of the Mississippi up to Cairo and thence up the Ohio to the narrow valley in the Mississippian strata, and are resumed in the wide valley in the Pennsylvanian strata, after an interruption of only some 50 miles. The only question is whether the cutting of the river channel is part of the normal process of flood-plain growth or is due to a separate cause.

<u>Theory</u>. The lengthening of a stream decreases its slope. This in turn causes the velocity to decrease, since the velocity of a stream varies with the square root of the slope*. As the transporting power of the stream, or its energy, varies approximately as the square of the velocity, the decrease in velocity results in deposition. The question is whether deposition can be limited to the flood-plain so that it can be built up without the channel being aggraded.

If the stream had reached a stage of equilibrium before the extension of its lower course caused aggradation at a given point, then, without doubt, the extension of the mouth must result in aggradation of the channel as well as the flood-plain.

This condition has been ascertained on the River Po, in northern Italy. Here it has been shown that the river bed has

*Chezy's formula: $v = c\sqrt{rs}$, where c = a constant, s = the slope, and r = the hydraulic mean depth. The hydraulic mean depth is the area of cross-section of the stream divided by the wetted perimeter.

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probably risen about 8 inches in 200 years, that aggradation of the bed has taken place in the lower 90 miles of its course, and that these effects are most probably due to the extension of the mouth of the Po into the Adriatic sea at the rate of about 200 feet per year. It should be emphasized that the building up of the bed has taken place despite the construction of levees along the course of the Po. It appears probable that the aggradation of the bed would have been greater had there been no levees to confine the water. The confinement of a stream within levees is usually accompanied by degradation of the channel, despite popular impression to the contrary.* It is therefore to be expected that

*See, for instance: Van Ornum, J. L., The Regulation of Rivers, McGraw, Hill Book Co., pp. 318-325; 1914.

the aggradation of the flood-plain in the normal life of a river will be accompanied by at least a tendency to aggrade its bed.

However, if the channel had never reached a graded condition at a given place before the lengthening of the river forced aggradation of the flood-plain there, it is entirely possible that aggradation of the flood-plain and degradation of the channel might proceed for a time simultaneously. An inspection of conditions at Louisville will render this possibility clear. Here, as shown in Figure 19 , the low water profile drops abruptly some 25 feet at the "Falls", or rapids. The high water profile, however, shows no irregularity as it passes the "Falls". If now the lengthening of the river eventually raises the levels of both high and low water in this vicinity, there may well be a period when the flood-plain responds to the higher level of high water by aggradation while at the same time the "Falls" have not yet entirely disappeared. At this point, then, it is entirely conceivable that the normal growth

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of the river will produce a temporary condition, at which time the flood-plain will rise and the channel degrade. It should be noted that this condition will be only temporary; eventually the rock ledge will be cut to the general level of the aggrading bed, and finally it will be covered by the debris of the river.

Application of this hypothesis to Henderson County. One difficulty, however, presents itself when we try to apply this hypothesis to conditions in and near Henderson County. This is the lack of evidence that the rock ledges have ever represented great obstacles in the down-cutting of the stream.

The section of the river channel in which the rock bottoms show is, to be sure, not quite graded. If an average low water profile is drawn from the upper end of the coal field to Cairo, at the mouth of the river, that portion of the river in which the rock bottoms are found stands slightly above it. This portion is on the average about 2 feet above the average profile over the longer distance, but only one of the rock ledges stands as much as 4 feet above it.

However, while the profile shows evidence that the channel in this section is degrading, it also shows that the river has been able to almost entirely eliminate the rock ledges which served as obstacles in its down-cutting. The ledges are not greatly above the average grade. They do not cause conspicuous irregularities in the low water profile. The steepest parts of the gradient are frequently above the rock ledges rather than below them. The channel has been cut in them to varying depths in order to establish its grade; the channel at Mount Vernon is cut 40 feet into the rock, while near Uniontown it has cut only 15 feet.

The difficulty in accepting this hypothesis is that all

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the ledges which originally stood up above the ideal profile toward which the river was tending, are now reduced practically to grade. Such a condition would mark only a very short period in the history of the river. We are forced to the conclusion under this hypothesis that we are observing the river at one ansient period in its history. Had we seen it some thousands of years earlier, the river would have shown a very irregular profile, with noteworthy rapids over these rock ledges; could we observe it a thousand or two years hence, the rock bottoms should be entirely covered with unconsolidated debris. The unique character of the present condition of the river when interpreted as the result solely of normal growth, leads us to wonder if nothing outside the normal growth of the stream has been instrumental in producing this condition. Perhaps, the lengthening of the river has merely set up critical conditions whereby the effects of some other process have been made more apparent here.

Possibility of Recent climatic change producing effects

This leads us to the fourth hypothesis, that of a climatic change in Recent time. We must ask ourselves (1) Could a climatic change produce the effects? and (2) Is there any evidence for a climatic change?

Effect of climatic change upon regimen of river. There can be no doubt that if the climate in the Ohio valley had varied in the most recent time so as to produce greater floods in its lower portion, the aggradation of the flood-plain and the degradation of the channel would go on simultaneously.

In considering this question, it should be emphasized again that the work of a stream, both in aggrading its flood-plain and in degrading its channel, is done in times of flood. During normal flow a stream merely equalizes the irregularities of its

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bed, eroding the shoals and filling up the holes. During times of flood, not only is the sediment dropped from the slack water upon the flood-plain, but also the channel is deepened. This follows theoretically from the increased velocity of the current in time of flood and it is demonstrated by the effects observed. After the great flood of the Missouri river in 1881, for instance, a general deepening was noted on all sounded sections, while, at the same time, deposits were left upon the banks often four feet in thickness*. The scouring effect of increased flood heights is

*Todd, James E., River action phenomena, Bulletin Geological Society of America, Vol. 12, p. 488; 1901.

also shown in the case of artificial levees. As a system of levees is developed, the flood heights rise, and in connection with this, the channel is almost always increased in depth as well as width**.

**Van Ornum, J. L., op. cit., pp. 318-325.

If then, it is true that floods both scour deeper the river channel and build up the flood-plain, it must also be true that a change toward greater floods may change a degrading flood-plain to an aggrading one, while at the same time the channel continues to degrade. As applied to Henderson County and vicinity, this means that if greater floods now pass here than there did formerly, the conditions found here find a natural explanation.

Evidence of possible climatic change. Considering the known pulsating character of the Pleistocene climate and the lack of a sharp distinction between Pleistocene and Recent time, it is almost inevitable that climatic changes have taken place repeatedly since the final withdrawal of the ice from the Ohio valley. The Pleistocene climate varied widely, giving at least four major periods of

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advance of the ice, separated by periods when the climates a known to have been more genial than those now obtaining in the same regions. The last or Wisconsin period, can itself be divided into two, or three, stages of advance and retreat.

Two of the glacial stages of Wisconsin time are represented in the Henderson County region by terraces. During the times of glacial advance the Ohio river aggraded its flood-plain; during the warmer inter-glacial periods it degraded it. Under the hypothesis here considered, the pulsating climate of the Pleistocene, manifested in Henderson County by the alluvial terraces, has been followed by a still weaker climatic pulsation at present, expressed by the aggrading flood-plain.

The fact that a change in climate, at least as regards temperature, has taken place during Recent time has been established for the eastern United States as well as for many other places in North America and Europe. The retreat of the ice was followed by a period during which the eastern United States and northern Europe were warmer than they now are. For the United States, this fact is demonstrated by the distribution of the shelled fauna along the Atlantic Coast*, by the distribution of mammals in the interior of the United States**, and by the distribution of floras***.

*Grabau, A. W., Principles of Stratigraphy, Second edition, A. G. Seiler, New York, p. 89; 1924. Pages 90 and 87 give synopses of the two succeeding references also.
**Hay, O. P., On the changes of climate following the disappearance of the Wisconsin ice sheet, International Geological Congress XI, Stockholm, Die Veranderungen des Klimas seit dem Maximum der letzten Eiszeit, p. 374; 1910.
***Knowlton, F. H., The climate of North America in later Glacial and subsequent post-Glacial time, publication above, p. 369.

Although the fact that there has been a period warmer than the present since the close of the Glacial age does not necessarily

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prove that the floods of the Ohio were of less magnitude formerly, certain characteristics of a warmer climate would unquestionably tend to minimize the floods. A higher temperature would promote evaporation and thus reduce run-off. There would be a smaller tendency to preserve the winter snows upon the ground until they were melted away with the spring rains. Practically all the floods of the Ohio now occur in late winter and early spring, and the snow preserved upon the ground is a factor in their rise*.

*Horton, A. H., and Jackson, H. J., The Ohio valley flood of March-April, 1913, U. S. G. S., Water-Supply Paper 334, p. 13; 1913

The evidence for a post-Glacial epoch of drier climate is not nearly so clear as the evidence for a warmer climate. Yet in many parts of the world such a drier epoch is indicated. In Scandinavia*, northern Germany**, and Rumania***, such climates have been postulated. While many of these climatic changes, and perhaps all, may be ascribed to local conditions****, the evidence is clear that they have occurred in many parts of the world.

*Andersson, Gunnar, Das spatquartare Klima, eine zusammenfassende Ubersicht, International Geological Congress XI, Stockholm, Die Veranderungen des Klimas seit dem Maximum der letzten Eiszeit p. xxxii, 1910.

**Loc. cit., p. xxxiii.

***Murgoci, G., The climate in Roumania and vicinity in the late-Quaternary time, same reference (above), p. 163.

****Andersson, Gunnar, Die verandorungen des Klimas seit dem Maximum der letzten Eiszeit, International Geological Congress XI, Stockholm, Compte Rendu, p. 377; 1910.

In the eastern and interior United States, the evidence is not clear. The loess fauna has been sometimes interpreted as indicating a somewhat drier climate during its deposition*. Alden,

*Shimek, B., The significance of Pleistocene mollusks, Science, n.s., Vol. 37, p. 508; 1913.

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in reviewing the evidences of climate changes in Recent time, states that it may be said

"That during the deposition of the post-Wisconsin loess, the climate of the northern interior may have been somewhat drier than at present, but was not greatly different. This corresponds with the testimony of the tree stumps in some of the Dakota lakes and of the remains of white pine forests in peat bogs of the Atlantic border of northern New England.

"The phenomena of the Pleistocene lakes of the Great Basin and some other lakes in the Southwest do not indicate climatic conditions greatly differing from those of the present, though they show that there has been a period of somewhat greater aridity than prevails today and that there have been some oscillations greater in degree than the seasonal variations. The change now in progress, if any, seems to be toward a more humid climate."*

*Alden, Wm. C., Certain geological phenomena indicative of climatic conditions in North America since the maximum of the latest glaciation, International Geological Congress XI, Stockholm, Die Veranderungen des Klimas seit dem Maximum der letzten Eiszeit, p. 363; 1910.

The evidence, though unsatisfactory, suggests the existence of a warmer and probably drier period between the close of the Pleistocene and the present. It, therefore, tends to substantiate the hypothesis that the conditions along the river in Henderson County may be due to climatic change.

In conclusion, it may be said that the aggrading floodplain and degrading channel in Henderson County cannot, at least at present, be taken as proof of a climatic change, unless the normal growth hypothesis is shown to be inadequate to explain them. The ultimate decision will depend upon further studies, of a quantitative nature, of the normal growth of a river. The two hypotheses do not exclude each other. It may well be that a slight climatic

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change has hastened the natural growth of the flood-plain on the lower Ohio River.

CAUSES OF THE FLAT HIGH WATER PROFILE

There is one peculiarity of the highwater profile of the Ohio in the coal field which should be correlated with certain characteristics of the valley.

The high water profile is abnormally flat. The gradient from Cloverport to Caseyville, at the extremes of the coal field, a distance of 160 miles, is only 0.268 feet per mile, and in the 63 miles from Henderson down to Caseyville, it is only 0.174 feet per mile. In contrast to this, the gradient from Caseyville to the mouth of the Ohio, at Cairo, Illinois, a distance of 107 miles, is 0.355 feet per mile, and from Louisville down to Cloverport, 101 miles, the gradient is 0.59 foot per mile.

A part of this flattening of the gradient in the coal field is probably due to the wide meandering of the river within its valley. If the gradient is computed as the fall divided by the length measured along the centerline of the flooded valley, instead of the length along the channel, this new gradient is about equal to that below the coal field.

All of this flattening, however, is not due to this cause; it must not be thought that the high water surface forms approximately a plane surface dipping regularly down the flooded valley. If the profile is examined in detail, it is found that it is often steepest where the channel runs perpendicular to the general trend of the valley. Thus between Dam 48 and West Franklin, there is a difference in high water level of about 2 feet, although these two points are nearly opposite each other across the valley, while in an equal distance above Dam 48, the fall is negligible, although the

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channel here is running almost parallel to the general trend of the valley.

This flattening is probably not due to the width of the flood-plain, which might be conceived to exert a retarding influence upon the floodwaters because of the friction generated over its larger surface. If the width of the flood-plain has any effect at all, it is in the opposite direction, that is, it would tend to increase the gradient. Its great area would tend to retard the flow of the water, more should be delivered above than could be carried off below, and hence the water would rise to the rear and the gradient would be increased.

One cause of the flat gradient is probably the Caseyville gorge. The valley here is only about 3/4 mile wide, as contrasted to 5 or 6 miles average width upstream. This constriction must retard the flow and consequently raise the water level immediately above it, at the downstream end of the coal field. At this point the gradient of the river, which has been nearly flat in the coal field, becomes distinctly more steep and continues so to the mouth of the Ohio. The range between high and low water near Caseyville is greater than at any other place between Cloverport, at the eastern edge of the coal field and 175 miles above Caseyville, and the mouth of the river, 100 miles below Caseyville.

A second cause for the retardation of flow near the lower end of the coal field seems to be the entry of Wabash river. The entry of large rivers frequently causes a flattening of the high water profile of the Ohio for some distance above their mouths. This can be seen at the mouth of Salt river, at Mile 631 (below Pittsburg), and especially at the mouth of Kentucky river, at Mile 546. The probable reason is that the tributaries are frequently also in flood

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at the times of flood in the main stream, and so deliver an amount of water in excess of the capacity of the channel below. This is true for the Wabash. The fact that the crest of the flood of 1913 occurred a day sooner at Mt. Vernon, near the mouth of the Wabash, than it did at Evansville, 35 miles up-stream, indicates the ability of the Wabash to hold back the waters of the Ohio in time of flood.

It may be pointed out in conclusion, that these characteristics of the Ohio in the lower part of the coal field, which increase abnormally the flood heights, are such as would make this region an ideal one for showing the effects of such a climatic change as has been postulated above.

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CHAPTER VII

E C O N O M I C G E O L O G Y

COAL

Coals Now Worked

Only two seams of coal are worked in this county at present. No. 12-14 is mined at Smith Mills and was formerly worked at Corydon, while No. 9 is the bed worked in all other mines in the county.

Coal No. 9. Coal No. 9 is, as has been shown before, the most important coal of the Eastern Interior Coal Field. In Henderson County, five companies ship coal from this bed over the railroad at present. These are the Southland Coal Company at Henderson (localities 20 and 21), the Panama Coal Company at Robard (locality 60), the old Pittsburg Coal Company (lately reorganized) at Baskett (locality 30), another at Jennings Switch (locality 31) and the L. H. & W. Coal Company at locality 26.

The thickness of No. 9 coal remains constant within one or two inches in any one locality. It seems to thicken southwestward, ranging from 3 feet 8 inches to 4 feet along the Ohio and Green Rivers to 4 feet 10 inches at Robard, 4 feet 8 inches at Smith Mills, and in the churn drill coal test hole at locality 5 on Highland Creek, 5 feet 7 inches. It is the standard coal of Western Kentucky. Its characteristics are shown by the analyses appended.

The roof of No. 9 is usually a black slate carrying "niggerheads" and smaller concretions. It generally requires extensive propping in this county although in the Yankeetown mines in Indiana it is said to have a firm roof.

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"Cut-outs" of the coal are reported in the Robard mine. Here the coal practically pinches out in places but is reported to be always picked up again always at the same elevation, generally within a distance of a few feet but, in one case, after a hundred feet. Such "cut-outs" may be the result of non-deposition of the coal or of later erosion but are more probably structural features resulting from the folding in the region. When strata are folded, any more plastic beds included between stronger or more competent ones are pinched out from the sides of the folds and squeezed into the troughs or crests of the folds. Coal behaves as such a plastic bed. The writer has seen this excellently demonstrated in the mines at Rockwood, Tenn. Here a coal normally about 5 feet thick is squeezed out to a mere streak in some places where the rocks are dipping, while at a reversal of the dip the coal in one place is increased to a thickness of about 100 feet.

A similar condition seems to be present at the Burnwell mine opposite Curdsville (locality 44). This mine is not now in operation and hence could not be visited. A "cut-out" of the coal occurs here, trending northeast, or approximately parallel to the suspected direction of the Curdsville fault, and following a somewhat irregular course for a distance of several hundred feet. Different men who had worked in the mine gave various reports but it is certain that a place was found to the northeast of the shaft where the coal was continuous. The coal south of the "cut-out" is reported to have been several feet thicker than normal. Reports as to dip and relative position of the coal to the south and north of the "cut-out" vary, but no reports were heard which indicated that there was any sharp offset in the coal bed. Dips around this "cut-out" at the place where the workings passed it were described

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as being "about all that a loaded mule could pull". It is possible, considering the proximity of the Curdsville fault, that a fault of small displacement occurs here. However, it seems more likely, considering the fairly moderate dips indicated by the reports and the thick coal in the vicinity, to be another one of those pinchings caused by sharper minor folding due to the proximity of the Curdsville fault.

No. 9 coal has been found in every part of the county in which it has been sought, with the exception of the region southwest of Henderson, embracing localities 7, 8, 9, 12 and 13. Considering its known continuity throughout the Eastern Interior Coal Field, it is believed to be present throughout the county with the exception stated. More drilling would probably indicate a definite trend of this "cut-out" portion but there are at present no data which would show this. In many regions of the Eastern Interior Coal Field, there are restricted areas in which this coal is absent and it is therefore imperative to test out the coal by drilling before operation is begun.

In the alluvial bottoms of Green River and that portion of the county east of Green River, it has probably been eroded. The lowest elevation of bed rock underneath the bottoms in this county is 255 feet, given by an oil well record at Newman, just east of the Daviess County line. Assuming that this represents approximately the lowest elevation of the bottom of the alluvial filling, the coal is probably present under the alluvium from the mouth of Green River westward. In the upland portion of the county it is probably at no place more than 350 feet below drainage level. Its approximate depth at any place may be obtained by subtracting the elevation of the structural contour passing near that point

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from the elevation of that point above sea level.

In practically all localities, this coal can be recognized by the fossil content of its roof, or by the presence of the fossiliferous Providence limestone from 80 to 125 feet above it.

No. 12-14 Coal. As the Smith Mills and Corydon coals are correlated by Glenn with the No. 14 of Webster County* and as that at Smith Mills at least is probably No. 12, it will be referred to here by the double numbers, in the belief that the two coals are really the same coal.

Neither of the mines which work this coal are operating at present and so it was not seen in place. At Smith Mills, it is reported by Mr. W. W. Cooper, who originally opened the mine and operated it for 21 years, to be about 7 feet in thickness and to increase in some places to 8 feet. It has commonly a very weak shaly roof, necessitating the leaving of a foot or 18 inches of coal to serve as a roof. In some places at Smith Mills a soft sandstone comes very close to the top of the coal and in such places the sandstone makes an excellent roof. The appended analyses of this coal show it to be higher in moisture than No. 9 but to have a greater proportion of fixed carbon. It is in very high repute in Henderson County as a domestic coal because of its ready burning qualities. It is reported that attempts made to coke it met with some success.

This coal is very irregular in its occurrence. It is not found in minable thickness in the northern and eastern parts of the county and only sporadically as far as known in the western and

*Glenn, L. C., The geology and coals of Webster County, Kentucky Geological Survey, Ser. VI, Vol. 5, p. 108; 1922.

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southwestern parts of the county. In the mines at Smith Mills it has the thickness given above; a mile and a quarter north, at locality 2, it is 6 feet 3 inches thick; two miles southeast of the shaft, at locality 6, it is only about 4 feet thick in two benches separated by 3 feet of shale; at Corydon it is reported thinner than at Smith Mills and in some of the wells west of Corydon it is recorded, while in others it is not. It is probably that the thick coal reported found in the old Cairo oil well (locality 59) at a depth of 200 feet, belongs to this horizon, although this cannot be asserted with certainty. While No. 9 coal would be assumed to be present until proven absent, No. 12-14 would be assumed to be absent or thin until proven present.

Seams Not Worked At Present

Coal No. 11. No. 11 coal is not worked at present in this county. It is a coal worked regularly at Waverly and Uniontown, where it is about 6 feet thick. It is probably also the Herrin coal of Illinois.

In this county it is very irregular but thickens toward the west. In the section east of the meridian 87° 30', it is reported by Hutchinson* to average one foot 6 inches in thickness.

*Op. cit. p. 121, p. 109

Above the Shiver shaft (locality 44) opposite Curdsville, it was opened to a reported thickness of 4 feet but this greater thickness is probably due to squeezing, in the same way as shown in No. 9 coal below it at the same place.

In several of the Kleiderer drill holes, southwest of Henderson, notably at locality 12, it reached a thickness of 6 to 7 feet. In the Kleiderer shaft (locality 13) it is reported to have a thickness of 7 feet and was worked there for a time but later abandoned because of the very poor roof, the creek filling here

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beginning only a few feet above the coal. In several of the wells near Corydon, it is of workable thickness while in others it is thin or absent, according to the records of these wells. It is probable that it may be found of workable thickness in large areas south and west from the Kleiderer locality. The depth to its horizon may be approximately determined by subtracting 80 to 125 feet from the depth determined for No. 9, as previously indicated.

No. 6 Coal. No. 6 coal is located at a distance of 250 to 300 feet below No. 9. The Southland mine at Henderson started operation on this seam but due to poor mining conditions, it was abandoned in favor of the No. 9 above it. It is a very constant seam, being present in nearly all the drill records to a thickness of about 4 feet. It may be counted on to furnish large reserves of coal in Henderson County after the exhaustion of No. 9. The greatest depth which it has in this county is about 600 feet in the extreme western part of the county. Assuming the base of river cutting to be about 250 feet above sea level, it is probably present under the bottoms between Green and Ohio Rivers at a depth of about 300 feet.

Coals Nos. 7 and 6A. Coal No. 7, occuring about 110 feet below No. 9, is sporadically developed in workable thickness in various parts of the county, notably in the region of the Kleiderer shaft, according to the interpretation here put upon those records. It is also reported in the well at locality 27, in the eastern part of the county at localities 36 and 39, and in some of the wells around Corydon.

Coal No. 6A, probably the No. 6 of Owen, occurs in the lower half of the interval between coals No. 9 and No. 6. It is reported of workable thickness west of Henderson in the well at locality 18, in the eastern part of the county at locality 41, and

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also in some of the wells around Corydon.

Other Coals. Several other seams of coal are represented in well logs obtained, but because of the lack of data are not discussed here. Their characteristics, as far as known, may be obtained from the well logs appended.

Oil and Gas

Development. There is at present (1927) no commercial oil well in the county. A few shallow wells near Corydon and at Hitesville, locality 4, gave oil shows and one near Corydon (locality 51) gave five barrels per day, according to reports. Deeper holes (Approximately 1500 feet) near Spottsville (locality 36), Hebbardsville (locality 41), Zion (locality 39), and Cairo (locality 59) were none-productive, although those near Spottsville and Hebbardsville are favorably located as far as surface structure is concerned.

Petroliferous Strata. So little oil has been produce in the region in and surrounding Henderson County that it is impossible to designate any sand in this region as an "oil sand". It may only be said that there are many sandstones within reach of the drill which have a physical nature apparently suitable for serving as oil reservoirs.

In Union County, just west of the Henderson County line near Corydon, the Procter No. 1 well obtained oil in small quantities from a sandstone about 150 feet below the Sebree sandstone. This sandstone is a fairly continuous member and might be expected to give oil at shallow depths for some distance eastward before it rises too close to the surface to make a paying sand.

Other lenticular sands occur beneath this horizon and above the Caseyville, but the oil and gas possibilities of these have not been tested.

The Caseyville sandstone at the base of the Pennsylvanian

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correlates with the Mansfield sandstone of Indiana, which serves as an oil reservoir in southwestern Indiana.*

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*Logan, W. N. Handbook of Indiana Geology; Dept. of Cons.; State of Indiana, Pub. #21, p. 837, 1922.

The Chester group of the Mississippian contains several sandstones, which serve as reservoirs in southwestern Indiana.**

**Op. cit. p. 837.

The St. Genevieve below this contains thin sands which act as oil horizons in Illinois.***

***Glenn, L. C., Op. cit p. 140.

The depth to the strata last mentioned cannot be determined from data in the near vicinity. The lowest lies probably in the neighborhood of 2500 feet from the surface.

Structure. The structure of the county has been discussed at length in Chapter V of this report. The bearing of the structure upon the accumulation of oil and gas remains to be pointed out.

It should be noted first that the structure map is not intended to be entirely accurate in detail. It is financially impossible and inadvisable for the State to resort to accurate surveying methods in order to work out a detailed structure for the benefit of the prospective driller. The structural work done here is intended for the guidance of the man interested in oil exploration. The elevations of the strata were determined by means of the aneroid barometer, and hence, although precautions were taken to make this work as accurate as possible with such instruments, an error of ten feet in the elevation as given is easily possible for any one location and a larger error is not improbable. In this region of gentle folding and few outcrops, such an error can easily

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change the detail of the structure. While it is believed that the major features of this structure are correct, the reader interested in oil prospecting is referred to the description of the data relating to the various structures, as treated in Chapter V. Before drilling, all structures should be checked up by means of a plane table-stadia survey.

If the pore space of a rock contains water, any oil in the same rock will naturally tend to rise to the top of the water by virtue of its lower specific weight. If a porous rock containing oil and water is capped by an impervious rock, the oil will rise to the contact and, if the strata dip, continue to rise along that contact. If the rise of the beds continues to the surface, the oil will rise and escape. If, however, beds are bent over in the shape of a dome, the oil will rise to the highest point and remain there. This is the essence of the anticlinal theory of oil accumulation. There are many factors which tend to make the simple operation here described more complicated, but generally these factors cannot be judged from the surface.

Of the wells drilled for oil in an near this county, the Gregory well southwest of Spottsville, the Rolland well southeast of Hebbardsville and the Procter wells west of Corydon (localities 50 and 51) seem to be favorably situated. The Gregory well indicates that the shallow dome on which it stands is probably dry, at least in the strata penetrated. The Rolland well seems to be drilled in a slight sag in the anticline. It casts doubt upon the value from an oil and gas standpoint, of the anticline which parallels the Curdsville fault, but this structure would seem to be worth further testing. The Procter wells seem to be located on a small terrace on the nose of an anticline.

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The Geneva Dome. A very interesting structure from an oil and gas standpoint has been indicated, though not proven, by the work here reported. This is the Geneva dome. The data on which it is based have been discussed already in the chapters on structure and stratigraphy. With regard to the oil possibilities of this structure it should be pointed out that all the oil showings of this county and vicinity have occurred on the far outskirts of this structure. These showings of oil were made in the Procter wells, the Hitesville well, and in a diamond drill hole at locality 12. It is also reported that oil shows occur in water wells near Cairo, although the 1500 foot hole near here (locality 59) failed to disclose any oil. The showings in the three localities mentioned were all in the Curlew (?) or slightly lower sandstones which are so near the surface at the crest of the dome as to be of little or no value as possible oil reservoirs. They may be taken, however, to indicate the possibility of the presence of oil in lower beds in this vicinity.

As shown in the preceding chapter, this structure is based upon an interpretation of the stratigraphy. Before drilling deeply, at least one shallow well should be put down to the Providence limestone somewhere southwest of Marshall Corner in order to test the closure of the structure to the southeast. The records of such shallow wells should be very carefully kept. It will be remembered that doubts are felt as to the accuracy of the interpretation of the log of the water well at locality 22, which furnished the only data on this side of the structure.

Possible Anticline Toward Mt. Vernon. The probable presence of an uplift of the strata at Mt. Vernon, and the possible presence of an anticlinal axis running from Mt. Vernon to the Wil[illegible] Station dome,

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have been discussed in the chapter on structure. This may very possibly be a structure of large dimensions. To prove its existence, the elevation of the Providence limestone or No. 9 coal would have to be sought by drilling several wells of 200 to 250 feet depth from Mt. Vernon to Alzey and southeast.

Agricultural Geology

Soils. The soils of Henderson County are all transported soils. They include the recent alluvium of the bottom lands on the flood-plain, the more sandy alluvium of the terrace and the large creeks near the river, the loess soils of the upland, the sandy soils of the mounds near Dam 48 and the clayey soils where the Tertiary clay has come near enough to the surface in a few ridges in the Green River section to become incorporated into the overlying loess by the action of digging and boring animals.

Topography. Most of the land, except that near Green River, is of a gently rolling character, making farm operations easy. The slopes are so low in the Canoe Creek section that there would probably be little trouble with the washing of soils except for the extreme looseness of the thick loess. As it is, practically any locality in the upland shows many fields being ruined by extensive and deep gullying.

In the flood-plain and terrace, the problem of drainage is difficult. Tiling and ditching must be resorted to. In the flood-plain, drainage is frequently accomplished by means of wells. A well is sunk into some porous and ordinary dry lens and the tiling system centers in this well. Although porous lenses may be found at any place in the flood-plain, they are most likely to occur near the river, where the river, in forming its natural levees, has dropped the coarsest material.

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The floods of the Ohio River cover a very large portion of the county. The natural levees are, throughout the county, about 5 feet below the high water crest of 1913, and the remainder of the land of the flood-plain is lower. The floods are of course responsible for the fertility of this land but their suddenness often causes great loss of crops and sometimes of stock.

A chart showing the flood crests at Evansville for each year from 1874 until 1925 and for Cincinnati for a somewhat longer period is included in this report. It will be seen that there is no regularity in this chart which can be definitely established. However, in the two high floods in 1883 and 1913, there is a suggestion of one weather cycle having about this period. There is also a suggestion of an 11-year period; low high water stages having occurred in 1878, 1889, 1900, and 1911, although none in 1922. Nevertheless, there are no regularities definite enough to be of practical value.

No data are at hand to show that the uplands of the county are less troubled by frost than the lowlands. It would seem, however, that the broad valleys would furnish ideal conditions for a system of air drainage whereby the cooler air would be drained off the highlands at night and thus reduce the likelihood of frost.

Marls. During the last two years, the extension service of the College of Agriculture has shown the existence in many places in the county of beds of marl or lime-rich sediment. Samples collected and analyzed by the Kentucky College of Agriculture have averaged about 25 per cent calcium and magnesium carbonate, with several analyses showing about 35 per cent of these compounds, after eliminating the concretions in the samples. They have been described as occurring generally at the base of low mounds. Such deposits

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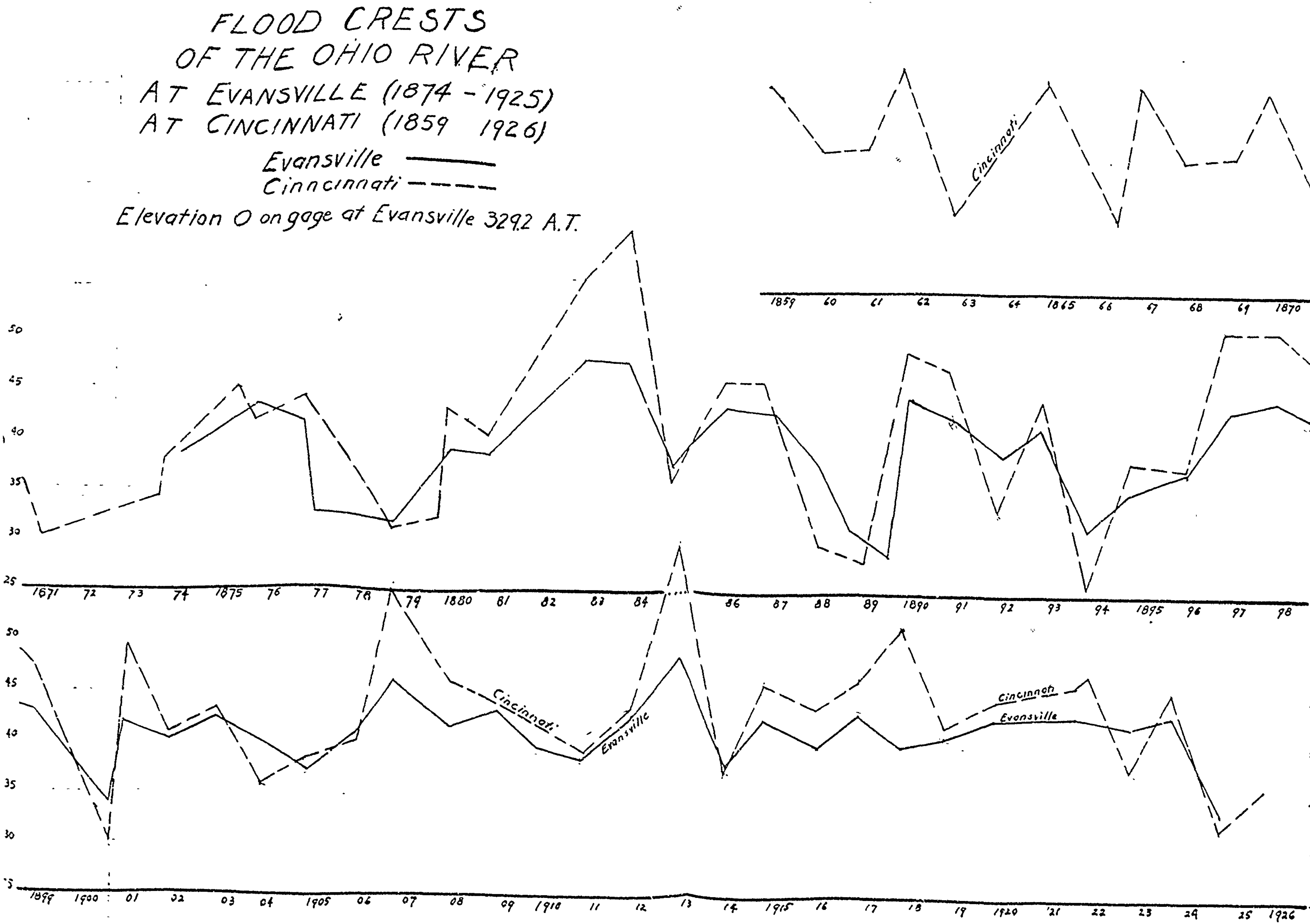

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Figure 20 Flood crests of the Ohio for each year from 1859 to 1926. (See page 159)

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may be recognized by the presence of small or large calcareous concretions in the wash.

These deposits have two origins. Neither of the types are original deposits of rich calcareous materials but in both cases have been enriched by weathering action.

The first type occurs near drainage base in the loess and is the result of the leaching of the calcareous constituents from the overlying loess and their deposition near the water table or level of underground water. The upper portion of the terrace seems also to be calcareous so that similar deposits are formed at its base, just above the flood plain of the river. Marl deposits of this type are found, for instance, in the Smith Mills vicinity, at the edge of the terrace by the road from Geneva to Alzey, and near Corydon. Their origin is indicated by the flat tabular shape of the concretions which occur near the water table in all the loess bluffs.

The other type of marl deposit, found on hill sides, is formed by the enrichment of the soil by limy material derived from waters which have seeped laterally from a limestone bed beneath the soil cover. This is the more clayey marl frequently found in the eastern part of the county. Its origin is indicated by the extensive solution of the limestones where seen, and the fact that the marls are found regularly near the Providence limestone horizon.

The first type should be sought near drainage levels in the terrace, Canoe Creek, and Smith Mills sections of the county where the overlying soils are thick. The second type will be found in the localities passed through by the Carbondale-Lisman contact - the approximate horizon of the Providence limestone - shown on the map.

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Structural materials

Gravel. The gravels used in this county for road building and other purposes are obtained from either the river bed or the Tertiary gravels found in some of the hills near Green River. The river gravels are composed of pebbles of crystalline rocks and chert. Before use on roads, some clay is frequently added as a binder.

The Tertiary bank gravels on the hills and at the level of the terrace are composed entirely of quartz and chert, with scattered pebbles or boulders of sandstone, case-hardened by iron oxide. Streaks of red clay are said to run irregularly through the gravel, in some places making the material too clayey for use as road surfacing. These gravels are overlain generally by 10 to 20 feet of loess.

The thickness of the deposits varies and their extent is generally unknown. In some places in the Spottsville pit (locality 32) they are said to be 20 feet thick and the area tested and shown to contain workable gravel is said to comprise five acres. In the pits around Hebbardsville, about 8 feet of gravel has been exposed but the thickness of this deposit has not been thoroughly tested.

This gravel has been used only for road surfacing and railroad ballast.

Limestone. The limestones exposed in this area belong either to the Providence or Madisonville horizons. The Madisonville has been quarried to a small extent in the vicinity of Smith Mills for use as road metal and is reported to make a better material for this purpose than the Mississippian limestone shipped into the county.

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Both limestones are siliceous, and because of their impurity, seem to be unfitted for any purpose other than ballast or road surfacing.

Clay. The Kleymeyer-Klutey Company in Henderson is the only company in the county making use of the clay. This company has a capacity of 90,000 bricks a day. The clay for the brick is obtained from a layer about 3 feet thick with its top about 18 inches beneath the surface of the terrace. This clay is of Pleistocene age.

Drain tile is also manufactured by this company. For this, the clay is obtained from the post-Pleistocene alluvium in a meander of Canoe Creek southwest of the city.

Fire clays underlying the coal, reported in well logs, have never been utilized or tested.

WATER SUPPLY

The water supply of Henderson is obtained from the Ohio River. The purification plant is located in Atkinson Park above the town.

The wells in the flood-plain are all shallow driven wells. A pipe is forced down in the unconsolidated materials until it reaches a water-bearing lens, the material of which is coarse enough so that the well may be pumped clean. These wells are usually less than 40 feet deep. The quality of such water is said to be generally good. Frequently the water comes from a layer of gravel carrying iron-bearing compounds, which gives the water a chalybeate nature.

The wells in the remainder of the county obtain water from bed rock. In the eastern portion of the county, where the Providence limestone is under shallow cover, the water-bearing

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stratum is usually this limestone with its associated coal. In the remainder of the county, the wells obtain their water from various coarse sands, generally near the base of the Lisman.

For the purpose of supplying water for agricultural uses, ponds are usually constructed. These ponds are a general feature of the landscape. The weathered loess makes a very tight embankment and the construction of such ponds offers no difficulty.

ENGINEERING GEOLOGY

Cutting and Silting of Ohio River

The Ohio is cutting away its banks rapidly. David Dale Owen* mentions the home of Mr. Walter Alves on the river 5 or 6

*Kentucky Geol. Survey- vol. I, 1856, p. 23

miles below Henderson. This house is reported to have been moved back at least once and was undermined and fell into the river a score of years ago. A survey made in 1909 on the land of J. E. Rankin, Jr. on the point of the peninsula of Kentucky jutting out toward Evansville, compared with a survey of the same land made in 1855, shows that the river has, at one point, cut back 555 feet during the 54 years, or approximately 10 feet per year. This instance, however, represents an unusually rapid erosion due to the deflection of the current at this point by the rock bar extending out from Howell. All banks, however, on the outside of the meanders, must be thoroughly protected by riprap.

On the other hand, on the inside of the meanders and at places where the river is artificially obstructed, the river bed is being rapidly silted up. The same surveys cited above show that despite the cutting mentioned, the land on the point of this bend (excluding the easternmost part) had received an accretion of

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24 acres, due to the silting up at the inside of the bend. Since the construction of Dam 48, below Henderson, a good-sized island, not shown on the map, has developed.

Danger of Cut-Off Above Henderson

The long peninsula of Kentucky jutting out above Henderson is overflowed at every high water. Much of the water of the river flows across the "neck" of the peninsula through the several sloughs there. During the ice jam of 1917, the ice formed a dam just below Evansville and for several days practically the entire volume of the Ohio River was directed through these sloughs. At this time, holes 15 or more feet deep are reported to have been scoured out in the sloughs.

The mouths of these sloughs are at an elevation of about 345 feet above sea level, while their heads are at an elevation of about 360 feet. As long, therefore, as the river maintains an elevation between these figures, or from 7 to 22 feet above pool stage, the sloughs are filled with backwater and are built up by the deposit of alluvium dropped upon them. When, however, the river rises above this stage, a large amount of water is diverted through them. As there is a fall of nearly 3 feet in a distance of one and a half miles across this neck, considerable erosion must be done at time of flood. It is not known which of the two processes is most effective, that is, whether these sloughs are now being deepened or are being filled up. Conflicting opinions on this point are given by persons interested in this section.

However, the ox-bow lakes that are numerous on the lower course of the Mississippi must have been formed in just this way. A meander such as this one continued to extend itself at the points of reversal until two points came so close together that the river

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However, the ox-bow lakes that are numerous on the lower course of the Mississippi must have been formed in just this way. A meander such as this one continued to extend itself at the points of reversal until two points came so close together that the river

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could wash away the intervening material and take a new and shorter course, leaving the old channel as one of these crescent shaped lakes. This will be, without doubt, the future history of the river in this section.

Whether or not this will happen within the next few generations, it is impossible to state without accurate and repeated surveys of the region in question. It would seem, however, that the possibility of danger is great enough to justify more extensive efforts to impede the current across this neck and thus to minimize whatever erosion there may be.

Road Building

Road construction is a somewhat difficult problem in Henderson County due to the low elevation of much of the land and the thick loess covering of the region. Many of the roads must cross low portions of the county and are therefore subject to frequent overflow. In such places it is, of course, difficult to maintain a good road bed. It is necessary to construct levees, on which to build the roads, if those roads are to be placed above the reach of high water in the flood-plain section of the county.

Where the roads are not graveled, the loess washes badly and the road is likely to develop trenches across it if the ditches are not in good shape. When traffic passes over these roads immediately after a rain, deep ruts are left in them. Constant grading is therefore required and the roads are sunk lower and lower into the loess cover. Bed rock has already been exposed in many places where the road is on a steep grade. Several roads have already been relocated because the old road bed has been washed so badly that it is impossible to maintain it in condition for travel.

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Bad holes occur in most of the roads. Some of these are at low places in the bottoms while others occur on the hills. These latter are caused by the outcrop here, under loess, of some stratum carrying water. The Providence limestone is the stratum most important in this respect. Wherever a dirt road crosses it a bad, swampy hole is found. The position of this limestone is indicated on the map by the contact between the Lisman and Carbondale formations. Where roads cross this contact, particular attention should be paid to their drainage.

LEGAL GEOLOGY

An unusual feature connected with the geology of the county is the litigation between Kentucky and Indiana over the ownership of Green River Island. The original survey of the Henderson Grant (1797?) shows Green River as a true island, yet today, at normal stages of the river it is connected with the Indiana shore.

The litigation over the ownership of this island was finally ended by the decision of the United State Supreme Court on May 19, 1890, the decision being written by Justice Field.

Kentucky claimed that when it became a state June 1, 1792, this island was a real island. Indiana produced hearsay testimony to prove its claim that when it became a state this was an island only at high water. Kentucky replied by producing other testimony of the same type, claiming that the "island" was an island most of the year.

In making the decision, the Court ruled out this conflicting hearsay evidence and decided the question chiefly on the basis of the fact that Indiana made no legal claim to this territory for 70 years after becoming a state, while Kentucky

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always acted as though this land were part of its territory. It was also pointed out that a survey of this general region, authorized by Congress and performed in December 1805 and April 1806, did not include this land as territory north of the Ohio River. Moreover a line run in 1877 "in accordance with United States Surveys" by bi-state commissioners, placed Green River Island in Kentucky. This line was not, however, accepted by Indiana. Virginia ceded the Northwestern Territory to the United States in 1784 but as late as 1790 granted a patent to an individual giving him Green River Island, "the first large island below the mouth of Green River". In 1821 a case arose as to whether the island was in Kentucky and the United States District Court held that it was*.

*U. S. Supreme Court Decision, October Term, 1889.

Advantage was taken of this unique bit of mixed geology and law when some enterprising people built Dade Park race track upon this "island", thus making it possible for pari-mutual betting to be carried on practically within Indiana confines.

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CHAPTER VIII

WELL AND SHAFT LOGS.

LOG. No. 1
LOCALITY 3

Shaft of mine at Smith Mills
Authority, Mr. W. W. Cooper, from memory.
Elevation 410.

STRATA	THICKNESS	DEPTH
(1) Loose dirt	40'	40
(2) Soapstone	?	?
(3) Sandstone	4"	
(4) Coal	4"	
Interval	40' - 50'	
(5) Coal	1' 6"	170' (about)
(6) Shale	?	?
(7) Sandstone	7'	
(8) Coal	7' 1"	185'
(9) Fireclay	7'	192'

LOG. No. 2
LOCALITY 4

Lessor- Culver #1 Location- near Hitesville
Drilled for Wilson
Elevation 400.

STRATA	THICKNESS	DEPTH
(1) Surface soil	17	17
(2) Quick sand	23	40
(3) Slate	10	50
(4) Slate, sandy	10	60
(5) Slate, dark	35	95
(6) Sandstone	50	145
(7) Slate	8	153
(8) Coal	½	153½
(9) Fire Clay	4½	158
(10) Slate, blue	18	176
(11) Coal	2	178
(12) Limestone	6	184
(13) Fire clay	4	188
(14) Slate	12	200
(15) Slate, dark, sandy	14	214
(16) Limestone, dark (Providence)	6	220
(17) Coal (No. 11)	4	224
(18) Slate, sandy	26	250
(19) Slate, dark	18	268
(20) Coal (No. 10)	2	270
(21) Slate, sandy	6	276
(22) Sandstone	4	280

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STRATA	THICKNESS	DEPTH
(23) Slate, dark	12	292
(24) Sandstone, rotten	4	296
(25) Slate, dark, sandy	4	300
(26) Slate, blue	39	339
(27) Slate, very hard black	2	341
(28) Coal (No. 9)	6	347
(29) Slate, light	4	351
(30) Slate, sandy	4	355
(31) Slate, light	4	359
(32) Slate, dark	20	379
(33) Slate, lighter	12	391
(34) Slate, dark	12	403
(35) Slate or shale, black	12	415
(36) Sandstone	13	428
(37) Slate, dark	36	464
(38) Coal (No. 7)	4	468
(39) Slate, brown	8½	476½
(40) Shell, sandy	3½	480
(41) Slate, dark	12	492
(42) Slate, black	20	512
(43) Slate, light	13	525
(44) Slate, dark	5	530
(45) Slate, brown	50	580
(46) Shale, black	8	588
(47) Slate, light	8	596
(48) Limestone, brown	1	597
(49) Shale, black	29	626
(50) Limestone, sandy	5	631
(51) Shale	7	638
(52) Shell, limy	5	643
(53) Shale, sandy	9	652
(54) Sandstone, brown with rainbow color or oil, salt water & bottom (Corydon Oil Sand)	33	685

LOG. No. 3
LOCALITY 5

Robins & Reynolds-Aubrey Head Well
Location- Near Culvain bridge, Union County, Ky.
Authority, J. T. Sights
Elevation 380.

STRATA	THICKNESS	DEPTH
(1) Surface clay & gravel		30
(2) Mud, blue	20	50
(3) Quicksand	10	60
(4) Gravel	8	68
(5) Soapstone	42	110
(6) Limestone	3	113
(7) Sandstone	43	156
(8) Shale, grey	6	162

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	STRATA	THICKNESS	DEPTH
(9)	Coal	1	163
(10)	Fire clay	10	173
(11)	Slate, grey	9	182
(12)	Coal	2	184
(13)	Fire clay	8	192
(14)	Shale, limy	8	200
(15)	Fire clay	10	210
(16)	Shale, sandy	7	217
(17)	Sandstone	8	225
(18)	Shale, sandy	10	235
(19)	Slate, grey	4	239
(20)	Limestone (Providence)	3½	242½
(21)	Coal	½	243
(22)	Gob	1	244
(23)	Limestone (Providence)	1	245
(24)	Coal (No. 11)	6	251
(25)	Fire clay	17	268
(26)	Sandstone	11	279
(27)	Slate, grey	29	308
(28)	Coal (No. 10)	1	309
(29)	Slate, grey	53	362
(30)	Slate, black	3½	365½
(31)	Coal (No. 9)	4½	370
(32)	Fire clay	3	373
(33)	Limestone	4	377
(34)	Fire clay	8	385
(35)	Slate, grey	41	426
(36)	Slate, black	1	427
(37)	Limestone	3	430
(38)	Slate, black	2	432
(39)	Coal	1	433
(40)	Fire clay	14	447
(41)	Sandstone	10	457
(42)	Slate, grey	30	487
(43)	Coal (No. 7)	1	488
(44)	Slate, grey	11	499
(45)	Sandstone (Sebree)	37	536
(46)	Slate, black	4	540
(47)	Limestone, black	4	544
(48)	Slate, grey	16	560
(49)	Sandstone	20	480
(50)	Slate, grey	38	618
(51)	Coal (No. 6)	2	620
(52)	Fire clay	8	628
(53)	Slate, grey	7	635
(54)	Slate, black	2	637
(55)	Slate, grey	21	658
(56)	Coal	1	659
(57)	Fire clay	4	663
(58)	Slate, grey	7	670
(59)	Limestone	5	675
(60)	Slate, grey	8	693*
(61)	Coal	1	694
(62)	Fire clay	3	697
(63)	Sandstone, grey (Corydon Sand)	3	700

*Discrepancy in original record.

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LOG. No. 4
LOCALITY 6

Diamond Drill Coal Test near Smith Mills
Authority, Gardner Abbott, Cleveland
Elevation 415.

STRATA	THICKNESS	DEPTH
(1) Yellow clay	33	33
(2) Soft grey shale	7	40
(3) Dark shale	9	49
(4) Grey sandy shale	22	71
(5) Grey shale	10	81
(6) Limestone	1	82
(7) Grey shale with soft bands	55	137
(8) Grey shale	18'10"	155'10"
(9) Coal	1'11"	157' 9"
(10) Grey shale	3' 3"	161
(11) Coal	1'10"	162'10"
(12) Fire clay	3' 2"	166
(13) Soft grey shale	3	169
(14) Limestone (Providence)	8	177
(15) Soft dark shale	4	181
(16) Limestone (Providence)	4	185
(17) Soft dark shale	7"	185' 7"
(18) Coal	3' 3"	188'10"
(19) Shale band	2	189
(20) Coal	8"	189' 8"
(21) Fire clay	3' 4"	193

LOG. No. 5
LOCALITY 7

Diamond Drill Record
J. R. Barrett #3
Authority, W. H. Yeaman
Elevation 410

STRATA	THICKNESS	DEPTH
(1) Soil	1	1
(2) Clay, sandy	13	14
(3) Sand	3	17
(4) Clay, sandy	13	30
(5) Sandstone, soft	15	45
(6) Sandstone, red	17	62
(7) Shale, soft, grey	6' 8"	68- 8
(8) Coal (No. 12)	10"	69- 6
(9) Shale, soft, grey	1' 6"	71
(10) Shale, soft	1' 6"	72- 6
(11) Limestone (Providence)	1' 5"	73-11
(12) Shale, soft grey	7' 1"	81
(13) Sandstone	3	84
(14) Shale, sandy	26	110
(15) Sandstone	4	114

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STRATA	THICKNESS	DEPTH
(16) Shale	6	120
(17) Sandstone	2	122
(18) Shale	1	123
(19) Sandstone and shale	7	130
(20) Sandstone	25	155
(21) Sandstone, Shaly	5	160
(22) Sandstone	53' 7"	213- 7
(23) Coal (No. 8 ?)	5"	214
(24) Sandstone, black	1	215
(25) Sandstone	5	220
(26) Shale, sandy	15	235
(27) Shale	15	250
(28) Shale, dark, tough	13' 4"	263- 4
(29) Coal (No. 7?)	4' 1"	267- 5
(30) Fire clay	1' 7"	269

LOG. No. 6
LOCALITY 8

Diamond Drill Record
J. R. Barrett #2
Authority, W. H. Yeaman
Elevation 410

STRATA	THICKNESS	DEPTH
(1) Soil	1	1
(2) Clay, sandy	13	14
(3) Sand	2	16
(4) Clay, sandy	13	29
(5) Shale, soft grey	1' 6"	30- 6
(6) Shale, soft	1	31- 6
(7) Sandstone, red	2' 6"	34
(8) Sandstone	32	66
(9) Shale, soft, grey	1' 2"	67- 2
(10) Coal (No. 12)	7"	67- 9
(11) Shale, soft, grey	6' 3"	74
(12) Limestone (Providence)	1	75
(13) Shale, soft, grey	8	83
(14) Sandstone	5	88
(15) Shale	7'10"	95-10
(16) Coal (No. 11)	5' 8"	101- 6
(17) Fire clay	2	103- 6
(18) Shale, soft	9' 6"	113
(19) Shale, sandy	1' 3"	114- 3
(20) Shale, dark	3	117- 3
(21) Shale, dark, with small coal streaks	2' 3"	119- 6
(22) Coal, bone (No. 10?)	3"	119- 9
(23) Shale, black streaks of coal	2' 3"	122
(24) Shale, soft grey	7	129
(25) Shale, sandy	67	196
(26) Sandstone	22	218
(27) Shale, sandy	19	237
(28) Shale, dark, hard bands	9' 5"	246- 5
(29) Coal (No. 7?)	4' 2"	250- 7
(30) Fire clay	1'11"	252- 6

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LOG. No. 7
LOCALITY 9

Diamond Drill Record
J. R. Barrett #1
Authority, W. H. Yeaman
Elevation 410

STRATA	THICKNESS	DEPTH
(1) Soil	1	1
(2) Clay, sandy	11	12
(3) Sand	7	19
(4) Clay, sandy	8'10"	27-10
(5) Sandstone	1	28-10
(6) Sandstone, red	9' 2"	38
(7) Sandstone, grey	5	43
(8) Shale, soft, grey	8	51
(9) Sandstone	2	53
(10) Shale, soft	8"	53- 8
(11) Coal (No. 12)	9"	54- 5
(12) Shale, grey	6' 7"	61
(13) Limestone (Providence)	2' 6"	63- 6
(14) Shale, soft, grey	8' 6"	72
(15) Shale, dark	16	88
(16) Sandstone, shaly	2	90
(17) Sandstone and shale	10	100
(18) Shale, sandy	10	110
(19) Shale	5	115
(20) Sandstone, shaly	5	120
(21) Shale, dark, sandy	59	179
(22) Shale, sandy	2	181
(23) Shale, dark	4	185
(24) Shale, sandy	1	186
(25) Sandstone	58	244
(26) Shale, blue	5	249
(27) Shale, dark, tough	1' 3"	250- 3
(28) Shale, black	2	252- 3
(29) Coal, bone	3"	252- 6
(30) Coal, (No. 7?)	4' 3"	256- 9
(31) Fire clay	2	258- 9

LOG. No. 8
LOCALITY 10

Water well at Geneva
Authority, E. F. Doudna
Elevation 390.

STRATA	THICKNESS	DEPTH
(1) Soil quicksand, etc. to bottom of casing	100	100
(2) White "sand" (stone?)	15	115
(3) Grey slate	6	121
(4) White "sand" (stone)	30	151
(5) Coal (No. 9?)	4	155
(6) Fire clay	2	157

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LOG. No. 9
LOCALITY 12

Kleiderer Property
Drilled by Peabody Coal Co.
Records in possession of Ohio Valley Bank
Elevation 374.8

STRATA	THICKNESS	DEPTH
(1) Soil & yellow clay	5	5
(2) Clay, blue	40	45
(3) Sandy clay & shale	3	48
(4) Shale, dark, hard and soft seams	30' 4"	78- 4
(5) Coal (No. 12)	1' 5"	79- 9
(6) Fire clay	1' 3"	81
(7) Limestone (Providence)	1' 3"	82- 3
(8) Shale, solid, blue	2'11"	85- 2
(9) Shale, soft, dark	1' 2"	86- 4
(10) Coal)	3	
(11) Sulphur bands) No. 11	3/8"	
(12) Coal)	4	
(13) Dirty coal)	4"	
(14) Fire clay	4"	94-3/8"
(15) Shale, light grey, sandy	11' 4"	105- 4 3/8
(16) Shale, dark	10	115- 4 3/8
(17) Shale, dark, with thin coal seams	8	123- 4 3/8
(18) Shale, dark, hard and soft seams	30	153- 4 3/8
(19) Shale, dark	6	159- 4 3/8
(20) Shale, light, sandy	6	165- 4 3/8
(21) Coal (No. 9?)	2"	165- 6 3/8
(22) Shale, dark, hard and soft seams	15	180- 6 3/8
(23) Sandstone, hard, light	1	181- 6 3/8
(24) Shale, dark grey	1'10"	183- 4 3/8
(25) Shale, dark grey, sandy	30'	213- 4 3/8
(26) Sandstone, shale streaks	16	229- 4 3/8
(27) Shale, dark grey, sandy	31	260- 4 3/8
(28) Shale, dark and tough	34	294- 4 3/8
(29) Shale, black, sandy, showing oil	4	298- 4 3/8
(30) Shale, black	2	300- 4 3/8
(31) Coal (6A ?)	1' 8"	302- 3/8
(32) Fire clay	2	304- 3/8
(33) Shale, grey, sandy	4' 1"	308- 1 3/8

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LOG. No. 10
LOCALITY 13

Diamond Drill Record
Kleiderer Property
Drilled by Peabody Coal Co.
Records in possession of Ohio Valley Bank
Elevation 373.7

STRATA	THICKNESS	DEPTH
(1) Soil & yellow clay	12	12
(2) Clay, tough, blue	59' 6"	71- 6
(3) Shale, soft, yellow	1' 6"	73
(4) Coal, soft, dirty (No. 11?)	1' 4"	74- 4
(5) Fire clay	5' 8"	80
(6) Shale, blue	12	92
(7) Sandstone with shale partings	49	141
(8) Shale, brown, limy	5	146
(9) Shale, dark	15	161
(10) Shale, brown, limy	16	177
(11) Sandstone	35' 3"	212- 3
(12) Shale, dark	1' 9"	214
(13) Shale, dark grey, soft partings	5' 1"	219- 1
(14) Sandstone	4"	219- 5
(15) Dirt band	2"	219- 7
(16) Coal (No. 8?)	1' 1"	220- 8
(17) Shale, grey, sandy	11' 4"	232
(18) Shale, dark, soft, with sandy streaks	26	258
(19) Shale, black	1	259
(20) Coal (No. 7?)	2' 1"	261- 1
(21) Fire clay, sandy	1'11"	263

LOG. No. 11
LOCALITY 13

L. P. Kleiderer Property
Authority, W. S. Kleiderer
Elevation 380.

STRATA	THICKNESS	DEPTH	
(1) Clay, red	31	21	
(2) Clay, blue	41	62	
(3) Clay, sandy	12	74	
(4) River sand	1	75	
(5) Limestone (Providence)	2' 6"	77- 6	
(6) Dark shale and coal mixed	1' 6"	79	
(7) Coal (No. 11)	4' 6"	83- 6	(In the shaft this coal is 7')
(8) Fire clay	4' 6"	88	
(9) Shale, light	7	95	
(10) Sandstone	2	97	
(11) Shale, dark, sandy	38	135	
(12) Slate, grey	6	141	

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STRATA	THICKNESS	DEPTH
(13) Coal (No. 10)	10"	141-10
(14) Fire clay	1	142*
(15) Limestone	6	149*
(16) Shale	4	153
(17) Slate, black	1' 6"	154- 6
(18) Coal (No. 9)	4' 6"	159

*Discrepancies in original record.

LOG. No. 12
LOCALITY 14

L. P. K. Kleiderer Property
May, 1918
Authority, W. S. Kleiderer
Elevation 380

STRATA	THICKNESS	DEPTH	
(1) Soil	20	20	
(2) Clay, yellow	20	40	
(3) Sand, red	15	55	
(4) White "Q" sand (White clay ?)	14	69	
(5) Coal	6"	69- 6	
(6) Shale	1' 6"	71	
(7) Coal	1	72	
(8) White "Q" sand (White clay ?)	3	75	
(9) Gravel and shale	8	83	
(10) Shale, blue	3	86	
(11) Limestone (Providence)	1	87	
(12) Slate, "G"	4	91	
(13) Slate, black	6"	91- 6	
(14) Coal (No. 11)	4' 2"	95- 8	
(15) Fire clay	4' 4"	100	
(16) Shale	5	105	
(17) Limestone	11'10"	116-10	
(18) Shale	2' 2"	119	
(19) Limestone	1	120	
(20) Shale	5	125	
(21) Limestone	1	126	
(22) Limestone & shale	30	156	
(23) Slate, hard, grey	4	160	
(24) Shale, black with coal mixed	10"		(about 4½' Coal)
(25) Coal (No. 9)	3' 8"	164	
(26) Limestone, hard	1	165	
(27) Shale with hard lime streaks	2	167	

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LOG. No. 13
LOCALITY 15

L. P. Kleiderer Property
Authority W. S. Kleiderer
May, 1918
Elevation 390

STRATA	THICKNESS	DEPTH
(1) Clay	20	20
(2) Soap stone	20	40
(3) Shale (?), sandy	5	45*
(4) Quicksand	15	51*
(5) Gravel	2	53
(6) Shale (sand)	19	72
(7) Slate, black	-- 6"	72- 6
(8) Coal	1' 6"	74
(9) Fire clay	1	75
(10) Limestone (Providence)	3	78
(11) Coal, soft, rotten (No.11)	1' 6"	79- 6
(12) Shale	5' 6"	85
(13) Hard, blue bastard rock	1	86
(14) Shale	10	96
(15) Limestone with mineral	7	103
(16) Shale	1	104
(17) Limestone	3	107
(18) Shale	4	111
(19) Blue, hard rock	1	112
(20) Shale	18	130
(21) Limestone	1	131
(22) Shale, grey	24	155
(23) Slate	-- 9"	155- 9
(24) Coal	4	159- 9
(25) Fire clay	1'3"	161

*Discrepancy in original log.

LOG. No. 14
LOCALITY 16

Kleiderer Property,
Drilled by Peabody Coal Co.,
Records in possession of Ohio Valley Bank,
Elevation: 365

STRATA	THICKNESS	DEPTH
(1) Clay, yellow	21	21
(2) Clay, blue	48	69
(3) Coal, soft, dirty (No.12)	1' 10"	70-10
(4) Fire clay	-- 6"	71- 4
(5) Limestone, hard with soft partings (Providence)	3' 3"	74- 7
(6) Coal-blue band near bottom (No.11)	6' 6"	81- 1
(7) Fire clay	2	83- 1
(8) Shale, soft, blue	22' 11"	106

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STRATA	THICKNESS	DEPTH
(9) Shale, blue, with soft partings	21	127
(10) Coal (No.10)	-- 3"	127- 3
(11) Shale, dark with hard l.s.layers	4' 9"	132
(12) Sandstone	2	134
(13) Shale, limy	9	143
(14) Shale, dark with hard & soft partings	39' 7"	182- 7
(15) Shale, black	-- 9"	183- 4
(16) Shale, dark grey, sandy	-- 10"	184- 2
(17) Coal (No.9?)	3' 8"	187-10
(18) Fire clay	4' 2"	192
(19) Shale, dark grey, sandy	17'	209
(20) Shale, dark	7	216
(21) Shale, light, soft	8	224
(22) Shale, dark	6	230

LOG. No. 15
LOCALITY 17

Kleiderer Property
Drilled by Peabody Coal Co.
Records in possession of Ohio Valley Bank
Elevation: 389.8

STRATA	THICKNESS	DEPTH
(1) Clay, yellow	20	20
(2) Clay, blue	40	60
(3) Clay, blue, sandy	31' 6"	91- 6
(4) Shale, blue, sandy	18	109- 6
(5) Shale, sandy	20	129- 6
(6) Shale, black	4	133- 6
(7) Shale, grey, sandy	5	138- 6
(8) Shale, dark with sandy streaks	15' 6"	154
(9) Shale, dark	15	169
(10) Shale, dark grey, sandy	1' 2"	170- 2
(11) Slate, black	-- 8"	170-10
(12) Coal (No. 9)	3' 4"	174- 2
(13) Fire clay	2' 9"	176-11
(14) Sandstone, hard	3' 1"	180
(15) Shale, light, soft with hard bands	7' 6"	187- 6
(16) Shale, light	7	194- 6
(17) Shale, dark	46	240- 6
(18) Shale, dark	16'10"	257- 4
(19) Shale, dark, sandy	1' 2"	258- 6
(20) Slate, black	4' 3"	262- 9
(21) Coal (No. 7?)	1' 6"	264- 3
(22) Fire clay	2' 9"	267

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LOG. No. 16
LOCALITY 18

L. P. Kleiderer Property
Authority W.S. Kleiderer
Commerce Coal Company, drillers
Elevation 390

STRATA	THICKNESS	DEPTH
(1) Clay	20	20
(2) Clay, blue	25	45
(3) Clay, sandy, blue	2	47
(4) Clay, fine, blue	25	72
(5) Sandstone	6	78
(6) Sandstone, hard	10	88
(7) Limestone, blue (Providence)	6	94
(8) Sandstone	6	100
(9) Shale, sandy	5	105
(10) Bastard rock, blue	2	107
(11) Slate, black	-- 6"	107- 6
(12) Coal	1' 6"	109
(13) Fire clay	3'	112
(14) Limestone	4	116
(15) Shale	2	118
(16) Sandstone, black	3	121
(17) Shale with hard rocks 2'3" apart-3'4" thick	23'	144
(18) Sandstone, dark	13' 6"	151- 6*
(19) Slate, black	1' 6"	159*
(20) Coal (No. 9)	4' 6"	163- 6
(21) Fire clay	3	169- 6*
(22) Sandstone, hard	8' 6"	175*
(23) Shale, sandy	2	177
(24) Sandstone, hard	2	179
(25) Shale	22	201
(26) Hard, black rock	1	202
(27) Shale	11	213
(28) Blue, hard rock	2	215
(29) Shale	28	243
(30) Shale, sandy	8	251
(31) Sandstone, hard	4' 6"	255- 6
(32) Slate, black	-- 6"	256
(33) Coal (No. 7 (?))	3	259
(34) Fire clay	2	261
(35) Sandstone, hard	34	295
(36) Shale	3	298
(37) Shale, soft	7	305
(38) Coal (No. 6 A?)	3' 6"	308- 6
(39) Fire clay	2' 6"	311
(40) Sandstone, hard	25	336
(41) Shale, sandy	77' 6"	413- 6
(42) Shale, hard, black	8' 7"	422- 1
(43) Slate, black	1' 1"	423- 2
(44) Coal (No. 6)	6' 2"	429- 4
(45) Blue rock	1' 6"	431

"Drill would not go any deeper"
*Discrepancies in original record

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LOG. No. 17
LOCALITY 19

L. P. Kleiderer Property
Authority, W.S. Kleiderer
April 25, 1918
Elevation 390

STRATA	THICKNESS	DEPTH
(1) Surface, sandy clay	19	19
(2) Sand, yellow river	40	59
(3) Sand, fine, blue	30	89
(4) Gravel	2	91
(5) Clay, soft, blue	7	98
(6) Sandstone	33	131
(7) Sandstone, bastard	2	133
(8) Sandstone	12	145
(9) Limestone	5	150
(10) Slate, black	-- 6"	150- 6
(11) Shale, blue	-- 6"	151
(12) Slate, black	1	153*
(13) Sandstone	5	158
(14) Shale, soft, grey	2	160
(15) Shale, hard, grey, with light streaks	21	181
(16) Slate, black	1	182
(17) Coal (No. 9)	4'4½"	186- 4½
(18) Fire clay	3'6"	189-10½
(19) Shale, grey	2'6"	192- 4½

*Discrepancy in original record.

LOG. No. 18
LOCALITY 20

Diamond Drill Record
Drilled by Sullivan Machine Company
New Southland Shaft, Henderson
Elevation 395

STRATA	THICKNESS	DEPTH
(1) Clay	44	44
(2) Shale, gray	16	60
(3) Shale, sandy	7	67
(4) Shale, gray	3	70
(5) Coal (No. 12)	1'7"	71' -7"
(6) Shale	7	78 - 7
(7) Limestone	6'2"	84 - 9
(8) Shale, limy	1'3"	86
(9) Limestone (Providence)	3'6"	89 - 6
(10) Sandstone	4'6"	94
(11) Shale, sandy	16	110
(12) Shale, blue	16	126
(13) Shale, gray	33'3"	159 - 3
(14) Slate	-- 9"	160

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	STRATA	THICKNESS	DEPTH
(15)	Coal (No. 9)	3'9"	163 -9
(16)	Shale, gray	58'3"	222
(17)	Shale, dark	20	242
(18)	Slate	4	246
(19)	Coal	1'3"	247 -3
(20)	Fire clay	2'3"	249 -6
(21)	Shale, dark	38'6"	288
(22)	Sandstone with shale streaks	42	330
(23)	Sandstone (Sebree?)	38	368
(24)	Slate	1	369
(25)	Shale	6	375
(26)	Sandstone	15	390
(27)	Shale, sandy	29	419
(28)	Shale, gray	22'5"	441 -5
(29)	Coal (No.6)	4'1"	445 -6
(30)	Slate	-- 6"	446
(31)	Shale, gray	35'5"	481 -5
(32)	Coal	-- 9"	482 -2
(33)	Shale, gray	8'10"	491
(34)	Sandstone	18	509
(35)	Shale, dark	10	519
(36)	Shale, gray	6	525
(37)	Shale, blue	2'2"	527 -2
(38)	Coal (No. 4?)	--10"	528
(39)	Limestone (Curlew?)	3'5"	531 -5
(40)	Sandstone (Corydon?)	13'7"	545
(41)	Shale	6	551
(42)	Coal	-- 5"	551 -5
(43)	Fire Clay	-- 5"	551-10
(44)	Sandstone	7'2"	559
(45)	Shale, limy	19	578
(46)	Sandstone	35	613
(47)	Shale, sandy	16	629
(48)	Sandstone with shale partings	10	639
(49)	Shale, gray	4	643
(50)	Fire clay	5'5"	648 -5
(51)	Shale, blue	31'7"	680
(52)	Shale, dark	46	726
(53)	Coal	1'8"	727 -8
(54)	Fire Clay	2'2"	729-10
(55)	Shale, sandy	18'2"	748
(56)	Shale, blue	20	768
(57)	Soapstone	17	785
(58)	Shale, blue	22	807
(59)	Shale, dark	8	815
(60)	Shale, blue	2'3"	817 -3
(61)	Shale, sandy (Top of Caseyville)	62'9"	880
(62)	Slate	6'10"	886-10
(63)	Shale	8'2"	895
(64)	Shale, sandy	3'	898
(65)	Shale, sandy	20	918
(66)	Sandstone	17	935
(67)	Shale	5	940
(68)	Slate	2'7"	942 -7
(69)	Shale, sandy	16'5"	959
(70)	Shale, dark	18	977

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STRATA	THICKNESS	DEPTH
(71) Shale, sandy	3	980
(72) Sandstone	19	999
(73) Shale, sandy	4	1003
(74) Shale, sandy	4'7"	1007 -7
(75) Sandstone	22'5"	1030
(76) Shale, sandy	30	1060
(77) Sandstone	146	1206
(78) Shale, blue	4	1210
(79) Sandstone	6	1216
(80) Shale, dark	10	1226
(81) Shale, blue	6	1232
(82) Shale, sandy	5	1237
(83) Sandstone with shale bands	20	1257
(84) Shale, sandy	3'5"	1260 -5
(85) Shale, blue	5'7"	1266
(86) Shale, dark	11	1277
(87) Shale, blue	6	1283
(88) Shale, sandy	5	1288
(89) Shale, dark	10	1298
(90) Shale, blue	10	1308
(91) Shale, dark	10	1318
(92) Shale, blue	9	1327
(93) Shale, sandy	10	1337
(94) Sandstone with shale	13	1350
(95) Shale, sandy	18	1368
(96) Sandstone with shale bands	7	1375
(97) Sandstone	55	1430
(98) Shale, sandy	3	1433
(99) Sandstone	12	1445

LOG. No. 19
LOCALITY 21

Location Drill hole near Southland mine
Authority J. L. Nicholson
Elevation 390

STRATA	THICKNESS	DEPTH
(1) Surface soil	53	53
(2) Fire clay	12	65
(3) Coal, boney (No.11.)	4'6"	69- 6
(4) Fire clay	4'6"	74
(5) Shale, sandy	40	114
(6) Shale, dark	10	124
(7) Coal (No. 10)	-- 4"	124- 4
(8) Fire clay	3	127- 4
(9) Slate, dark	23'8"	151
(10) Coal (No.9)	4	155
(11) Fire clay	30	185
(12) Slate, light	53	238
(13) Shale, dark	6'2"	244- 2
(14) Coal (No.7)	--10"	245
(15) Fire clay	4	249
(16) Shale, sandy	13	262

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	STRATA	THICKNESS	DEPTH
(17)	Slate, light	27	289
(18)	Slate, dark	6	295
(19)	Shale, sandy	11	306
(20)	Sandstone	2	308
(21)	Shale, sandy	11	319
(22)	Sandstone (Sobree?)	43	362
(23)	Slate, dark	1' 6"	363- 6
(24)	Coal (6 A?)	-- 2"	363- 8
(25)	Fire clay	5	368- 8
(26)	Shale, sandy	18' 4"	387
(27)	Sandstone	14	401
(28)	Shale, dark	25	426
(29)	Slate, dark	12	438
(30)	Coal (No.6)	5	443
(31)	Fire clay	7	450
(32)	Shale, sandy	27	477
(33)	Coal	-- 6"	477- 6
(34)	Fire clay	8	485- 6
(35)	Sandstone	19' 6"	505
(36)	Shale, light	13	518
(37)	Slate, dark	6	524
(38)	Coal (No. 4?)	1' 8"	525- 8
(39)	Fire clay	2'4"	528
(40)	Sandstone	53	581
(41)	Fire clay	4	585
(42)	Sandstone	63	648
(43)	Shale, dark	10	658
(44)	Clay, soft	9	667
(45)	Limestone	1	668
(46)	Clay, soft	11	679
(47)	Slate, dark	47	726
(48)	Sandstone	12	738
(49)	Clay & shale	8	746
(50)	Slate, dark	2	748
(51)	Fire clay	6	754
(52)	Shale, sandy	4	758
(53)	Clay & Shale	22	780
(54)	Shale, sandy	4	784
(55)	Limestone	2	786
(56)	Shale & Clay	6	792
(57)	Slate, dark	24	816
(58)	Fire clay	2	818
(59)	Shale, sandy	2	820
(60)	Sandstone	1	821
(61)	Shale, light	7	828
(62)	Slate, dark	5	833
(63)	Shale, light	1	834
(64)	Fire clay	2	836
(65)	Shale, dark	22	858
(66)	Sandstone (Top of Caseyville?)	2	860
(67)	Quicksand	11	871
(68)	Sandstone	13	884
(69)	Quicksand	4	888

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LOG. No. 20
LOCALITY 22

Water well on Green Farm, 8 miles from Henderson, for Mr. Henry Barrett,
October 1908.
Authority, E. F. Doudna,
Elevation 415

STRATA	THICKNESS	DEPTH
(1) Soil	6	6
(2) Sand. yellow	12	18
(3) Clay, yellow	8	26
(4) Clay, white	11	37
(5) Limestone	25	62
(6) Limestone	15	77
(7) Shale & Coal	2	79
(8) Mud or Clay	6	85
(9) Soapstone	25	110
(10) Sandstone, brown	21	131
(11) Sandstone, white	40	171
(12) Soapstone, blue	11	182
(13) Sandstone, white	45	227
(14) Shale, gray	14	241
(15) Sandstone, brown	3	244
(16) Slate, black	1	245
(17) Coal (#9 ?)	4	249
(18) Fire clay	1	250
(19) Limestone	21	271

LOG. No. 21
LOCALITY 23

Shaft of Graham Hill Coal mine
Authority, L. A. Hazelwood, Pres.
Elevation 470

STRATA	THICKNESS	DEPTH
(1) Soil	17	17
(2) Sandy Shale	4	21
(3) Sandstone	45	66
(4) Shale with concretions	68' 8"	134' 8"
(5) Coal	2' 2"	136'10"
(6) Fireclay	2	138'10"
(7) Sandstone	4	142'10"
(8) Sandy shale	-- 4"	143' 2"
(9) Black shale	-- 4"	143' 6"
(10) Limestone and gob (Providence)	1' 6"	145
(11) Coal (No.11)	3	148
(12) Fire clay	3	151
(13) Bastard limestone	10	161
(14) Sandstone	65	226
(15) Black slate	4	230

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LOG. No. 22
LOCALITY 25

Old Holloway Coal test
(Owen, D. D., Ky. Geol. Survey, Vol. I, 1856; p. 32
Owen, D. D., Ky. Geol. Survey, Vol. IV, 1861; p. 428)
Elevation 440.

STRATA	THICKNESS	DEPTH
(1) Clay	20	20
(2) Indurated argillaceous shale, with cherty rocks	40	60
(3) Coal, foeted odor when burnt? (No. 12?)	3' 6"	63' 6"
(4) Soft shale or fire clay	5	66' 6"
(5) Hard, grey, heavy rock containing some lime	4' 1"	70' 7"
(6) Coal - Little Newburg (No. 11)	4' 5"	75
(7) Shale with fire clay	3' 9"	78
(8) Hard, grey, heavy rock limestone?	3' 6"	81' 6"
(9) Shale with 10 inches of coal	4'10"	86' 4"
(10) Shale or fire clay	4	90' 4"
(11) Soft sandstone	46	136' 4"
(12) Hard black shale with some coal (No. 10)	3' 2"	139' 6"
(13) Tough dark shale	21	160' 6"
(14) Coal (No. 9)	4' 3"	164' 9"
(15) Indurated argillaceous shales	93' 3"	258
(16) Hard black shale	3' 6"	261' 6"
(17) Sandstone	1	262' 6"
(18) Coal (No. 7)	2' 6"	265
(19) Sandstone	182	447
(20) Coal	1' 6"	448' 6"
(21) Shale	13	461' 6"
(22) Coal - Blue and Bonharbor? (No. 5 of Owen, now called No.6)	5' 6"	467
(23) Shale	45' 8"	512' 8"
(24) Sandstone (Curlew?)	26' 8"	539' 4"
(25) Shale	11	550' 4"
(26) Limestone	22' 6"	572'10"
(27) Coal (No. 4)	1' 8"	574' 6"
(28) Shale	18'11"	593' 5"
(29) Limestone	29' 7"	613
(30) Shale	9' 8"	622' 8"
(31) Limestone	8	630' 8"
(32) Shale	5	635' 8"
(33) Limestone	33' 4"	672
(34) Shale	5	677
(35) Black, hard rock with a little grit	7	684
(36) Indurated shale	179' 9"	861' 9"
(37) Coal (No. 16)	6' 6"	868' 5"
(38) Sandstone	156?	1024' 5"

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LOG. No. 23
LOCALITY 26

Shaft of L. H. & W. Mine
Elevation 425.

STRATA	THICKNESS	DEPTH
(1) Yellow clay	20	20
(2) Sandy shale	25	45
(3) Soapstone	40	85
(4) Coal (No. 12)	2	87
(5) Flint rock (Providence)	2	89
(6) Soft slate	1	90
(7) Coal (No. 11)	2' 6"	92' 6"
(8) Fire clay	-- 6"	93
(9) Blue shale with bands of concretions	17' 2"	110' 2"
(10) Sandstone	65	175' 2"
(11) Slate	12	187' 2"
(12) Coal (No. 10)	-- 8"	187'10"
(13) Fire clay	-- 2"	188
(14) Slate	15	203
(15) Coal (No. 9)	4' 3"	207' 3"

LOG. No. 24
LOCALITY 27

Well drilled about 1885 by Excelsior Drilling and Prospecting Company on property of F. M. Wolf
Authority, G. A. Wolf
Elevation well 390
Elevation Madisonville limestone nearby 450

COALS	THICKNESS	DEPTH
(1) No. 11?	thin	93
(2) No. 9	4' 6"	194
(3) No. 7	4	290
(4) No. 6A	4	395
(5) No. 6	5	471

LOG. No. 25
LOCALITY 36

Lessor- Susan Gregory
Contractor- R. J. Randall
Completed January 24, 1924
Elevation 430.

STRATA	THICKNESS	DEPTH
(1) Clay, yellow	15	15
(2) Slate, black	60	75

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		THICKNESS	DEPTH
(3)	Coal (No. 9)	5	80
(4)	Fire Clay	2	82
(5)	Limestone	15	97
(6)	Slate, dark	10	107
(7)	Limestone	13	120
(8)	Slate, dark	42	162
(9)	Coal (No. 7)	4	166
(10)	Slate, dark	4	170
(11)	Limestone	10	180
(12)	Slate, light	15	195
(13)	Slate, dark	10	205
(14)	Limestone, broken	45	250
(15)	Sandstone	20	270
(16)	Limestone	10	280
(17)	Shale, dark	5	285
(18)	Slate, light	35	320
(19)	Shale, brown	30	350
(20)	Limestone	10	360
(21)	Slate, light	35	395
(22)	Limestone	5	400
(23)	Slate	25	425
(24)	Limestone	4	429
(25)	Fire clay	16	445
(26)	Sandstone	65	510
(27)	Slate	3	513
(28)	Limestone	2	515
(29)	Limestone	40	555
(30)	Slate	5	560
(31)	Limestone	55	615
(32)	Slate	22	637
(33)	Limestone	33	670
(34)	Slate	15	685
(35)	Shale, sandy	15	700
(36)	Slate	30	730
(37)	Sandstone (Top of Caseyville?)	45	775
(38(	Red Rock	49	824
(39)	Sandstone	2	826
(40)	Limestone	24	850
(41)	Slate, brown	25	875
(42)	Limestone, light	35	910
(43)	Sandstone, light	5	915
(44)	Shale	145	1060
(45)	Sandstone	15	1075
(46)	Limestone, grey	30	1105
(47)	Slate, brown	15	1120
(48)	Sandstone, grey	25	1145
(49)	Slate, dark	10	1155
(50)	Sandstone (with water)	28	1183
(51)	Sandstone, brown	15	1198
(52)	Shale, sandy	15	1213
(53)	Sandstone (with water)	27	1240
(54)	Slate, dark (Top of Mississipian?)	15	1255
(55)	Limestone	20	1275
(56)	Slate, dark	2	1277
(57)	Limestone, brown	68	1345
(58)	Limestone, broken	8	1353

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STRATA	THICKNESS	DEPTH
(59) Slate, light	12	1365
(60) Limestone	10	1375
(61) Shale, sandy	5	1380
(62) Limestone, brown	15	1395
(63) Slate, dark	10	1405
(64) Sandstone (with water)	25	1430
(65) Shale, dark	20	1450
(66) Sandstone (with water)	15	1465
(67) Slate, dark	20	1485
(68) Limestone	15	1500
(69) Slate, grey	5	1505
(70) Sandstone, white	6	1511
(71) Limestone, grey	19	1530
(72) Slate	10	1540
(73) Sandstone, light	3	1543
(74) Slate, dark	2	1545
(75) Limestone	17	1562
(76) Sandstone, light	10	1572
(77) Limestone, hard, grey	43	1615

LOG. No. 26
LOCALITY 39

Lessor- Fred Williams.
Lessee- Hyatt Oil & Gas Co.
Contractor- R. J. Randall.
Location- 2 miles s. e. of Zion, Ky.
Started: October 5, 1925
Abandoned: November 3, 1925
Elevation 420.

STRATA	THICKNESS	DEPTH
(1) Clay	25	25
(2) Slate	9	34
(3) Limestone	31	65
(4) Slate	5	70
(5) Sand	20	90
(6) Slate	47	137
(7) Coal (No. 9)	4	141
(8) Slate	9	150
(9) Limestone	25	175
(10) Slate	37	212
(11) Coal (No. 7)	3	215
(12) Slate	25	240
(13) Limestone	3	243
(14) Limestone, broken	27	270
(15) Slate	30	300
(16) Sand with water (Sebree?)	45	345
(17) Slate	3	348
(18) Limestone	2	350
(19) Slate	33	383
(20) Sand	5	388
(21) Slate	75	463
(22) Sand	3	466

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STRATA	THICKNESS	DEPTH
(23) Slate	62	528
(24) Sand	40	568
(25) Slate	6	574
(26) Limestone	2	576
(27) Slate	4	580
(28) Limestone	35	615
(29) Slate	15	630
(30) Sand- water	20	630*
(31) Slate	20	650
(32) Sand	20	670
	20	690
(33) Slate	70	760
(34) Limestone, broken	10	770
(35) Slate, sandy	28	798
(36) Slate	27	825
(37) Sand (Top of Caseyville?)	25	850
(38) Slate	4	854
(39) Sand	16	870
(40) Limestone	20	890
(41) Sand with water	133	1023
(42) Slate, chocolate	15	1038
(43) Sand	2	1040
(44) Slate	2	1042
(45) Sand	28	1070
(46) Slate	16	1086
(47) Limestone	10	1096
(48) Slate	24	1120
(49) Sand- water	25	1145
(50) Slate	48	1193
(51) Limestone	7	1200
(52) Slate	18	1218
(53) Limestone, sandy	27	1245
(54) Sand, good	23	1268
(55) Limestone, sandy	27	1295
(56) Slate	13	1308
(57) Sand, good	24	1332
(58) Slate (Top of Mississippian?)	5	1337
(59) Limestone	3	1340
(60) Slate	27	1367
(61) Limestone	13	1380
(62) Slate	25	1405
(63) Limestone	5	1410
(64) Slate	30	1440
(65) Limestone, sandy	45	1485
(66) Slate, dark	15	1500
(67) Limestone, hard	5	1505
(68) Slate	10	1515
(69) Limestone	3	1518
(70) Slate	7	1525
(71) Limestone, broken	25	1550
(72) Slate	23	1573
(73) Limestone, hard	25	1578*
(74) Slate	12	1590
(75) Sand, broken	25	1615
(76) Sand- water		1625

Hole abandoned and plugged

*Discrepancy in original well record.

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LOG. No. 27
NEAR LOCALITY 38

Old Zion Coal Co. mine shaft.
Hutchinson, H. M., Ky. Geol. Survey,
Bull. 19, 1912; insert

STRATA	THICKNESS	DEPTH
(1) Soil	24	24
(2) Hard, flinty, limestone (Providence)	4	28
(3) Soapstone	12	40
(4) Soft sandstone	30	70
(5) Gray slate	49	119
(6) Black slate	3	122
(7) Coal (No. 9)	4	126

LOG. No. 28
LOCALITY 41

Rolland No. 1, Lessor.
Petroleum Exploration, Inc. and
Eastern Gulf Oil Co., Lessees.
Commenced: May 20, 1924.
Completed: July 4, 1924.
Contractor: J. H. Randall.
Elevation 490

STRATA	THICKNESS	DEPTH
(1) Clay, yellow, soft	34	34
(2) Limestone, light, hard (Providence)	1	35
(3) Shale, light, soft	35	70
(4) Coal, dark, soft (No. 10)	3	73
(5) Shale, dark, soft	27	100
(6) Shale, light, soft	31	131
(7) Coal, dark, soft (No. 9)	4	135
(8) Shale, light, soft	85	220
(9) Limestone, light, hard	1	221
(10) Shale, dark, soft	19	240
(11) Limestone, light, soft	35	275
(12) Shale, dark, soft	50	325
(13) Coal, dark, soft (No. 6A?)	5	330
(14) Shale, light, soft	2	332
(15) Limestone, light, soft	10	342
(16) Shale, dark, soft	40	382
(17) Limestone, light, soft	10	392
(18) Shale, dark, soft	59	451
(19) Sandstone, light, hard	16	467
(20) Shale, dark, soft	1	468
(21) Limestone, light, hard	10	478
(22) Shale, light, soft	30	508
(23) Limestone, light, soft	25	533
(Water to drill with 540-hole filled 550)		550

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STRATA	THICKNESS	DEPTH
(24) Sandstone, light, hard	27	560
(25) Shale, light, soft	2	562
(26) Limestone, light, broken	5	567
(27) Shale, light, soft	23	590
(28) Shale, dark, soft	44	634
(29) Shale, light, sandy	34	668
(30) Sandstone, light, hard	22	690
(31) Shale, dark, soft	35	725
(32) Limestone, light, soft	50	775
(33) Shale, light, soft	45	820
(34) Sandstone, light, hard (Top of Caseyville?)	10	830
(35) Shale, dark, hard	40	870
(36) Limestone, broken, light, soft	15	885
(37) Shale, dark, soft	25	910
(38) Limestone, light, soft	10	920
(39) Sandstone, light, hard	15	935
(Water at 935-hole filled 940)		
(40) Shale, light, soft	5	940
(41) Limestone, light, soft	5	945
(42) Shale, black, soft	55	1000
(43) Limestone, light, hard	31	1031
(44) Shale, light, hard	19	1050
(Hole filled up 1050).		
(45) Sandstone, light, hard	60	1110
(46) Shale, black, soft	15	1125
(47) Sandstone, (water) light, hard	10	1135
(48) Limestone, grey, hard	20	1155
(49) Sandstone, light, hard	10	1165
(50) Limestone, grey, hard (Top of Mississippian ?)	15	1180
(51) Shale, showed coal, broken, brown, soft	15	1195
(52) Shale, light, soft	5	1200
(53) Limestone, light, hard	35	1235
(54) Shale, light, soft	10	1245
(55) Limestone, broken, light, hard	12	1257
(56) Shale, light, soft	3	1260
(57) Limestone, grey, hard	5	1265
(58) Shale, light, soft.	15	1280
(59) Sandstone, light, soft	10	1290
(60) Shale, light, soft	5	1295
(61) Limestone, grey, soft	10	1305
(62) Shale, dark, soft	10	1315
(63) Shale, dark, soft	25	1340
(64) Limestone, grey, hard	5	1345
(65) Shale, dark, soft	15	1360
(66) Limestone, dark, hard	5	1365
(67) Shale, dark, hard	2	1367
(68) Limestone, broken, grey, hard	33	1400
(69) Shale, light, soft	10	1410
(70) Limestone, dark, hard	10	1420
(71) Shale, dark, hard	15	1435
(72) Limestone, dark grey, hard	5	1440
(73) Shale, dark, soft	62	1502
(74) Limestone, grey, hard	5	1507
(75) Shale, dark, soft	43	1550

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LOG. No. 31
LOCALITY 48

Shaft of mine at Coraville
Hutchinson, H. M., Ky. Geol. Survey,
Bull. 19, 1912; p. 113.
Elevation 415

STRATA	THICKNESS	DEPTH
(1) Soil	8	8
(2) Soft sandstone (Anvil Rock)	17	25
(3) Coal (No. 12)	2	27
(4) Fire clay	3	30
(5) Limestone (Providence)	6	36
(6) Soapstone	8	44
(7) Flint Rock	6	50
(8) Soapstone	10	60
(9) Sandstone	30	90
(10) Grey slate	30	120
(11) Black slate	2	122
(12) Coal (No. 9)	4	126
(13) Fire clay	4	130

LOG. No. 32
LOCALITY 49

Lessor- Martin
Lessee- J. S. Garretson & Son
Elevation 370.

STRATA	THICKNESS	DEPTH
(1) Top soil & quicksand	80	80
(2) Slate, blue	40	120
(3) Sandstone (Anvil Rock)	75	195
(4) Limestone (Providence)	2	197
(5) Slate, blue	8	205
(6) Coal (No. 11)	4	209
(7) Slate, light	37	246
(8) Slate, dark	18	264
(9) Coal (No. 10)	2	266
(10) Slate	14	280
(11) Sandstone	40	320
(12) Slate, blue	8	328
(13) Slate, black & little trace of coal (No. 9)	12	340
(14) Limestone	5	345
(15) Sandstone	5	350
(16) Slate	40	390
(17) Slate, black & trace of coal (No. 8)	18	408
(18) Slate	33	441
(19) Coal (No. 7)	4	445
(20) Slate, light	10	455
(21) Slate, brown	5	460
(22) Slate, dark	5	465

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STRATA	THICKNESS	DEPTH	
(23) Slate, sandy	5	470	
(24) Sandstone (Sebree?)	8	478	
(25) Fire clay	2	480	
(26) Slate, dark	44	524	
(27) Slate, black	4	528	
(28) Coal & Fire clay (No. 6A)	6	534	
(29) Sandstone, rotten	4	538	
(30) Slate, light	4	542	
(31) Limestone or shale, hard, black	4	546	
(32) Slate, black	8	554	
(33) Slate, brownish	28	582	
(34) Coal (No. 6)	4	586	
(35) Slate, black	4	590	
(36) Slate, sandy	8	598	
(37) Slate, black	20	618	
(38) Slate, hard, black	4	622	
(39) Slate, light	2	624	
(40) Slate, sandy	12	636	
(41) Hard cap & sandstone (Corydon?)	4	640	Show of oil at 636-640.
(42) Slate, blue, sandy	16	656	
(43) Shale, black	4	660	Salt water at 660-675
(44) Slate, black	15	675	
(45) Slate, sandy	27	702	

LOG. No. 33
LOCALITY 50

Lessor- George Proctor #3
Driller and Authority- Garretson.
Elevation 370.

STRATA	THICKNESS	DEPTH
(1) Soil- Quicksand		68
(2) Slate	17	85
(3) Sand (Anvil Rock)	50	135
(4) Trace of coal #12	1	135-136
(5) Fire clay	4	140
(6) Limestone, brown (Providence)	2	142
(7) Slate, light	6	148
(8) Limestone, grey (Providence)	7	155
(9) Slate	5	160
(10) Limestone (Providence)	5	165
(11) Trace of coal (No. 11)	½	165½
(12) Slate, dark	14½	180
(13) Sand	12	192
(14) Slate, dark	23	215
(15) Trace of coal (No. 10)	1	216
(16) Slate, light	74	290
(17) Slate, black	10	300
(18) Coal (No. 9)	1	301
(19) Fire clay	2	303
(20) Limestone, brown	2	305

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STRATA	THICKNESS	DEPTH
(21) Sand	8	313
(22) Soapstone	35	348
(23) Limestone, brown	2	350
(24) Shale, black, hard	8	358
(25) Sand	12	370
(26) Slate, sandy	10	380
(27) Slate, dark	46	426
(28) Slate, sandy	14	440
(29) Sand (Sebree?)	35	475
(30) Slate, black	10	485
(31) Limestone, black	2	487
(32) Slate, sandy	13	500
(33) Slate, dark	8	508
(34) Slate, brown, sandy	24	532
(35) Slate, dark	18	550
(36) Coal (No. 6)	3	553
(37) Slate, sandy	7	560
(38) Sand	6	566
(39) Shale, black	4	570
(40) Shale, black	18	588
(41) Slate, sandy	16	604
(42) Slate, dark	13	617
(43) Limestone, blue	2	619
(44) Shale, black	4	623
(45) Slate, light	16	639
(46) Pay Sand (Corydon)	6	645
	5	650

LOG. No. 34
LOCALITY 52

Lessor- Martin #1
Lessee- J. S. Garretson & Son
Location- Casey Creek
Elevation 365

STRATA	THICKNESS	DEPTH	
(1) Surface, yellow clay	20	20	
(2) Slate	20	40	
(3) Mud or muck, blue	15	55	
(4) Quicksand	17	72	
(5) Soapstone	40	112	
(6) Slate, sandy	13	125	
(7) Sand	50	175	Water at 135
(8) Limestone (Providence)	16	191	
(9) Coal (No. 11)	4	195	
(10) Slate, sandy	35	230	
(11) Coal (No. 10)	3	238*	
(12) Slate	72	310	
(13) Coal (No. 9)	1	311	
(14) Slate	9	320	
(15) Shell, sandy	10	330	
(16) Slate	40	370	

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STRATA	THICKNESS	DEPTH
(17) Coal (No. 8?)	2	372
(18) Slate	48	420
(19) Slate, black	70	490
(20) Slate, black	12	502
(21) Shell, sandy	8	510
(22) Slate, black	46	556
(23) Slate, light, sandy	8	564
(24) Slate, dark	31	595
(25) Slate, light	25	620
(26) Black cap, very hard	3	623
(27) Shale, black	4	627
(28) Slate, light	9	636
(29) Sandstone (Corydon)	10	646
(30) Slate, dark	10	656
(31) Sandstone & slate	59	715
(32) Salt water	3	718

Discrepancy in original well record.

LOG. No. 35
LOCALITY 54

Location- Near Jones Station
Authority- Charles Burbank
Elevation- 370

STRATA	THICKNESS	DEPTH	
(1) Clay, yellow	12	12	
(2) Hard (Clay?)	27	39	
(3) Quicksand	8	44*	first water
(4) Sandstone, yellow	1	45	
(5) Shale, soft, blue	8	54*	
(6) Shale, hard, blue	44	98	
(7) Shale, dark, sandy	12	110	
(8) Limestone, grey	4	114	
(9) Coal	½	114½	
(10) Shale, blue	20	134½	
(11) Limestone, grey	4	152½*	
(12) Coal (No. 12?)	4½	156½*	
(13) Fire clay, white	1½	158	
(14) Limestone, light brown	4	162	
(15) Limestone & sandy shale	6' 8"	168- 8	
(16) Limestone, brown	2	170- 8	
(17) Limestone, blue	4	174- 8	
(18) Shale, blue	11	185- 8	
(19) Coal (No. 11)	-- 4"	186	
(20) Shale, light	11	197	
(21) Shale, sandy	8	205	
(22) Shale, dark blue	10	215	
(23) Shale, light blue	10	225	
(24) Shale, light and dark	77	302	
(25) Shale, black	3½	305½	
(26) Coal (#9)	4'10"	310- 4	

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STRATA	THICKNESS	DEPTH
(27) Fire clay, blue	4' 8"	315
(28) Limestone, with shale partings	5	320
(29) Shale, dark brown	45	365
(30) White (water sand)	10	375
(31) Shale, sandy	25	400
(32) Shale, blue	26	426
(33) Coal (No. 4?)	4	430
(34) Fire clay, soft white	2	432
(35) Sandstone & blue shale, alternating (Sebree in part)	70	502

*Discrepancy in original record

LOG. No. 36
LOCALITY 55

Lessor- John Mattingly #1
Lessee- J. S. Garretson & Son
Location- West of Corydon
Elevation 400.

STRATA	THICKNESS	DEPTH
(1) Soil	20	20
(2) Slate, blue	80	100
(3) Sandstone (Anvil Rock)	45	145
(4) Coal (No. 12)	3	148
(5) Slate	4	152
(6) Limestone (Providence)	8	160
(7) Slate	4	164
(8) Limestone (Providence)	6	170
(9) Coal (No. 11)	4	174
(10) Fire clay	4	178
(11) Sandstone	20	198
(12) Slate, sandy	84	282
(13) Coal (No. 9)	4	286
(14) Slate, light	14	300
(15) Slate, dark	60	360
(16) Slate, sandy	30	390
(17) Slate	106	496
(18) Shell, sandy	8	504
(19) Slate, sandy	26	530
(20) Slate, dark	70	600
(21) Sandstone (Corydon)	8	608
(22) Slate, light	4	612
(23) Slate, dark	4	616
(24) Shell, hard, black	4	620
(25) Shale, dark	4	624
(26) Slate, light	4	628
(27) Slate, sandy	32	660
(28) Sandstone, brown	20	680
(29) Sandstone, blue	20	700
(30) Slate, dark	30	730

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STRATA	THICKNESS	DEPTH
(31) Shale, black	8	738
(32) Sandstone, white	8	746
(33) Sand- water	4	750
(34) Salt water		

LOG. No. 37
LOCALITY 60

Log of test hole near shaft of mine at Robard
Authority, Mr. M. V. Denton
Elevation 420

STRATA	THICKNESS	DEPTH	
(1) Soil	18	18	
(2) Sandstone (Anvil Rock)	11	29	
(3) Soapstone	20	49	
(4) Black Slate	-- 1"	49' 1"	
(5) Coal (No. 12)	4	53' 1"	
(6) Soapstone (Providence) (with boulders of limestone in shaft)	20	73' 1"	
(7) Coal (No. 11)	-- 8"	73' 9"	(varies from 2' to 7' in shaft)
(8) Soapstone	10	83' 9"	
(9) Sandstone	14	97' 9"	
(10) Soapstone	5	102' 9"	
(11) Grey slate	4	106' 9"	
(12) Massive sandstone	17	123' 9"	
(13) Soft sandstone	10	133' 9"	
(14) Sandstone and black shale	13	146' 9"	
(15) Sandstone	33	179' 9"	
(16) Grey slate	15	194' 9"	
(17) Black slate	1	195' 9"	
(18) Coal (No. 9)	4'10"	200' 7"	

LOG. No. 38
LOCALITY 51

Proctor Well No. 1
Authority, J. H. Garretson
Elevation 375.

STRATA	THICKNESS	DEPTH
(1) Surface clay	7	7
(2) Blue clay	20	27
(3) Blue shale	30	57
(4) Sandy shale (Anvil Rock?)	60	117
(5) Limestone	14	131

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STRATA	THICKNESS	DEPTH
(6) Black shale	2	133
(7) Coal (No. 12?)	1	134
(8) Blue shale	2	136
(9) Limestone (Providence)	3	139
(10) Shale	5	144
(11) Dark slate	4	148
(12) Coal (No. 11)	5	153
(13) Fire clay	2	155
(14) Sandy shale	45	200
(15) Soapstone	15	215
(16) Grey shale	10	225
(17) Dark shale	30	255
(18) Blue shale	15	270
(19) Grey slate	20	290
(20) Black slate	5	295
(21) Coal (No. 9)	4	299
(22) Fire clay	3	302
(23) Blue limestone	2	304
(24) Sandy shale	10	314
(25) Grey shale	20	334
(26) Dark shale	30	364
(27) Grey shale	40	404
(28) Dark shale (salt water)	35	439
(29) White sandy shale	20	459
(30) Dark shale	30	489
(31) Black slate and Coal (No. 6A?)	4	493
(32) Fire clay	3	496
(33) Sandy shale	10	506
(34) Dark shale	20	526
(35) Coal (No. 6)	1	527
(36) Fire clay	2	529
(37) Dark shale	10	539
(38) Limestone	2	541
(39) Dark shale	40	581
(40) White shale	10	591
(41) Dark shale	46	637
(42) Oil sand drilled (Corydon)	7	644

LOG. No. 39
LOCALITY 53

(Jillson, W. R., Oil Field stratigraphy of Kentucky, Ky. Geol. Survey, Ser. VI, Vol. III, 1922; p. 194)
O'Nan Heirs, No. 1, lessors.
Union County Syndicate, Union County, Ky., lessee
Commenced: March 4, 1922.
Completed: April 1, 1922
Authority: Ivyton Oil and Gas Co.
Production: Salt water; well plugged and abondoned.
Elevation 370.

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STRATA	THICKNESS	DEPTH
(1) Drift	125	125
(2) Shale and slate	47	172
(3) Fire clay	2	174
(4) Lime, flinty (Providence)	4	178
(5) Fire clay	2	180
(6) Coal (No.11)	4	184
(7) Slate	61	245
(8) Slate	55	300
(9) Shale, hard	12	312
(10) Slate	38	350
(11) Coal No. 8 7)	22 (??)	372
(12) Fire clay	3	375
(13) Sand, dark	20	395
(14) Slate	25	420
(15) Coal (No.7)	1	421
(16) Slate, dark	64	485
(17) Coal and slate (No. 6 A?)	4	489
(18) Slate	4	493
(19) Sandy shell	4	497
(20) Slate, sandy	53	550
(21) Slate, dark	15	565
(22) Coal (No. 6)	1	566
(23) Shale, black	3	569
(24) Shale, light	17	586
(25) Slate, dark	27	613
(26) Sand, gritty, dark	8	621
(27) Slate, dark	5	626
(28) Slate, hard	4	630
(29) Fire clay and light shale	34	664
(30) Sand, white (Corydon)	31	695
(31) Sand, salt water	15	710

LOG. No. 40
LOCALITY 61

Record of well drilled near Mt. Vernon
by Mt. Vernon Coal & Mining Co.,
(Logan, W. N., Geology of Deep Wells of
Indiana, Indiana Dept. of Conservation,
Publication No. 55, 1926; p. 474)
Elevation 405

STRATA	THICKNESS	DEPTH
(1) Yellow clay	22	22
(2) Clay and gravel	8	30
(3) Gravel	2	32
(4) Clay and gravel	6.6	38.6
(5) Shale, blue	6.2	44.8
(6) Shale, black, with Aldrich coal parting	3.2	48
(7) Shale, black	4	52
(8) Shale, blue	19	71
(9) Sandstone, shale, parting	15	86

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STRATA	THICKNESS	DEPTH
(10) Sandstone	14	100
(11) Conglomerate	2.6	102.6
(12) Sandstone	11.4	114
(13) Shale, dark, blue	.4	114.4
(14) Coal, Friendville	.6	115
(15) Fire clay	1	116
(16) Shale and limestone	3	119
(17) Shale, dark	1	120
(18) Coal core, Parker	.4	120.4
(19) Shale, blue, light	4	124.4
(20) Conglomerate	1.6	126
(21) Shale, dark, blue	28.4	154.4
(22) Limestone	3	157.4
(23) Limestone	2.6	160
(24) Shale, dark, blue	2.4	162.4
(25) Shale, light	10	172.4
(26) Sand, shale,dark	18	190.4
(27) Shale, light	4	194.4
(28) Sand, shale, dark	3	197.4
(29) Sandstone	9	206.4
(30) Sand, shale, dark	6	212.4
(31) Sand, shale, blue	19	231.4
(32) Shale, dark	2	233.4
(33) Limestone	5	238.4
(34) Sand, shale	5.6	244
(35) Shale, black	.4	244.4
(36) Sandstone with shale parting	4	248.4
(37) Shale fossiliferous	2	250.4
(38) Shale, light, blue	1	251.4
(39) Limestone (Sommerville)	6	257.4
(40) Shale, dark	.6	258
(41) Coal VIII	6	264
(42) Fire clay	3	267
(43) Limestone	1.4	268.4
(44) Conglomerate	2	270.4
(45) Sandstone, fine	10	280.4
(46) Sandstone, core	4	284.4
(47) Shale, blue, limestone bands	24	308.4
(48) Shale, dark, blue	8	316.4
(49) Coal VII	2.2	318.6
(50) Shale, dark blue	1.7	320.3
(51) Conglomerate	1.7	322
(52) Sandstone, shale partings	2.8	324.8
(53) Sandstone, coal partings	8.6	333.4
(54) Coal VI	.6	334
(55) Shale, dark limestone	10.4	344.4
(56) Coal	4	348.4
(57) Fire clay	4	352.4
(58) Limestone	2	354.4
(59) Shale, dark, blue	2	356.4
(60) Sandstone, limestone bands	19	375.4
(61) Sand, shale, dark blue	22	397.4
(62) Shale, dark, blue, sandstone, bands	28	425.4
(63) Shale, light, blue	7	432.4
(64) Shale, black	1	433.4

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	STRATA	THICKNESS	DEPTH
(65)	Shale, light, blue	3	436.4
(66)	Shale, red and blue	2	438.4
(67)	Shale, light, blue	2.5	440.9
(68)	Clay, shale, limestone bands	3.7	444.6
(69)	Shale, light, blue	8	452.6
(70)	Shale, dark, sandstone bands	37	489.6
(71)	Shale, blue sandstone, bands	19	508.6
(72)	Shale, blue	36	544.6
(73)	Shale, light, blue	1.4	546
(74)	Shale, black, fossiliferous	2	548
(75)	Coal V	2.2	550.2
(76)	Fire clay	7.4	557.6
(77)	Sandstone, shale, partings	15	572.6
(78)	Sandstone, shale, bands	9	581.6
(79)	Shale, black	17	598.6
(80)	Limestone, fossiliferous	2.4	601
(81)	Shale, dark, blue	11.6	612.6
(82)	Shale, dark	2	614.6
(83)	Sandstone	17	631.6
(84)	Sandshale, limestone bands	24	655.6
(85)	Shale, blue	45	700.6
(86)	Shale, blue, limestone, bands	13	713.6
(87)	Shale, blue, clay bands	22	735.6
(88)	Shale, blue, limestone, bands	14.6	750.2
(89)	Shale, black	2.8	753
(90)	Coal III	2.2	755.2
(91)	Sandshale	8.4	763.6
(92)	Fire clay	1.1	764.7
(93)	Shale, blue, sandy	12	776.7
(94)	Shale, dark limestone bands	22.4	799.1
(95)	Shale, black	1.6	800.7
(96)	Shale, black	5.4	806.1
(97)	Coal	2.4	808.5
(98)	Shale, light, blue	5.2	813.7
(99)	Shale, sandstone, partings	5	818.7
(100)	Sandstone, fine, gray	3	821.7
(101)	Sandstone, shale, partings	15	836.7
(102)	Sandstone	4	840.7
(103)	Sand, shale	6	846.7
(104)	Sandstone, shale, partings	14	860.7
(105)	Shale, black	2	862.7
(106)	Coal II	3.4	866.1
(107)	Shale, light blue	1.6	867.7
(108)	Coal	1.3	869
(109)	Shale, dark, blue	2.7	871.7
(110)	Sandshale	11	882.7
(111)	Shale, dark	10	892.7
(112)	Shale, blue, limestone, bands, Minshall	10	902.7
(113)	Shale, block	8	910.7
(114)	Shale, dark	15.4	926.1
(115)	Coal, upper block	.6	926.7
(116)	Sandstone, shale, partings	8.4	935.1
(117)	Shale, dark	10.6	945.7
(118)	Coal, lower block	1.4	947.1
(119)	Fire clay	.6	947.7
(120)	Shale, dark	2.4	950.1

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STRATA	THICKNESS	DEPTH
(121) Sandstone, Mansfield, depth	85	1030.1

NOTE: Correlation of the members in the above log are those given in the publication cited.
In this report the members are correlated as follows (Kentucky Nomenclature):

Members	Equivalent to.
9-10-11	Anvil Rock?
22-23	Providence
41	Coal No. 9
49	Coal No. 8 (?)
56	Coal No. 7
75	Coal No. 6
121	Caseyville

LOG. No. 41
LOCALITY 2

Diamond drill coal test near Smith Mills.
Authority, Gardner Abbot,
Elevation 450

STRATA	THICKNESS	DEPTH
(1) Yellow sandy clay	47	47
(2) Sandy shale	3	50
(3) Soft sandy gray shale	20	70
(4) Blue limestone (Madisonville)	3	73
(5) Soft gray sandy shale	17	90
(6) Soft sandy shale	1' 6"	91' 6"
(7) Coal	-- 1"	91' 7"
(8) Black shale	-- 2"	91' 9"
(9) Soft sandy shale with hard bands	17' 3"	109
(10) Tough gray shale	36'	145
(11) Dark shale	72' 3"	217' 3"
(12) Coal	-- 11"	218' 2"
(13) Fire clay	2'10"	221
(14) Sandstone with shale bands	14	235
(15) Blue shale	8	243
(16) Black shale	3' 6"	246' 6"
(17) Dark shale	3	249' 6"
(18) Coal (No. 12)	6' 3"	255' 9"
(19) Fire clay	2' 3"	258
(20) Shale with fossils	2	260
(21) Limestone (Providence	8	268
(22) Soft blue shale	5	273
(23) Limestone (Providence)	5'10"	278'10"
(24) Coal (No.11)	2' 9"	281' 7"
(25) Lime shale	10' 5"	292
(26) Sandstone	5	297
(27) Blue lime shale	1	298
(28) Dark shale	31'11"	329'11"
(29) Coal, traces shale (No.10)	1' 1"	331

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	STRATA	THICKNESS	DEPTH
(30)	Hard black shale	-- 2"	331' 2"
(31)	Gray shale	1' 7"	332' 9"
(32)	Shaley sandstone	6' 3"	339
(33)	Sandstone	4	343
(34)	Dark sandy shale	6	349
(35)	Tough dark shale	25	374
(36)	Dark shale	4	378
(37)	Black shale	2' 4"	380' 4"
(38)	Limestone	-- 4"	380' 8"
(39)	Black shale	-- 9"	381' 5"
(40)	Coal (NO.9)	4' 8"	386' 1"
(41)	Sandstone with lime fossils	-- 2"	386' 3"
(42)	Fire clay	1'10"	388' 1"
(43)	Lime shale	-- 9"	388'10"
(44)	Limestone	5'10"	394' 8"
(45)	Dark shale	48' 4"	443
(46)	Gray slate	16	459
(47)	Tough gray shale	5	464
(48)	Dark shale with hard bands	11' 4"	475' 4"
(49)	Blue limestone	1	476' 4"
(50)	Coal (NO. 7 ?)	1' 4"	477' 8"
(51)	Limestone with fossils	5' 4"	483
(52)	Sandstone	17	500
(53)	Gray sandy shale	10	510
(54)	Sandy shale	9	519
(55)	Dark shale with hard bands	10' 4"	529' 4"
(56)	Coal	-- 8"	530
(57)	Lime shale	2	532
(58)	Sandstone	6	538
(59)	Dark shale	5' 4"	543' 4"
(60)	Coal	-- 4"	543' 8"
(61)	Soft dark shale	1	544' 8"
(62)	Coal	-- 2"	544'10"
(63)	Sandstone	4' 2"	549
(64)	Sandstone with shale band	13	562
(65)	Gray sandy shale	15	577
(66)	Tough dark shale with hard bands	23	600
(67)	Sandstone	1' 3"	601' 3"
(68)	Black shale	-- 7"	601'10"
(69)	Coal, traces shale (No. 6 A ?)	1' 1"	602'11"
(70)	Sandstone	10' 1"	613
(71)	Gray shale; sandstone bands	43	656
(72)	Dark shale hard bands	16	672
(73)	Dark shale	-- 5"	672' 5"
(74)	Coal (NO. 6)	4' 4"	676' 9"
(75)	Gray sandy shale	6' 3"	683
(76)	Tough gray shale	3	686
(77)	Dark shale hard bands	21' 2"	707' 2"
(78)	Coal	-- 10"	708
(79)	Fire clay	5	713
(80)	Gray sandy shale	2	715
(81)	Sandstone	2	717
(82)	Gray sandy shale	7	724
(83)	Dark shale	6	730
(84)	Limestone with fossils	2	732
(85)	Black shale	4' 4"	736' 4"

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	STRATA	THICKNESS	DEPTH
(86)	Coal	1' 1"	737' 5"
(87)	Black shale	-- 2"	737' 7"
(88)	Fire clay	2' 5"	740'
(89)	Gray shale	7	747
(90)	Black shale traces Coal	1' 9"	748' 9"
(91)	Sandstone	-- 3"	749
(92)	Dark sandy shale	3	752
(93)	Sandstone (Corydon)	13	765
(94)	Coarse sandstone	29	794
(95)	Dark sandy shale	1	795
(96)	Dark shale	-- 4"	795' 4"
(97)	Shaly Coal	1' 4"	796' 8"
(98)	Dark shale	-- 6"	797' 2"
(99)	Shale and coal	2' 2"	799' 4"
(100)	Coal, traces shale	-- 8"	800
(101)	Coal	1' 4"	801' 4"
(102)	Shale bands	-- ½"	802' 4½"
(103)	Shaly coal	1' 4½"	802' 9"
(104)	Soft gray shale	-- 3"	803
(105)	Sandstone	3	806
(106)	Dark shale	6	812
(107)	Sandstone	7	819
(108)	Gray sandy shale	4	823
(109)	Sandstone	4	827
(110)	Black shale	1	828
(111)	Shaly coal	-- 3"	828' 3"
(112)	Sandy shale	8' 9"	837
(113)	Sandstone	5	842
(114)	Dark shale	3' 9"	845' 9"
(115)	Coal	-- 7"	846' 4"
(116)	Black shale	-- 8"	847
(117)	Coal	-- 11"	847' 11"
(118)	Dark slippy shale	4' 1"	852
(119)	Sandy shale	2	854
(120)	Dark sandy shale	10	864
(121)	Gray sandy shale	4	868
(122)	Sandy shale	1	869
(123)	Dark sandy shale with hard bands	16	885
(124)	Sandy shale	2	887
(125)	Dark sandy shale	1	888
(126)	Limestone	1	889
(127)	Dark shale	8	897
(128)	Gray shale	3	900
(129)	Dark shale	4	904
(130)	Sandstone	1	905
(131)	Dark shale	9	914
(132)	Coal	-- 10"	914' 10"
(133)	Limestone	3' 2"	918
(134)	Sandy shale	6	924
(135)	Sandstone	2	926
(136)	Shaly sandstone	10	936
(137)	Sandy shale	12	948
(138)	Sandstone	6	954
(139)	Shaly sandstone	14	968
(140)	Coal	-- 4"	968' 4"
(141)	Dark shale coal partings	2' 8"	971

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	STRATA	THICKNESS	DEPTH
(142)	Gray shale	4	975
(143)	Sandy shale	3	978
(144)	Dark shale, hard bands	20' 5"	998' 5"
(145)	Coal	1' 2"	999' 7"
(146)	Fireclay	2' 5"	1002
(147)	Gray sandy shale	8	1010
(148)	Sandstone	7' 9"	1017' 9"
(149)	Coal	3' 7"	1021' 4"
(150)	Bone coal	-- 6"	1021'10"
(151)	Limestone	2' 2"	1024
(152)	Gray sandy shale	5	1029
(153)	Dark shale	8	1037
(154)	Dark sandy shale	4	1041
(155)	Dark shale	6	1047
(156)	Dark shale, Coal partings	-- 7"	1047' 7"
(157)	Coal	-- 7"	1048' 2"
(158)	Dark shale	8'10"	1057
(159)	Shaly sandstone	8	1065
(160)	Sandstone	3	1068
(161)	Coarse sandstone	59	1127
(162)	Sandstone	20	1147
(163)	Dark sandy shale, sandstone bands	19	1166
(164)	Sandstone	21	1187
(165)	Dark sandy shale	3	1190
(166)	Sandstone	4	1194
(167)	Dark sandy shale	1	1195
(168)	Sandstone with a few shale bands	20	1215
(169)	Sandstone	10	1225
(170)	Sandstone	27' 6"	1252' 6"
(171)	Coal	-- 2"	1252' 8"
(172)	Sandstone, shale bands	21' 4"	1274
(173)	Sandstone	49	1323

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CHAPTER IX

COAL ANALYSES

Most of the analyses given below have been published already in the U. S. Bureau of Mines Technical Paper No. 308, "Analyses of Kentucky Coals". They are assembled here for the convenience of anyone interested in the coals of the county.

Authority:- Bureau of Mines, 1918, No. 19107.
Mine: Corydon Composite of samples 19103 to 19106, inclusive.
Bed: No. 12?

	As received	Moisture free	Moisture and ash free
Proximate			
Moisture	11.3	---	---
Volatile matter	35.7	40.3	46.2
Fixed carbon	41.6	46.9	53.8
Ash	11.4	12.8	---
Ultimate			
Sulphur	2.9	3.3	3.8
Hydrogen	5.3	4.6	5.3
Carbon	60.8	68.6	78.7
Nitrogen	1.4	1.6	1.8
Oxygen	18.2	9.1	10.4
Air drying loss	5.4	---	---
Calorific value			
Calories	6,056	6,822	7,828
B. T. U.	10,900	12,280	14,090

Authority:- Bureau of Mines, 1918, No. 18975.
Mine: Nicholson; Composite of samples 18973 and 18974.
Bed: No. 9.
Location: Henderson, near race track.

	As received	Moisture free	Moisture and ash free
Proximate			
Moisture	11.8	---	---
Volatile matter	36.2	40.9	46.6
Fixed carbon	41.4	46.9	53.4
Ash	10.8	12.2	---
Ultimate			
Sulphur	3.2	2.6	4.1
Hydrogen	5.4	4.7	5.3
Carbon	61.3	69.3	79.0
Nitrogen	1.4	1.6	1.8
Oxygen	17.9	8.6	9.8
Air drying loss	5.0	---	---
Calorific value			
Calories	6,133	6,933	7,900
B. T. U.	11,040	12,480	14,220

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Authority:- Bureau of Mines, 1918, No. 19112.
Mine: Smith Mills; Composite of samples 19108 to 19111, inclusive.
Bed: No. 12.

	As received	Moisture free	Moisture and ash free
Prosimate			
Moisture	13.0	---	---
Volatile matter	33.4	38.4	42.4
Fixed carbon	45.3	52.1	57.6
Ash	8.3	9.5	---
Ultimate			
Sulphur	1.8	2.1	2.3
Hydrogen	5.5	4.6	5.1
Carbon	62.9	72.3	79.9
Nitrogen	1.4	1.7	1.8
Oxygen	20.1	9.8	10.9
Air drying loss	5.5	---	---
Calorific value			
Calories	6,228	7,156	7,906
B. T. U.	11,210	12,880	14,230

Authority:- Kentucky Geological Survey, 1910, No. 2905.
Mine: Keystone; Face of main heading 550 feet from shaft.
Bed: No. 9.
Location: Henderson.

	Air dried	Moisture free
Proximate		
Moisture	3.1	---
Volatile matter	35.7	36.9
Fixed Carbon	45.00	46.4
Ash	16.2	16.7
Sulphur	7.8	8.0
Calorific value		
Calories	6,411	6,617
B. T. U.	11,540	11,910

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Authority:- Bureau of Mines, 1918, No. 18978.
Mine: Panama; Composite of samples 18976 and 18978.
Bed: No. 9.
Location: Robard, Locality 60.

	As received	Moisture free	Moisture and ash free
Proximate			
Moisture	9.7	---	---
Volatile matter	37.0	41.0	46.3
Fixed carbon	43.0	47.6	53.7
Ash	10.3	11.4	---
Ultimate			
Sulphur	3.8	4.2	4.7
Hydrogen	5.3	4.7	5.3
Carbon	62.2	68.9	77.7
Nitrogen	1.4	1.6	1.8
Oxygen	17.0	9.2	10.5
Air drying loss	4.3	---	---
Calorific value			
Calories	6,256	6,928	7,817
B. T. U.	11,260	12,470	14,070

Authority:- Kentucky Geological Survey, 1910, No. 3109.
Mine: Green River
Bed: No. 9.
Location: ?

	Air dried	Moisture free
Proximate		
Moisture	5.8	---
Volatile matter	38.1	40.4
Fixed Carbon	46.9	49.8
Ash	9.2	9.8
Sulphur	2.7	2.9
Calorific value		
Calories	6,789	7,206
B. T. U.	12,220	12,970

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Authority:- Kentucky Geological Survey, 1910, No. 3106.
Mine: Zion
Bed: No. 9.
Location: About ½ mile southeast of locality 38.

	Air dried	Moisture free
Proximate		
Moisture	6.1	---
Volatile matter	37.2	39.6
Fixed Carbon	46.0	49.0
Ash	10.7	11.4
Sulphur	3.2	3.5
Calorific value		
Calories	6,394	6,806
B. T. U.	11,910	12,250

Authority:-Kentucky Geological Survey, 1910, No. 3105.
Mine: Utopia
Bed: No. 9.
Location: Locality 46, on Green River.

	Air dried	Moisture free
Proximate		
Moisture	6.2	---
Volatile matter	34.7	37.0
Fixed Carbon	46.9	50.0
Ash	12.2	13.0
Sulphur	2.6	2.8
Calorific value		
Calories	6,589	7,028
B. T. U.	11,860	12,650

Authority:- Vureau of Mines, 1918, No. 18966.
Mine: Baskett No. 1; Composite of four samples.
Bed: No. 9
Location: Locality 30

	As received	Moisture free	Moisture and ash free
Proximate			
Moisture	11.1	---	---
Volatile matter	36.3	40.8	46.0
Fixed carbon	42.6	47.9	54.0
Ash	10.0	11.3	---
Ultimate			
Sulphur	3.1	3.5	3.9
Hydrogen	5.5	4.8	5.4
Carbon	62.6	70.4	79.3
Nitrogen	1.4	1.5	1.7
Oxygen	17.4	8.5	9.7
Calorific value			
Calories	6,256	7,033	7,928
B. T. U.	11,260	12,660	14,270
Air drying loss	3.0	---	---

Softening temperature of ash varies from 1910° to 2100° F.

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Authority: Kentucky Geological Survey, 1910; No. 2869.
Mine: Pittsburgh Coal Co; Baskett.
Position in mine: Average of samples from Reeds room right north entry, and 2 room, 1 right south entry.
Bed: No. 9.
Location: Locality 30.

	Air dried	Moisture free
Proximate		
Moisture	7.6	---
Volatile matter	35.0	37.8
Fixed Carbon	46.0	49.8
Ash	11.4	12.4
Sulphur	2.5	2.8
Calorific value		
Calories	6,656	7,200
B. T. U.	11,980	12,960

Authority: Kentucky Geological Survey, 1910; No. 3108.
Mine: Pittsburgh Coal Co. Baskett
Position in mine: Face of mine south heading.
Bed: No. 9.
Location: Locality 30.

	Air dried	Moisture free
Proximate		
Moisture	5.8	---
Volatile matter	35.7	37.9
Fixed Carbon	48.2	51.1
Ash	10.3	11.0
Sulphur	3.1	3.3
Calorific value		
Calories	6,533	6,939
	11,760	12,490

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Authority: Kentucky Geological Survey, 1910; No. 3107.
Mine: John Archbold; Bluff City.
Bed: No. 9.

	Air dried	Moisture free
Proximate		
Moisture	5.7	---
Volatile matter	35.2	37.4
Fixed Carbon	42.6	45.1
Ash	16.5	17.5
Sulphur	6.3	6.7
Calorific value		
Calories	5,889	6,244
B. T. U.	10,600	11,240

Authority: Kentucky Geological Survey, 1912; No. 3219.
Mine: John Archbold; Bluff City.
Bed: No. 9.

	Air dried	Moisture free
Proximate		
Moisture	11.3	---
Volatile matter	35.0	39.4
Fixed Carbon	44.2	49.9
Ash	9.5	10.7
Sulphur	3.3	3.7
Calorific value		
Calories	---	---
B. T. U.	---	---

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The following analyses were obtained through the courtesy of the Ohio Valley Bank at Henderson. The analyses, made by the Dearborn Chemical Company, Chicago, are of coal cores obtained in the diamond drilling west of Henderson.

Analyses of Coal No. 11.

	Locality 12 Excluding parting.	Locality 16 Including parting.	Locality 16 Excluding parting.
Moisture	6.24	7.78	7.44
Volatile matter	31.86	32.94	34.36
Fixed Carbon	42.77	43.23	44.03
Ash	19.13	16.05	14.17
Sulphur	2.59	2.93	3.49
B. T. U. (dry)	10,957	11,689	12,040

Analyses of Coal No. 9.

	Locality 17	Locality 16
Moisture	6.43	7.75
Volatile matter	35.17	34.46
Fixed carbon	48.79	44.54
Ash	9.61	13.25
Sulphur	2.98	3.34
B. T. U. (dry)	10,013	12,297

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Authority: Kentucky Geological Survey, 1910; No. 3869.
Mine: Pittsburgh Coal Co. Baskett
Position in mine: Average of samples from Reeds room right north entry, and 2 room 1 right south entry.
Bed: No. 9.

	Air dried	Moisture free
Proximate		
Moisture	7.6	---
Volatile matter	35.0	37.8
Fixed Carbon	46.0	49.8
Ash	11.4	12.4
Sulphur	2.5	2.8
Calorific value		
Calories	6,656	7,200
B. T. U.	11,980	12,960

Authority: Kentucky Geological Survey, 1910; No. 3108.
Mine: Pittsburgh Coal Co. Baskett
Position in mine: Face of main south heading.
Bed: No. 9.

	Air dried	Moisture free
Proximate		
Moisture	5.8	---
Volatile matter	35.7	37.9
Fixed Carbon	48.2	51.1
Ash	10.3	11.0
Sulphur	3.1	3.3
Calorific value		
Calories	6,533	6,939
B. T. U.	11,760	12,490

Authority: Kentucky Geological Survey, 1910; No. 3107.
Mine: John Archbold; Bluff City
Bed: No. 9.

	Air dried	Moisture free
Proximate		
Moisture	5.7	---
Volatile matter	35.2	37.4
Fixed Carbon	42.6	45.1
Ash	16.5	17.5
Sulphur	6.3	6.7
Calorific value		
Calories	5,889	6,244
B. T. U.	10,600	11,240

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Authority: Kentucky Geological Survey, 1912; No. 3219.
Mine: John Archbold; Bluff City.
Bed: No. 9.

	Air dried	Moisture free
Proximate		
Moisture	11.3	---
Volatile matter	35.0	39.4
Fixed Carbon	44.2	49.9
Ash	9.5	10.7
Sulphur	3.3	3.7
Calorific value		
Calories	---	---
B. T. U.	---	---

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Pocket

PLATES 1 and 2.

Note:

Plates 1 and 2 are not included with this thesis because they have become temporarily unavailable due to the shifting of materials in the offices of the Kentucky Geological Survey in consequence of the partial destruction of the Survey building by fire. These plates will be added to the thesis when the reorganization of the Survey materials is completed.

O.K.
Walter H. Bucher

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GEOLOGIC MAP

OF

HENDERSON COUNTY, KENTUCKY.

BY

C. V. THEIS

1928

LEGEND

Quaternary	Undifferentiated Quaternory Alluvium.	Qal
	Alluvium of the Recent Flood plain	Qr
	Alluvium of the Late Wisconsin Terrace	Qlw
	Alluvium of the Early Wisconsin Terrace	Qew
	Union Formation (Loess)	Qu
Tertiary Pliocene	"Lafayette" Formation (overprint)	
Pennsylvanian	Lisman Formation	Pl
	Carbondale Formation	Pc

Drift mine, pit, or quarry	⚒
Shaft	■
Abandoned shaft	╪
Diamond drilled coal test	◎
Churn drilled well	○
Water well	ϕ
Oil well	●
Dry hole	☼
Outcrop of Madisonville limestone	×M
Outcrop of Providence limestone	×P
Other noteworthy locality	△
Elevation of bed rock at well or shaft	El. Rock.

~ Contours on Coal No. 9
(Elevations in feet above sea level)

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