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1877

GEOLOGICAL SURVEY OF KENTUCKY.

N. S. SHALER, DIRECTOR.

REPORTS OF PROGRESS.

VOLUME II. NEW SERIES.

STEREOTYPED FOR THE SURVEY
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1877.

INTRODUCTORY LETTER.

To His Excellency, JAMES B. McCREARY,

Governor of Kentucky:

SIR: I have the honor to submit herewith the Reports forming the second volume (new series) of the Reports of the Geological and other Surveys of the Commonwealth. All necessary explanations concerning the same will be found in the introduction preceding the Reports.

Very respectfully,

Your obedient servant,

N. S. SHALER,

Director of the Surveys.

FEBRUARY 10, 1877.

INTRODUCTION TO THE SECOND VOLUME.

The order of succession and the character of the reports of this volume require some discussion. The reader is respectfully requested to bear in mind the following conditions, which have determined the character of the work of this Survey: First, that, though in name a geological survey, it is practically, by the wording of the several enactments providing for its institution and continuance, charged with the study of a wider range of subjects than is commonly included within that science. Topography, zoölogy, botany, archæology, detailed studies of the forests, and streams as well, are all required from this Survey. It is, moreover, limited in its action by the obligation laid upon it of continuing the work of the first Survey of the State, the progress of which was arrested by the death of its able Director, Dr. David Dale Owen, and the outbreak of the civil war. Furthermore, as the Survey was instituted with an especial view to the economic development of the Commonwealth, it has been deemed best to hasten the publication of reports of progress with the greatest rapidity consistent with accuracy, leaving the matter of the natural sequence of subjects quite out of the question.

It has been deemed best to divide the publications of the Survey in such fashion that the economic results should be grouped in one set of volumes termed Reports, and the purely scientific matter, that having no immediate relation to the development of industries, should be placed in another series of publications termed Memoirs. Of these series, the first volume of reports was published in 1876, the volume to which this is the introduction forming the second of the series. The third, containing principally the general annual reports of the Director of the Survey for the years 1873–'4–'5, and '6, together with the preliminary geological map, is expected to be through the press in April of this year. Parts of the fourth, fifth, and sixth volumes of reports will also be ready for delivery during the present year. The first volume of memoirs, or the series of purely scientific publications of the Survey, is already stereotyped, and a limited edition, designed especially for use at the Centennial Exhibition at Philadelphia, has been printed. The plates of the second volume are in preparation. Those memoirs and reports, &c., already printed, or prepared for printing, will be furnished separately to those entitled by law to receive them, and will be sold at the cost of press-work, paper, and carriage to others, who may apply to the State Cabinet, at Frankfort. A list of these publications of the Survey will be found at the close of this introduction.

The several reports and memoirs contained in these and subsequent volumes will, in time, furnish the data for the making of a final report on the physical and vital history of the Commonwealth. They should all be considered as essentially preliminary statements, and not as the final work of the Survey.

In accordance with design to give, in the introduction of each volume, a brief system of cross-references to the work contained in the other publications of the Survey, I shall now point out some special features in the several treatises contained in this second volume of reports, with a view to aiding the reader in connecting the information which is scattered through these several volumes.

The first of these reports, that by Assistant A. R. Crandall, "On the Geology of Greenup, Carter, and Boyd Counties, and a part of Lawrence County," was the first work undertaken by the present Survey. A beginning in the study of this very important district had been made during the Survey of Dr. Owen. Very great changes had taken place in the economic conditions of these counties since the discontinuance of his work in 1860, so that it was necessary to go over every stage of the work from the very beginning. The reader, who is desirous of extending the study of this field beyond the limits of this report, should consult the "Report on the Iron

Ores of Greenup, Boyd, and Carter Counties, the Kentucky Division of the Hanging Rock Iron District,"* by Assistant P. N. Moore; the "Report on the Geology of the Counties of Bath, Menifee, Powell, and Lee," by Assistant A. R. Crandall;† the "Preliminary Report on the Geology of Martin County," by Assistant A. R. Crandall.‡ The timber resources of this field are treated in the "Report on the Timber Growth of Greenup, Carter, Boyd, and Lawrence Counties," by N. S. Shaler and Assistant A. R. Crandall.§ The reader will also get much information from the four volumes of reports of the Survey made by Dr. David Dale Owen in the years 1854 to 1860, inclusive. Owing to the discursive nature of these reports, the matter can only be found by reference to the indexes of the several volumes, under the head of the names of the several counties.

The second report, "On the Geology of the Edmonson Coal and Iron District," in this volume, is intended as the first of a series designed to set forth the geology of the most difficult district of the Commonweath—the western coal field, or that part of its area which is covered by the southern end of the Illinois coal field. The studies for this series of reports were begun in the Edmonson county district, for the reason that this district presents us with very good sections along its deep-bedded streams, thus showing the relations between the several members of the lower carboniferous and the coal measures. The present work of the Survey is extending the observations thus begun to the district lying to the north of the Louisville, Paducah and Southwestern Railroad, and between that line and the Ohio river. The results of these explorations will be contained in the fifth volume of this series of reports. This work of investigating the structure of the coal field will be continued, on the western part of the field, by special geological and topographical reports, which will, if the

*Volume I, Reports Kentucky Geological Survey, new series, part III.

†Volume IV, new series.

‡Volume IV, new series.

§Reports of the Kentucky Geological Survey, new series, volume I, part I.

Survey is continued for a sufficient length of time, come to include the whole of the outline of the field. The interior of the basin is also undergoing investigation at the hands of Mr. C. J. Norwood, who has already prepared an extensive report on the geology of the country adjacent to the line of the Louisville, Paducah and Southwestern Railroad.* A set of reports on the geology of the districts adjacent to the north and south-running railways of Western Kentucky has also been prepared by Mr. Norwood, and will be published in the fourth volume. The reader is also referred to the several parts, in the four volumes of reports published under the direction of Dr. Owen, for various reports concerning the geology of this district. Although these reports are discursive in their nature, and are so scattered through the several volumes as to make reference to them, except through the names of the several counties, not very easy, yet they contain the results of a careful preliminary reconnoissance of this district, which is singularly accurate in its results, considering the limited opportunities for observation enjoyed by this explorer.

The third report of this volume, that "On the Chemistry of the Hemp Plant," by Dr. Robert Peter, is one of a series of important contributions to the chemical history of the most important of our Kentucky agricultural products. These separate monographs will, it is planned, in time be collected into a special report on the agricultural chemistry and geology of the Commonwealth. Reports from the same source, having a more or less direct bearing on the questions raised in this report, on the chemistry of the hemp plant, will be found in each of the annual reports of the Survey made by Dr. Owen, and in the first volume of the new series. Other similar reports will be found in the four volumes of reports published during the Survey directed by Dr. Owen, which has already been referred to.

The fourth report in this volume, that by Mr. P. N. Moore, Assistant, is not closely connected with the other work of the Survey. It was designed to meet an especial need arising

* See volume I, part VII, new series.

from the apparent failure of the working of the great furnace described in this report. This case shows the criminal nature of human blunders. A man of vast fortune was seized with the notion of making an experiment in the manufacture of iron. Knowing nothing about it himself, he put the matter in the hands of men to whom the region where he designed operating is quite unknown. Lavish expenditure prepared the ground for a great industry in an efficient manner; but a little friction in the starting disgusted the owner with the business. So, without having tried his works, he left them to be a scarecrow to frighten capital from this field. I have long believed that the Green River possesses advantages for the manufacture and shipment of high-grade iron at lower rates than in any other part of this country. Cheap ores, good coking coals, or abundant charcoal timber, and permanent water navigation to great markets, all combine to make conditions so advantageous that they could not have been left unused had it not been for this great monument of seeming failure, the Airdrie Furnace. I sincerely hope that the study Mr. Moore has given to the matter, the results of which I have corroborated by personal inspection of the furnace and its surroundings, will serve to remove this unfortunate obstacle to the industry of a very important iron district.

The topographical report of W. B. Page, which is the fifth of this volume, is designed to furnish the data for an understanding of the conditions of surface in this district, and incidentally to give some account of a matter closely connected with the topography of the region, viz: its water-powers. In the fourth volume of these reports, and also in the fifth, reports containing the studies on the surface-conditions of this part of the Commonwealth may be sought for.

The next report, that "On the Geology of a Proposed Line of Railway from Livingston Station to Cumberland Gap," is designed to give the results of a detailed reconnoissance along this very important line of communication between the southwest and southeast parts of our country. For the first half century of our history this was one of the most important routes of trade between the Ohio Valley and the sea-board States south of the Potomac. The exigencies of the present time demand that this should be made again a line of travel. It will be seen from this report that there is a certainty of securing access to a very important coal and iron district through this way. The reader is also referred to the general report on the conduct of the Survey,* and also to the report on the lines of communication necessary to the development of the mineral interests of the State, in the same volume.

The report "On the Geology of the Henry County Lead District" is a part of the same matter as that which is discussed in the previous report. The known exposures of lead-bearing rocks in this district are given in detail. It will be seen that these deposits have a very interesting character. The origin of the crevices in which the deposits occur, as well as the nature of the processes by which the metals have been introduced into them, deserve especial study. The Survey is gathering facts bearing on these questions, which will be elaborated in subsequent reports.

The second report, on the conditions of occurrence of the galena deposits in the State of Kentucky, is especially designed to set forth the essential character of our mineral deposits of this character. There has always been a natural desire to prove the existence of silver ores within the Commonwealth of Kentucky, which has led to the building of a great many castles in the air, which have, sooner or later, met the fate which overtakes all such structures. A great deal of capital and labor have been wasted in this search for precious metals within our borders. If there is anything in geological conditions, we may accept it as certain that this search is entirely hopeless. While hundreds of thousands of dollars have been expended therein, not one dollar's worth of silver, gold, or copper has ever been secured.

There is good reason to hope that in time the lead ores of both the Kentucky river and the lower Ohio lead districts may become of sufficient value to make them sources of profit

* See Biennial Report of N. S. Shaler, volume III, new series.

to the State; but at present, so great is the product of lead taken from the mines of precious metals in the far West, that the cost of production in Kentucky much exceeds the value of the product.

Especial attention is called to the extended extracts from the works of Professors Whitney and Pumpelly and Dr. T. Sterry Hunt, printed as appendices to these reports. The matter taken from the works of Dr. Hunt and Professor Whitney is of difficult access to any one not near great libraries; and the lecture of Professor Pumpelly is hitherto unpublished. By bringing these important contributions together in this volume, the reader is put in possession of the latest views of the great masters of this branch of geology. I can confidently assert, that nowhere else will be found the question of the origin of metalliferous deposits more completely presented than in these appendices. The Geological Survey owes its especial thanks to the above named gentlemen for the permission to publish these important extracts from their works.

As these reports must, in many cases, serve as the only means whereby their readers will come in contact with the literature of certain subjects, it will frequently be found desirable to make similar appendices to the reports of the Survey, embodying the results of the studies of leading authorities on the most important economic questions that concern the Commonwealth. I deem this method of printing such matter preferable to paraphrasing the writings which it is necessary to present to the reader.

The next report in this volume, that "On the Timbers of Grayson, Breckinridge, and Hancock Counties," by Assistant L. H. DeFriese, is the third of the series of reports on this class of subjects already printed in the reports of the Survey. I attach a high value to these examinations of our woods. It will be observed that the statistical method is used in this as in the other reports on the same subject. So far as is known to me, these reports are the first made in this country that give the conditions of our forests in great detail. I know of no other in this or any other country where the statistical method has been applied to their study. The frequency of replacement of our white oaks by the inferior species of black oak, pin oak, and Spanish oak, is a matter that demands attentive consideration, both on account of its scientific and its economic aspects.

The "Report on the Geology and Resources of the District Adjacent to the proposed Line of the Lexington and Big Sandy Railway," which comes next in the series, is intended to furnish an outline of the geological and other economic conditions of the country which will be immediately tributary to this important road. I have elsewhere in these reports frequently called attention to the great importance of this line to the development of our industries. I know of no line of equal length which will provide access to so much mineral wealth, and at the same time do so much to open new markets to our present productions.

The last report of this volume is entitled "A General Account of the Commonwealth of Kentucky." This was prepared for the Centennial Exhibition, but it has been thought desirable to give it a more permanent shape in the publications of the Survey, as it serves to assemble the general facts concerning the Commonwealth that have as yet been ascertained.

The third volume of the reports of this Survey is now nearly ready for the press, and can be issued within two months of the appearance of the present volume. It will contain various special reports of the Director, and his general reports on the conduct of the Survey for the years 1873–'4–'5, and '6, together with the general preliminary geological map of the Commonwealth.

Separate parts of the fourth, fifth, and sixth volumes will be ready for issue during the year.

N. S. SHALER.

OFFICERS OF KENTUCKY GEOLOGICAL SURVEY

DURING THE TIME OF PREPARATION OF THE REPORTS CONTAINED IN THIS VOLUME, IN THE ORDER OF THEIR APPOINTMENTS.

NATHANIEL SOUTHGATE SHALER, *Director and Principal Geologist.*
ROBERT PETER, *Principal Chemist.*
ALBERT ROGERS CRANDALL, *First Assistant in Geology.*
PHILIP NORTH MOORE, *Assistant in Geology.*
CHARLES SCHENK, *Assistant in Topography.*
CHARLES JOSEPH NORWOOD, *Assistant in Geology.*
WILLIAM BYRD PAGE, *Assistant in Topography.*
LUCIAN CARR, *Assistant in Ethnology.*
JOHN HOLLIDAY TALBUTT, *Assistant in Chemistry.*
JOHN ROBERT PROCTER, *Assistant in Geology.*
HERMANN HERZER, *Assistant in Geology.*
CHARLES WICKLIFFE BECKHAM, *Assistant in Topography.*
EUGENE UNDERWOOD, JR., *Assistant in Topography*
LEOPOLD TROUVELOT, *Artist of the Survey.*
JOHN BELKNAP MARCOU, *Aid.*

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GEOLOGICAL SURVEY OF KENTUCKY.

N. S. SHALER, DIRECTOR.

REPORT ON THE GEOLOGY

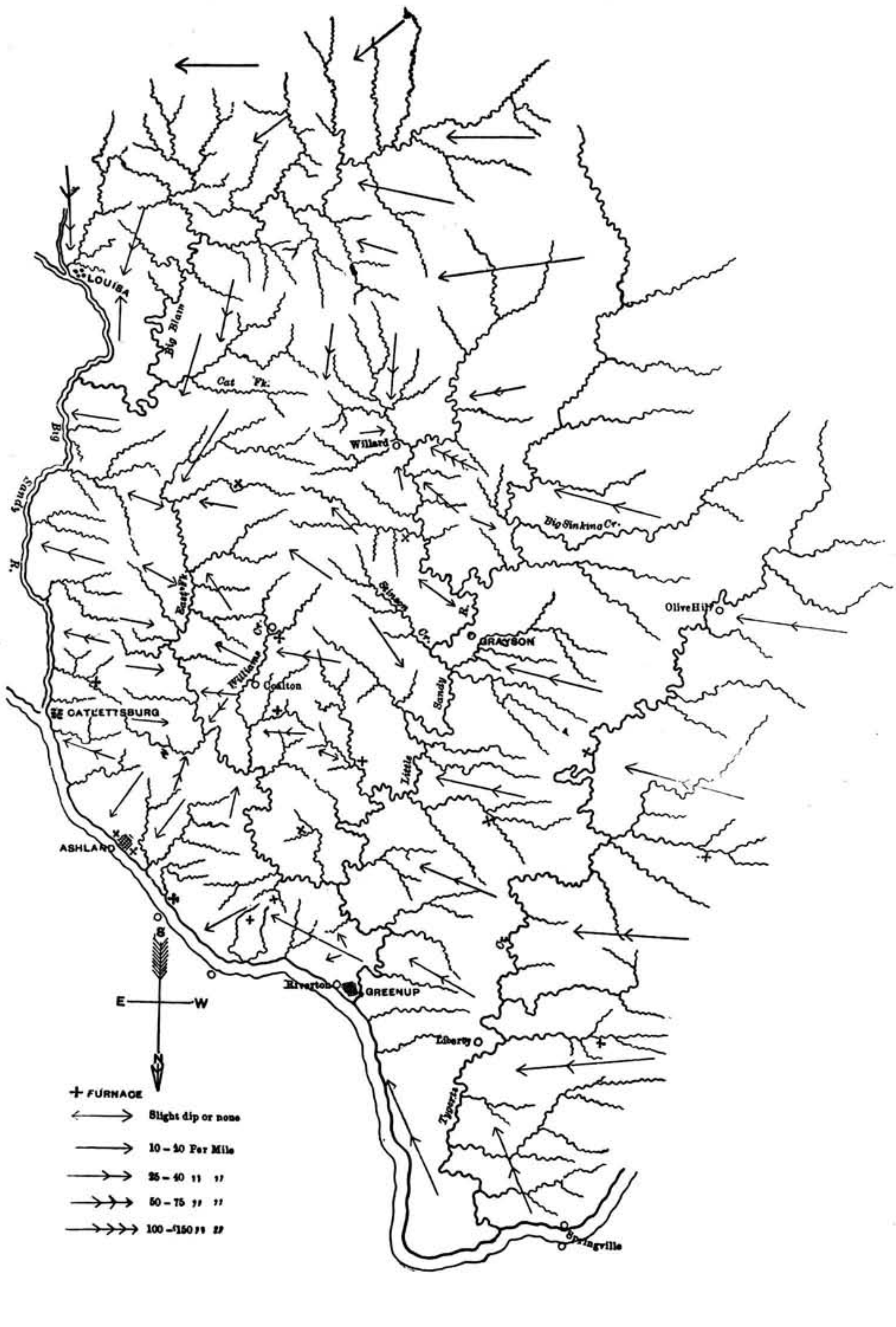
OF

GREENUP, CARTER, AND BOYD COUNTIES, AND A PART OF LAWRENCE,

BY A. R. CRANDALL, ASSISTANT.

PART. I. VOL. II. SECOND SERIES.

KENTUCKY GEOLOGICAL SURVEY,
N. S. SHALER, Director.
1876
Map of the Counties of
GREENUP, CARTER, BOYD
and a part of
LAWRENCE.
Topography by Assistants C. Schenk and W.C. Mitchell.
SCALE
PORTSMOUTH
GREENUP
RIVERTON
HANGING ROCK
IRONTON
ASHLAND
CATLETTSBURG
CASSVILLE
LOUISA
GRAYSON
WILLARD
CANNONSBURG
GEIGERVILLE
DALTON
EAST COALTON
BIG SANDY RIVER
LOUISA FORK
G R E E N U P
C A R T E R
B O Y D
L A W R E N C E



LOUISA
Big Blain
Cat Fk.
Big Sandy R.
Willard
Big Sinking Cr.
East Fk.
Williams Cr.
Stinson Cr.
Olive Hill
GRAYSON
Coalton
Little Sandy R.
CATLETTSBURG
ASHLAND
S
E
W
N
Riverton
GREENUP
Liberty
Tygerts Cr.
Springville
+ FURNACE
Slight dip or none
10 – 20 Per Mile
25 – 40 " "
50 – 75 " "
100 – 150 " "

REPORT ON THE GEOLOGY OF GREENUP, CARTER, AND BOYD COUNTIES, AND A PART OF LAWRENCE.

The coal measures of Eastern Kentucky are represented, in the counties included in this report, by rocks which have an aggregate thickness of about 900 feet. These rocks rest on the sub-carboniferous limestone, or, in its absence, on the lower carboniferous sandstone and shale, at such an inclination as to present the whole series, included in this thickness, in an upward order, along any line from the limstone-capped hills west of Tygert's Creek to the Chatterawha or Big Sandy river. Variations in thickness of the different parts of the series, and also in the aggregate thickness, are found along different lines; but the order is generally preserved, with no considerable disturbances to complicate the problems involved in a study of this part of the coal field.

A brief description of the underlying formations will serve to make the geological position of the coal and iron-bearing rocks plain, and also to throw some light on the question of the inclination or dip, to which reference has been made.

To facilitate a study of these lower rocks, a profile section is given, which shows the order of superposition and the thickness of different formations along the located line of the Lexington and Big Sandy Railroad, from the Licking river to the mouth of Soldier's Fork of Tygert's Creek. The Upper Silurian rocks, which cap the hills around Owingsville, and which bear the iron ore deposits of Bath county, fall below the drainage at the Licking river. The Devonian black shales form the base of the hills east of the river. The thickness of these shales is not clearly shown; but the base of the overlying formation, the Waverly sandstone, is about 150 feet above the bed of the river, which is formed in the limestone of the Upper Silurian, apparently near the top of the formation. The Devonian shales at this point are clayey, somewhat bituminous, and are interesting chiefly from the effect which they have in giving character to the topography of the country.

The Waverly* sandstones and shales, or the knobstone formation of Mr. Joseph Lesley has a thickness of 400 feet in this section. At Springville, and on Indian Run, in Greenup county, over five hundred feet of this formation is shown, and it is probable that the whole thickness is considerably greater. The thickness in the eastern part of Montgomery county, in the opposite direction, is given by Mr. Lesley as 330 feet. In Ohio this formation has been found by Mr. Andrews to have characters which warrant a division into three parts. South of the Ohio river, however, such natural divisions are not so apparent, the whole series being made up of fine-grained sandstones and shales, generally of an olive-greenish color, but with occasional bands of red and of whitish shales. At the base, and at various other levels, fine building stone is found, which has already acquired a wide reputation. Fossils are abundant in many parts; but the most characteristic impression is that of a Fucoid, the form of which, resembling somewhat the cocktail, is readily recognized, and not easily forgotten. It is not found in the coal measures above, and therefore, in the absence of the sub-carboniferous limestone, it serves to mark the transition from the coal-measure to the Waverly rocks, the line of which is often without other distinctive marks.

Going eastward along Triplet Creek, the Waverly rocks form the whole height of the hills at Morehead, in Rowan county, the Devonian shales having fallen below the drainage. The hills to the east of Morehead are capped by a coarse hard sandstone, at the base of which a thin band of cherty limestone is found in some places. These are the outlying representatives

*I have preferred the name Waverly to that of knobstone, for the reason that the latter term is likely to lead to confusion from the fact that other formations give rise to a topography equally or more knobby; as illustrated by the "knobs" of East Tennessee, in the Lower Silurian, the knobs of Owsley county in the coal measures, and other instances. The former name is without particular appropriateness, but is the one adopted in the Ohio reports, and is as widely known as any perhaps, and therefore has some claim to general use.

of the sub-carboniferous limestone and the conglomerate sandstone, both of which have a considerable thickness to the east and south. The latter becomes particularly conspicuous over a large area of country. The dip of the rocks is slight from Licking river eastward; the rise of the bed of the creek accounting in part for the disappearance of the lower rocks. East of the divide between Triplet and Tygert's Creeks, the base of the limestone is found, at the mouth of Soldier's Fork, only about 75 to 80 feet above drainage; giving a fall of about 320 feet in 24 miles, or nearly 14 feet to the mile along this line. The dip does not appear to be greater more directly east or south of east, as may be seen by the height above tide of the top of the Waverly in section 4, plate No. 2.*

The Waverly sandstone is shown in most of the sections given west of the divide between Little Sandy river and Tygert's Creek. The inclination is such that this formation falls below the Little Sandy, except near the Ohio. At the mouth of the Little Sandy it rises from 15 to 20 feet above low

*The sections on plates 1 to 24 are arranged with reference to tide level. Low water at the mouth of the Little Sandy river, or 485 feet above the sea, is chosen as the base, and the figures at the left of the plate reckon up from this level. The locality of each section is indicated by a number on the map corresponding with the number of the section. A good idea of the position and dip of the various rocks in this region may be obtained by a study of these sections in connection with the map. But to present the main facts in a more ready form, profile sections are also given, extending across the field in three lines; the first from the Ohio, below Springville, in Greenup county, to Catlettsburg, in Boyd county. The second, from Kenton Furnace, in Greenup, to the mouth of the Bear Creek, in Lawrence county. The third, from Boone Furnace, in Carter county, to Louisa, in Lawrence.

The determination of the height from tide, and also above drainage, has been greatly facilitated by the numerous railroad surveys that have been made in this field. Repeated barometric measurements have, for the most part, supplied the details; the hand-level being used sometimes, and such other means as could be made available.

The abreviations made use of in the sections are as follows:

S. S., sandstone.
L. or L. S., limestone.
S., shales.
S. S. S., shaly sandstone.
Cong., conglomerate; Cong. S. S., conglomerate sandstone.
C., coal; C. C., cannel coal.
F. C., fire-clay.

Sections on plates numbered 24 to 30 are not arranged to indicate height above tide. In each column the natural succession of rocks is shown. When two sections from different localities are included in the same perpendicular column, they are joined on some identical coal or ore; as in sections 5 and 6, on plate 26, where an oblique space indicates the top of one and the bottom of the other; or where all the rocks of the series, from the base of one to the top of the other, are not included, the intervening space represents the normal thickness of the rocks wanting, unless it is otherwise indicated by including lines, or by statement on the plate to the contrary.

water. It is not seen further eastward than Riverton, where it is exposed at low water.

The limestone formation, which follows the Waverly in the order of superposition, is wanting or very thin over a large part of Greenup county. Section 25, plate 9, near the mouth of Little Sandy, shows no trace of limestone. On Coal Branch a few inches of calcareous rock is shown. (Section 1, plate 29.) A thin layer of limestone is found on Smith's Branch. The hills back of the lime-kilns show the only considerable development of this formation near the Ohio. Here the deposit reaches a thickness of 35 feet at one point; but it rapidly falls away in thickness, so that outside of an area of a few square miles, only a thin cherty rock occurs to represent this formation; and often this is entirely wanting in the neighboring hills. The hill back of Springville shows no limestone. (Section 5, plate 3.) At the head of Indian Run a cherty bed several feet in thickness occurs. (Section 1, plate 2.) Fragments of a similar bed, in the valley of Montgomery Creek, show its extension into Lewis county, where the hills, for some distance westward from Greenup, are capped by rocks similar to the outlying rocks of Rowan, as mentioned on a previous page. Southward the sub-carboniferous limestone increases in thickness from a few feet, at the head of Shultz Creek, to 140 feet, at a point on Tygert's Creek near Carter Caves. (Section 20, plate 6.) On Kenton Furnace lands 10 to 20 feet is shown. (Section 12, plate 5.) On Boone Furnace lands from 80 to 100 feet is exposed, and this thickness is repeated or increased along Tygert's Creek southward to the divide between Tygert's Creek and Big Sinking Creek. Westward from Tygert's Creek, this formation rapidly loses its importance. To the eastward, also, it thins out nearly as rapidly. (Profile sections II and III.) A considerable thickness of limestone is reported, however, in some of the wells drilled in the Big Sandy valley, near the southern line of Lawrence county. The effect of the thinning out of this formation eastward is an increased inclination of the overlying rocks towards the east, and a corresponding limitation of the area in which a given thickness of rock is exposed by the drainage of the Little Sandy. The decrease in thickness northward also tends to increase the inclination of the overlying rocks in that direction. The fall towards the Ohio river, a little east of north, is about the same as that of the general surface of the country, and, in general, the disappearance below drainage of rocks of the same geological level is along a line running nearly north-northeast and south-southwest. In the southern part of Carter and Lawrence counties the dip is changed to the north; the underlying rocks to the southward being elevated or thickened so as to form, with those along the western side of this field, two sides of a geological basin.*

The top of the Waverly, near Morehead, where the place of the limestone is shown, is about 1,150 feet above tide. At the head of Indian Run the height above tide is about 1,000 feet. At the most western outcrop near the Ohio, of the conglomerate formation and the thin representative of the sub-carboniferous limestone, the height would reach 1,050 feet, a difference of 100 feet in a distance of 30 miles, or an average fall towards the Ohio river of three and one third feet to the mile. Besides the general inclination of the top of the Waverly, it is characterized by undulations, which, together with the varying thickness of the sub-carboniferous limestone, give to the base of the coal measures an irregularity which is not only very noticeable, but which sometimes leads to confusion in the order of the overlying beds. The sub-carboniferous limestone, when present in considerable thickness, is usually made up of rocks varying in character from a pure white or grayish limestone to that which is sandy or ferruginous or cherty. The former rock makes an excellent quicklime, as shown by the demand for the products of the lime-kilns on the Ohio, in Greenup county. At some points a thin bed of what may prove to be lithographic stone of good quality, has been noted. At the bridge across Tygert's Creek, near Olive Hill, on the old State road, a thickness of eight inches is shown

*Whether to the east of the Big Sandy, and near the Ohio, the rocks dip to the westward, forming the third side of a great geological basin, has not, so far as I can learn, been fully determined; but there seems to be strong indications that this is the case.

near the level of the bridge, and about 25 feet above the base of the formation. The notion prevails to some extent, that silver may be found in these rocks; but any effort to find the precious metals must necessarily result in disappointment. This remark applies equally well to all the formations in this region.

THE COAL MEASURES.

At the top of the sub-carboniferous limestone, and resting upon it, is the so-called "limestone ore," or "lower limestone ore." With this ore, which is one of the most valuable in Eastern Kentucky, the coal and iron-bearing rocks begin; though, strictly speaking, from its association with the limestone and its limitation to the area of this formation, the ore itself might perhaps be regarded as belonging to the sub-carboniferous period. The character of the ores of this section are fully discussed by Mr. Moore in his report on the ores of this part of Kentucky.

The coal-measure rocks of Eastern Kentucky are readily separated into minor divisions by characteristic rocks at different horizons. What the relation of these natural divisions is to those which are found in localities widely separated from this field, is a question that may be left for future consideration; the present purpose being as well subserved by a statement of the facts as they are found in this field. The names which have come to be used to designate these rocks will be retained, however, without assuming the equivalency which they suggest. The conglomerate formation, as described by Mr. Lesley, is the lowest division, and varies in thickness from a few feet, as shown near the mouth of Tygert's Creek, to 100 feet or more, as exposed on the Big Sinking. It usually occurs as a coarse ferruginous sandstone; but at various points, and more especially to the southward, it is a true conglomerate, or is banded with pebbled layers. At some points in Greenup and Carter this rock is found resting immediately upon the sub-carboniferous limestone (section 2, plate 3), but generally it is separated from that rock by shales varying in thickness, nowhere in these counties exceeding 30 to 40 feet. These shales, which constitute the sub-conglomerate member of the series, become thicker and include a number of important beds of coal, to the southwest. In Greenup and Carter one thin bed is found. The rocks above the conglomerate are more uniform in thickness, as shown by measurements between well-known beds of coal at different points, but they are also much more varied in character. Shales and sandstones frequently interchange with each other in such a way as to greatly disguise the real stratification of this region. In general terms, the coal measures above the conglomerate may be said to be made up of, first, a shale formation of from 50 to 100 feet, resting on the conglomerate, a series in which shales largely predominate, and which include Coal No. 1, and one or two block ores. (See general section, plate No. 1.) Second, a sandstone series, or one in which the sandstone makes up a large part of the whole thickness, or from 240 to 340 feet. This series includes Coals 2, 3, 4, 5, and 6, with two block ores, and the so-called limestone and limestone kidney ores. Above, shales again predominate, in a third series of rocks largely made up of greenish shales, with shaly sandstone, which have a thickness in Greenup, Carter, and Boyd counties of 90 to 120 feet. In some parts of Lawrence this series is almost entirely wanting, or replaced by coarse sandstone. Coals 7 and 8 and the kidney ores, with the so-called "bastard limestone ore," are included in this formation. Above these shales, a coarse ferruginous sandstone, sometimes banded with conglomerate layers, is usually found in varying thickness—the Mahoning sandstone of Owen and of Lesquereux. This, with the overlying rocks, which are largely shales and shaly sandstone, with beds of impure limestone, but which in some places appear in an almost unbroken series of sandstones, adds to the coal measures of this section a thickness of nearly 400 feet. Sections 71, plate 19; and 81, plate 21; and section 6, plate 25, show a large part of this series, which reaches to the tops of the hills along the Big Sandy. It includes Coals

9, 10, 11, and 12; the so-called Rough-and-Ready ore, with other ores of less importance.

COALS, ORES, AND FIRE-CLAYS.

Beginning at the base of the coal-bearing rocks, a thin coal is found near the sub-carboniferous limestone, or, in its absence, near the Waverly sandstone, as at Olive Hill, in Carter, and Coal Branch, in Greenup, and at other points; and though the conglomerate formation is wanting over a part of Greenup, where this coal is shown, yet it should doubtless be regarded as a sub-conglomerate coal. As the coals below the conglomerate are known to have a considerable development elsewhere, this bed is left to be numbered with them. It is mentioned in reports of the old Survey as Coal No. 1 A, being erroneously regarded as the same bed as that found on Chinn's Branch, and at Steam Furnace, &c. (Volume IV, page 410.) The bed of non-plastic fire-clay, which occurs near this horizon, is also a sub-conglomerate bed. (See section 2, plate 29, and section 28, plate 8.) Like the coal with which it is sometimes closely associated, it is often entirely wanting at points where the conglomerate sandstone follows the limestone, without an intervening bed of shales of considerable thickness. This is the same fire-clay as that used at Sciotoville, in Ohio. The value of the deposit can hardly be estimated at present. It is of fine quality, and inexhaustible in quantity. An analysis of an average sample, taken from an exposure at Boone Furnace, shows the following result:

UPPER PART OF BED.

Silica	48.56
Alumina	37.471
Iron oxide	a trace.
Lime	.112
Magnesia	a trace.
Phosphoric acid	.255
Potash	.289
Soda	.283
Water expelled at red heat	13.030

Other analyses show a larger per cent. of silica. (See the last report of Dr. Peter.) This bed has a thickness of four to six feet. On the place of Mr. Ratcliff, near the lime-kilns, a thickness of eight feet is shown, but the additional thickness is of poorer quality apparently. The bed is found over nearly all of that part of Greenup and Carter counties which presents the rocks of this horizon above drainage. (See sections 1 and 4, plate 2; sections 5, 7, and 8, plate 3; section 9, plate 4; section 19, plate 6; and section 25, plate 8, in addition to those referred to above.) It has also been noted further southward, along the western outcrop of the coal measures. It is mined and shipped in large quantities to Cincinnati from the head of Indian Run, in Greenup. It is reasonable to suppose that this deposit will in time become one of the important sources of wealth to this part of Kentucky.

Above the conglomerate sandstone, in the shale series which follows it in the order of succession, are several ore deposits of greater or less range, and also a coal bed, which, from its wide range and its quality, will prove one of the most valuable in Eastern Kentucky. In thickness this coal is variable, being, in some places near the Ohio, too thin to work with profit, except for local purposes. It appears to be the equivalent of the Jackson shaft coal in Ohio; and as it is the first coal above the conglomerate, and the first of any importance in this part of the coal field, I have designated it Coal No. 1, or the first in a series which includes all the coals of importance in this section, including also those above the so-called Mahoning sandstone. This separation of the sub-conglomerate coals from those above, while no division is made on the Mahoning sandstone, is adopted simply as a matter of convenience. The sub-conglomerate formation, not having been worked up, is left to be considered by itself. The rocks above have been carefully studied, and, as seems most convenient for practical purposes, the beds are numbered in a continuous series, without reference to any division into periods, the equivalent or otherwise of those demonstrated in other parts of the continent. Coal No. 1 has been opened and worked at a number of points in Greenup county. Near the foot of the hill back of Greenup it is 12 to 18 inches thick. Back of Riverton it is near the bed of the creek. Eastward from this point it falls below drainage. (See profile section No. I.) At Raccoon Furnace it is 30 inches thick. On the Little Sandy, nearly opposite Buffalo Furnace, a thickness of three feet is shown, with a clay parting separating it into about equal parts. On Barrett's Creek it is about the same thickness, without parting. A bed of coal recently opened by Mr. Pierce, near Hopewell Station, is probably the same coal. Near Willard, on Little Fork, this coal is three and a half feet, with an inch of slate near the bottom. To the eastward from all these places, this coal soon falls below the drainage; to the west it is found, along with the dip of the formation, in varying thickness, but generally thinning out towards its most western exposure, in the tops of the hills along the line between Greenup and Carter on the one side, and Lewis and Rowan on the other.

The change in the dip of the rocks mentioned on a previous page, brings this coal above drainage further eastward, south of Willard. It is exposed near the head of Dry Fork, near the bed of the creek. On all the upper branches of Blaine Creek, and on Little Blaine and George's Creek, always in shales, and here about 60 to 70 feet above the conglomerate, as shown at the mouth of Hood Creek, and along Blaine for some miles above, where the conglomerate comes to the surface, as also on Brushy Creek, between Mr. Holbrook's and Mr. Swetnam's, where the conglomerate rises to a height of 25 feet above the bed of the creek; on Hood Creek, where the cliffs reach a height of 80 feet, and on the Laurel Creeks, where the cliffs of conglomerate reach a height of 120 feet (see section 8, plate 3; sections 9 and 10, plate 4), and on Keaton's Creek, where, at one point near the mouth, the conglomerate rises 20 feet above the bed of the creek, the coal always occurring at about the same distance above the conglomerate. The shale series above the conglomerate is greatly thickened up in this direction, and includes several bands of calcareous rock and many lozenge-shaped blocks of calcareous rock imbedded in the shales.

Northward, along Blaine and Brushy Creeks, Coal No. 1 falls below the drainage. Its furthest exposure northward in the valley of Blaine is at Haw's Mill, at the junction of Brushy Creek with Blaine. At Mr. Graham's, near the mouth of Cherokee, it is carried below the bed of the creek by a downward bend of the rocks. Probably the coal shown in the bed of Irish Creek may be referred to this bed. Eastward, from Hood and Brushy Creeks, the conglomerate disappears below the drainage, and Coal No. 1 falls to near the bed of the main streams. It is opened at several points on George's Creek, and on Little Blaine. It is not opened immediately on the Louisa Fork of Sandy, in Lawrence county, that I can learn, but would be found near low water, probably. At Warfield, on Tug Fork of Sandy, in Martin county, it is the main coal, and near high-water mark. At Flat Gap, in Johnson county, this coal is found in good thickness near the base of the hills. It is below the drainage in all the country drained by Rockcastle Creek and to the northward between the Forks of Sandy. Southward, from the line of Lawrence and Johnson, the change of level is slight along the Louisa Fork at least, No. 1 Coal being near high-water mark at Prestonsburg. It is probable that the dip to the east, which follows the disappearance of the conglomerate sandstone eastward from Hood Creek, will be found to continue in the belt of country to the southward, along Louisa Fork.

In thickness, Coal No. 1 varies in different sections; but so far as developed, it has a local uniformity which promises to make mining easy and profitable at these points when it reaches a workable thickness. Openings already made show 15 inches near the Ohio; three feet at the Hanna bank; about the same thickness on Barrett's Creek; three and one half feet near Willard, on Little Fork, and on Dry Fork, about three feet on Deer Creek west of Willard in the Little Sandy valley, two to three feet on the head waters of the Blaine, and on George's Creek, and at Warfield five feet. At all these points, except the Hanna bank, it is without any considerable parting. At some points it has no underlying fire-clay. (See plate VII.)

This coal is no exception to the general rule as to variation in quality at different points. It ranks with the best coals, however, as will be seen from analyses by Prof. Peter and Mr. Talbutt, of average samples taken at two points, which show the range in quality in Carter and Lawrence counties. Two samples carefully averaged* from Little Fork, near Willard, show the following results:

Specific gravity	1.269	
Moisture	3.50	3.60
Volatile combustible matter	36.00	35.40
Fixed carbon	57.30	57.60
Ash	2.90	3.40
Sulphur	1.148	1.108

Sample from Mr. Swetnam's coal, on Brushy Creek, gives a still better result. The ash is doubtless too low. Near the Ohio river this coal is less reliable in quality than in Carter

*A remark on the method of collecting samples of coals for analysis is made necessary by the seeming excess of ash and of sulphur, which will be noticed in some coals known to be of superior quality, and of which analyses have been made on a different plan of sampling. In all instances, the aim has been to secure an average of the whole thickness of the bed to be represented, or of different parts of the bed, including all impurities that would not be separated from the coal in the ordinary process of mining. When practicable, this has been repeated, at different points in the same mine, to average as nearly as possible the variations that are found at different points in the same entry. Unless this is fully understood, the result of comparison with the analyses of coals of other States will be an unfavorable impression of the quality of the coals of Kentucky, while in reality they do not suffer by comparison. Analyses of the best coals from neighboring States, collected in the same way, are given by way of comparison. It is taken for granted that practical men desire to know the average quality of coal as it goes to market in bulk, rather than to know how pure it can be made to appear on paper; and though in attempting to obtain samples to this end, there is a likelihood of giving too large a per centage of impurities from the increased proportion found in that part which becomes slack by exposure, and is eliminated to some extent by handling, and also from local variations; yet this average carefully made is more likely to be near the true representation than samples as ordinarily taken. The analyses of the coals of Eastern Kentucky were made from average samples, taken by Mr. Moore or myself, unless otherwise stated, as also were the analyses of coals from other States, which are introduced by way of comparison.

The following table shows how imperfectly a single block of coal represents the whole bed:

	No. 6. Turkey-pen Hollow.		No. 7. Pritchard's coal.	
	Average.	Single block.	Average.	Single block.
Moisture	3.40	4.70	5.40	4.50
Volatile combustible matter	32.30	34.30	32.70	37.10
Fixed carbon	55.40	59.04	52.52	56.40
Ash	8.90	1.90	9.38	2.00
Sulphur	1.23	.983	2.306	.571

The difference shown in the proportion of ash and of sulphur is such as should be expected in any bed of considerable thickness. When an attempt is made to select a block that is an average of the whole bed, in quality, the difference would be less perhaps; but aside from the impossibility of selecting an average sample in this way, the personal bias is always on the side of the best specimens, and the result of comparison with a sample carefully taken from the whole face of the bed would, in nearly every instance, be very much like that shown in the table.

and Lawrence. The following is the result of an analysis of Mr. Swetnam's coal:

Specific gravity	1.281
Moisture	5.10
Volatile combustible matter	35.30
Fixed carbon	57.80
Ash	1.80
Sulphur	0.73

An analysis, by Dr. Peter and Mr. Talbutt, of a sample collected by myself at Jackson, Ohio, at a point in the Star Furnace mine where the coal was regarded by the superintendent of the mine as equal in quality to any in that region, gives the following result:

Specific gravity	1.361
Moisture	4.54
Volatile combustible matter	29.68
Fixed carbon	58.86
Ash	8.72
Sulphur	0.756

The Jackson shaft coal has already acquired considerable reputation as an iron-making coal. In Kentucky no trial has been made of this coal for this purpose. Steps have been taken towards the mining of this coal near Willard, and I understand that it will be used for iron-making. The Warfield and Prestonsburg coals appear to be fully an average in quality, while considerably increased in thickness. This coal is not mentioned in the old report on Greenup and Carter.

Coal No. 2 is of less importance in this field than Coal No. 1, being less trustworthy, both in thickness and in quality. It is present, however, over a wide range of country, and on Everman's and Barrett's Creeks (Kibby's, Jones's, and Lewis's coal), in Carter county, it is found in workable thickness and of very good quality. This coal has been opened on a small branch back of Riverton (see section 4, plate 27), where it showed a thickness of two and one half feet at the outcrop, but soon disappeared on account of a slide of the rocks, and no further effort was made to ascertain the value of the bed. On Ulin's Branch, twenty-five feet above the bed of the branch, a thickness of two and one half feet is shown in two parts, separated by seven inches of clay, and immediately under a thick-bedded sandstone. This coal is spoken of as Coal No. 1 A, in the first reports (volume IV, page 410), but is not the equivalent of the Chinn's Branch bituminous coal, and of the others enumerated as belonging to No. 1 A.

Mr. Moore reports two beds between Coals 1 and 3, at Raccoon, Buffalo, and Laurel Furnaces. The same occurs at Iron Hills Furnace. The upper bed being thin, and limited in range, I have thought best to call it Coal 2 A. The Kibby coal, on Everman's Creek, is 28 inches thick, without parting. The opening by Mr. Elwood, on Everman's Creek, shows about two feet of coal. The entry of Dr. Jones, on Stand Branch of Barrett's Creek, presents a forty-three inch face, including six inches parting. On Mr. Lewis's place it is about the same. This coal has not been traced continuously southward across Carter and to the east, along the northward dip in Lawrence; but it has been noted at a number of points as a stain, or, where better exposed to view, as a thin coal. At Peach Orchard it is about two feet thick, and is known as the Barn Branch coal. The following is an analysis of the Kibby coal, which appears to be an average in that section:

Specific gravity	1.289
Moisture	4.10
Volatile combustible matter	34.60
Fixed carbon	55.25
Ash	4.775
Sulphur	1.414

The place of Coal No. 3 is generally well defined in Greenup and Carter, and in a part of Lawrence. It is found above drainage in a small portion of Boyd. It is the Coal No. 1 A of M. Lesquereux, as mentioned on Indian Creek, Chinn's Branch (Chinch Branch of his report), near old Steam Furnace, at Caroline Furnace, Hamer's coal at Amanda Furnace, on Bush Creek, and near the bed of Williams' Creek below Buena Vista Furnace. But to the westward it is higher up than the coal referred to No. 1 A. At Raccoon and Buffalo Furnaces it is sometimes called the Top-hill coal. (See sections 21 and 22, plate 7, and section 26, plate 8.) It is more commonly known as the Turkey Lick coal. Eastward from the localities named it is lower down than the coals referred to 1 A by M. Lesquereux, falling below drainage east of Hood's Creek and Little

Hood. (Section 50, plate 14; section 53, plate 15.) On the former stream it is shown near the bed of the creek for some miles above Bellefont Furnace. In the greater part of Carter it has about the same eastward dip, being near the bed of the creek at Mt. Savage Furnace (section 37, plate 10), and well up in the hill on Wolf Creek, and in the hills on Barrett's Creek, and on the Sinking Creeks. In the latter places it is a cannel coal, as appears from observations made in that section both by Mr. Moore and by myself. (Section 32, plate 9; sections 23 and 24, plate 7.) In Lawrence it follows the change in dip which has been noticed, being near the bed of Blaine at the ford near Mr. F. Carter's (section 10, plate 28), and about 180 feet above the bed of Brushy Creek at Mr. Holbrook's.

McHenry's coal, six miles south of Louisa, and the main Peach Orchard coal, which are referred to this bed, are 170 and 200 feet, respectively, above the bed of Big Sandy. (Sections 86 and 87, plate 23.) A coal imperfectly opened one half mile below the mouth of Rockcastle Creek, and 175 feet above Tug Fork, is probably the same bed. At Louisa it is probably from 60 to 70 feet below the bed of the river. In Greenup and Carter a block ore is generally found 30 to 35 feet above. In Lawrence this ore is not exposed; probably it might be found in the western part of the county. The rocks below Coal 3 to Coal 1 are variable in thickness. Between Coals 2 and 3 a block ore is sometimes found. These rocks are variable in character also, as will be seen from the sections given. The rocks above, for nearly 200 feet, are variable in character, but preserve a uniformity in thickness that is in marked contrast with those below; and this fact comes to have a very considerable importance from the facility which it secures in the tracing of beds both of coal and of ore. This will be seen as the beds above are taken up in this order; and the identification of Coal 3 will be made more certain, in most of this field, from its relation to overlying beds.

In thickness, Coal No. 3 varies with the different localities. At Raccoon, Buffalo, and Laurel Furnaces, it is pretty uniformly three feet. At Pennsylvania Furnace it reaches five feet, with two partings. At Bellefont Furnace it is about three feet, with a thin parting. At Hunnewell (old Greenup Furnace), it is two and a half feet. At Mt. Savage it is not fully opened, but is probably thin. On Wolf Creek, in Carter, it is said to be three feet. On Blaine it is generally three feet. At Peach Orchard it is six feet, including three thin partings. McHenry's bank shows four feet four inches, including two thin partings. On plate III this coal is shown, as found at a number of points, with its immediate surroundings. It will be seen at once how unreliable an identification would be, based on resemblances, either in appearance or in details of the bed. The same is shown on other coals, in fewer representations on the same plate. Nor is the quality of the coal a satisfactory evidence of equivalency, as will be seen from the following table of analyses of Coal 3 by Dr. Peter and Mr. Talbutt:

	Specific gravity.	Moisture.	Volatile combustible matter.	Fixed carbon.	Ash.	Sulphur.
Raccoon, Greenup	1.335	4.54	35.58	49.79	10.05	3.77
Buffalo, Greenup	1.385	2.80	34.98	49.44	12.50	4.279
Laurel, Greenup	1.289	4.10	34.96	55.54	5.40	1.590
Pennsylvania Furnace, Greenup	1.300	3.20	36.60	53.14	7.06	2.264
McHenry's, Lawrence	1.316	4.60	35.70	53.28	6.42	1.080
Boggs' bank, Lawrence	1.317	2.50	38.78	53.10	5.57	2.466
Holbrook's, Lawrence	1.349	2.10	33.90	56.00	8.00	6.736
Peach Orchard, Lawrence	....	3.24	36.56	54.95	5.24	1.189
Carter Farm, near Grayson, Carter	1.389	3.00	36.20	49.24	11.56	1.381
Hunnewell, Greenup	1.333	3.20	32.90	53.80	10.10	1.043

Part of the variation shown by this table is doubtless owing to imperfect opening of some of the coals, which have been mined only along the outcrop, and which therefore show, to some extent, the effects of the broken and displaced surrounding rocks.

Coal No. 4 is less persistent than the previous. It is a cannel coal, with accompanying bituminous parts and is found 35 to 40 feet above Coal No. 3, or just above the block ore mentioned in connection with that coal, though that ore is commonly wanting where Coal No. 4 has any considerable development. It is the Coal 1 B of Mr. Lesquereux, as described on the land of the Maysville Oil Company, and on Indian Creek, and around Greenup Furnace, now known as Hunnewell Furnace. It is traced eastward in Greenup and Boyd to Hood Creek (section 50, plate 14), though not opened to show either the thickness or the character of the coal. It is probable that only the bituminous part is present in this direction, though in the bed of Mile Branch, near Star Furnace, as shown by section 9, plate 29, by Mr. Moore, a considerable development of cannel coal is found. The cannel coal of Stinson Creek, and on the McGuire place, in Carter county, may be referred to this bed; though Mr. Moore, who has given more special attention to this part of the field, regards it as uncertain whether it is the equivalent of the Hunnewell cannel, or of the cannel coals of Barrett's Creek and the Sinking Creeks, which are referred to Coal No. 3. Coal No. 4 has not been found in Lawrence county, though at a number of points a bituminous slate occurs so nearly in its horizon that it might be regarded as its representative in this direction; section 5, plate 27, and section 9, plate 29, with section 33, plate 10, and section 41, plate 12, show the place of Coal No. 4, and its relation to other beds where it is present. The cannel coal of this bed is well known in the market as the Hunnewell cannel coal.

Coal No. 5 is from 30 to 50 feet higher up. It has its greatest development in Carter and Lawrence counties, where it is known as the Pennington coal, and the Cooksie Fork coal. It is mined at Buena Vista Furnace, in Boyd county, at a point a little way east of the furnace on Straight Creek. It is here considerably divided up by thin partings at the top of the bed, but shows a thickness of 38 to 40 inches of coal of good quality. On Brush Creek, it is shown with a blue ore, immediately above, in a thin bed of shales, which separates it from a thick sandstone above. It is also exposed, though not opened, close to the furnace. (Section 61, plate 14.) On East Fork, near Mr. Calvin's, it is exposed in the bank of the creek at the bridge. (Section 7, plate 25.) And at many points along the eastern division of the Lexington and Big Sandy Railroad, this coal is shown near the grade. (Sections 54 and 56, plate 15; and sections 57, 58, and 59, plate 16.) But few openings have been made to show its thickness and value. As shown in some of the railroad cuts, it is not thick enough to work to advantage. It is probable that Coal No. 5 might be found at some points in the eastern parts of Greenup county, as it is shown to be present at Old Kentucky Steam Furnace, by a well marked coal stain (section 34, plate 10), but no openings of note have been made. In Carter and Lawrence counties this bed is greatly increased in thickness. Little has been done, however, to determine the real value of the bed. Section 39, plate 11; section 66, plate 18, show its position in the series. Plate 31 (Coal 5) shows the thickness and surroundings at several points chosen to illustrate the general character of the bed, where it has a considerable thickness. The place of Coal No. 5 is from 30 to 40 feet below the so-called limestone ore, where that is present. The horizontal range of the two beds seems to be about the same, though their boundaries do not coïncide.

The quality of Coal No. 5 has not been fully determined from the difficulty of obtaining average samples; the bed not being worked, except at Buena Vista Furnace, where the following result was obtained by Dr. Peter and Mr. Talbutt:

Specific gravity	1.360
Moisture	3.20
Volatile combustible matter	32.30
Fixed carbon	53.00
Ash	11.50
Sulphur	1.999

The per cent. of ash is largely increased by including the upper thin layers, which might be rejected; the slaty portions of the bed interfere with the profitable mining of this coal, as shown by such openings as have been already made.

Coal No. 6 is found from 15 to 20 feet above the limestone ore. It is the Coal No. 1 B of Mr. Lesquereux, as reported near Catlettsburg, on Horse Branch, and on Catlett's Creek, and Coal No. 2, as described at Amanda Furnace and at Ashland. It is known as the Keys' Creek or the River Hill coal. Profile section No. 1 shows the position of this coal along the

Ohio. It has its greatest development in Boyd county, where it is mined at many points for local use and for shipment. Section 81, plate 22; section 77, plate 18; sections 61 and 62, plate 17; section 57, plate 16; sections 53 and 54, plate 15; sections 49, 51, 52, plate 14; and sections 1, 3, 4, 5, and 7, plate 25, give a good notion of the coal in Boyd. Detailed sections, plate 31, give the thickness and surroundings of this bed.

In Greenup this coal is shown at many points, but is less reliable both in thickness and quality. It occurs, but is not opened, at Old Steam Furnace. (Section 34, plate 10.) At Hunnewell Furnace it has been opened at several points. In Carter county the bed has still less development, though it is readily traced along with the outcrop of the limestone ore and the overlying ore. It is shown at Mt. Savage. (Section 45, plate 13, and in sections given in Mr. Moore's report.) At Willard it is shown in a railroad cut, and at a number of points west and south. (Section 1, plate 26, shows the place of Coal No. 6 on Little Fork, a short distance westward from Willard.) In Lawrence county this coal has been noted at several points, but it has been worked only at Louisa, along the Big Sandy river, near high-water mark. (Section 10, plate 28.) It is little more than two feet thick where opened at this point. The quality of Coal No. 6 is good, and even superior in some localities, especially in Boyd county, where it has its greatest thickness.

The following table is made up from analyses, by Dr. Peter and Mr. Talbutt, of average samples from Boyd county:

	Specific gravity.	Moisture.	Volatile combustible matter.	Fixed carbon.	Ash.	Sulphur.
Turkey-pen Hollow .	1.359	3.40	32.30	55.40	8.90	1.230
Keys' Creek	1.279	2.94	32.50	56.70	7.74	1.972
Horse Branch . . .	1.315	2.70	36.70	52.60	8.00	1.711
Amanda Furnace . .	1.335	4.04	33.60	53.34	9.00	1.318

Plate VII shows the variable character of this bed and its surroundings.

Coal No. 7 is normally from 40 to 45 feet above Coal No. 6, and 20 to 25 feet above the so-called yellow kidney ore, or the "black vein," as it is known by miners in some localities. This is Coal No. 2 of the old report, as observed at Kilgore's. It is now widely known as the Coalton coal, having been extensively mined originally at Coalton, as it is now at a number of points on the eastern division of the Lexington and Big Sandy Railroad, and also at Willard, on the Eastern Kentucky Railroad. This coal has already acquired a wide reputation as an iron-making coal. Its western outcrop is along the eastern border of Greenup county, and across Carter, a few miles west of Mt. Savage Furnace; and thence along the line of hills east of Little Fork and of Little Sandy. The low hills of the "Flat Woods" country do not include this coal, there being very little eastward dip across this belt, and the hills being barely high enough to include the limestone ore. From a little east of Ashland Coal No. 7 rapidly falls to the base of the hills that skirt the Big Sandy. (See first profile section.) The thickening of the sandstone above Coal No. 6, near the Big Sandy, on Keys' and Catlett's Creeks, is accompanied by a corresponding decrease in the thickness of Coal No. 7, and the distance between the coals is increased to 55 feet or more, the sandstone entirely replacing the shales below, and even the coal itself in places. At Catlettsburg it is shown as a stain evidently of a thin coal, about 60 feet above Coal No. 6, which is opened below high-water. (Section 81, plate 22.) Near the mouth of Chadwick's Creek, however, it has a thickness of three feet without partings. It was formerly worked at Clinton Furnace, about 40 feet above the bed of the creek. (Coal No. 1 C, of first reports.) It is opened near Cannonsburg in several places, and it shows a good thickness in the road from Cannonsburg to Coalton, near the tunnel. Along the railroad southward to Rush Station it is from 80 to 100 feet above grade. (Sections 57, 58, and 59, plate 16.) On East Fork, at the mouth of Old Trace, it is from 40 to 50 feet above the bed of the Fork. A coal that appears to be the same is shown in the bed of Ellington's Bear Creek, near the school-house and church. At the school-house, above *Mr. Kouns's*, it is in the bed of East Fork. On Four-mile Creek it is opened at *Mr. McBrayer's.* Further southward it is below the waters of East Fork. It is found on all the Buena Vista lands, rising towards the tops of the hills on the west side. (Section 51, plate 14.)

On the Hunnewell side of the divide between the waters of East Fork and of the Little Sandy, Coal No. 7 is too high up to be profitably mined at present. Its place is shown by a stain in the road leading down from the ridge to Cannel Branch of Cane Creek, and at the head of Cane Creek it is opened. (Section 36, plate 10.) It is present in most of the Mount Savage Furnace lands, following the eastern dip, which brings it below drainage on the East Fork side of the main ridge. (Section 27, plate 8; section 65, plate 18.) (See also sections in Mr. Moore's report.) At Willard Coal No. 7 is about 90 feet above Dry Fork, rising rapidly to the tops of the hills westward and southward, from near the mouth of Caney Fork, where it is lowest; while northward it rises less abruptly, and to the eastward it rises slightly for some distance, probably to the divide between Lost Fork and East Fork. In Lawrence county Coal No. 7 is below drainage along the northern part, and it has not been opened, except near Louisa (section 2, plate 28), and perhaps on the farm of Mr. Burchett, on Muddy Branch of Blaine, where a coal not readily distinguished from Coal No. 8 has been mined for local use. In the southeast part of Lawrence county the coals above Coal No. 3 have not been fully identified, the work not being completed in this section, partly from a want of time, and partly from the fact that in this direction changes in the character of the rocks occur, which make it desirable to study this section in connection with the adjoining counties to the south and southwest. The thickness of Coal No. 7, where it has been identified, is from three and a half to six feet, in two or three parts of about two feet each; the upper part disappearing when the bed is less than six feet. The partings are remarkably regular, and have a thickness of from one to three inches each. The Big Sandy valley furnishes an exception to the general character of the bed as found elsewhere. Plate 31 shows the general character of the bed at some of those points where it is best known. Coal No. 7 is more widely known as an iron-making coal than any other bed in Eastern Kentucky, being used without coking with marked success. Mr. Moore has discussed the metallurgical qualities of this coal in his report.

Above Coal No. 7 from 20 to 30 feet is the red kidney ore, as it is commonly designated. This ore and the ore below, generally accompany this coal. From 40 to 55 feet above Coal No. 7 is Coal No. 8, the bed next below the Mahoning sandstone of Owen. It has its best development apparently on Garner Creek. It is commonly known, however, as the Hatcher coal. It is present in a field very nearly coinciding with that of Coal No. 7 in its western outcrop, but it is found above drainage over a large territory to the eastward, being above the bed of most of the main creeks. On East Fork, from the mouth of Jack's Fork to near Mr. Webb's; on Bolt's Fork, and on Long Branch of Blaine, it is below drainage. It is sometimes wanting entirely in parts of this field. At Coalton it was opened, and showed, as reported, between three and four feet. On Garner Creek, and near the head of Lost Fork, near Willard, it shows nearly four feet of coal without parting. At Mr. Webb's, on East Fork, a coal, part cannel, occurs in the bed of the creek in such stratigraphical relations as to be referred to Coal No. 8. (Section 65, plate 18.) Along the Big Sandy it is seen at a number of points above and below high water. On the West Virginia side it is mined at a number of points above the mouth of Bear Creek; and the openings along Tug Fork, near Louisa, appear to be in this bed. Coal No. 8 is generally inferior in quality to Coal No. 7, and has therefore been opened in but few places. In a part of Boyd county a so-called "bastard limestone ore" occurs about 20 feet above, and also kidney ores still above. Generally, however, an impure yellowish limestone follows Coal No. 8, at a short distance above, succeeded by a coarse sandstone or a conglomerate sandstone. Section 60, plate 16; sections 62, 63, plate 17; sections 69, 71, plate 19, also furnish examples of this. See also sections on plates 26, 28, and 30.

Coal No. 9 is from 40 to 50 feet higher. It is not worked except for local use, but it is present over such an *extent* of country as to entitle it to a place in the list of coals of this region. It is opened at Mr. William Davis's, on East Fork, in the hill opposite the mouth of Garner Creek. It shows at the head of Lost Fork and of Bell's Trace, near Willard; is seen occasionally eastward, on the waters of Cat Fork of Blaine. Sections 69 and 71, plate 19; section 3, plate 30; section 8, plate 26; and section 4, plate 28, show this coal.

Coal No. 10 is known over less territory, and is opened in only one place, so far as I can learn, though a coal stain has been noted at a number of points, showing that it is more than a local deposit. On Cannel or Rock-house Branch of Jordan's Fork, where it is opened, it is a cannel coal of good quality, two and a half feet in thickness, immediately under a calcareous rock, the second fossiliferous limestone. (See section No. 1.)

Coal No. 11 is also little known, and opened only at one point near Col. Bolt's, on East Fork. (Section 8, plate 28.) It is known as Bolt's coal, and has a thickness of three and a half feet. It is about 40 feet above the second fossil limestone. (See general section, plate 1.)

Still another coal is shown near the top of the hills between the Falls of Blaine and Louisa, but little is known of its thickness or value.

Having given an account of the coals, and incidentally of the ores that occur in this part of Eastern Kentucky, and such an account of their range as is shown by openings already made, it seems desirable to present the whole subject in such a way as to give the number of coals and of ores that are likely to occur in each considerable valley, and to point out as well as may be the place of each bed. This will place, in the most available form, the facts, which it is the purpose of the survey to collect, at the disposal of those who are most immediately interested, viz: the owners of the land. At the same time the geology of this field may be presented more in detail for the student, and for those who are interested in mineral lands generally. If there were no considerable variations in the rock beds as they extend across the country, and as they appear in the series from the base upwards, there would be little need of a more detailed account than has already been given. But the changes which occur in the rocks of the same geological level—changes which affect the distribution of the coals and ores—make it impossible to represent by sections and general statements the range of beds so distinctly as to present the facts in the most useful form for each locality. In the sections which accompany this report (excepting the profile sections), it is intended to present such features only as have been seen, though there might be good reason for supposing that other features, known to hold a somewhat constant relation to those observed, were covered by the soil which hides a large proportion of the rocks of most hills. In offering suggestions as to what may reasonably be expected to occur in a particular valley or hill, it is necessary to go beyond this, and to consider the probability of the occurrence of beds known to be present elsewhere at the same geological level. It will be well, therefore, to keep in mind the distinction between what is known to exist and what may be looked for with a reasonable hope of success; for, with all the knowledge that can be brought to bear on a question of probability, there is room for error in the conclusions reached, and this fact would be a sufficient excuse for presenting simply that which is known, if it were not the purpose of the survey to aid in developing the unknown resources of the country, as well as to call attention to what is already exposed to view. The forces and the conditions which gave rise to the carboniferous rocks were not so uniform, but that the development of a coal region has in it something of the nature of an experiment; and the part that science must take in the matter is to point out, from what is known, the line of experiment most likely to lead to good results. This it can do for the coal measure, by showing, from the character and the stratification of the rocks, at what level certain coals and ores may be found. The thickness or value of the beds may, to some extent, be inferred from its character, where known; but only actual working of the bed can fully determine such questions. But while in general a good deal of useless expenditure, both of time and money, would be saved by such directions as will be given here, it is possible that local beds of great value may have been overlooked in so rapid a survey as it has been necessary to make of this large field.*

The general section (plate 1) presents, in one view, all of the most important beds of coal and of iron ore, as also of limestone and of fire-clay, as they occur in different parts of this field. The profile sections show most of these beds with their probable range, east and west. From these sections it is easy to determine, in a general way, what geological horizons are included in the hills along the different belts of country from west to east. For instance, profile section No. II shows that it would be useless to look for Coal No. 6, or the ferriferous limestone and ore just below it, west of the Little Sandy river, along this line, and that it would be equally useless to look for Coal No. 1 above the drainage, for any considerable distance east of the Little Sandy. The reasons for this are sufficiently apparent from the section itself. Profile sections I, II, and III, together with those sections which are based on tide-level, complete this general representation of the range of beds in this field. It remains to call attention to the special geological features of different localities as they affect the question of distribution of the coals and iron ores.

For convenience of reference to the map, the prominent streams will be used to indicate locality.

On Indian Run the Waverly formation rises to a height of about 500 feet above low water in the Ohio. Neither coal, nor ore in paying quantity, will be found in it. Some compensation for this is found in the building stone that occurs in the Waverly formation, and in the nearness to river transportation. A few feet above the top of the Waverly, as marked by a flinty

*Observations which come within the range of the report cover a territory something more than 1,000 square miles in extent.

bed of rock, occurs the bed of non-plastic fire-clay, which is shown at many points along the western part of the coal field. A general description of this bed has been given on a previous page. Below this bed, and at the top of the flinty rock, there are slight indications of the lower "limestone ore." As this cherty rock is doubtless the representative of the sub-carboniferous limestone, it is not unlikely that the ore which rests upon that formation may extend to this part of the field; but the indications do not warrant the assertion that it would be found in paying quantities at this point. About 40 feet above the fire-clay Coal No. 1 occurs, as shown in a well near the top of the hill. The *thinness* of this coal at this point will make it available for local use only. All of these beds rise towards the west, and to the eastward would be found lower down. The average dip to the eastward is about 45 feet per mile from the head of Indian Run. The character of the rocks between the fire-clay and Coal No. 1 is imperfectly shown, but from what is known of the rocks of this horizon, it may be assumed that no other beds of considerable value occur in this section.

White Oak Creek heads back of Springville, the river hills forming one side of the White Oak valley. The river hills at Springville show a continuous section of Waverly rock to near the top. (Section 5, plate 3.) The fire-clay bed is found covered by no more than ten feet of rock and soil. The dip of the rocks to the eastward brings this bed lower in the hill toward the Tygert's Creek valley, so that, though the hills are lower, yet above the fire-clay towards the mouth of White Oak there is sufficient thickness of overlying rock to include No. 1 Coal. Southward across the White Oak valley, an exceptional dip of the rocks also brings those beds lower down in the hills; but with the addition of a block ore, which sometimes occurs above Coal No. 1, no other beds of importance are likely to occur. The top of the Waverly formation is easily recognized from the occurrence of limestone or flinty rock, or, in the absence of both, by a change from greenish fine-grained sandstone or shale to dark shale or to a coarse grey sandstone. The readiest way to find this bed is to measure upward from the Waverly the normal distance, as shown in sections given, nearest the point where it is desired to develop them. Some variations in thickness will be found, but these variations will be readily detected and indications of the beds found when they are present.

The exceptional dip mentioned in this region deserves a passing notice. In general the rocks of a given geological level rise towards the south, as noticed before, but the elevation* of the Waverly rocks, as shown in the hills back of Springville, presents a marked exception to the general rule, and this exception continues eastward to the river hills above the lime-kilns. The top of the Waverly at the lime-kilns is fully 100 feet higher than at Bennett's Mills. (Section 9, plate 4, and section 17, plate 6.) The top of the Waverly again rises to the southward, from Bennett's Mills. It will be seen by reference to the map that this region of southward dip is included in the bend of the Ohio river. It has its limit on the south, near a line which might be drawn from near the mouth of Smith's Branch, to a point a few miles south of Indian Run, including most of the Shultz Creek valley. Probably the dip is not uniform over the area included in these boundaries.

The hills which form the valley of Shultz Creek rise to the height of from 350 to 450 feet above the creek. The following section of the hill, on the south side of the valley, near the mouth of the creek, shows an ore which may have more than a local distribution:

Top of hill above creek	440	feet.
Covered slope	15	"
Block ore	6	inches.
Shale	5	feet.
Conglomerate sandstone	20	"
Shale	3	"
Cherty limestone	?	
Waverly sandstone and shale	395	"

*It is probable that the change in dip is in consequence of an upheaval of the Waverly rocks, rather than of a thickening of those rocks. Mr. Andrews has remarked inequalities in the surface of the Waverly formation of Ohio, which would give rise to nearly as great a change of inclination of the surface of the Waverly. But in the region in question the overlying rocks conform very nearly with the top of the Waverly in stratification, and the occurrence of slight faults, such as noted near the mouth of Linn Branch, tend to make probable the former explanation.

On the Plum Fork side, on the place of Judge Fullerton, this ore is shown, and also another, 30 feet higher up—the well-known lower block ore of this belt of country.

Top of hill.	
Covered slope	15 feet.
Block ore.	
Covered space	30 "
Block ore shown in well.	
Shale	5 "
Conglomerate sandstone.	

The fire-clay is wanting on the south side of the valley, where the conglomerate sandstone has a considerable development. On the opposite side the conglomerate is not so prominent, and the fire-clay is said to be present. Near the head of the valley the following section is shown on the right hand side:

Top of hill above creek at Mr. Aldrich's	340 feet.
Covered slope	10 "
Block ore (lower block).	
Covered space	40 "
Limestone, cherty at top	8 "
Waverly sandstone and shale to bed of creek	280 "

The fire-clay would probably be found all along the ridge. Coal No. 1 has not been opened in this region, but it would doubtless be found, wherever the hills are high enough to include it, in sufficient thickness to supply local demands. The conglomerate sandstone in this region is a coarse ferruginous sandstone simply. It is well shown at Mr. Fullerton's, where it forms an escarpment around the hill, and at the head of Petre Cave Branch, where a small cave is formed by the overhanging rocks. Towards the head of the valley this rock is less prominent, so that it is not noticed as affecting the topography of the country. Plum Fork valley is nearly the center of the geological basin formed by the uplift that has been described. The conglomerate sandstone is present in this valley, resting in places immediately on the Waverly, and excluding the fire-clay, as in the section on Judge Fullerton's place given above. On Beechy Creek the conglomerate appears to have lost its importance, and probably the fire-clay, Coal No. 1, and the lower block ore would be found in this valley.

At the mouth of Brushy Creek the coal measures begin at about 150 feet above the bottom land of Tygert's Creek valley. At the New Hampshire Furnace it is also about 150 feet above the creek; the dip to the eastward being about the same as the fall of the stream. The lower limestone ore is found towards the head of the valley; its limit eastward is not clearly made out, but it is not likely to occur in paying quantity near the main Tygert Creek valley. The following section, together with section 11, plate 4, and section 41, plate 12, indicates what ores are likely to be found in this valley:

Top of hill north of furnace.	
Covered slope	15 feet.
Block ore.	
Covered space	50 "
Limestone ore.	
Waverly to hearth of furnace	100 "

No coal is shown. It is likely, however, that a thin coal would be found a short distance below the lower block ore. The limestone ore is not present throughout, but it is mined at many points for Kenton Furnace. The fire-clay bed was not seen in this valley, but there are no geological features that would lead to the conclusion that it is not present.

The hills near the head of Big White Oak Creek are high enough to include the lower block ore only; towards the mouth of the creek the hills include more of the carboniferous rocks. Section 12, plate 4, and section 2, plate 29, and sections given in the report of Mr. Moore, show the position of the ores of this valley. It will be noticed that in Powder-mill Hollow the fire-clay is shown between the limestone (sub. carb.) and the coarse sandstone (cong. S. S.) above, while at the Shover drift, where the sandstone is considerably increased in thickness, it is entirely wanting. Coal No. 1 is from one to two feet in thickness, and is mined for local use on the Kenton Furnace lands. It is valuable for blacksmithing purposes. An analysis made by Dr. Peter and Mr. Talbutt, from sample taken from stock pile, shows the following properties:

Moisture	4.82
Volatile combustible matter	32.90
Fixed carbon	55.18
Ash	7.10
Sulphur	1.407

The coal opened at Thompson's bank appears to be lower than Coal No. 1, though it is doubtless above the fire-clay, and may be found to be the equivalent, in this locality, of No. 1. The section at Thompson's bank is interesting as showing a band of somewhat silicious limestone, which has been noted at a number of points, and which is probably the equivalent of the Putnam Hill limestone of the corresponding belt of country in Ohio.

Top of high point.		
Covered slope	40	feet.
Blue silicious limestone	2	"
Covered (sandstone and shales)	95	"
Rough block ore.		
Shales with sandstone at top	15	"
Block ore (lower block).		
Shales mostly	30	"
Sandstone	5	"
Coal	1½	"
Shales, including fire-clay	20	"
Limestone ore.		
Waverly to bed of White Oak Creek, about	175	"

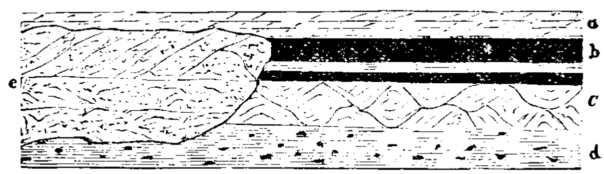
The thickening of the limestone, as shown southward from Brushy Creek, continues across the heads of Little White Oak, Big Lost, and Leatherwood Creeks. Few openings have been made on these creeks. The sections given on the Kenton Furnace lands would doubtless be found a sufficient guide for developing the ore of the region drained by these creeks. Section 18, plate 6, near the mouth of Big Lost Creek, shows only the limestone ore; but the hills are high enough to include all the ores shown in the sections near Kenton Furnace.

On Three Prong little is shown beyond the general geological features. The sections on the Boone Furnace lands, together with those referred to in the preceding paragraph, will serve to point out the place of the beds that are likely to occur in this valley.

On Grassy Creek the ore beds have been quite extensively developed. The Waverly rocks rise to a height of nearly 300 feet above the creek at Boone Furnace, and the carboniferous rocks are separated from them by sub-carboniferous limestone reaching in places a thickness of 90 feet. Near the furnace the hills are high enough to include the beds shown in the following section, taken south of the furnace:

Top of hill.		
Covered slope	35	feet.
Block ore.		
Covered space	50	"
Limestone ore.		
Limestone	80	"
Waverly sandstone, nearly	300	"

To the westward only the limestone ore is left, as in section 7, plate B, at Old Orchard drift. In this section a thin coal is shown, which is a sub-conglomerate coal, as indicated by its position. An instructive feature is shown at one point, where the coal is abruptly replaced by a coarse sandstone. The accompanying cut, which represents this feature, will serve to explain what may be expected to occur in other beds, both of coal and of ore.



a. Shaly sandstone.
b. Coal with clay parting.
c. Fire-clay, non-plastic.
d. Dark shales, with nodules of iron ore.
e. Coarse S. S., showing cross-bedding.

The interruption of a bed by the interposition of deposits of sandstone or of other rock, has frequently proved an annoying feature in mining. Generally the interruption may be regarded as a local feature, limited to a narrow belt, along which the character of the deposit was modified by local currents. Sometimes, as reported in the mines of the Maysville Oil Company, near Riverton and Greenup, a thickness of only a few feet of rock is interposed, and the bed continues with slight interruption. Coal No. 1 is not shown in the valley of Grassy Creek, so far as I can learn. There appears to be no special geological reason for the absence of this bed, and it is likely that it will be found at its proper level. Southward from Boone Furnace the limestone formation continues to increase in thickness, and also the conglomerate becomes more prominent, and rests in places immediately on the limestone, cutting out both the fire-clay and the limestone ore. This is the case at Sellard's Bank, on the waters of Buffalo Creek, opposite Boone Furnace. At the roadside, about 400 yards above Mr. Frailer's, on Grassy, below the furnace, a highly fossiliferous band of sandstone is found in fragments which have fallen from the cliff above. At no other point have fossils been discovered in this Waverly rock in so great numbers both in individuals and species. The Waverly formation in this region is less shaly than near the Ohio, and would furnish superior building stone at a number of levels.

Buffalo Creek drains a country very much like that drained by Grassy Creek, which is one of its main branches. There is greater thickness of limestone and of conglomerate, as shown in section 14, plate D, and in a section on Smith's Branch (report of Mr. Moore), which gives the following thickness:

Top of hill.	
Covered slope	60 feet.
Block ore.	
Covered space	60 "
Conglomerate sandstone	90 "
Limestone ore.	
Limestone	105 "
Waverly.	

The thickening of these formations is strongly marked in the topography of the country. The effect which it has on the distribution of the ores, which are shown in the section at Kenton and Boone, is not clearly made out; but the rocks above the thickened conglomerate masses appear to be identical with those which rise above the thin conglomerate formation at these places, and it is probable that the block ores which follow in those rocks, with the coal sometimes included, are the beds that will be found in the tops of the hills in this valley. Towards the mouth of the creek the hills may include beds higher up, the dip of the rocks to the eastward giving a greater thickness of the rocks of the coal measures. The geology of Cave Branch is similar to that of the head of Buffalo Creek. The well-known Carter Caves and the Natural Bridges are formed in the limestone near the bed of the branch, or about seventy-five feet above Tygert's Creek; the conglomerate rises 90 feet above the limestone, and the hills, reaching only a moderate height, are capped by the shale series above the conglomerate; the highest probably including rocks as high as Coal No. 2, though no trace of the bed has been found in this locality. The limestone ore is doubtless present over some of this territory, though at some points the conglomerate is observed to rest immediately on the limestone ore, as in section 20, plate 6. The topography which arises from the rocks shown by this section adds very much to the picturesqueness of the scenery around the caves.

Smoky Creek and Trough Camp Creek cut through the same formation as Cave Branch and the head of Buffalo. A section, as shown in the road between Trough Camp and Smoky Creeks, gives the position of the limestone and the limestone ore:

Sandstone, with shale at base.	
Limestone ore.	
Limestone (sub-carb.)	150 feet.
Waverly to bed of creek (Trough Camp)	35 "

The hills here include 100 to 150 feet of the rocks above the conglomerate, or to the place of Coal No. 2. (See general section.)

The section at Olive Hill (section 15, plate 5), and section 8, plate 3, and section 4, plate 2, with section of east side of Garvin's Hill, Mr. Moore's report, gives a good notion of the economic geology of the country drained by the forks of Tygert's Creek. Towards the head of North Fork and of Soldier's Fork, the coal measures are carried near to the tops of the hills, as in all the valleys of the main creeks west of Tygert's Creek. Very little has been done to open the ore or coal beds in this region. On Garvin's Hill several ores have been imperfectly opened, and near Olive Hill the sub-conglomerate coal is worked for local use. The hills east of the Tygert's Creek valley, and nearly opposite the mouth of Soldier's Fork, show the following section:

Divide between Tygert's Creek and Big Sinking.	
Covered slope	50 feet.
Coal thickness not shown.	
Coarse sandstone and covered space	60 "
Limestone (sub-carb.)	60 "
Waverly to bed of creek	55 "

The coal shown is above the conglomerate, and is probably Coal No. 1. Both the limestone and the conglomerate are less prominent than at Olive Hill, or than farther south. To the westward, from a line starting at Boone Furnace, touching Olive Hill, and extending to Big Falls Branch of Big Sinking, both formations rapidly lose their importance. This is well shown along the old Lexington and Big Sandy Turnpike. At the bridge below Olive Hill 90 feet of limestone is shown, and a considerable thickness of conglomerate sandstone. On the west side of Garvin's Hill only 25 feet of the former, and 10 to 15 feet of the latter, is found. This will explain the occurrence of the coal-measure rocks above the conglomerate, west of the waters of Tygert's Creek, along the border of Rowan and Lewis counties. It will be noticed that Tygert's Creek flows along the line of the greatest thickness of the limestone and conglomerate, fed almost exclusively by branches from the west, which have cut their way through these formations, and have their beds in the Waverly rocks. The branches from the east are all short, and flow rapidly across the slightly upturned edge of these formations from the coal-measure rocks above. From 100 feet to 200 feet of these latter rocks will be found along the eastern side of the Tygert's Creek valley, down to the bend in which is situated the Iron Hills Furnace property. Here the eastward sweep of the creek, with the thinning out of the limestone and conglomerate sandstone, give to the rocks above a thickness of more than 300 feet in some of the higher hills. A section of the high hill, to the south of Iron Hills Furnace, about two miles (known as "Potato Hill"), shows the following:

Top of hill.	
Covered slope	40 feet.
Block ore ("Potato Hill ore.")	
Covered slope	65 "
Block ore.	
Covered space	55 "
Coal, thickness not shown.	
Sandstone and shales	65 "
Thin coal.	
Covered to limestone, about	150 "

Section 19, plate 6, and the following of Smith's Hill, and on Tygert's Creek, one mile south of furnace, show the geological position of most of the beds of this region.

SMITH'S HILL.

Top of hill.	
Covered slope	40 feet.
Block ore ("Crown ore.")	
Shales and sandstone	21 "
Block ore ("German ore.")	
Sandstone and shales	32 "
Lambert ore.	
Covered to limestone	75 "

TYGERT'S CREEK, ONE MILE ABOVE FURNACE.

Block ore.	
Shales	5 feet.
Coarse sandstone (Cong. S. S.)	45 "
Shales	10 "
Ore.	
Shales	15 "
"Blue ore."	
Limestone	35 "
Waverly formation.	

Coal No. 1 is opened in the hill back of the furnace, showing only about a foot of good coal. Some of the beds of ore are local, as will be seen by comparison with sections at the nearest furnaces, as also by comparison of one section with another, as the Lambert ore section and the section one mile south of furnaces. The Lambert ore shows a thickening which makes it the most important bed in this locality. The coals shown in the section of Potato Hill are Nos. 2 and 2 A. No. 3 Coal would probably be found from 30 to 40 feet below the "Potato Hill" ore, though no stain has been observed, showing its exact position or its extension to this part of the field.

Further to the north the thickness of the coal-bearing rocks, in the hills forming the east side of Tygert's Creek valley, varies from 200 feet to 300 feet, including, with some local variations, the beds shown in the general sections above the conglomerate formation. The conglomerate sandstone and the limestone are present in reduced thickness for some distance northward of the Iron Hills region. On Hood Run the limestone is reported by Mr. Moore; thickness not fully determined. No limestone is shown on Rock Lick Branch, above

Liberty. Section 17, plate 6, near Bennett's Mills, shows no limestone. In the former place a coarse sandstone probably represents the conglomerate, and the coarse sandstone shown in section 17 may be the same, giving the thin coal the place of No. 1 rather than of the sub-conglomerate coal of other localities. Section 7, plate 4, near the Ohio, includes less of the coal-measure rocks, for reasons which have been given Coal No. 1 would probably be found here as a thin bed. The limestone ore is shown on Mr. Ratcliff's place; but as no attempt has been made to develop the ores in this section, no very definite information has been obtained as to the extent of the deposit. The presence of the sub-carboniferous limestone is of itself a sufficient reason, however, for presuming that the ore is not wanting in this region.

The branches which empty into the Ohio between the mouth of Tygert's Creek and the Little Sandy river are comparatively short. They all rise in the coal-bearing rocks and flow down, across the edge of the rocks of that formation, and out to the river, in the Waverly sandstone and shale. The river hills here appear to be more barren of both coal and ore than the hills of the same geological level farther back. Whether this is really true, to the extent that appears from what is now known, may be regarded as doubtful. Section 25, plate G., shows most of the face of the hill at the mouth of Little Sandy river, without indication of either coal or ore above Coal No. 2, which is thin, as shown here. But it is not unlikely that Coal No. 3 would be found at the proper level here and in all the hills that include the rocks of this level, or that rise 300 feet above the line which marks the top of the Waverly, the limestone being mostly absent, and the conglomerate formation having only a slight representation along these hills. The band of coarse sandstone shown in the tops of the hills, between Coal Branch and Smith's Branch, appear to be the same as that which frequently rises above Coal No. 3. In the profile section, the block ore is represented as falling below this sandstone; but this is an error, as the block ore is usually wanting where this thick sandstone is present. Vol. 4, page 373, report of 1861, mentions this sandstone on Whetstone Creek, near Mr. Steward's, but it is there mistaken for the Mahoning sandstone. The coal just below was therefore wrongly referred. This is doubtless Coal No. 3, as numbered in this report, and not the equivalent of the Stinson Hill cannel. The thin coal at the base of section 25, near the mouth of Little Sandy, is referred to the sub-conglomerate series, as well as the Coal Branch Coal near Mr. Richards' house. The reason for this is seen from its relation to the non-plastic fire-clay bed, which is clearly a sub-conglomerate bed. In this region, therefore, the sub-conglomerate shales unite with the shales above the conglomerate, to form one series, having a thickness of nearly 60 feet. At many points, however, a coarse ferruginous sandstone marks the line of separation, as near the head of Coal Branch, where the coarse sandstone, which forms a large rock house, becomes locally prominent. Smith's Branch and Gray's Branch have nearly the same geological features as Coal Branch, except that the rise of the top of the Waverly reduces the thickness of the coal-bearing rocks in that direction, as shown by profile section No. 1.

Comparatively little has been done to develop the mineral resources of Whetstone Creek, and the same may be said, with some qualifications, of Allcorn Creek. On Whetstone Creek several coal beds were formerly opened near Mr. Steward's, as described by M. Lesquereux. They are doubtless Nos. 1, 2, and 3, as numbered in this report. The ores of this region will be readily found from their relation to these coals, as shown in the sections on Raccoon Creek, where the location of the Raccoon Furnace has led to the development of the ores more especially, but where the coals are also opened sufficiently to show the geological position of the beds and their relations to the ore. Sections 21, plate 7, shows the height above drainage of some of these beds. From the base of the section to the Waverly formation is probably not more than ten to fifteen feet, as I am informed by Mr. Moore, who has given more especial attention to this region. This would place the coal in the bed of the creek* nearly in the position of the Coal Branch coal, which is referred to the sub-conglomerate formation. The absence of the fire-clay bed and other well-known evidences of position in the series, makes this somewhat doubtful, however, and its relation to the beds above make it more probable that it is No. 1 Coal.

Sections at different points, as given in report of Mr. Moore, show the relative positions of the beds found in this section, nearly as follows:

Sandstone, near top of hill opposite furnace	5 to 10	feet.
Shale	3 to 4	"
Block ore (main block).		
Sandstone mostly	35	"
Coal No. 3, in two parts	3	"
Sandstone with shales at top and bottom	70	"
Hearth rock	4	"
Thin coal and shales (No. 2 A)	2	"
"Grey ore."		
Sandstone and shale	8	"
Coal (No. 2)	2	"
Shales and sandstone	30	"
Lower block ore.		
Shales	35	"
Coal in bed of creek above furnace	2½	"
Shales	10	"

The grey ore is a local bed, and would not be found over the whole area in question. The second coal has been mined for local use here, and would probably extend into the other valleys. Coal No. 3 and the main block ore are constant, and would be found wherever the hills include the rocks of this level, or form a line considerably to the west of Raccoon Furnace, eastward, over the whole region in question; though the supposition that the coals near the Ohio fall off in thickness may prove true. The sandstone above the main block ore, at some points, is filled with plant impressions, representatives of the Lepidodendron and of the Calamites principally. The shale above this ore has, at some points, abundant representations of ferns and other plant forms. A thin coal is also in-

*This bed has been recently opened, and about thirty inches of coal is shown, instead of about one foot, as exposed by the creek. The following analysis, made by Dr. Peter and Mr. Talbutt, is of this coal:

Specific gravity	1.409
Moisture	4.10
Volatile combustible matter	28.90
Fixed carbon	49.60
Ash	17.40
Sulphur	.668

cluded at one point where the plant impressions are most abundant.

The section in the valley of Clay Lick Creek is similar to that at Raccoon Furnace. There is, however, a marked difference in the whole thickness of the corresponding rocks, especially on the south side and near the Little Sandy. Section 26, plate G, shows this. A general section of this region would include a coal (thickness not fairly shown) 70 feet below Coal No. 3, and a local bed of ore is shown near the furnace, 50 feet above the "Lower Block ore."

A general section for this region is as follows:

Covered slope.	
Sandstone (hearth rock)	5 feet.
Shale	3 "
"Top-hill" or main block ore.	
Sandstone and shale	35 "
Coal No. 3	3 "
Sandstone and shale	30 "
Rough block ore.	
Sandstone and shales	40 "
Coal No. 2 A; thickness not shown.	
Sandstone and shales	65 "
Grey ore; local so far as known.	
Shales and sandstone	50 "
Lower block ore.	
Shales	45 "
Coal No. 1 in bed of creek below furnace.	

A greater variation from this general section will be found than in the valley of Raccoon Creek.

The valley of Old Town Creek shows a continuation, with some variations, of the geological features already described in this belt of country. The North Fork has its bed in the base of the coal-bearing rocks for nearly its whole length; but as the fall of the stream is less than the dip of the rock, the sub-carboniferous limestone is exposed near the head of this fork, with the limestone ore and the bed of non-plastic fire-clay. The ore is not shown in its usual thickness, as exposed where the limestone is quarried for use at the furnaces. The fire-clay appears at its usual thickness and in its usual place at the base of the coal measure, as in the following section:

Fire-clay, not seen directly over the limestone	4 to 5 feet.
Shales, probably	10 "
Coal stain.	
Shales	2 "
Greenish, irregularly-bedded limestone	6 "
Grey limestone	4 "
Waverly.	

Section 22, plate 7, near Laurel Furnace, with the general section for Buffalo Furnace, gives a good notion of the economic geology of both forks of Old Town Creek. Some openings on North Fork, at various points, show nearly all the constant beds, as given in the general sections for Buffalo Furnace, with the addition of clay-stone ore, as exposed in dark shales near the bed of the creek below the Buffalo Furnace road—a local deposit in the dark shales just above the limestone. At a point a little way up the creek a coarse sandstone occupies the same level. This is probably the representative of the conglomerate sandstone. The sandstone above the lower block ore is characterized by a profusion of plant impressions similar to those noted above the main block at Raccoon Furnace. The ore of the Buck Smith's bank is the upper or main block ore. Coal No. 3 is not opened, but would doubtless be found at the usual distance below this ore. Coal No 1 is not shown to be present in any considerable thickness above the fork of the creek. Near the Little Sandy it is present in workable thickness, as shown at the Hanna bank, just below the mouth of Old Town Creek. It would be found, if present, above the bed of North Fork, for the greater part of its length, as also for some distance on the main creek. What the exact place of the bed is has not been satisfactorily made out. The lower block ore would probably offer the best indication of its location by its quite constant occurrence 40 to 50 feet above this bed. Near Laurel Furnace the economic geology is well shown by section 22. Less has been done to develop the coals than the ores; as is true for all this belt of country. The furnaces being constructed originally for charcoal, and an abundance of timber being found, there is little inducement as yet to incur the expense of opening and testing mineral coals. Little else can be done, therefore, than to point out the place of such beds as are known to hold a somewhat constant place in the series. The sections given by Mr. Moore in his report, with those already given, will seem to indicate the place of these beds, together with such local beds as have been developed.

Lost Creek flows for the greater part of its course in a coarse sandstone—the conglomerate sandstone, which shows at the base of section 22. As the geological features of this valley differ little from those of Old Town Creek, the geological section for that valley would doubtless be repeated here with such variations as usually occur within a limited field. The same is true of Crane Creek, which is separated from Lost Creek by a narrow ridge only. Near the mouth of Lost Creek the conglomerate sandstone rises in cliffs which are characteristic of this formation.

On Everman's Creek the conglomerate sandstone is prominent at many points as a coarse ferruginous sandstone, which will be recognized at once, and can be made serviceable in making out the equivalency of the beds in the hills above. At some points this formation is entirely wanting, or so changed in character as not to be recognized. The sub-conglomerate shales are present, however, as shown by the occurrence of the fire-clay bed, as exposed above the forks of the creek on the Middle Branch, where six feet of non-plastic clay, of fine quality throughout, is shown near the bed of the creek. The top of the limestone appears at a short distance from this exposure at the same level, showing that the fire-clay is separated from the sub-carboniferous rocks by only a few feet of rock. Section 28, plate 8, gives the general arrangement of the rocks in the lower part of the hills. Nearly the same order is shown at Mr. Kibby's and at Elwood's opening of Coal No. 2 on Barrett's Creek. These, with the "Potato Hill" section on Tygert's Creek, already given, and following section from the observations of Mr. Moore, furnish a key to the economic geology of this region:

STEWART SECTION.

Clay shales.	
Stewart ore (main block).	
Slope	65 feet.
Block ore.	
Slope	165 "
Thin coal.	
Slope (shales)	45 "
Conglomerate sandstone	30 "
Non-plastic fire-clay	6 "
Covered (shales)	15 "
Limestone.	

Coal No. 3 would doubtless be found a short distance below the main block ore, or about 240 feet above the conglomerate sandstone, over all this region. The thickness and value of the bed of coal can be determined only by trial. It is probable that it will be found in workable thickness, as at other points along this belt of country.

The valley of Barrett's Creek presents geological features which are easily comparable to those of Everman's Creek, yet changes are introduced which give to it a geology in some respects peculiar to itself. The absence or slight development of conglomerate sandstone is notable in the topography of this region, and this becomes an interesting feature when it is remembered that only a little way to the south the conglomerate becomes much more prominent than on Everman's Creek, rising in cliffs from 80 feet to 100 feet high. The question arises whether the absence of the greater part of the conglomerate formation in this valley is real or apparent. At first thought it seems incredible that a formation 100 feet in thickness should almost entirely disappear within a distance of three miles, and that it should become prominent again a little further on; and this might easily lead to the supposition that the change is in the character of the rock rather than in the disappearance of the formation. This supposition seems most natural from the changes known to occur at many points higher up in the coal measures, in the rocks of a given geological level. But in the instance in question, and generally where the conglomerate sandstone is wanting, it is found that the thickness of the formation is reduced to the thickness of the underlying shales, as in the section on Coal Branch, in Greenup. In the absence of the non-plastic fire-clay bed, the sub-conglomerate shales are not, in such instances, readily distinguishable from the shales above. This bed is not exposed, that I can learn, in the valley of Barrett's Creek. The limestone of the sub-carboniferous period rises above drainage in several localities, however, and it is probable that the fire-clay is present in some parts of the valley, and that the lower member of the conglomerate formation has some thickness over the greater part of this region, as it is usually present, unless cut out by the thickened conglomerate sandstone. It is evident, however, that the rocks which properly follow the conglomerate formation in the order of superposition, begin at no considerable distance from the limestone, as shown by the position of Coal No. 1 and the overlying beds.

Mr. Andrews reports in Ohio a number of isolated patches of conglomerate of considerable thickness, which thin out in all directions, until no trace is left of the formation, showing an inequality much greater than is found in this field. With respect to the overlying rocks, however, the instances mentioned in Ohio do not furnish an exact parallel; for, in this section, the order of the beds above is generally preserved, notwithstanding the inequalities of the top of the conglomerate sandstone. Coal No. 1, so far as known, is in no instance interrupted by the thickening of the conglomerate; nor does the thickness of the shales below Coal No. 1 appear to be increased by the disappearance of the conglomerate, beyond what follows from the union with the shales below. The general section of this region does not, therefore, necessarily differ materially from that of Everman's Creek, or from that of the Sinking Creeks, as regards the rocks above the conglomerate. Section 23, plate 7 (above Bull's Eye Spring), shows three coals and the main block ore. A comparison of this section with the sections on Everman's Creek shows little variation in the whole thickness of the rocks included to the main block ore.

Coal No. 3 is here a cannel coal, or part cannel; but this fact does not present any serious objections to the reference of this bed to Coal No. 3, which is usually a bituminous coal. Instances of a change of the whole or a part of a bed from the one to the other are not uncommon, as will be seen from a statement further on of the number of coals known to be, wholly or in part, cannel at some point or points. A section at Bull's Eye Spring shows a block ore 20 feet to 25 feet above the limestone, followed by shales mostly, to a block ore 40 feet higher up. A coal stain is shown still above. At Mr. Lewis's and on Stand Branch, Coal No. 2 is about 90 feet above the drainage, and about three feet thick. The identification of these coals is not so perfect as might be wished. I have referred them to Coal No. 2 as the most probable solution of the question of equivalency from what is known of the geology of this region. But it must be acknowledged that the evidences on which this reference is based are not entirely satisfactory, from the exceptional characters which appear in these valleys. It is evident that the dip of the rocks to the eastward is considerably greater than the fall of the creek from Bull's Eye Spring to the Little Sandy.

Coal No. 1 occurs near the bed of the Little Sandy, opposite Grayson, apparently not in such thickness as to be workable. Two coals follow in the order given by Mr. Lesley. (Volume IV, page 459.) The upper one, which is of workable thickness, may be the equivalent of Coal No. 3, though this would involve a considerable shortening of the section in this region, as compared with Everman's Creek section, and as compared with section 23, plate 7. At Grayson, and extending around into the valley of Bennett's Creek, a band of sandstone, five to six feet thick, is found, which makes a fine building stone. It is exposed around the foot of the hill, about 40 to 50 feet above the bed of Little Sandy, on the west side only, rising with the other rocks to the westward. It abounds in well-preserved impressions of stigmariæ. A coal stain shows directly above this rock. A similar bed has been noted at many points; west and north, frequently with a coal stain immediately above, as in the road just above Argilite Mill. It is not probable that this similarity may be accepted as sufficient evidence of equivalency, however, though such a bed, extending over a considerable field, would aid very much in making out the true stratification of the country. I have not found, in the country west of the Little Sandy, any bed of rock that is persistent both in character and place over an extended range of country; and, indeed, of some the beds of coal and of ore the same may be said with respect to place; for although, throughout the whole belt of country, there is such an arrangement of beds as to make the general section an approximate guide for the whole area, yet it is by no means probable that all the beds are continuous at precisely the same geological level. This remark is especially applicable to Coals 2 and 2 A, which are less constant in position than the other beds.

Coal No. 1 is less variable and more easily identified, but it is not so regular in its place and in its relation to other beds as to be always identified with certainty. Coal No. 3, on the other hand, holds a place so uniform in the series, that it may be traced with ease over most of the region, and may be confidently relied on as a guide or base from which the beds above and below may be determined.

Southward from Barrett's Creek the conglomerate immediately attains a thickness which makes it a very important feature of the country. The great body of this formation begins in the Little Sandy valley, with the masses of coarse sand rock exposed in Little Sinking; the detached masses noticed on Everman's Creek, and other branches of the Little Sandy, being outlying masses only, along the northern border of the formation and along the eastern border of the narrow northward extension of the conglomerate in the Tygert's Creek valley. The cliffs of the Sinking Creeks and of Clifty Creek rise to such a height as to reduce somewhat the thickness of the coal-bearing rocks in the country drained by those creeks. Near the Little Sandy, where the greater part of the formation is below drainage, the hills include Coal No. 3 and the main block ore. The rest of the section is not shown as completely as on Barrett's Creek; but Coal No. 1 is present along the Little Sandy west of the river, and would doubtless be found generally through this region. The stain has been noticed in the divide between Tygert's Creek and Sinking Creek. At the head of Dry Branch of Little Sinking, on the place of Mr. James, the following section is shown:

Coal toward the top of the hill, thickness not shown.		
Sandstone and shales about	90	feet.
Coal	2½	"
Shales and sandstone	35	"
Coarse sandstone	25	"

Some ores were found still lower in shales. On the Pleasant Valley side a similar ore is found on Mr. Harris's place, near the house, 25 to 30 feet above the top of the conglomerate, which is little more than 30 feet thick at this point. One hundred and eighty feet up from this ore is a blue, somewhat silicious limestone, similar to a band noted on a high point at Thompson bank, Kenton Furnace. This rock has been noted at the head of Long Branch of Everman's Creek, at about the same geological level, and at a few other points. It is less prominent, however, than in Ohio, as described by Mr. Andrews. The second coal in the section at Mr. James's is reported as cannel, or part cannel. It was covered at the time so as not to show its thickness and character. In section 24, plate 7, a cannel coal is shown, opened near the top of the hill, which is probably the same bed, and the equivalent of the Barrett's Creek cannel coal, or No. 3 Coal. This reference is made from evidence that is not altogether satisfactory. Near the same point, however, a thin cannel coal was opened lower down, and a thin coal in bituminous slate is shown just above the top of the conglomerate. The hills in this region generally include these beds, and doubtless the ores at the base of the general sections, while the highest hills would probably include the main block ore. The section up to that ore is considerably shortened in this region. The conglomerate formation is in some of its layers a true conglomerate, otherwise it is a very coarse-grained, somewhat ferruginous sandstone throughout. Cross-stratification, as mentioned in other localities, is very strongly marked on the faces of the cliffs as exposed along the creeks from the west. The direction of the inclination of this cross-bedding is very uniformly to the southeast. To this I have observed no important exception in this region. Nearer the Big Sandy, in Lawrence county, there is less uniformity in this respect, though this is still the predominating direction.

East of the Little Sandy, in this region, the branches are comparatively short, resembling somewhat in this respect the Tygert's Creek valley; and the ridge which extends down to the first considerable branch from the eastward includes about 100 feet more of the coal-measure rocks than those to the west, or to the "ferriferous limestone,"* which, like the sub-carboniferous limestone, has at the top a band of ore—"limestone ore," as known in this region. The ferriferous limestone varies in thickness, when present, from one to eight feet. It is entirely wanting over a large part of the field where its horizon is above drainage. The ore is not limited to the area of the limestone, however. It continues to mark the place of the limestone over a considerable additional area, where it is easily recognized from its constant character.

East of the Little Sandy river the conglomerate is not found above the drainage, except at points close to the river. Coal No. 1 is near the creek bed in the valleys of both Deer and Wolf Creeks. In the former the following section is shown near Mr. McDavid's:

Sandstone	15 feet.
Thin coal.	
Shale and sandstone	10 "
Cannel and bituminous coal	2 "
Sandstone and shale, about	90 "
Coal, with nodules of ore above in shales	3 "
Shales, including a calcareous band and thin coal	50 "
Bedded coarse sandstone (top of conglomerate).	

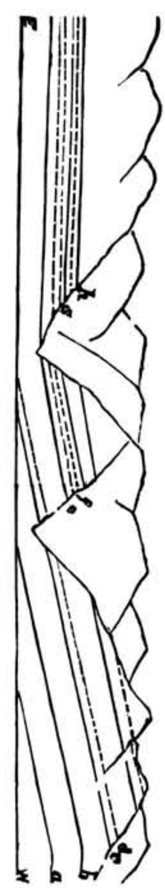
Section 33, plate 9, at Mr. Ball's, on Wolf Creek, shows Coal No. 3 and the main block ore, and a high point in the divide between these creeks and Little Fork includes the limestone ore, as in the following section:

Covered slope	10 feet.
"Limestone ore."	
Shaly rock	15 "
Coarse sandstone (cliff)	20 "
Slope of hill	300 "

Coal No. 5 would probably be found immediately under the coarse sandstone which caps most of the points of this dividing ridge, as it is present in considerable thickness in the valley of Little Fork. The distance from Coal No. 3 to the limestone ore in this region is from 110 to 125 feet. The whole thick-

*This limestone, which marks a distant horizon, both in Eastern Kentucky and in Ohio, along the opposite side of the river, has come to be known as the ferriferous limestone from the nomenclature of Mr. Andrews; and as this term is unobjectionable, and in some sense descriptive, it will be used in this report.

ness from Coal No. 1 to the limestone ore is about 320 feet. Coal No. 4 is wanting in this region, or so covered as to give no indication of its presence. The lower block ore has not been opened, though it would probably be found at its proper geological level. The beds which recur in the western slope of the ridge are, therefore, Coal No. 1, the lower block ore? Coal No. 2, here part cannel, Coal No. 3, the main block ore, and Coal No. 5—some of the highest points including the "limestone ore." To the northward this ridge runs across the general line of outcrop to the westward, and therefore includes less of the rocks above Coal No. 3. North of the mouth of Little Fork, however, the western slope of the Little Sandy valley includes more of the beds above; the river, by an eastward bend, recrossing the line of outcrop.



a. Coal No. 1. *b.* Coal No. 2. *c.* Coal No. 3. *d.* Block ore.
e. Coal No. 5. *f.* Limestone and kidney ores. *g.* Coal No. 7. *h.* Coal No. 8.

The Little Fork of Little Sandy, and its tributaries, drain a large tract of country which lies between the ridge just considered and the range of hills that form the divide between Little Fork and the waters of Blaine, and of East Fork of Little Sandy. From the top of the ridge on the west, to the center of the basin formed by the two ridges, the dip of the rocks is more marked than elsewhere on the Little Sandy, and this is especially true at Willard, where such a depression of the rocks of the whole series occurs as to form a well-defined geological basin.

The annexed diagram represents approximately the depression of the coal-measure rocks along a line eastward from Graham Hill, through the hills between Lost Fork and Bell's Trace. A section along a north and south line, intersecting this on Dry Fork, would also show a depression, the lowest point of which would be near the intersection of the two lines, the greatest dip being northward to that point. The coals and ores on Little Fork, and in the Willard and Dry Fork region, have been so generally developed as to afford a key to the mineral resources of the surrounding country. The beds that are known to be present in some parts of this region are shown in sections on plate 26, and sections 38, 39, and 40, plate 11. The formations exposed on the branches of Little Fork from the westward are included between the "limestone ore" and Coal No. 1, though the varying dip and the windings of the valley give considerable variation to the sections on the different branches. John's Run and Muddy Branch show the whole series, while Hilton's Branch cuts through only the upper part of this series. Field Branch and Huff's Run probably show only the middle part of the series, including Coal No. 5, Coal No. 2, and the intermediate beds. The hills between Little Fork and Dry Fork, in Carter county, include the beds between Coals 5 and 8, with overlying rocks, which belong to the Mahoning sandstone period. Southward, in Lawrence county, the dip changes to the north, as previously described, so that the hills include the lower beds up to and above the "limestone ore." A line drawn from the mouth of Cane Fork of Dry Fork to a point a little south of Louisa will mark very nearly the origin of the rapid rise of the rocks to the southward. At the head of Dry Fork the rocks below Coal No. 3 appear to be somewhat reduced in thickness. A section at Mr. Hensley's is as follows:

Top of point.	
Covered slope	106 feet.
Impure limestone (yellow lime)	3 "
Shaly rock	25 "
Small kidneys of ore in greenish shale.	
Covered (shales and sandstone)	50 "
"Limestone ore"—abundant.	
Mostly sandstone	100 "
Shales (place of Coal No. 3).	
Sandstone (mostly with shale at base)	180 "
Coal No. 1 near bed of creek.	
Shales.	

The thickness of rocks between Coal No. 1 and the "limestone ore" is 280 feet. At Graham Hill the thickness is 317 feet. On Big Blaine it is about 250 feet, as will be seen from sections in that valley. Coal No. 3 is shown at the head of Dry Fork, under 15 feet of sandstone, exposed in a cliff or overhanging rock. (Section 6, plate 26.) Coal No. 5 is not seen here, but is shown at the head of Equal Fork on the east side of the divide. (Section 66, plate 18, and near Willard, section 4, plate 26.) It would probably be found generally at a level, varying somewhat from its normal distance of 35 feet below the "limestone ore." Coal No. 7 appears to lose its importance in this direction, though no effort has been made to open the bed in this region. Its presence is shown in section 66, plate 18, along the ridge between Dry Fork and Big Blaine, and it would probably be found in some thickness in all the hills which include the rocks of this geological level.

Cane Fork flows along near the foot of the steep northward dip, having its bed at a lower geological horizon than the branches to the northward, however, from a gentle rise of the rocks to the point from the center of the basin. Little mining has been done on this stream. A section at the mouth (section 2, plate 26) shows the "limestone ore," with a greatly shortened section above, in which the Coals 7 and 8 are apparently wanting or thin. Above the falls Coals 6 and 7 are shown, while a thickening of the sandstone below Coal No. 6 cuts out the "limestone ore." (Section 48, plate 13.) Higher up a coal stain is shown under the second impure fossil limestone,* the place of Coal No. 10, which is a cannel coal further east.

Bell's Trace and Lost Fork are so similar, geologically, that little can be said for the one that is not applicable to the other. Coal No. 7 is above the bed of both valleys for a distance of two or three miles; Coal 8 for four to five miles; and the first impure fossil limestone is shown in the beds of both streams near the head of the valleys, at the foot of the main ridge. Very perfect specimens of characteristic fossils are easily ob-

*Above Coal No. 8, 10 to 25 feet, and 100 to 125 feet higher, with others in the series still above, impure fossil limestones occur over a wide range of territory, varying in thickness, but never more than six or seven feet. I have for convenience called these the 1st, 2d, 3d, and 4th impure limestones. (See section 71, plate 19.) In character the 1st and 2d impure limestone bands vary from a somewhat impure limestone to a fine-grained silicious rock, resembling limestone, and filled with fossils characteristic of the carboniferous period.

tained in both places. On Lost Fork the kidney ores, associated with Coals 7 and 8, are mined, as also at one point the so-called Rough-and-Ready ore, just above the second impure limestone (section 46, plate 13). At the top of a high point on the head of Lost Fork, a third conglomerate sandstone occurs, as shown in section 1, plate 28, nearly 200 feet above the second impure fossil limestone. The pebbles found in the soil at the top of the hills around Willard are derived from this rock. No conglomerate rock has been observed at this geological level at other points in Carter or Boyd counties.

A greater thickness of rock is exposed from the base of the hills west of Willard to the tops of the hills, at the head of Lost Fork and Bell's Trace, than in any other valley in this part of Eastern Kentucky. The combined section shows the entire series, from Coal No. 1 to the highest coal-measure rocks of this field, or a thickness of about 750 feet. An opportunity is offered here, therefore, to verify the stratigraphical determinations for the rest of the field, as shown by profile sections I, II, and III. It will be noticed that this section at Willard so fully corroborates the arrangement of beds, as shown in both the profile sections and the general section, that there is left no room for doubt as to the correctness of the classification as here adopted.

An impression prevails to some extent that Coal 8, as shown in sections 3 and 7, plate 26, is the equivalent of the Coalton coal, rather than the coal next below. A careful comparison of these sections with sections in Boyd county will show the incorrectness of this view. The occurrence of the yellowish, impure limestone, which marks the place of, and which sometimes accompanies the "bastard limestone ore," of Boyd county, and the coarse sandstone (cliffs) above, as shown at many points in both Carter and Boyd, are of themselves conclusive on this point; but the relation to beds below—the kidney ores and the limestone ore—beds which preserve a remarkable uniformity, both in character and in place, puts the question of equivalency beyond a doubt. The bed of coal at the head of Lost Creek, at Mr. Roberts', as well as the Garner Creek coal, is, therefore, the equivalent of the Hatcher coal.

The geological features of Davy Run are similar to those of Lost Creek. The coals exposed are No. 6, which is thin, as at Willard, and Nos. 7 and 8, associated with the kidney ores. The limestone ore is not present in its usual thickness, except, perhaps, towards the mouth. The opening of Mr. Ellwood, on Deal Branch, is probably in Coal 8, and not Coal 7, as was supposed. Coal 3 and the main block ore would probably be found at the mouth of the run, considerably above drainage.

The valley of Straight Creek presents, near Mt. Savage Furnace, the rocks of the series from below Coal 3 to the Mahoning sandstone, with a considerable dip to the southeast. Section 37, plate 11, shows the height above drainage of such beds as are exposed at this point. At the head of the valley, the first impure limestone band is exposed in the bed of a branch, and along the sides of the valley, at a level 50 to 100 feet lower than its place at the furnace. The valuable coals and ores of Mt. Savage Furnace are below this band, and below drainage at the head of the main creek; the dip of the rocks and the fall of the stream tending to place the rocks, which are high up in the hills, at the furnace, below the beds of the branches at the head of the valley. On Lefthand Branch, however, the upper beds are above drainage to the head of the valley. As reported by Mr. Moore, a general section for Mt. Savage would include Coals 3, 4, 5, 6, 7, and 8, with the ores usually associated with these beds. Coal 4 and the main block ore have been noted only on the Stinson Creek side, but would probably be found in the valley of Straight Creek. Coals 5 and 6 have not been worked. Coal 7 is mined at a number of points for local use.

Sections at different points in this region show some considerable departures from the order of the general section, some beds being cut out locally by heavy masses of sand-rock, others occurring at such intervals as to make the classification uncertain in some minor particulars.

Stinson Creek shows, in most particulars, a repetition of the geology of Straight Creek. Much less has been done to develop the resources of this valley. Section 31, plate 9, shows Coal 3 with the main block ore, and near the top of the section Coal 7, associated with the kidney ores; Coal 4, the Stinson Creek cannel, is also present, and no doubt the other beds would be found. The dip of the rocks in this region, as determined by levels run by Mr. Goodwin, is the reverse of that of Straight Creek, or slightly to the northwest. Near the mouth of Stinson, coals were reported by Mr. Jos. Lesley, which no doubt represent Coals 1 and 2.

Wilson's Creek shows some important changes in the rocks exposed on Stinson and Straight Creeks. A heavy mass of sandstone near the head of the creek interrupts some of the regular beds, and makes the equivalency of other beds, especially those below, uncertain. A section near Mt. Savage cribs shows the yellow kidney ore near the top of a low hill. The following is the section at this point:

Slope to top of hill.	
Yellow kidney ore.	
Shales and sandstone	25 to 30 feet.
Sandstone (cliff)	40 "
Covered space	5 to 10 "
Sandstone (cliff)	40 "
Coal, thickness not shown.	
Sandstone and shale	25 to 30 "
Blue block ore—"Wilson blue block"—in bed of creek.	

On the Star Furnace road the following section is shown:

Top of hill.	
Shales, with kidney ore	50 feet.
Covered space, S. S. at base	50 "
Slate ore, with fire-clay.	
Sandstone mostly	55 "
Coal, thickness not shown.	
Sandstone and shales	25 "
Blue block ore in dark shales.	

It is probable that the so-called slate ore is the representative of the limestone ore in this valley, as found at other points; while the blue block ore is more likely to be a local bed, though not far removed from the place of the main block. Towards the mouth of the creek the section is less disguised, and would show the rocks from Coal 2 to the limestone or slate ore. Little has been done to develop the coals in this valley.

Kane Creek, like the preceding, rises in the ridge between the waters of main Little Sandy and of East Fork. This ridge extends along a line nearly north and south from the Lawrence county line to East Fork; and as the average dip is south of east, the rocks which are below the drainage at the head of Straight Creek and of Lost Creek rise towards the tops of the hills along the northern extension of this ridge. This rise is abrupt from the head of Straight Creek to the head of Stinson. At the former place, Coal 7 is below drainage; at the latter, it is well up in the ridge, as seen in section 31. The reverse dip mentioned on Stinson is opposed to this rapid rise, forming an anticlinal, which cuts across the ridge by the direction of its axis, but which does not appear to be continued out into the main valleys on either side. Further north, the general inclination of the surface of the country towards the Ohio will largely account for the gradual disappearance of the upper beds of this region, at the tops of the hills. At the head of Kane Creek Coal 8 is opened near the top of the hill. Section 36, plate 10, shows the beds which are opened in this region. The covered space includes the horizon of several important beds, as will be seen from the general section. Whether they are present in workable thickness is uncertain. The slate ore (L. ore) is shown at a number of places near the head of the valley, while Coal 4, the Hunnewell cannel, becomes prominent to the northward. Section 30, plate 9, near Hunnewell Furnace, shows the economic geology of this region more completely. A fine building stone is exposed 15 feet below Coal 3, which, at this point, is charged with petroleum, and is easily worked before it is hardened by exposure. Nearly the same section is shown at the head of Turkey Lick Creek. The hills at the head of Cannel Branch include Coals 7 and 8, with the accompanying kidney ores, as at the head of Kane Creek. (Section 36.) The dip to the eastward is slight in this valley, and the hills west of Hunnewell include the series from Coal 2 to Coal 6. Near the Little Sandy Coal 1 and the lower block ore would probably be found above drainage. Coal 2 does not appear to be prominent in this region. A thin coal shown in the railroad cut above the machine shops of the Eastern Kentucky Railroad Company is in the place of Coal 2.

The valley of Culp's Creek differs from that of Kane Creek in few particulars. The cannel coal is apparently wanting, though it is found on East Fork, near the mouth of Indian Run. A thin cannel slate marks the place of the cannel coal at one place on the head of Culp's Creek. Section 35, plate 10, shows most of the geological features of this valley. A thin coal is shown immediately under the ferriferous limestone. Section 3, plate 27, near Mrs. Callahan's, and the Pea Ridge section, near Hunnewell, show the same bed. At no place in this region is this coal known to reach a workable thickness. But while it is not of sufficient thickness to be counted as one of the coals of this field, it presents an interesting feature as being the representative on this side of the Ohio of the Nelsonville coal, which Mr. Andrews, of the Ohio Geological Survey, describes as immediately below the ferriferous limestone. It appears from this, that while there is a marked similarity between the arrangement of the beds of Southwestern Ohio and of Eastern Kentucky, the most important beds of coal are not continuous across both fields, as supposed by Mr. Andrews.*

East Fork, along its westward course in Greenup county, presents, in the hills on either side, geological features of which sections 1 and 3, plate 27, give the outline. The heavy sandstone above the ferriferous limestone and ore replaces the shales and coal usually found from 15 to 20 feet above, and in some places the yellow kidney ore, which otherwise catches in the tops of the hills east of the mouth of Ash Creek. Near the mouth of Indian Creek the cannel coal (No. 4) is opened about 40 feet above the bed of the creek, and the limestone ore is found under the sandstone cliffs nearly 100 feet above,

* The identification of the Coalton coal (No. 7) as the equivalent of the coal below the ferriferous limestone in Ohio by Mr. Andrews, report of 1870, page 211, was incorrect, as will be seen from the numerous sections which include the rocks of this geological level. The ferriferous limestone, when present, is quite uniformly 60 feet below the Coalton coal. Mr. Andrews was misled by assuming that the coal 20 feet below railroad grade, at Summit Station, is the same as the Coalton, or the same as the Eastham coal, it being in fact a much lower bed, or Coal 5 of this report, about 35 feet below the ferriferous limestone.

with "rolls" of the ferriferous limestone. The section on Ash Creek, near old Steam Furnace, shows the kidney ores and Coal 7 above in the top of the hill. (Section 34, plate 10.) Nearly the same rocks are shown at old Caroline Furnace, and on Chinn's Branch (section 33, plate 10), though the hills are not high enough to include Coal 7. The cannel coal has not been found on Ash Creek or on Pond Run, but it is present in good workable thickness on Chinn's Branch, at the level indicated by section 33.* In the valley of Yewland's Creek the hills include no important beds above Coal No. 3 and the main block ore, and near the Ohio a heavy sandrock replaces the latter. (Section 6, plate 27.) Coal No. 3 is opened in the hill between Deer Hill Branch and Hood Run, on the road to Riverton and Greenup.

From the ridge, between the waters of the main Little Sandy and of East Fork, the dip to the eastward is more marked to the center of Williams' Creek valley than in the belt of country to the west. Eastward, from the northern extension of the line of this ridge to the Ohio, the dip of the rocks is apparently a continuation of that from the west, as in profile section No. 1. A geological ridge extends eastward along the head waters of Hood Creek to Summit Station, on the eastern division of the Lexington and Big Sandy Railroad, and to the head waters of Keys' Creek, changing the inclination of the rocks exposed on either side northward toward the Ohio river, and southward for a short distance to the valley of East Fork and of Shope's Creek. From a point about two miles east of old Caroline Furnace to the eastern border of the "Flat Woods"† country, very little change of level takes

*The mines of the Maysville Company were abandoned at the time this region was visited, but work has since been resumed, and the increased thickness of the bed, as recently discovered, promises a large supply of this well-known coal.

†A section of country around Bellefont Furnace, and back of Ashland, which is characterized by low, flat hills, is known as the Flat Woods. The tops of these low hills, which are less than half the height of the surrounding hills, appear at a distance to form the bed of a basin. A great number of water-worn pebbles and boulders are found scattered over the whole region. These pebbles are evidently derived from the rocks of this region, being of quartzose rock or of sandstone slightly modified by the action of water. There is apparently no evidence of glacial action in the shaping and distribution of these pebbles and boulders. They are not limited strictly to the Flat Woods hills, but are also found at about the same height several miles above the mouth of the Big Sandy, thus connecting both the Ohio and the Big Sandy with this phenomenon. A collection of the pebbles has been made for the State collection.

place in the beds as exposed along the river. Sections 49 and 50, plate 13, show the essential features of the geology of this belt of country. The low hills of the Flat Woods include the ferriferous limestone and Coal No. 6 only at the top, as shown in the profile section. The higher hills around the Flat Woods include the beds up to the Mahoning sandstone, as in section 1, plate 25. An isolated hill in the bend of the river includes the rocks equivalent to those of this section; but all efforts to find the coals which give to this horizon its special interest seem to have failed. It is not unlikely that the thickening of the sand rock above Coal No. 6 has changed the section, so that Coal No. 7 may not be present in its full thickness; and it is possible, also, that Coal No. 6 may have lost its importance at this point; but the supposition is a contradiction of all the probabilities of the case, as drawn from the sections shown on all sides. This hill is at a point where the northward inclination of the formation is modified by the rapid eastward dip of the Big Sandy valley, and, therefore, the height above the river of these beds is not indicated by the opening of Coal No. 6 around Ashland, but rather by the openings at Sheridan. Hood Creek and its tributaries flow down from the geological ridge described above; and, therefore, though the hills along the head of the creek are much higher than those along the river, the rocks exposed near the top of the hill are of the same geological level as those shown in section 1, plate 25, and section 54, plate 15: the shale series containing the kidney ores and Coal 7 (and Coal 8, where that is present) being near the top of the hill.

The western slope of the Williams' Creek valley presents a similar geological field. The shale series, with Coals 7 and 8, and the associated kidney ores, is near the top of the ridge, capped by a massive sandstone at the highest points. Along Williams' Creek, as at Coalton and Rush Station, this series begins 30 to 40 feet above the bed of the creek; Coal 7, the main Coalton seam, being about 90 feet above the creek bottom. Section 42, plate 12, shows the geology of Brush Creek, the fall of the stream being about the same as the dip; so that, with some allowance for local variations, the section stands for the whole valley. On Straight Creek and Furnace Branch, the beds shown in section 51, plate 14, and section 7, plate 29, are found. Coal 3 is exposed on Williams' Creek below the mouth of Straight Creek. The coals of this region have been mined for local use only, the great body still remaining untouched. A high point between Straight Creek and Mile Branch, and a little more than a mile west of Coalton, shows the second impure fossil limestone, which is so well-marked a feature further south. There it is about 165 feet above the Coalton coal.

Mile Branch and Rachel Branch, and Williams' Creek, above Rush Station, present the same series of rocks, with some changes in character and thickness, as in section 52, plate 9, and section 8, plate 29. The rocks of the same geological level are relatively lower, however, and the hills are capped by a greater thickness of the overlying coarse sandstone. In Boyd county the rocks above the kidney ores are exceedingly variable in character. At some points a massive sandstone (the Mahoning sandstone of Owen) follows the so-called bastard limestone, or the ore which represents it, forming overhanging cliffs, which resemble somewhat the conglomerate sandstone cliffs of Tygert's Creek. At other points a shaly sandstone, or even a shale, continues the series upward from the same point for more than 100 feet. The term "Mahoning" sandstone has, therefore, come to have a very indefinite meaning, as applied to the rocks of this section. I have used the term, without accurate limitation, as applying to the rocks which follow the shale series containing Coals 7 and 8, and which often appear in characteristic ledges and cliffs immediately above this series. In Carter and Boyd these ledges or cliffs vary from 30 to nearly 100 feet; in the latter case, more or less interrupted by shales, with one or more thin beds of coal. Whatever may be the equivalency of these rocks, they form the base of a series which stands in marked contrast with the rocks below, as regards both the number and the value of the beds of coal and of ore included. The continued dip to the eastward, therefore, reduces the thickness above drainage of the most productive measures. Eastward from Williams' Creek the dip is slight. At East Coalton, and at Old Trace, it is only 20 feet lower than at Coalton. At Mr. Kouns', near the mouth of Old Trace, Coal No. 7 is about 40 feet above the bed of East Fork, the fall being less than that of the stream. It occurs in the bed of Ellington's Bear Creek, about a mile from the mouth. These points are along a line nearly east to west, and do not represent the full dip, which is toward the southeast in this region. At Mr. Wm. Davis', Coal No. 7 is below the bed of East Fork, and the rocks which form the steep faces of these hills are those of the so-called Mahoning sandstone, between two heavy layers of which Coal 9 occurs, as at the head of Lost Creek. Compare section 3, plate 28, with section 7, plate 26.

At Mr. McBrayer's bank, on Four Mile Creek, a section of the hill (section 2, plate 30) shows Coal No. 7 10 to 15 feet above the bed of the creek, with Coal 8 shown as a stain only, followed by the "Bastard limestone," here a yellowish, impure limestone, as in Lawrence county. The ore above is a local ore, and of little value. On the place of Mr. Kouns, on East Fork, a local ore is opened, which is several feet in thickness. It is a slaty ore, said to have been used at the Buena Vista Furnace. The following section shows the place of this bed:

Covered slope.		
Slaty ore (local bed)	2½	feet.
Sandstone and shale	20	"
Heavy sandstone	25	"
Coal (No. 7)	3½	"
Shales with bands of sandstone	25	"
Kidney ore.		
Shales and sandstone	20 to 25	"
Coal (No. 6), thickness not shown.		
Fire-clay.		

In this region, Coal 7 is immediately under a thick-bedded sandstone as in this section, and the so-called red kidney ore above is generally wanting, though at some points, as near the school-house above Mr. Kouns', a few large "blue" kidneys are imbedded with the thin layers at the top of the ledge.

Garner Creek flows for the greater part of its length in rocks of the same geological level. Section 60, plate 16, on

Pigeon Roost Branch, shows Coal 8 with its usual surroundings. The opening here shows 4 feet of good coal, 10 to 15 feet above the branch. The Coalton seam is below the drainage. Section 9, plate 28, near Mr. Pritchard's, also shows Coal 8, with a coarse sandstone cliff above, resting on the usual band of impure limestone.

Bolt's Fork presents the rocks still higher in the series, Coal 8 having fallen below drainage. At Sandy Furnace, the first impure fossil limestone band is exposed in the bed of the creek. Section 7, plate 28, includes also the second fossil limestone, with the Rough-and-Ready ore above and a thin coal below, the representative of Coal 10. Coal 9 would probably be found thick enough for local use. Towards the mouth of Bolt's Fork the rocks fall below the drainage, so that at the mouth the second fossil limestone is only 55 feet above East Fork. No trace of coal is seen with this band at this point.

East Fork above runs nearly parallel with Bolt's Fork, and the same series of rocks is exposed along the valley, except that, near the head, Coal 8 rises above the bed of the fork. (Section 65, plate 18, at Mr. Webb's). Of the branches of East Fork from the east, only Shope's Creek and Marsh's Run present a considerable thickness of the more productive coal-measure rocks. (Sections 4, 5, and 7, plate 25, and section 62, plate 17.) These streams flow in the geological basin formed by the depression of the rocks south of the geological ridge already described. Sections 55 and 56, plate 15, at Summit Station, and on Shope's Creek, show a rapid dip to the south—70 feet—in a little less than two miles. From Tunnel Station, on the other hand, to the valley of East Fork and Shope's Creek, a dip to the northward of 50 feet is found in about the same distance. To the eastward, along both Shope's Creek and Marsh's Run, the rise of the beds of the creeks gradually leaves the rocks of the series below the Mahoning sandstone, below the drainage, though a slight rise of these rocks is shown along Shope's Creek towards the ridge which forms the western boundary of the Big Sandy valley. Toward the head of all the branches of East Fork which rise in this ridge, the same western inclination is observed. Laurel Creek flows in the upper part of the series below the Mahoning sandstone, cutting through the horizons of Coals Nos. 7 and 8. Little is known of the coals in this valley, except the fact of their presence. On Ellington Bear Creek, except the coal shown in the bed of the creek near the school-house, no beds are exposed above drainage. Coal 8 appears to be wanting in this valley, though very likely it might be found above the sandstone which extends along the creek in a ledge, which resembles very much the heavy sandstone over Coal 7, in the East Fork region.

The streams which flow into the Big Sandy from the ridge on the west cut through rocks which present, in the different sections, geological features quite contradictory in details, but which, nevertheless, belong to one and the same series of rocks. The dip from this ridge to the center of the valley, like that along most of the eastward-flowing streams, is uninterrupted, though such variations in the steepness occur as to give to the rocks of the same geological level, as exposed along the Big Sandy, undulations which are well-defined from the river level.

Keys' and Catlett's Creeks belong to this slope, though they empty into the Ohio. The sections on these creeks show more of the productive coal-measure rocks than are exposed further south in Boyd county. These rocks have already been described somewhat in detail. Sections 77, plate 21, and 81, plate 22, show both these and the overlying rocks which make up the great body of the hills. The ferriferous limestone is not present in these valleys, and the "limestone ore" is found at one point only—at a cut on the coal railway on Keys' Creek–where it is shown closely adhering to the coarse overlying sandstone. A local recent ore deposit, two and a half feet thick, is found at one point on this creek with well-preserved impressions of leaves and stems of the species of trees now growing on the hills above. It is known as the "Honeycomb ore;" and if found in sufficient quantity, it would no doubt prove a valuable deposit.

With respect to the coals and iron ores, the geology of the Big Sandy valley, for 20 miles from its mouth, does not promise so much as is shown further west. The fall below drainage of nearly all of the beds which collectively make up the resources of the country drained by the Little Sandy, and the predominance of the series which begins with the so-called Mahoning sandstone, sufficiently explains this fact. Shafts sunk along this valley would, however, doubtless reach the lower beds in about the order shown in the general section. Coal No. 7 is above drainage at some points, as shown on Chadwick's Creek, where it is three feet thick, without parting. The character of this coal has led to the opinion generally that it is not the equivalent of the Coalton seam. It is here a bright peacock coal of good quality, but doubtless of less value as a furnace coal than that mined at Coalton; but this does not necessarily affect the question of equivalency, as is shown in the case of the Sheridan coal, which is unmistakably the equivalent of Coal 7. This coal is also regarded by furnace men as quite inferior to the Coalton coal for iron-making purposes. But the Sheridan and Chadwick's Creek coals closely resemble each other in character and general appearance; so much so, that the character of Chadwick's Creek coal becomes an evidence of its equivalency with the Coalton rather than otherwise. The occurrence of the red kidney ore above the Chadwick's Creek coal is also an indication of its place in the series. Some explanation of the closer resemblance of the Chadwick's Creek coal to the Sheridan than to the Coalton may be found in the fact that both are found in a belt of country which is only a prolongation of the western slope of the Big Sandy valley; or, in other words, that they are both found in a geological basin which is distinct from that in which the main Coalton coals are found. This will be seen from what has already been said of the dip of the rocks in the region in question. Section 78, plate 21, at Oakland Furnace, shows the general character of the rocks which make up the hills in this region. At the head of Peterman's Creek a thin coal is shown in the place of Coal 8, and

Coal 7 is also opened near the bed of the creek. A similar section, beginning near the bed of the creek with Coal 8, is shown on White's Creek (section 2, plate 25, and section 82, plate 22), and with such undulations as are marked by the rise and fall of the cliffs along the river, the rocks shown in these sections continue to form the western slope of the Big Sandy to the mouth of the Big Blaine. Sections 83 and 84, plate 22, at the mouth of Bear Creek and of Blaine, and section 79, plate 21, at the head of Bear Creek, show some considerable changes in the character of the rocks; but at the same time they indicate unmistakably the continuation of the series as already described.

The geology of Lawrence county is a continuation of what has been seen in the adjoining counties of Carter and Boyd, with some important changes in the details of the formations exposed. From the northern boundary of Lawrence to a line drawn from Louisa to the head of Jourdan's Fork, the rocks exposed are the same as have been described on East Fork and in the Sandy valley. A slight rise to the southward begins near the county line—a rise that is modified by considerable undulations, especially near the Big Sandy, where Coal 8 is easily traced by openings on both sides of the river, at varying heights above high waters. The shale series which carries Coals 7 and 8, is not so clearly marked in this region as in Boyd; and apparently the former coal loses its importance, appearing only as a thin coal, or entirely wanting in some places. The kidney ores are also less regularly present, though shown at a few points near high water, or near the bed of the creeks. The so-called "red kidney ore" is more commonly represented in Lawrence county, as in the Big Sandy valley in Boyd. This will be seen from an examination of the sections given. Sections 71, plate 19, and 4, plate 28, on Jourdan's Fork of Lost Fork, show most of the characteristic beds in this region. On Long Branch, two miles from the mouth, the first impure fossil limestone is exposed in the bed of the creek. The same bed is exposed on Seed Tick Branch of East Fork, at about the same level. Near the mouth of Long

Branch a coal is opened in the bed of the creek near Mr. Belcher's, from which point a rapid rise to the Falls of Blaine takes place; and apparently, 30 feet higher up, is found at several points another bed under a heavy sandstone, reaching a height of 120 feet above Blaine at the falls, a mile distant, as shown in section 80, plate 21. Neither of these coals exceed 2½ feet in thickness, as exposed; and though openings made for local supplies of fuel seldom show the full thickness of beds, it is not likely, as appears from the best information available, that these beds will prove so valuable as to warrant extensive mining at present. The most important beds of Lawrence county, unlike those of Greenup and Boyd, are lower down in the series, and these are available in this region only by shafts of considerable depth. The continuation of the rise of the whole series to the southward effects, in a short distance, however, what a shaft must do for this region, as will be seen from a brief study of the geology of the country southward on the waters of Big Blaine, and on the smaller branches of the Big Sandy.

In the valley of Thompson's Fork, near the mouth of Peach Orchard Branch, 42 inches of good coal is exposed (section 4, plate 30), at a level which appears to be that of Coal 6. The variation from the typical sections of this country which is exhibited in section 4, and the wide intervals at which the coals are exposed, leave the equivalency of this bed somewhat in doubt. Reasoning from the indications which are gathered from the face of the hill back of Mr. Van Horn's at this point, the reference of this bed to Coal 6 seems most consistent with the facts. The shales above, with the kidney ore, closely resemble the greenish shales which contain Coals 7 and 8, but which are largely replaced by a coarse, friable sandstone. The presence of an ore deposit at the base of the coarse sandstone is a local feature which may prove to be a valuable addition to the mineral wealth of this locality. As exposed, it appears to be a well-defined layer of limonite ore, similar to the block ores lower down in the series, though it is more likely that it is a thickened band of the so-called kidney ore. The section at the Falls of Blaine appears also to begin with Coal 6. On a comparison with the Thompson Fork section, this would seem to be no more than a repetition of that section with thickened parts, the bed of ore and of fire-clay in the latter occupying the place of Coal 8 in the former. This is shown not to be the case, however, by the occurrence of the first impure limestone (yellow limestone in Lawrence county) at the base of the thick sandstone of section 7, as shown along the continuation of the ledge on Long Branch; while on Thompson's Fork the same band is found at the top of the friable sandstone there exposed. Near Mr. McGuire's, three miles below Louisa, the rocks exposed in the river hills recall more nearly the order of the general section. (Section 2, plate 28.) The coals here have been opened only imperfectly, so that little could be seen as to the thickness of the several beds. On Cooksie Fork, at several points, Coal 5 is shown near the bed of the creek, under 25 feet of sandstone. (Plate 31.) Section 72, plate 19, on Crane Branch, just below the Brown place, where coal is exposed as just mentioned, gives a coal stain evidently of the same coal, and an ore that represents the limestone ore. From this point southward along the waters of Big Blaine, the "limestone ore" becomes a regular bed, which, with the ferriferous limestone often present with it, serves, as in Greenup, Carter, and Boyd, to make the identification of beds above and below comparatively easy. On the Twin branches slight traces of the limestone ore are found at the top of the thick sandstone ledge, which, near the head, forms a bench around the hill. Near Jourdan's Mill the same is shown above a coarse sandstone, which reaches in an almost unbroken ledge to the bed of Blaine, 120 feet below. Coal 3, which is very uniformly about 100 feet below the limestone ore, seems to be entirely replaced at this point. On the larger of the Twin branches near the school-house a thin coal is exposed, which is probably No. 3. The same bed is shown at the ford near Mr. Frank Carter's, under a coarse sandstone. At the top of the point on the opposite side, and along the ridge, 100 to 110 feet above this coal, and at the top of a high ledge of whitish coarse sandstone, fragments of the limestone ore are found. At Mr. Burchett's, on Muddy Branch, below Jourdan's Mill, a coal is shown higher up; probably Coal 8. The following is the order of the rocks at that point:

Covered slope.	
Shale	10 feet.
Coal	2 "
Shales, with kidney ore very abundant	8 to 10 "
Coarse sandstone	25 "
Shales with coal stain	10 "
Sandstone	15 "
Covered to bed of branch	45 "

On the opposite hill, 25 feet above the kidney ore, or only a few feet above the place of the coal, the yellow limestone (the first impure limestone) is present in considerable thickness.

On Green Brier Creek, near Mr. Hutchinson's, the "limestone ore" is shown in shales by the roadside, 20 feet above the bed of the creek, and 90 to 100 feet above Blaine. This is the furthest east that I have observed this ore. On Two Mile Creek the stain of Coal 6 is shown near the bed of the creek for nearly the whole length of the stream. Near the schoolhouse, and at Mr. Wellman's, it is partially opened at the roadside. At Louisa the same bed is scarcely above the river bottom. The place of the limestone ore is, therefore, below the drainage in this region, if present. The probability is, however, that it is not present in the immediate valley of the Big Sandy, in Lawrence county, as no trace of it has been discovered, either along the river, where it would be exposed, or southward along Lick Creek, where the rocks of the sandstone series below the limestone ore rapidly rise to form the body of the hills. Some notion of the steepness of the dip, from the head of Lick Creek towards Louisa, may be formed from the fact, that, notwithstanding the fall of the stream, it flows, within a distance of six miles, across rocks which have a thickness of more than 250 feet. The fall of the creek is about 100 feet for this distance. The McHenry coal (No. 3) will therefore be found falling rapidly to the base of the hills northward, disappearing below the bed of the creek, about half way to Louisa. The top of the thick sandstone which rises above Coal 3 nearly 100 feet, is seen in the bed of Lick Creek near the mouth, and it forms the cascade at the bridge across Two Mile Creek below Louisa, and also the Falls of Blaine. From the mouth of Lick Creek, therefore, the formations extend northward, with nearly a horizontal stratification. South of McHenry's bank the dip is not more than 10 feet to the mile. (See sections 86 and 87, plate 24.) The rise of the formations to the southward, in that belt of country which lies west-northwest, to the head of Cane Creek, is nearly as abrupt. On Daniels' Creek the limestone ore is shown 210 feet above the level of Blaine. At Mr. Large's, on Blaine, below the mouth of Daniels' Creek, the following section is shown:

Sandstone cliff near top of hill	20 feet.
Shales with kidney ore	30 "
Limestone ore (on surface).	
Shales and shaly sandstone.	15 to 20 "
Sandstone, with bands of shale (partly covered) to bed of Blaine	215 "

Both the kidney ore and the limestone ore are exposed in the road leading from Daniels' Creek to the Right Fork of Irish Creek, the latter in a bed a foot or more in thickness under fire-clay. A coal is shown in the branch below, which is probably No. 2, being associated with a thin black silicious band which accompanies Coal No. 2 in this region. Towards the head of Blaine from these points the series rises about 10 feet to the mile for the whole distance, though to the mouth of Cherokee the dip is somewhat less. (See sections on plate 25). The highest hills in this region show the first impure limestone (yellow limestone) near the top. At most points, it is shown at the surface in weathered nodules or rounded blocks of yellowish silicious limestone. It is exposed in the road at the top of the hill between Rich Creek and Little Blaine, where it closely resembles the ferriferous limestone, and might mislead as to the place of the limestone ore. On the Rich Creek side this ore is exposed 75 feet lower down, associated with fire-clay, as in Greenup, Carter, and Boyd. The coals are not exposed here; but near Mr. Berry's, on the road to Haw's Mill, the following order is shown:

Kidney ore at surface, near top of hill.	
Shale and sandstone, mostly covered	50 feet.
Limestone ore.	
Shales.	15 "

"Limestone kidney ore."	
Sandstone, shaly in parts	80 feet.
Coal stain (Coal 3).	
Shaly rock	18 "
Slight coal stain (probably local).	
Sandstone, coarse at top, forming cliff	85 "
Coal (not opened) No. 2.	
Sandstone and shales to bed of creek	20 "

The "limestone kidney ore" is the same, both in position and character, as that found in Carter county. It is a grey, somewhat oölitic ore, having a smaller per cent. of iron than the "limestore ore" above; but it is more easily smelted, and is therefore highly prized. Coal 1 is not shown in this section; it would be found 30 feet below the drainage, or about 50 feet below No. 2. The order which is shown in this section is so uniformly preserved over the country drained by the branches of Blaine to the southward, that it is only necessary to point out the place of the ferriferous limestone and ore, and the height above the main drainage, to indicate the economic geology of the several valleys. The "limestone kidney ore" is not always present. It will be noticed that the section is shortened very much, as compared with the same series of rocks in Greenup and Carter. The tendency of the rocks below the ferriferous limestone to thin out towards Lawrence county has been pointed out on a previous page. The fact is well attested on the head waters of Blaine, where all the rocks, from the conglomerate to the ferriferous limestone, are shown in one continuous section, so as to be easily compared with the same series as shown on Deer Creek west of Willard.

On Bushy Creek the ferriferous limestone and ore is shown at a number of places, as in the road over the ridge to the Swetnam settlement, from near the mouth of Bushy, and at the head of Saunders' Branch, 230 to 240 feet above Bushy. On the Blaine side of the ridge it is 10 to 20 feet higher. Along this ridge also the kidney ore, 50 feet above, is regularly present on the surface in such abundance as to indicate a valuable deposit. In quality, this ore is inferior to the limestone ore; but except that it occurs in rounded, kidney-like aggregations, it might easily be mistaken for that ore. No well-attested average could be obtained for analysis. A sample taken from the ore as exposed at the surface gives the following result:

Peroxide of iron	56.778	Iron 39.744
Alumina	.782	
Lime	trace.	
Magnesia	trace.	
Phosphorus	trace.	
Sulphur	.126	
Combined water	10.516	
Insoluble residue	31.280	Silica 25.60
Total	99.482	

An analysis of the limestone ore, from samples similarly obtained, shows the following result:

Peroxide of iron	68.550	Iron 47.985.
Alumina	.380	
Lime	trace.	
Magnesia	trace.	
Phosphorus	trace.	
Sulphur	.175	
Combined water	10.150	
Insoluble residue	20.480	Silica 16.96.
Total	99.735	

Sections 73, 74, and 75, plate 20, will serve to locate both the coals and the ores on Irish, Cherokee, and Kane's Creeks. Near the head of these creeks the height above drainage of the limestone ore would be reduced somewhat. (See sections 66 and 67, plate 18). A gradual rise is shown towards the head of Blaine. At the mouth of Upper Laurel, a rather rough block ore is shown in the place of the lower block ore of Greenup. Sections 68, plate 18, and 90 and 91, plate 24, although they do not show the upper beds, indicate the height above drainage at which they may be found in the neighboring hills. Section 66 shows the normal position of the coals higher up in the series than those which have been opened in this region. The higher hills generally include the rocks of this series; and doubtless some, perhaps all, of the coals shown in this section would be found in such relation to the limestone ore as is here shown. No effort has been made to open these coals, so that little can be said as to the thickness or quality of these beds. They are Nos. 5, 6, and 7, of the general section. The geology of the valley of Little Blaine is similar to that of the region just considered. The details have not been so fully worked out, however, and a fuller report will be deferred to be presented with that of George's Creek and of that part of Lawrence county which lies between the forks of Big Sandy river, which, for reasons already given, will be connected with Martin and Johnson counties in a future report.

GENERAL REMARKS.

The irregularities of the dip of the coal-measure rocks in this part of Kentucky has heretofore been the occasion of a good deal of misapprehension as to the equivalency of the coals, and of the stratification of the country generally. It has, therefore, been necessary to undertake a more careful study of this field than had previously been made: 1st, to make out the real stratification, and to establish from it a natural classification of beds; and 2d, to recognize the dip of the strata, as determining the distribution and also the local position of the beds. The first object has been in a large measure, if not fully, accomplished for this region, giving the true succession of beds in the whole series, and also what is of no less importance, giving a key to the coal measures further back from the Ohio. The second object has also been reached so far as to show the general range of beds, and to point out the most of their irregularities of dip which affect the local position of beds. As the topographical features of this region are more or less related to the facts which have been established in respect to the dip of the rocks, a more connected statement of the varying dip, and its relation to the drainage system of the country, may be found both interesting and useful. The accompanying map diagram will present this so as to be readily understood by every one. The steepness of the dip is represented approximately, and the variation, both in degree of inclination and in direction, is given in sufficient detail for the purpose intended. Many minor variations or undulations of the strata, which occur as waves, both parallel with the dip and interrupting it, are omitted as unimportant. West of Tygert's Creek the inclination of the top of the Waverly is followed. The overlying rocks (sub-carboniferous limestone and coal-measure rocks) would present a less uniform eastward dip, for reasons which have been given in connection with the geology of this valley. East of Tygert's Creek the inclination of the regular beds of coal and ore is represented. It will be seen that the changes in dip in this region are frequent and well-marked, representing local upheavals and depressions which are the accompanying effects of the grander upheavals to the southeast. Few indications of faults or dislocations of strata are found in this region. It is not unlikely, however, that local faults may exist in the regions which present the strongest evidences of disturbing forces.

THICKNESS OF WORKABLE COALS.

Nearly all of the beds of coal which have been found in this part of Eastern Kentucky are, at some points, of a workable thickness; some of them are rarely too thin to be worked profitably. The following table gives a general view of the beds as they appear from what is now known of them. The thickness is such as appears from openings already made. The areas include so much of the country as is within the line of outcrop of each bed. The actual area of the beds above drainage is reduced at least one half by the excavations of the valleys. The area below the main drainage is given as though each bed were continuous throughout, from the line where it falls below the drainage. No sufficient data is available for making up a decided opinion on this point. Quite a number of bored wells have been sunk in this region, but no reliable record has been found of any of them.

TABULAR VIEW OF COALS, &c.

GREENUP COUNTY.

Coals	1	2	3	4	5	6	7	8	9	10	11	Total thickness.
Greatest thickness—inches	36	30	60	50	?	54	36	. .	. .	. .	. .	22 feet.
Ordinary thickness	24	20	36	30	?	36	36	. .	. .	. .	. .	15 feet.
Area of territory—square miles	340	300	215	175	110	60	30	. .	. .	. .	. .	. . . . .
Area below the main drainage	65	47	. .	. .	. .	. .	. .	. .	. .	. .	. .	. . . . .
Average thickness of intervening rocks		90	100	35	100		40	. .	. .	. .	. .	. . . . .
Iron ores included	2	1	1	1	2		1	. .	. .	. .	. .	. . . . .

CARTER COUNTY.

Greatest thickness—inches	50	37	40	?	72	24	60	55	24	. .	. .	30 feet.
Ordinary thickness	30	20	30	?	?	20	36	36	20	. .	. .	16 feet.
Area of territory	360	315	276	270	140	132	76	68	60	. .	. .	. . . . .
Area below drainage	98	85	62	57	49	40	30	13	9	. .	. .	. . . . .
Average thickness of intervening rocks	.	50	100	70		50	43	55	35	. .	. .	. . . . .
Iron ores included	1	1	1	1		2	1	1	. . .	. .	. .	. . . . .

BOYD COUNTY.

Greatest thickness—inches	. .	. .	35	30	40	46	72	48	25	. .	. .	24½ feet.
Average thickness	. .	. .	30	?	28	38	52	30	20	. .	. .	16 feet.
Area of territory	169	169	169	169	169	169	160	158	155	. .	. .	. . . . .
Area below drainage	169	169	160	157	135	100	60	32	25	. .	. .	. . . . .
Average thickness of intervening rocks	. .	. .	30		50	40	40	45	35	. . .	. .	. . . . .
Iron ores included	. .	. .	1	. .		1	1	1	1	1	. .	. . . . .

LAWRENCE COUNTY.

Greatest thickness—inches	36	20	73	. .	84	46	36	40	. .	30	43	34 feet.
Ordinary thickness	30	20	36	. .	36	24	30	36	?	?	?	17½ feet.
Area of territory	386	386	386	. .	386	356	320	285	250	175	140	. . . . .
Area below drainage	210	180	164	. .	80	50	42	25	10	. .	. .	. . . . .
Average thickness of intervening rocks		50	100	65		45	35	40	35	75	45	. . . . .
Iron ores included	. . .		1	. . .		2	. .	1	. .	. .	1	. . . . .

Cannel coals	. .	. .	. .	*	. .	.	. .	. .	. .	*	. .	. . . . .
Beds changed to cannel at some points	. .	*	*	. .	. .	*	. .	*	. .	. .	. .	. . . . .

SOILS.

The soils of Eastern Kentucky are such as might be inferred from the character of the rocks which have been described in the foregoing reports. The soils of the whole region are of medium fertility, varying in character from clayey to sandy loam, with the successive rock formations, as observed in traveling eastward over this region. The distinct character of the soils, as derived from special formations, is rarely preserved, the height of the hills being great enough generally to include two or more distinct formations. The precise relation of the rock formation to the soil is not shown, therefore, either by the characters which appeal to the eye, or by analyses made as a test of fertility. There is, however, a general relation shown by the predominance of successive formations in the valleys eastward from Rowan and Lewis counties. The traveler, passing from west to east over the country, will readily detect the changes in the appearance of the soil, as well as in the topography of the country, as the different formations predominate in the hills along the way. West of the Tygert's Creek valley the Waverly sandstone and shales make up nearly the whole height of the hills, and the soil is readily recognized as derived from the Waverly Group. It is of a light brick color, shaded somewhat with the characteristic olive-green of this formation. The sand is fine, and the proportion of clay is large. The topography of this belt is equally well-marked; the hills rising rather abruptly from the flat creek bottoms in well-rounded knob-like forms. The outcrop of the conglomerate sandstone frequently forms an escarpment at the top of these hills, which, in a general way, marks the base of the coal measures.

In the greater part of the Tygert's Creek valley the subcarboniferous limestone and the conglomerate sandstone give character to the soil; a large proportion of coarse sand being seen in the soil, while an analysis shows an increased proportion of lime, potash, and soda. The outlines of the hills are equally characteristic of these formations, which give rise to the rugged cliffs and the wild scenery of the Tygert's Creek belt.

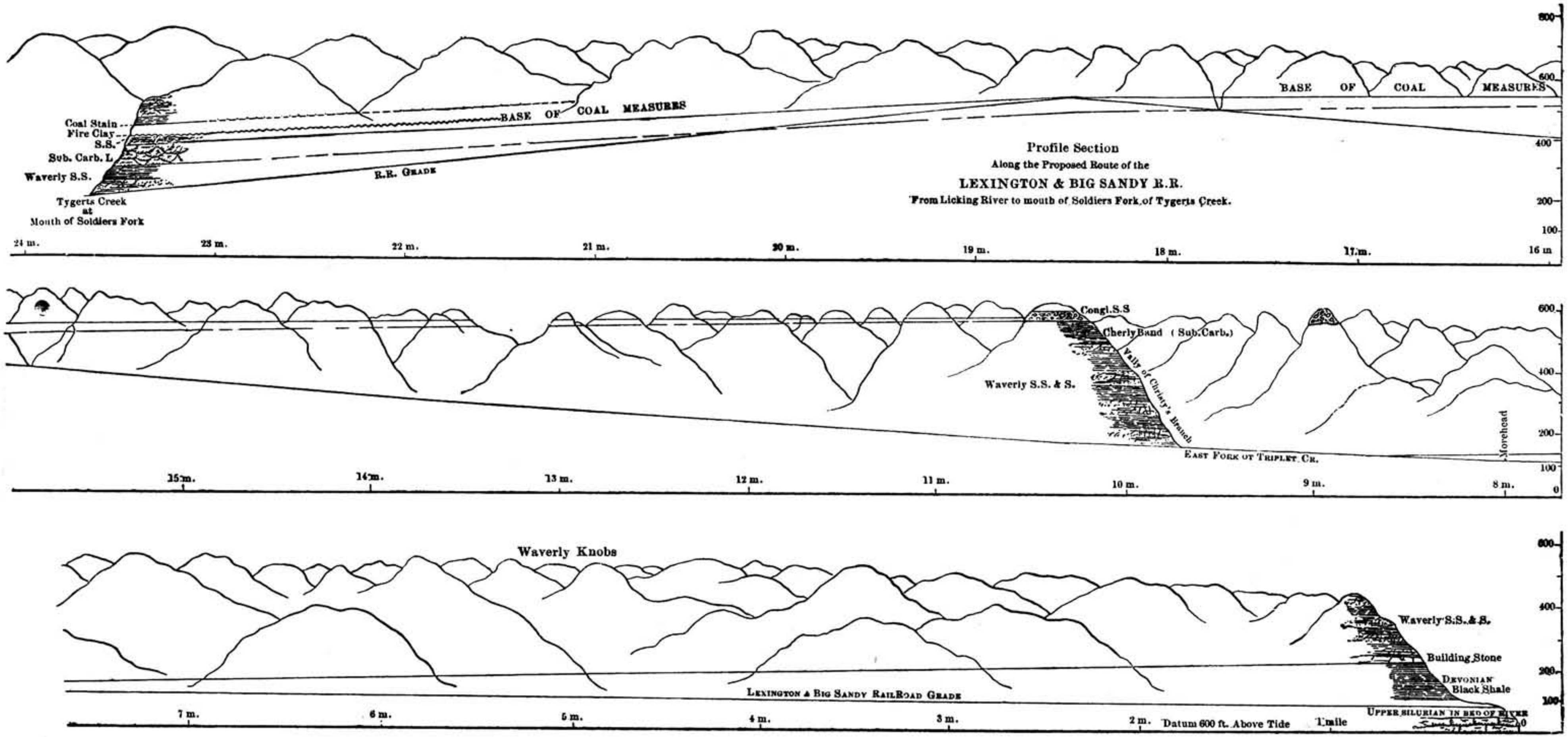
In the Little Sandy valley the soil is derived mostly from the coal-measure rocks, and, except near the head of the river, from the rocks above the conglomerate. The sandstones and shales of the coal measures give rise to sandy or clayey loam, accordingly as the former or the latter predominates in any given section. The shales next above the conglomerate sandstone give a fine clayey loam, as shown at many points in the valley of the Little Sandy, and on the head waters of Blaine and George's Creeks. The sandstone series gives rise to a sandy soil, often deeply colored with oxide of iron, as in the Flat Woods region near Ashland; while the greenish shale series above resembles in its soil the Waverly Group, but with a larger per cent. of iron, as shown by the deeper shade of red.

The Chatterawha or Big Sandy valley, from its geological features, has a larger proportion of coarse sandy soil, though at many points the red and greenish shales above the Mahoning sandstone become prominent, giving rise to a red loam, as seen around Louisa, in Lawrence county.

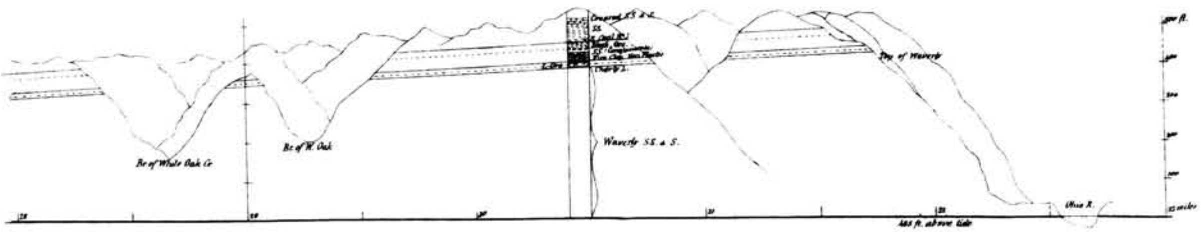
The following table of analyses, by Dr. Peter and Mr. Talbutt, shows the properties of the soil at a number of localities, which may be regarded as representative for the different belts of country, as marked out by the geological features of this region:

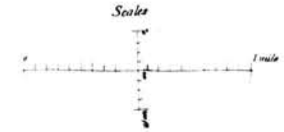
TABLE OF ANALYSES OF SOILS OF EASTERN KENTUCKY.

	West of Garvin's Hill, Carter co. Creek bottom; old field.		*West of Garvin's Hill, Carter county, 55 feet above the creek; old field.*		*West of Garvin's Hill, Carter co., 115 feet above creek; woods.*		*Three miles east of Olive Hill, Carter county. Old pasture; 50 feet above creek.*		*Pea Ridge, Greenup co. Woodland; near top of ridge.*		*Near Cannonsburg, Boyd co. East Fork bottom; old field.*		*Near Cannonsburg, Boyd co. East Fork bottom; woodland.*		*Near Cannonsburg, Boyd co. Hillside; woodland.*	
	WAVERLY FORMATION.		WAVERLY FORMATION.		WAVERLY FORMATION.		SUB-CARB. FORMATION.		HORIZON OF COAL NO. 6.		HORIZON OF COAL NO. 5.		HORIZON OF COAL NO. 5.		HORIZON OF COAL NO. 8.	
	Top soil	Sub-soil.	Top soil	Sub-soil.	Top soil	Sub-soil.	Top soil	Sub-soil.	Top soil	Sub-soil.	Top soil	Sub-soil.	Top soil	Sub-soil.	Top soil	Sub-soil.
Sand and insoluble silicates	89.390	91.215	91.240	91.575	89.515	89.940	91.690	90.515	86.505	84.565	83.765	83.385	90.490	88.420	81.410	83.230
Soluble silicates	.220	.120	.202	.020	....	....	....	.145	....	....	....	....	....	....	....	....
Alumina, oxides iron and manganese	6.115	5.600	4.540	5.890	4.013	5.410	4.777	6.409	6.831	9.595	9.019	9.675	5.091	6.642	7.425	9.984
Carbonate of lime	.245	.220	.145	.080	.109	.109	.880	.680	a trace.	.123	.259	.276	214	.116	.571	.392
Magnesia	.115	.178	.035	.056	.050	.061	.057	.155	.116	.223	.333	.053	.034	.178	.352	.251
Potash	.279	.366	.111	.204	.153	.371	.213	.255	.217	.231	.344	.282	.317	.307	.435	.205
Soda	.286	.048	.157	.131	.032	.046	.132	.151	.055	.097	.027	.176	.076	.099	.045	.050
Phosphoric acid	.076	.086	.125	.163	.147	.163	.093	.076	.089	.115	.150	.161	.134	.083	.208	.191
Sulphuric acid	not est.	not est.	not est.	not est.	.060	.046	....	....	.058	.017	.038	a trace.	a trace.	a trace.	a trace.	a trace.
Organic and volatile matters	3.740	2.200	2.860	2.000	4.685	2.625	2.250	1.815	5.056	4.030	4.915	4.905	3.140	3.085	7.985	5.190
Water	.828	450	.690	.450	.990	.720	.600	.480	1.000	.685	1.235	1.315	.656	525	.915	.500



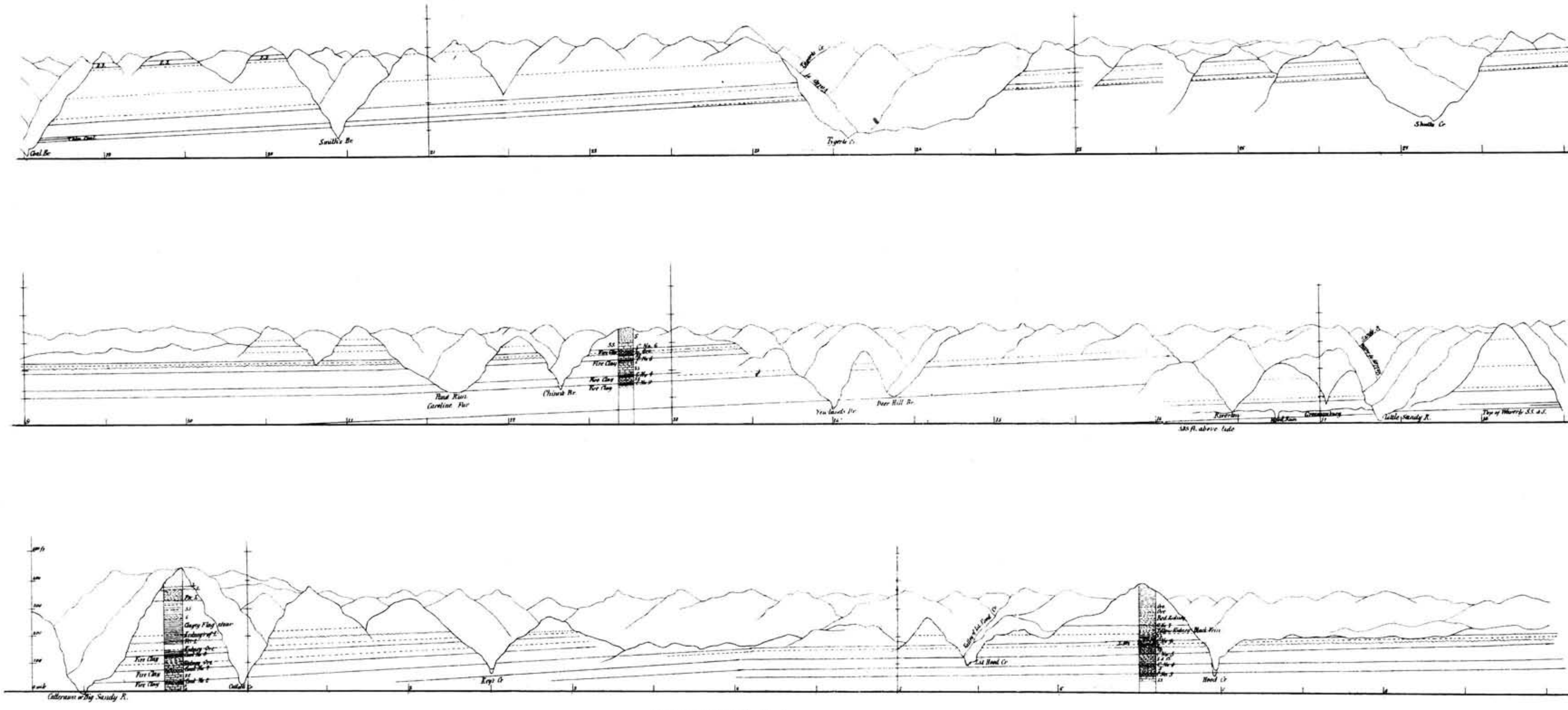
Profile Section
Along the Proposed Route of the
LEXINGTON & BIG SANDY R.R.
From Licking River to mouth of Soldiers Fork of Tygerts Creek.
BASE OF COAL MEASURES
BASE OF COAL MEASURES
Coal Stain
Fire Clay
S.S.
Sub. Carb. L
Waverly S.S.
Tygerts Creek at Mouth of Soldiers Fork
R.R. Grade
24 m.
23 m.
22 m.
21 m.
20 m.
19 m.
18 m.
17 m.
16 m
800
600
400
200
100
Congl. S.S
Cherly Band (Sub. Carb.)
Vally of Christy's Branch
Waverly S.S. & S.
East Fork of Triplet Cr.
Morehead
15 m.
14 m.
13 m.
12 m.
11 m.
10 m.
9 m.
8 m.
600
400
200
100
0
Waverly Knobs
Waverly S.S. & S.
Building Stone
Devonian Black Shale
Upper Silurian in bed of River
Lexington & Big Sandy RailRoad Grade
7 m.
6 m.
5 m.
4 m.
3 m.
2 m.
Datum 600 ft. Above Tide
1 mile
0
600
400
200
100



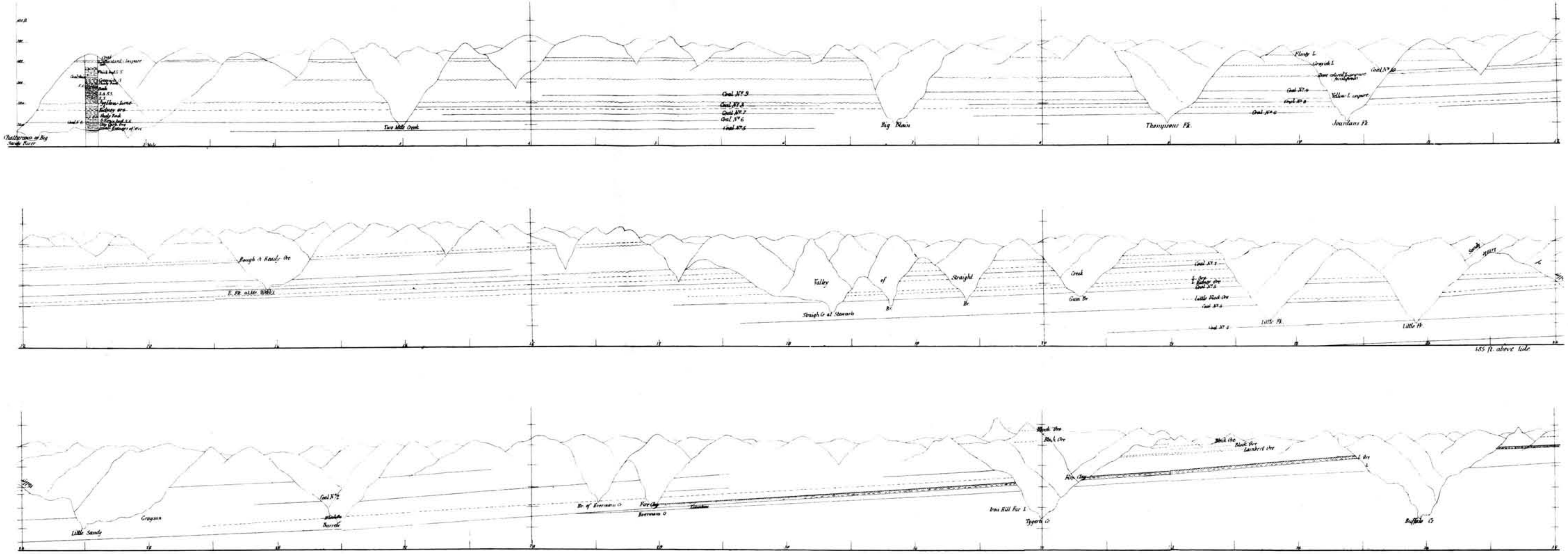


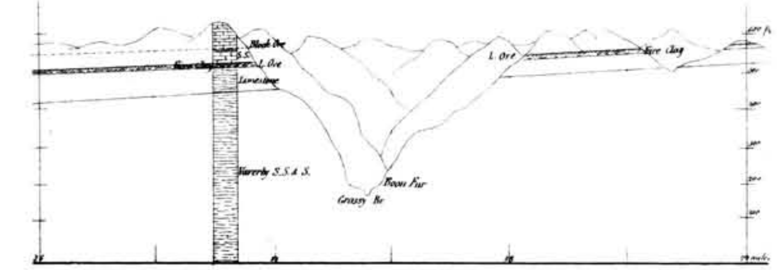
PROFILE SECTION
No. 1.
to accompany the Report
OF A. R. CRANDALL ON
THE GEOLOGY OF GREENUP, CARTER AND BOYD COUNTIES.

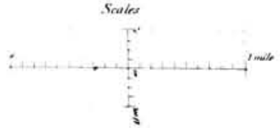
A. Meisel, Lith Boston



PROFILE SECTION No. 1.







PROFILE SECTION

No. 2.

to accompany the Report

OF A. R. CRANDALL ON

THE GEOLOGY OF GREENUP, CARTER AND BOYD COUNTIES.

A. Meisel, Lith. Boston.

GEOLOGICAL SECTION FROM MT. STERLING TO THE CHATTARAWA OR BIG SANDY RIVER

ON THE PROPOSED LINE OF THE ELISABETHTOWN LEXINGTON AND BIG SANDY RAIL ROAD.

Horizontal Scale 500 Ft. to the Inch. – Vertical Scale 500 Ft. to the Inch.

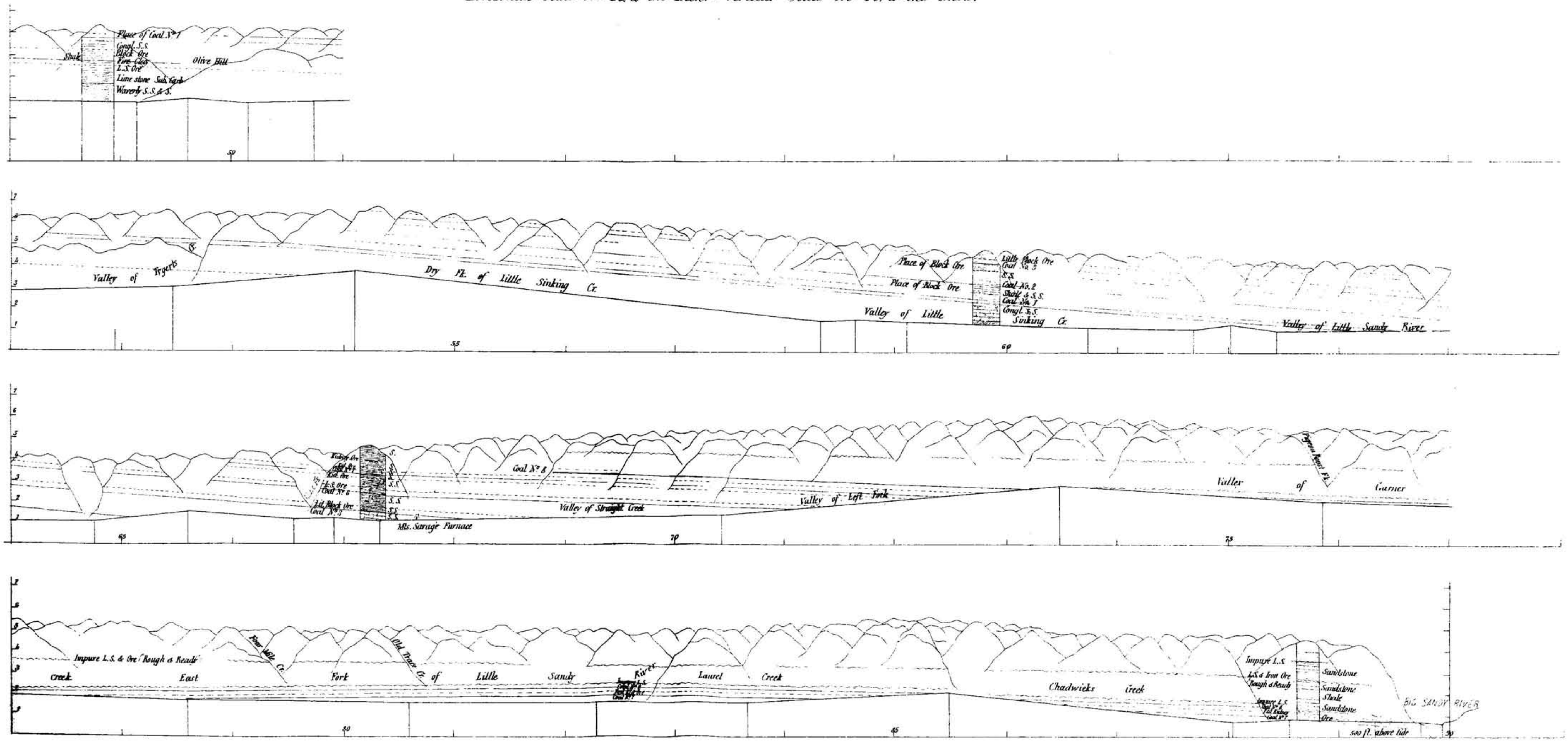


Plate No. 1.

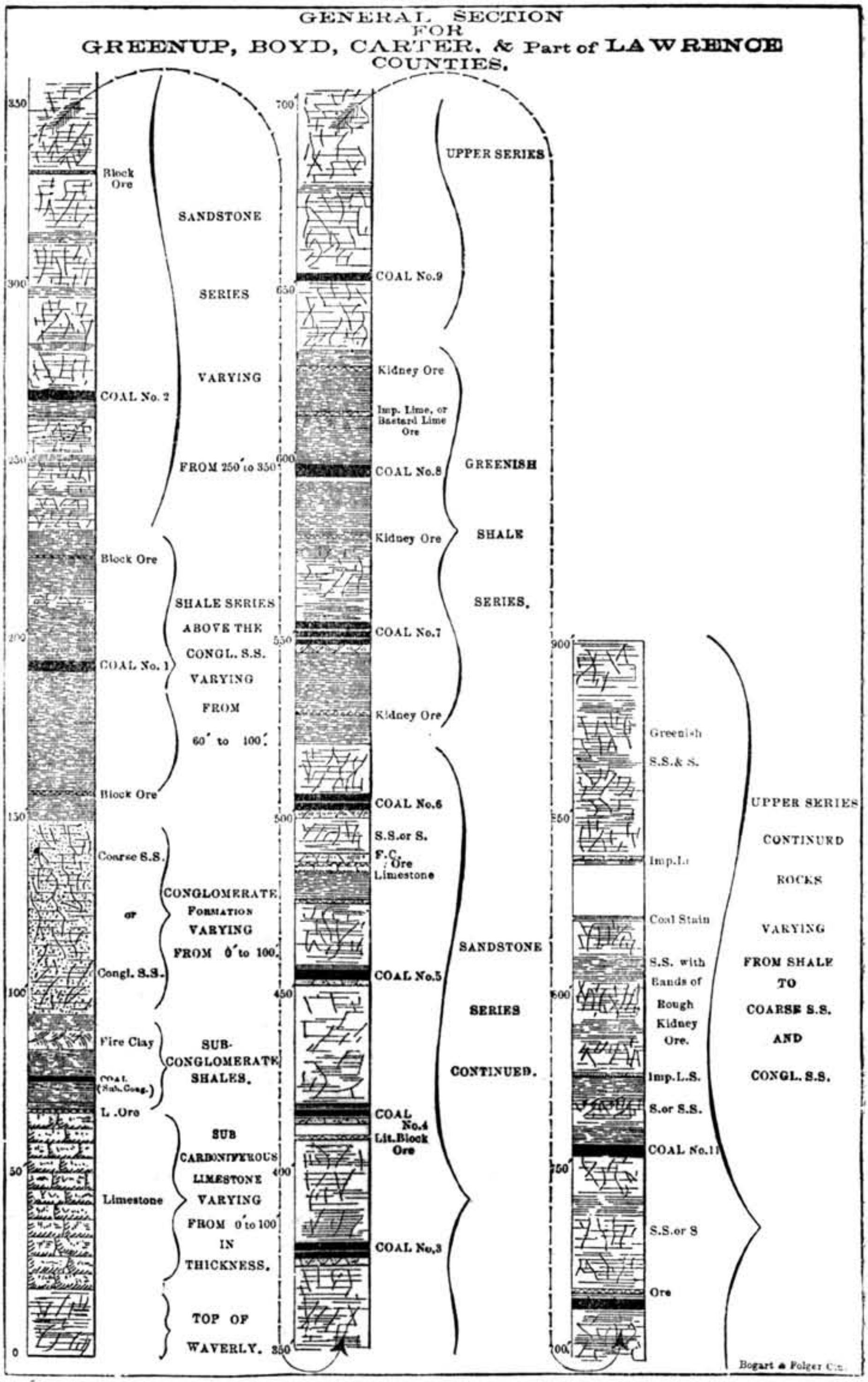
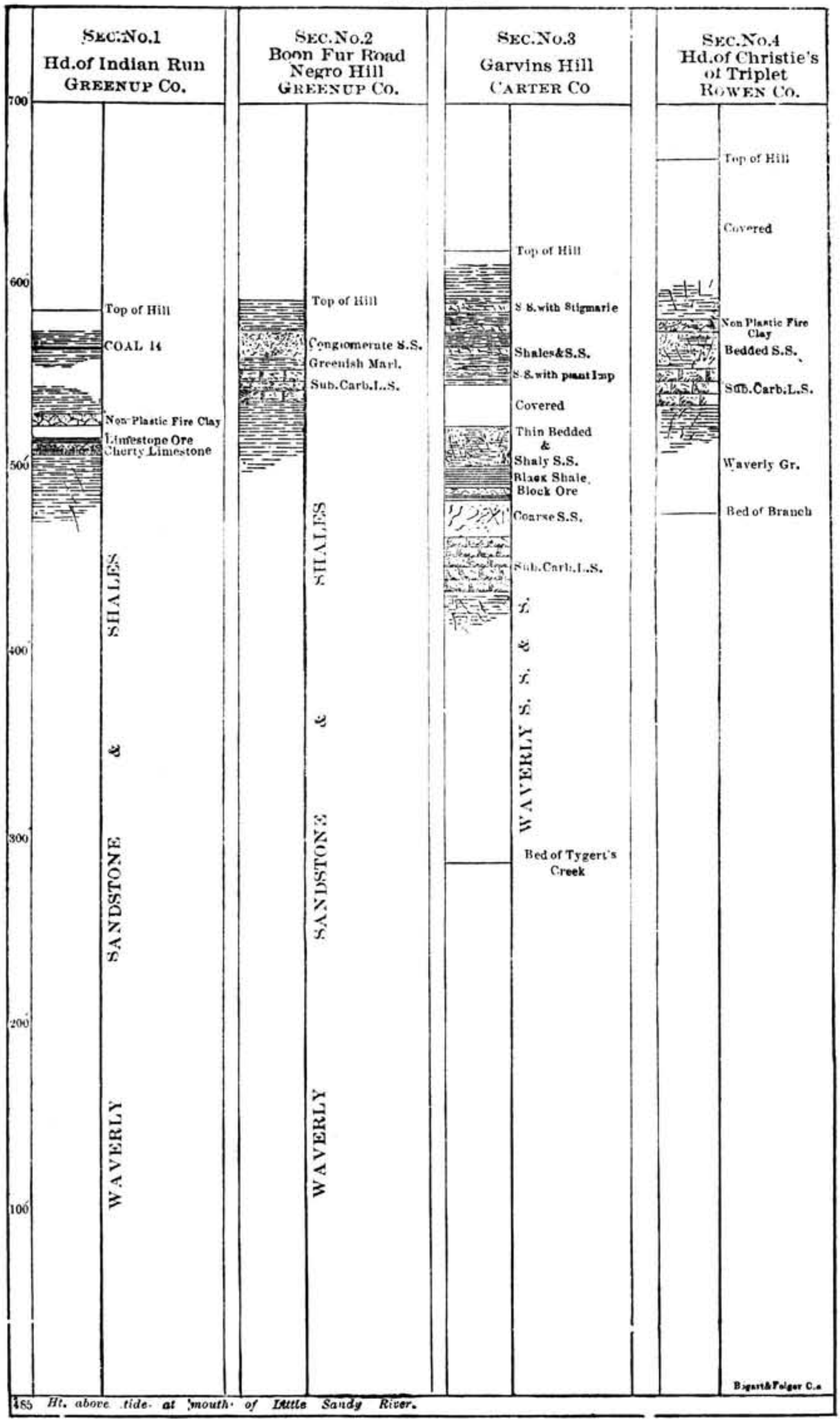

GENERAL SECTION
FOR
GREENUP, BOYD, CARTER, & Part of LAWRENCE
COUNTIES.
350
300
250
200
150
100
50
0
Block Ore
COAL No. 2
Block Ore
COAL No. 1
Block Ore
Coarse S.S.
or
Congl. S.S.
Fire Clay
COAL (Sub. Cong.)
L. Ore
Limestone
SANDSTONE
SERIES
VARYING
FROM 250' to 350'
SHALE SERIES
ABOVE THE
CONGL. S.S.
VARYING
FROM
60' to 100'.
CONGLOMERATE
FORMATION
VARYING
FROM 0' to 100'.
SUB-
CONGLOMERATE
SHALES.
SUB
CARBONIFEROUS
LIMESTONE
VARYING
FROM 0' to 100'
IN
THICKNESS.
TOP OF
WAVERLY.
700
650
600
550
500
450
400
350
COAL No.9
Kidney Ore
Imp. Lime, or Bastard Lime Ore
COAL No.8
Kidney Ore
COAL No.7
Kidney Ore
COAL No.6
S.S. or S.
F.C. Ore
Limestone
COAL No.5
COAL No.4
Lit. Block Ore
COAL No.3
UPPER SERIES
GREENISH
SHALE
SERIES.
SANDSTONE
SERIES
CONTINUED.
900
850
800
750
Greenish S.S. & S.
Imp. L.
Coal Stain
S.S. with Bands of Rough Kidney Ore.
Imp. L.S.
S. or S.S.
COAL No.11
S.S. or S
Ore
UPPER SERIES
CONTINUED
ROCKS
VARYING
FROM SHALE
TO
COARSE S.S.
AND
CONGL. S.S.
Bogart & Folger Cin.

Plate No.2



Sec. No.1
Hd. of Indian Run
Greenup Co.
Sec. No.2
Boon Fur Road
Negro Hill
Greenup Co.
Sec. No.3
Garvins Hill
Carter Co
Sec. No.4
Hd. of Christie's
of Triplet
Rowen Co.
700
600
500
400
300
200
100
485 Ht. above tide at mouth of Little Sandy River.
Top of Hill
COAL 14
Non-Plastic Fire Clay
Limestone Ore
Cherty Limestone
WAVERLY SANDSTONE & SHALES
Top of Hill
Conglomerate S.S.
Greenish Marl.
Sub.Carb.L.S.
WAVERLY SANDSTONE & SHALES
Top of Hill
S S. with Stigmarie
Shales & S.S.
S.S. with plant Imp
Covered
Thin Bedded
&
Shaly S.S.
Black Shale
Block Ore
Coarse S.S.
Sub.Carb.L.S.
WAVERLY S. S. & S.
Bed of Tygert's
Creek
Top of Hill
Covered
Non Plastic Fire
Clay
Bedded S.S.
Sub.Carb.L.S.
Waverly Gr.
Bed of Branch
Bogart & Folger Co.

Plate No.3

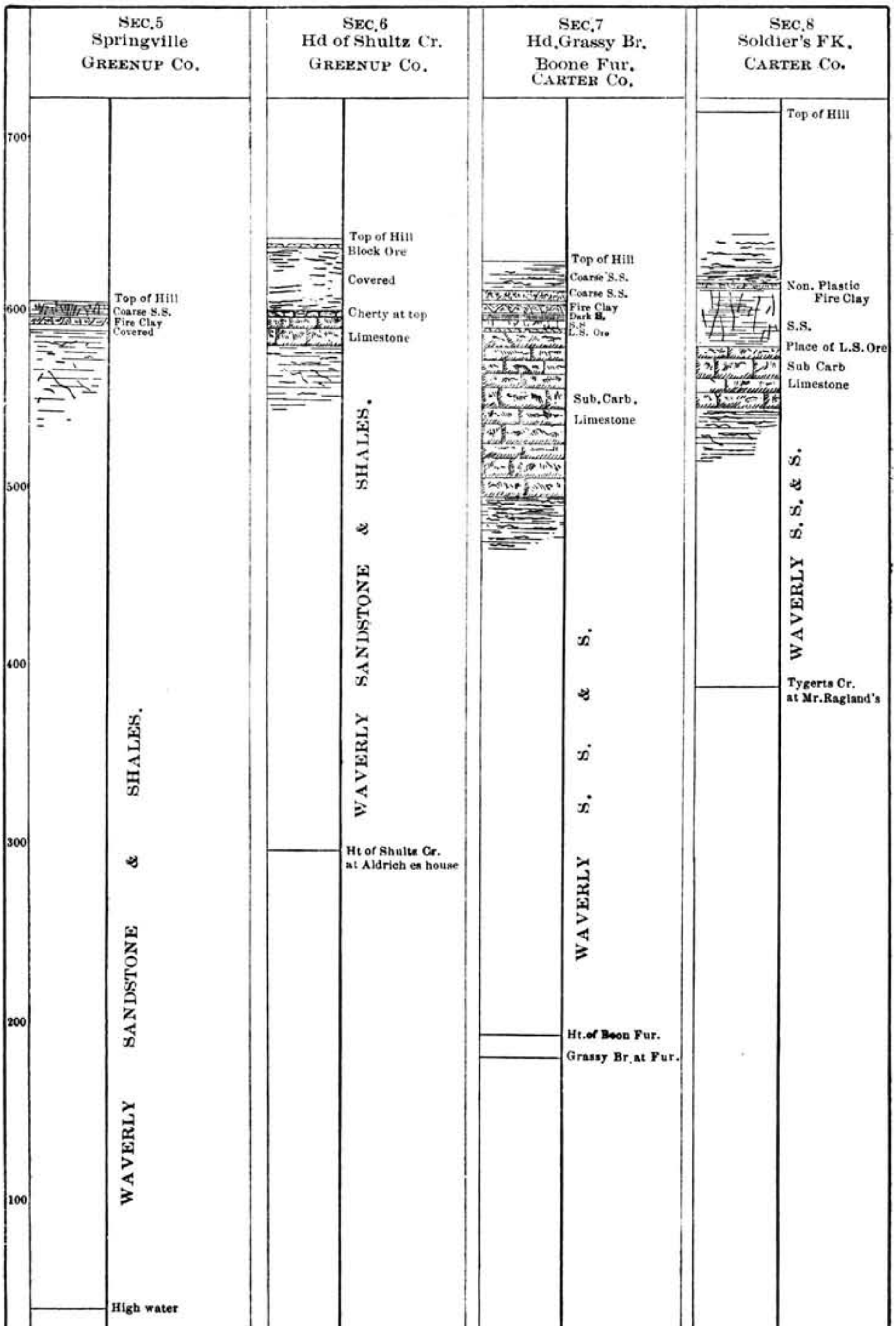

SEC.5
Springville
GREENUP CO.
Top of Hill
Coarse S.S.
Fire Clay
Covered
WAVERLY SANDSTONE & SHALES.
High water
SEC.6
Hd of Shultz Cr.
GREENUP CO.
Top of Hill
Block Ore
Covered
Cherty at top
Limestone
WAVERLY SANDSTONE & SHALES.
Ht of Shultz Cr.
at Aldrich es house
SEC.7
Hd.Grassy Br.
Boone Fur.
CARTER CO.
Top of Hill
Coarse S.S.
Coarse S.S.
Fire Clay
Dark S.
S.S.
L.S. Ore
Sub.Carb.
Limestone
WAVERLY S. S. & S.
Ht.of Boon Fur.
Grassy Br. at Fur.
SEC.8
Soldier's FK.
CARTER CO.
Top of Hill
Non. Plastic
Fire Clay
S.S.
Place of L.S. Ore
Sub Carb
Limestone
WAVERLY S. S. & S.
Tygerts Cr.
at Mr.Ragland's
700
600
500
400
300
200
100
485
Level of Ohio River at mouth of Little Sandy River 485 above tide.
Bogart & Folger Cin.

Plate 4

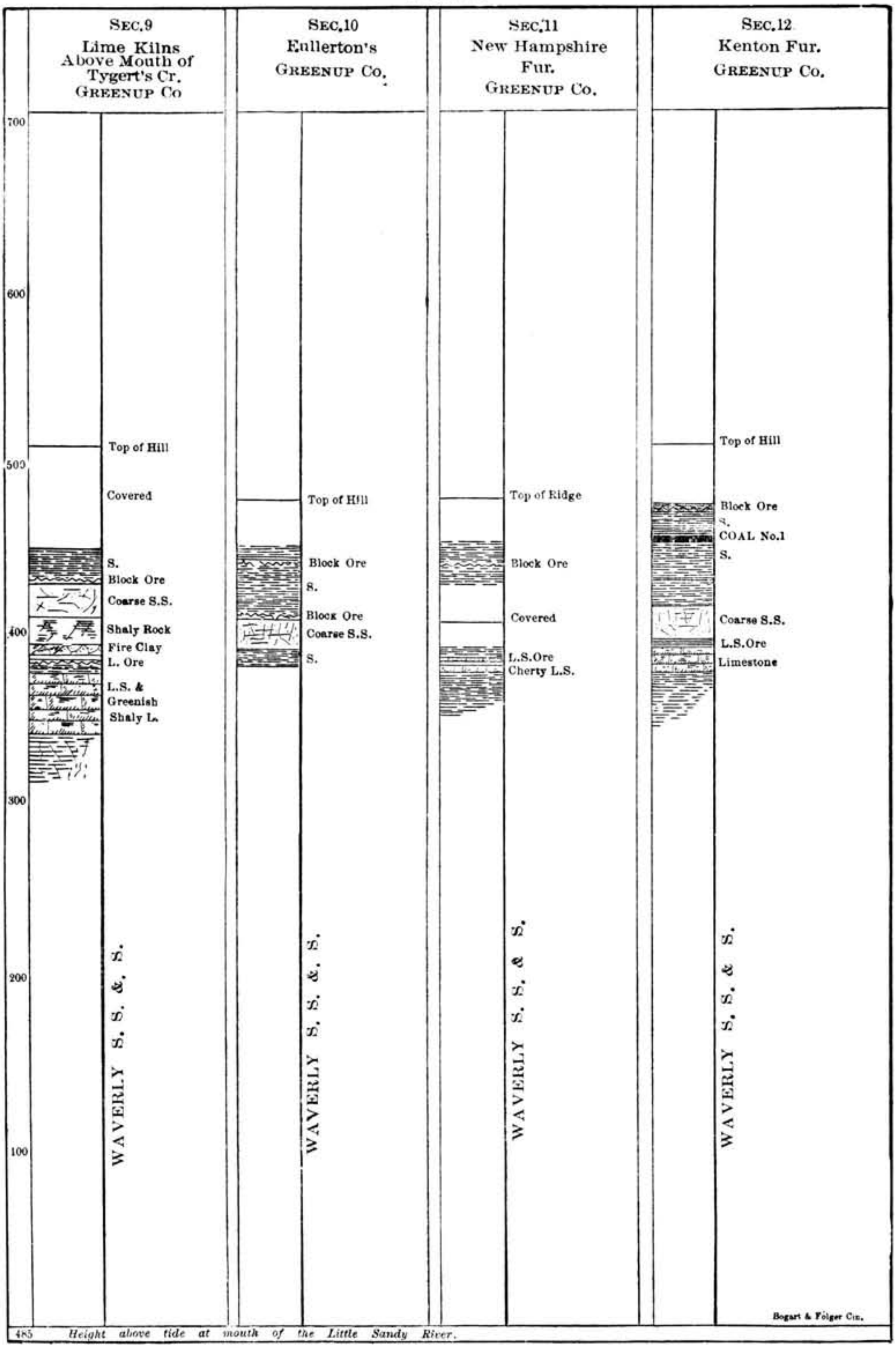

SEC. 9
Lime Kilns
Above Mouth of
Tygert's Cr.
GREENUP Co
SEC. 10
Fullerton's
GREENUP Co.
SEC. 11
New Hampshire
Fur.
GREENUP Co.
SEC. 12
Kenton Fur.
GREENUP Co.
700
600
500
400
300
200
100
485 Height above tide at mouth of the Little Sandy River.
Top of Hill
Covered
S.
Block Ore
Coarse S.S.
Shaly Rock
Fire Clay
L. Ore
L.S. &
Greenish
Shaly L.
WAVERLY S. S. & S.
Top of Hill
Block Ore
S.
Block Ore
Coarse S.S.
S.
WAVERLY S. S. & S.
Top of Ridge
Block Ore
Covered
L.S.Ore
Cherty L.S.
WAVERLY S. S. & S.
Top of Hill
Block Ore
S.
COAL No.1
S.
Coarse S.S.
L.S.Ore
Limestone
WAVERLY S. S. & S.
Bogart & Folger Cin.

Plate 5

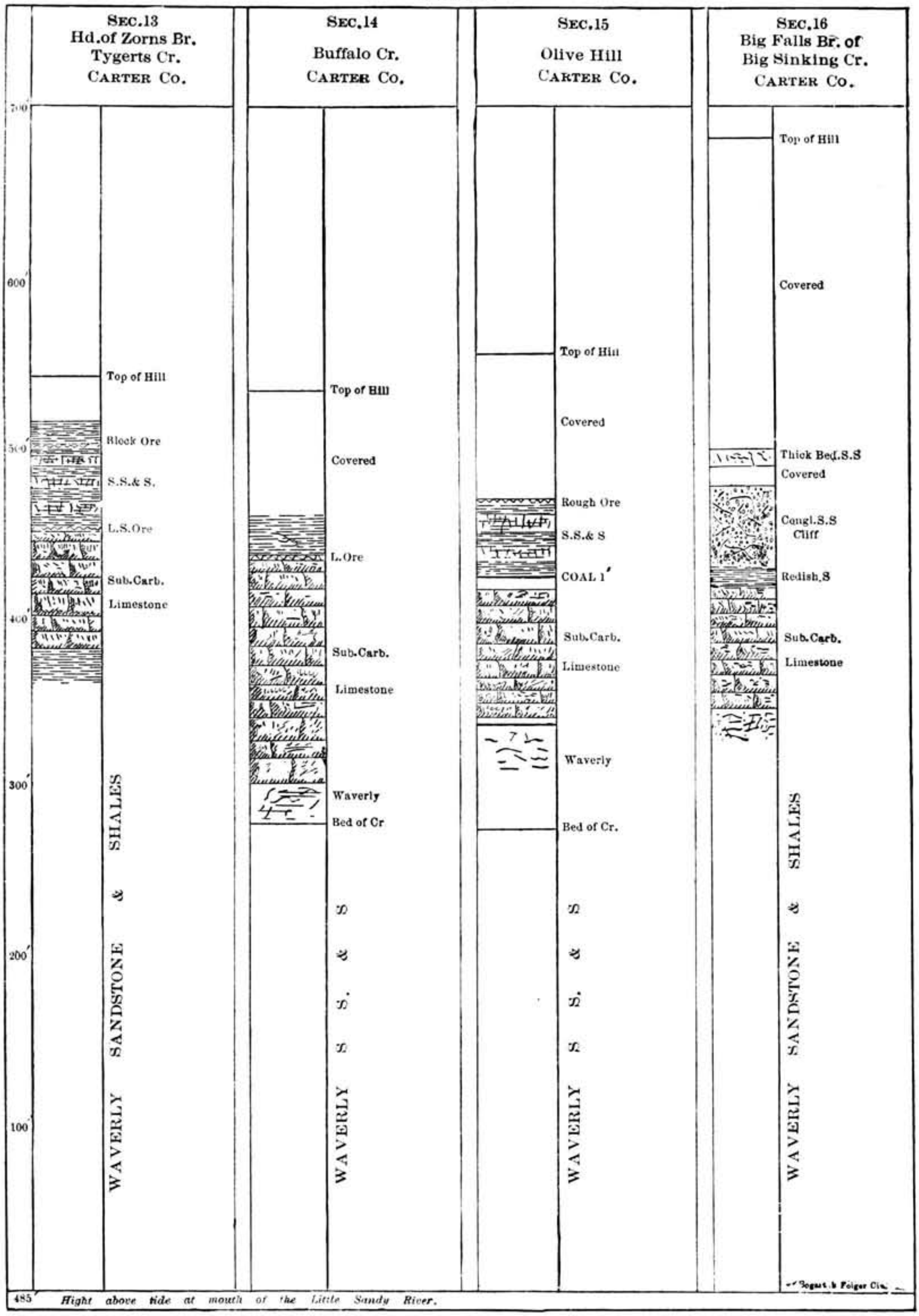

SEC.13
Hd. of Zorns Br.
Tygerts Cr.
CARTER Co.
SEC.14
Buffalo Cr.
CARTER Co.
SEC.15
Olive Hill
CARTER Co.
SEC.16
Big Falls Br. of
Big Sinking Cr.
CARTER Co.
700
600
500
400
300
200
100
485
Top of Hill
Block Ore
S.S.& S.
L.S.Ore
Sub.Carb.
Limestone
WAVERLY SANDSTONE & SHALES
Top of Hill
Covered
L.Ore
Sub.Carb.
Limestone
Waverly
Bed of Cr
WAVERLY S. & S. S.
Top of Hill
Covered
Rough Ore
S.S.& S
COAL 1'
Sub.Carb.
Limestone
Waverly
Bed of Cr.
WAVERLY S. & S. S.
Top of Hill
Covered
Thick Bed.S.S
Covered
Congl.S.S
Cliff
Redish.S
Sub.Carb.
Limestone
WAVERLY SANDSTONE & SHALES
Hight above tide at mouth of the Little Sandy River.

Plate No 6.

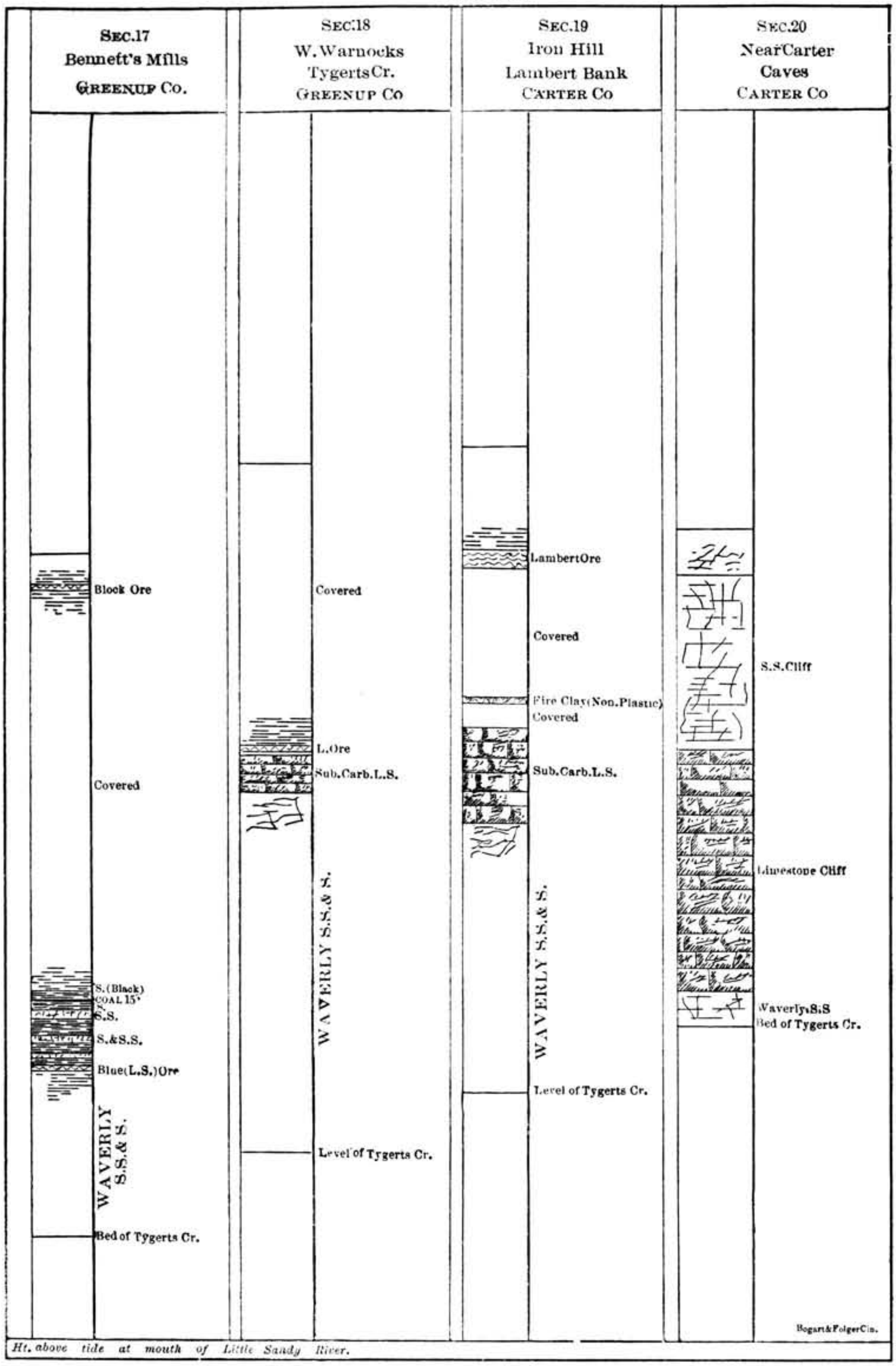

Sec.17
Bennett's Mills
Greenup Co.
Sec.18
W. Warnocks
Tygerts Cr.
Greenup Co
Sec.19
Iron Hill
Lambert Bank
Carter Co
Sec.20
Near Carter
Caves
Carter Co
Block Ore
Covered
S. (Black)
COAL 15'
S.S.
S.&S.S.
Blue (L.S.) Ore
WAVERLY S.S.& S.
Bed of Tygerts Cr.
Covered
L. Ore
Sub. Carb. L.S.
WAVERLY S.S.& S.
Level of Tygerts Cr.
Lambert Ore
Covered
Fire Clay (Non. Plastic)
Covered
Sub. Carb. L.S.
WAVERLY S.S.& S.
Level of Tygerts Cr.
S.S. Cliff
Limestone Cliff
Waverly S.S
Bed of Tygerts Cr.
Bogart & Folger Cin.
Ht. above tide at mouth of Little Sandy River.

Plate No.7

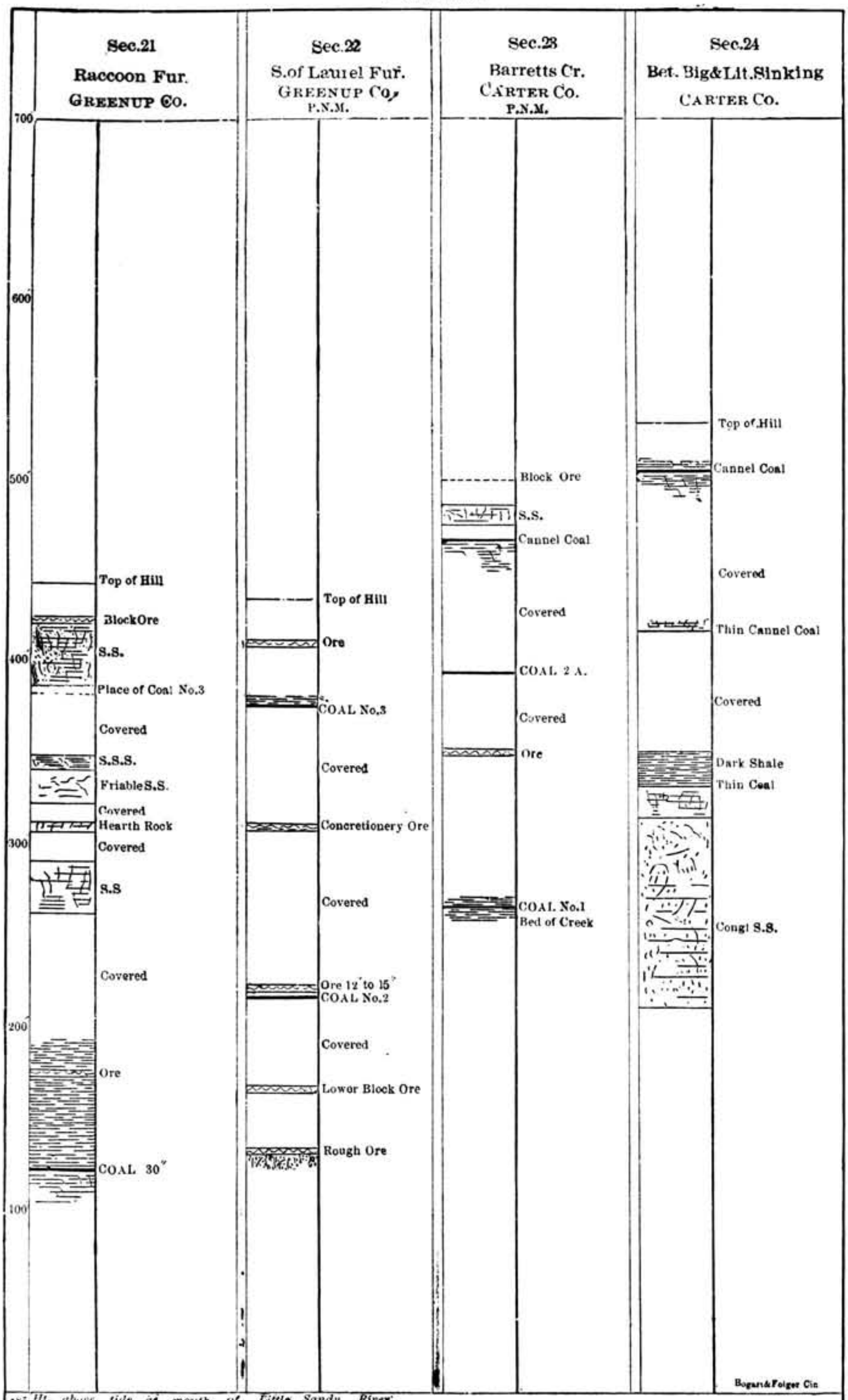
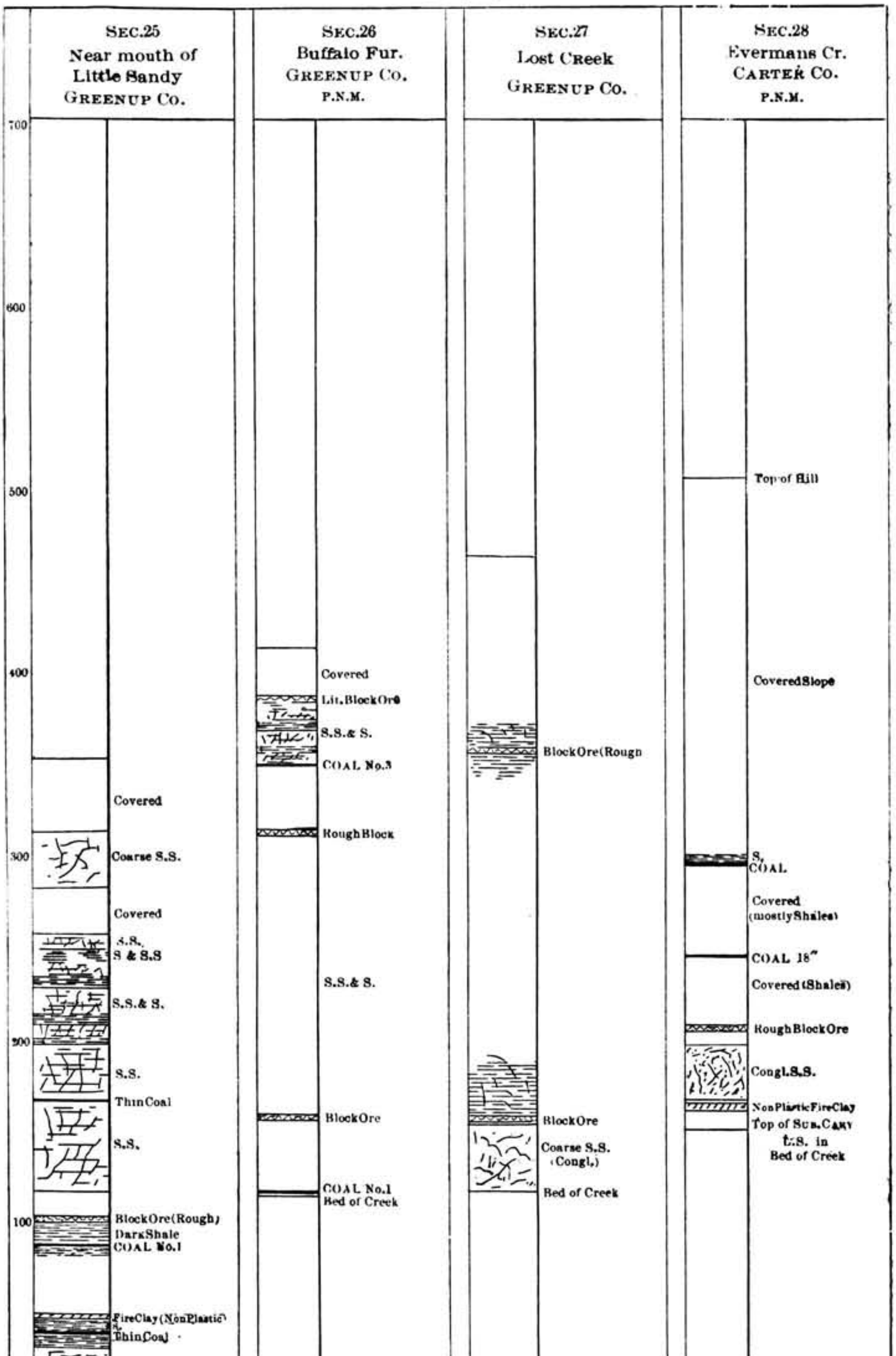
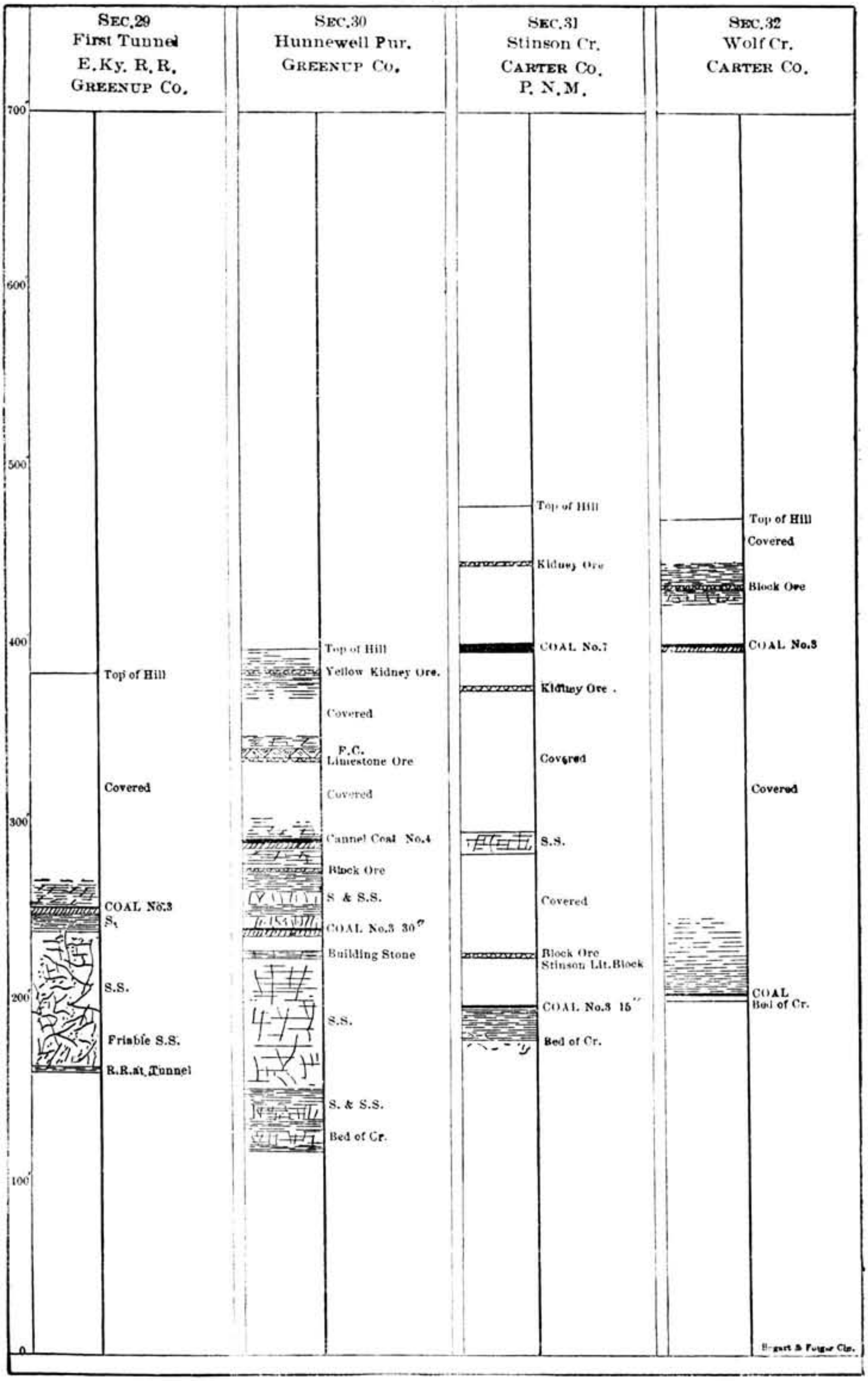

Sec.21
Raccoon Fur.
GREENUP Co.
Sec.22
S.of Laurel Fur.
GREENUP Co.
P.N.M.
Sec.23
Barretts Cr.
CARTER Co.
P.N.M.
Sec.24
Bet. Big&Lit.Sinking
CARTER Co.
700
600
500
400
300
200
100
Top of Hill
BlockOre
S.S.
Place of Coal No.3
Covered
S.S.S.
Friable S.S.
Covered
Hearth Rock
Covered
S.S
Covered
Ore
COAL 30"
Top of Hill
Ore
COAL No.3
Covered
Concretionery Ore
Covered
Ore 12" to 15"
COAL No.2
Covered
Lower Block Ore
Rough Ore
Block Ore
S.S.
Cannel Coal
Covered
COAL 2 A.
Covered
Ore
COAL No.1
Bed of Creek
Top of Hill
Cannel Coal
Covered
Thin Cannel Coal
Covered
Dark Shale
Thin Coal
Congl S.S.
Bogart&Folger Cin
485 Ht. above tide at mouth of Little Sandy River.

Plate No.8



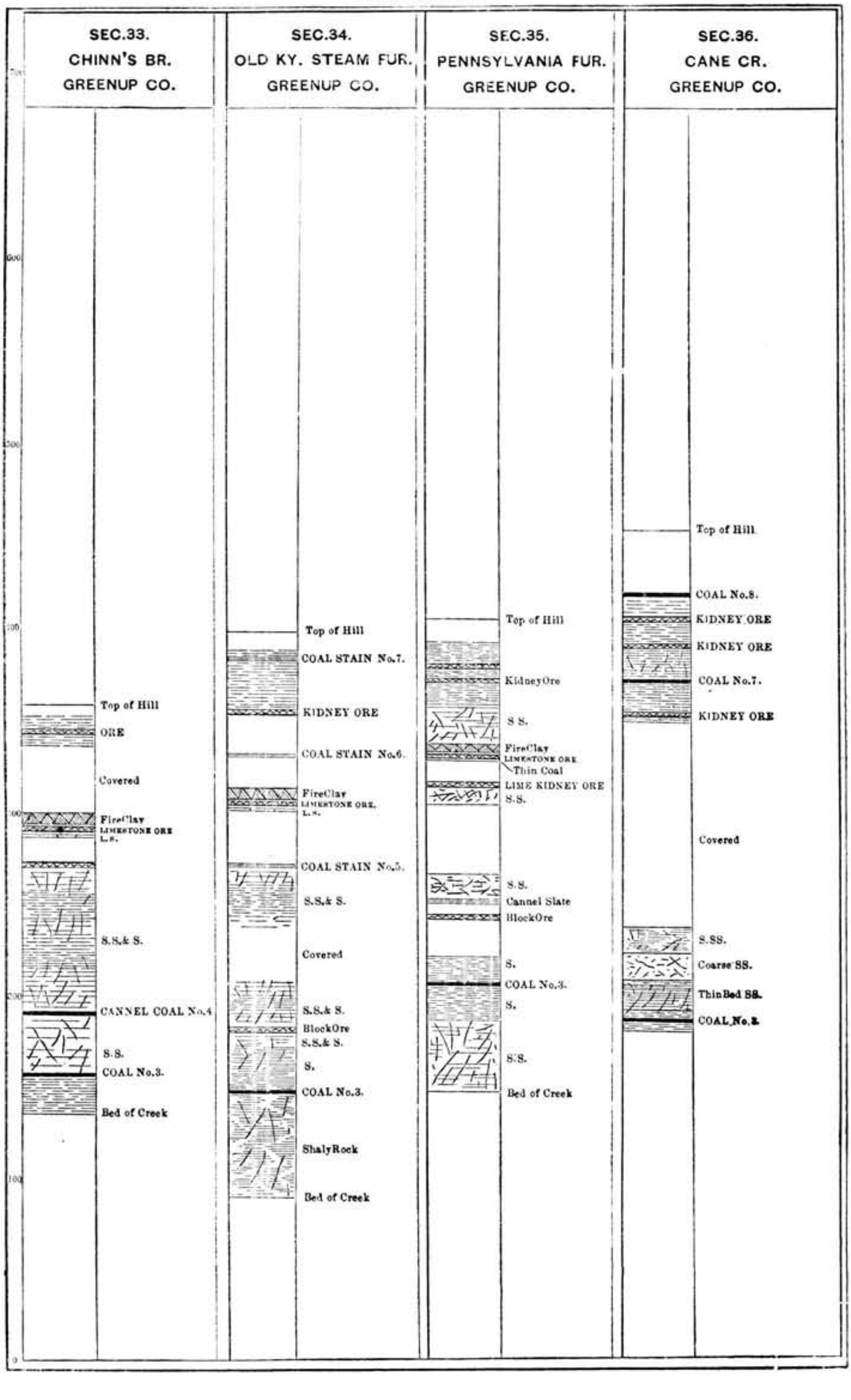
SEC.25
Near mouth of Little Sandy
GREENUP Co.
SEC.26
Buffalo Fur.
GREENUP Co.
P.N.M.
SEC.27
Lost Creek
GREENUP Co.
SEC.28
Evermans Cr.
CARTER Co.
P.N.M.
700
600
500
400
300
200
100
485 Ht. above tide at mouth of Little Sandy River.
Covered
Coarse S.S.
Covered
S.S.
S & S.S
S.S.& S.
S.S.
ThinCoal
S.S.
BlockOre(Rough)
DarkShale
COAL No.1
FireClay (NonPlastic)
S.
ThinCoal
WAVERLY S.S.
Covered
Lit.BlockOre
S.S.& S.
COAL No.3
RoughBlock
S.S.& S.
BlockOre
COAL No.1
Bed of Creek
BlockOre(Rough
BlockOre
Coarse S.S.
(Congl.)
Bed of Creek
Top of Hill
CoveredSlope
S.
COAL
Covered
(mostlyShales)
COAL 18"
Covered (Shales)
RoughBlockOre
Congl.S.S.
NonPlasticFireClay
Top of Sub.Carb
L.S. in
Bed of Creek
Bogardus Folger Co.

Plate 9.



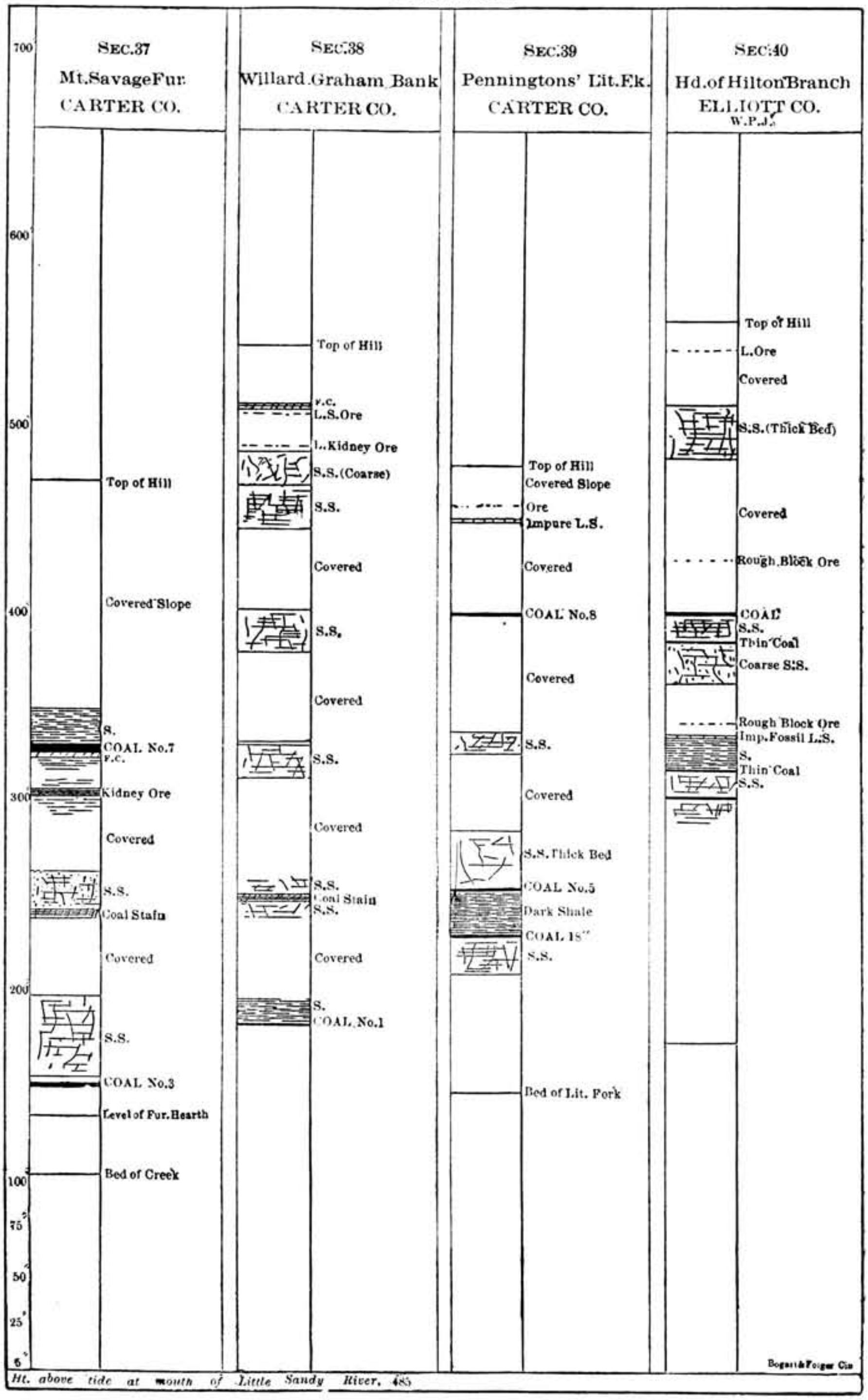
SEC. 29
First Tunnel
E. Ky. R. R.
GREENUP Co.
SEC. 30
Hunnewell Pur.
GREENUP Co.
SEC. 31
Stinson Cr.
CARTER Co.
P. N. M.
SEC. 32
Wolf Cr.
CARTER Co.
700
600
500
400
300
200
100
0
Top of Hill
Covered
COAL No.3
S.
S.S.
Friable S.S.
R.R. at Tunnel
Top of Hill
Yellow Kidney Ore.
Covered
F.C.
Limestone Ore
Covered
Cannel Coal No.4
Block Ore
S & S.S.
COAL No.3 30"
Building Stone
S.S.
S. & S.S.
Bed of Cr.
Top of Hill
Kidney Ore
COAL No.7
Kidney Ore.
Covered
S.S.
Covered
Block Ore
Stinson Lit. Block
COAL No.3 15"
Bed of Cr.
Top of Hill
Covered
Block Ore
COAL No.5
Covered
COAL
Bed of Cr.
Bogart & Folger Cin.

Plate No. 10.



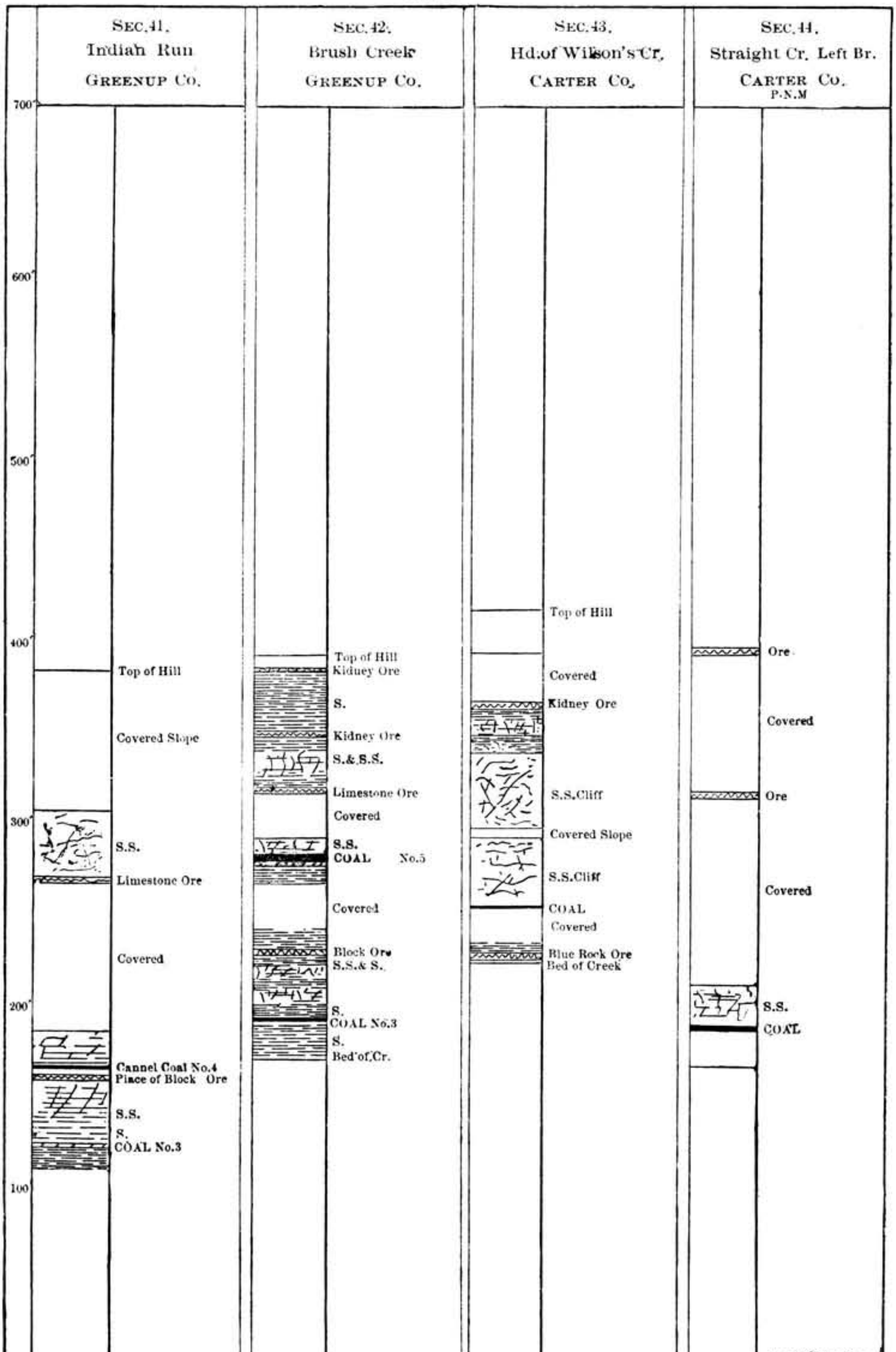
SEC.33.
CHINN'S BR.
GREENUP CO.
Top of Hill
ORE
Covered
FireClay
LIMESTONE ORE
L.S.
S.S.& S.
CANNEL COAL No.4
S.S.
COAL No.3.
Bed of Creek
SEC.34.
OLD KY. STEAM FUR.
GREENUP CO.
Top of Hill
COAL STAIN No.7.
KIDNEY ORE
COAL STAIN No.6.
FireClay
LIMESTONE ORE.
L.S.
COAL STAIN No.5.
S.S.& S.
Covered
S.S.& S.
BlockOre
S.S.& S.
S.
COAL No.3.
ShalyRock
Bed of Creek
SEC.35.
PENNSYLVANIA FUR.
GREENUP CO.
Top of Hill
KidneyOre
S.S.
FireClay
LIMESTONE ORE
Thin Coal
LIME KIDNEY ORE
S.S.
S.S.
Cannel Slate
BlockOre
S.
COAL No.3.
S.
S.S.
Bed of Creek
SEC.36.
CANE CR.
GREENUP CO.
Top of Hill
COAL No.8.
KIDNEY ORE
KIDNEY ORE
COAL No.7.
KIDNEY ORE
Covered
S.SS.
Coarse SS.
ThinBed SS.
COAL No.2.

Plate No.11



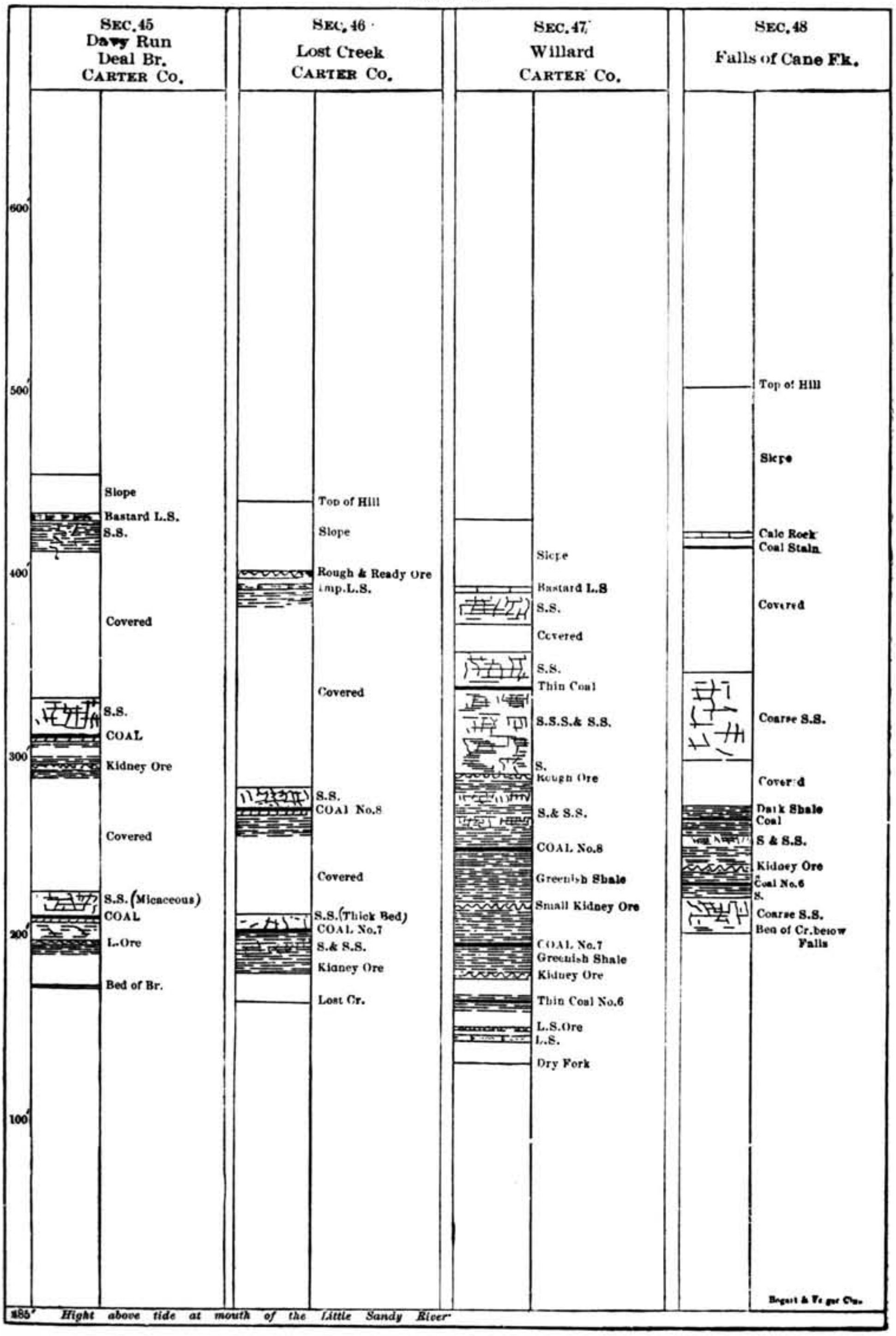
700
600
500
400
300
200
100
75
50
25
5
SEC.37
Mt.SavageFur.
CARTER CO.
Top of Hill
Covered Slope
S.
COAL No.7
F.C.
Kidney Ore
Covered
S.S.
Coal Stain
Covered
S.S.
COAL No.3
Level of Fur.Hearth
Bed of Creek
SEC.38
Willard Graham Bank
CARTER CO.
Top of Hill
F.C.
L.S.Ore
L.Kidney Ore
S.S.(Coarse)
S.S.
Covered
S.S.
Covered
S.S.
Covered
S.S.
Coal Stain
S.S.
Covered
S.
COAL No.1
SEC.39
Penningtons' Lit.Fk.
CARTER CO.
Top of Hill
Covered Slope
Ore
Impure L.S.
Covered
COAL No.8
Covered
S.S.
Covered
S.S.Thick Bed
COAL No.5
Dark Shale
COAL 18"
S.S.
Bed of Lit. Fork
SEC.40
Hd.of Hilton Branch
ELLIOTT CO.
W.P.J.
Top of Hill
L.Ore
Covered
S.S.(Thick Bed)
Covered
Rough Block Ore
COAL
S.S.
Thin Coal
Coarse S.S.
Rough Block Ore
Imp.Fossil L.S.
S.
Thin Coal
S.S.
Bogart&Folger Co
Ht. above tide at mouth of Little Sandy River, 485

Plate 12



SEC. 41.
Indian Run
GREENUP CO.
SEC. 42.
Brush Creek
GREENUP CO.
SEC. 43.
Hd. of Wilson's Cr.
CARTER CO.
SEC. 44.
Straight Cr. Left Br.
CARTER CO.
P.N.M
700
600
500
400
300
200
100
Top of Hill
Covered Slope
S.S.
Limestone Ore
Covered
Cannel Coal No.4
Place of Block Ore
S.S.
S.
COAL No.3
Top of Hill
Kidney Ore
S.
Kidney Ore
S.&S.S.
Limestone Ore
Covered
S.S.
COAL No.5
Covered
Block Ore
S.S.& S.
S.
COAL No.3
S.
Bed of Cr.
Top of Hill
Covered
Kidney Ore
S.S.Cliff
Covered Slope
S.S.Cliff
COAL
Covered
Blue Rock Ore
Bed of Creek
Ore
Covered
Ore
Covered
S.S.
COAL
Hight Above tide, at mouth of the Little Sandy River.

Plate 13



SEC. 45
Davy Run
Deal Br.
CARTER Co.
SEC. 46
Lost Creek
CARTER Co.
SEC. 47
Willard
CARTER Co.
SEC. 48
Falls of Cane Fk.
600'
500'
400'
300'
200'
100'
385' Hight above tide at mouth of the Little Sandy River
Slope
Bastard L.S.
S.S.
Covered
S.S.
COAL
Kidney Ore
Covered
S.S. (Micaceous)
COAL
L. Ore
Bed of Br.
Top of Hill
Slope
Rough & Ready Ore
Imp.L.S.
Covered
S.S.
COAL No.8
Covered
S.S. (Thick Bed)
COAL No.7
S.& S.S.
Kidney Ore
Lost Cr.
Slope
Bastard L.S
S.S.
Covered
S.S.
Thin Coal
S.S.S.& S.S.
S.
Rough Ore
S.& S.S.
COAL No.8
Greenish Shale
Small Kidney Ore
COAL No.7
Greenish Shale
Kidney Ore
Thin Coal No.6
L.S.Ore
L.S.
Dry Fork
Top of Hill
Slope
Calc Rock
Coal Stain
Covered
Coarse S.S.
Covered
Dark Shale
Coal
S & S.S.
Kidney Ore
Coal No.6
S.
Coarse S.S.
Bed of Cr. below Falls

Plate 14

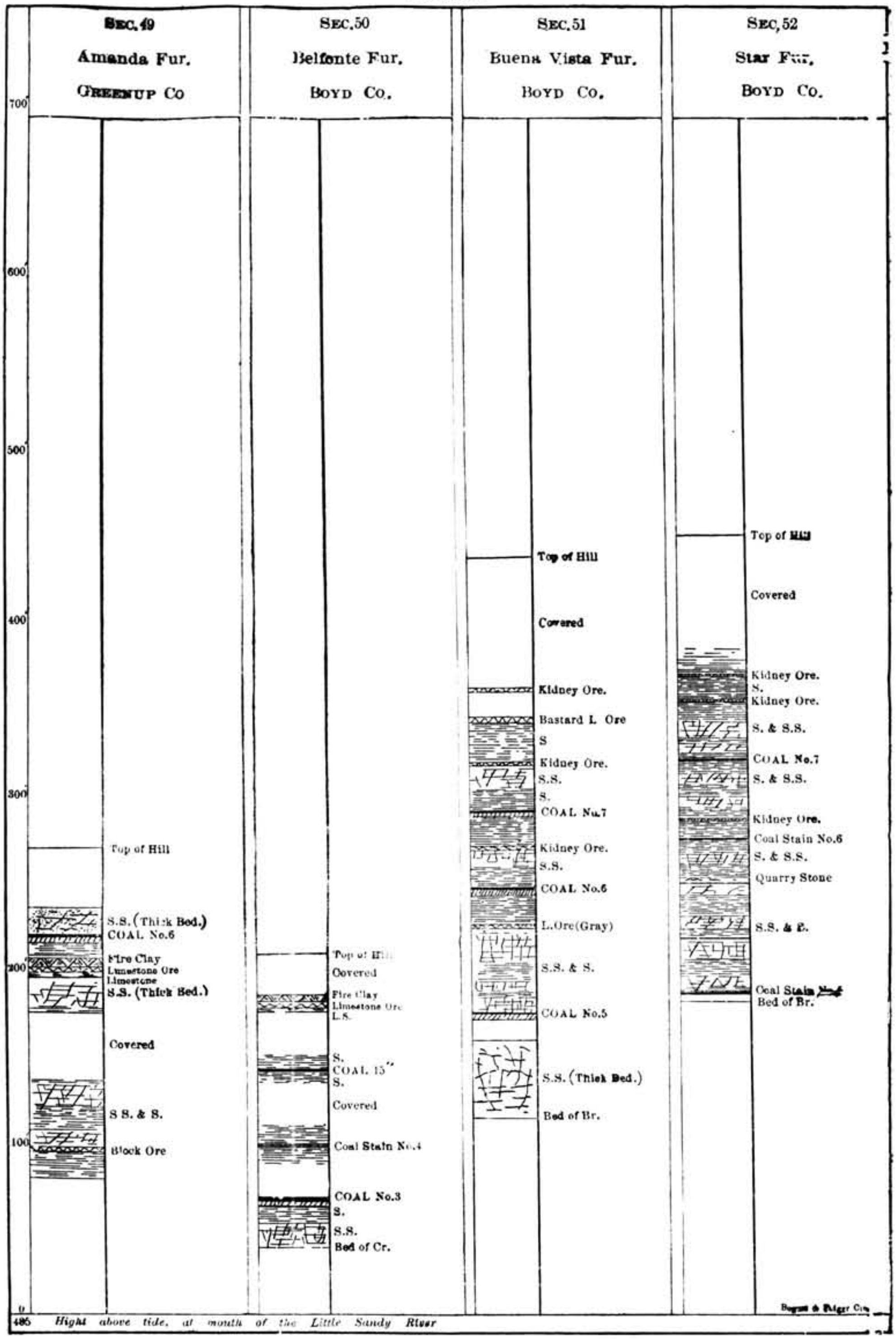

SEC. 49
Amanda Fur.
GREENUP Co
SEC. 50
Belfonte Fur.
BOYD Co.
SEC. 51
Buena Vista Fur.
BOYD Co.
SEC. 52
Star Fur.
BOYD Co.
700
600
500
400
300
200
100
0
Top of Hill
S.S. (Thick Bed.)
COAL No.6
Fire Clay
Limestone Ore
Limestone
S.S. (Thick Bed.)
Covered
S.S. & S.
Block Ore
Top of Hill
Covered
Fire Clay
Limestone Ore
L.S.
S.
COAL 15"
S.
Covered
Coal Stain No.4
COAL No.3
S.
S.S.
Bed of Cr.
Top of Hill
Covered
Kidney Ore.
Bastard L. Ore
S
Kidney Ore.
S.S.
S.
COAL No.7
Kidney Ore.
S.S.
COAL No.6
L.Ore(Gray)
S.S. & S.
COAL No.5
S.S. (Thick Bed.)
Bed of Br.
Top of Hill
Covered
Kidney Ore.
S.
Kidney Ore.
S. & S.S.
COAL No.7
S. & S.S.
Kidney Ore.
Coal Stain No.6
S. & S.S.
Quarry Stone
S.S. & S.
Coal Stain
Bed of Br.
486
Hight above tide, at mouth of the Little Sandy River

Plate 15

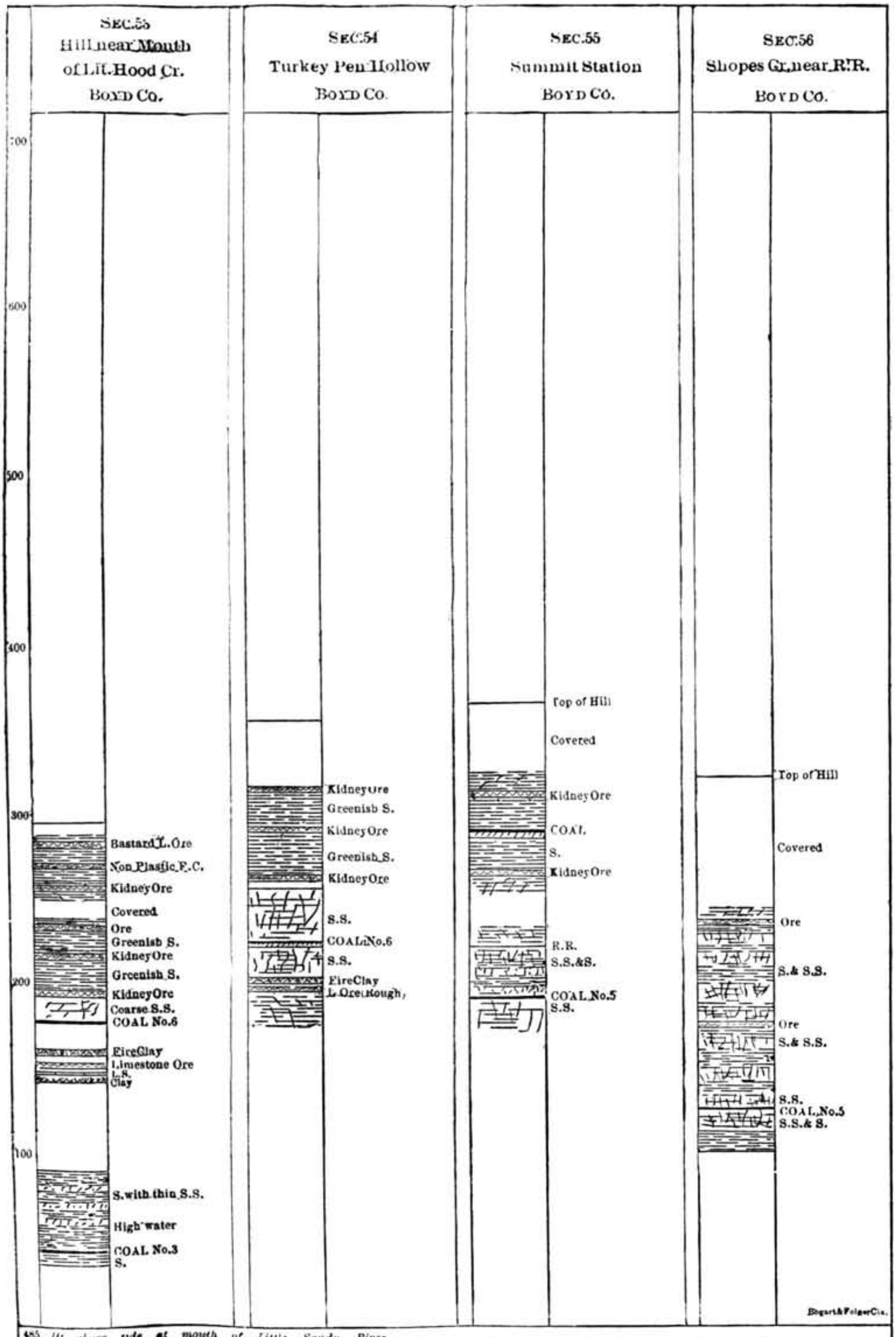

SEC.53
Hill near Mouth of Lit. Hood Cr.
BOYD CO.
SEC.54
Turkey Pen Hollow
BOYD CO.
SEC.55
Summit Station
BOYD CO.
SEC.56
Shopes Cr. near R.R.
BOYD CO.
700
600
500
400
300
200
100
Bastard L. Ore
Non Plastic F.C.
Kidney Ore
Covered
Ore
Greenish S.
Kidney Ore
Greenish S.
Kidney Ore
Coarse S.S.
COAL No.6
Fire Clay
Limestone Ore
L.S.
Clay
S. with thin S.S.
High water
COAL No.3
S.
Kidney Ore
Greenish S.
Kidney Ore
Greenish S.
Kidney Ore
S.S.
COAL No.6
S.S.
Fire Clay
L. Ore (Rough)
Top of Hill
Covered
Kidney Ore
COAL
S.
Kidney Ore
R.R.
S.S. & S.
COAL No.5
S.S.
Top of Hill
Covered
Ore
S. & S.S.
Ore
S. & S.S.
S.S.
COAL No.5
S.S. & S.
Bogart & Folger Co.
485 ft above tide at mouth of Little Sandy River.

Plate 16

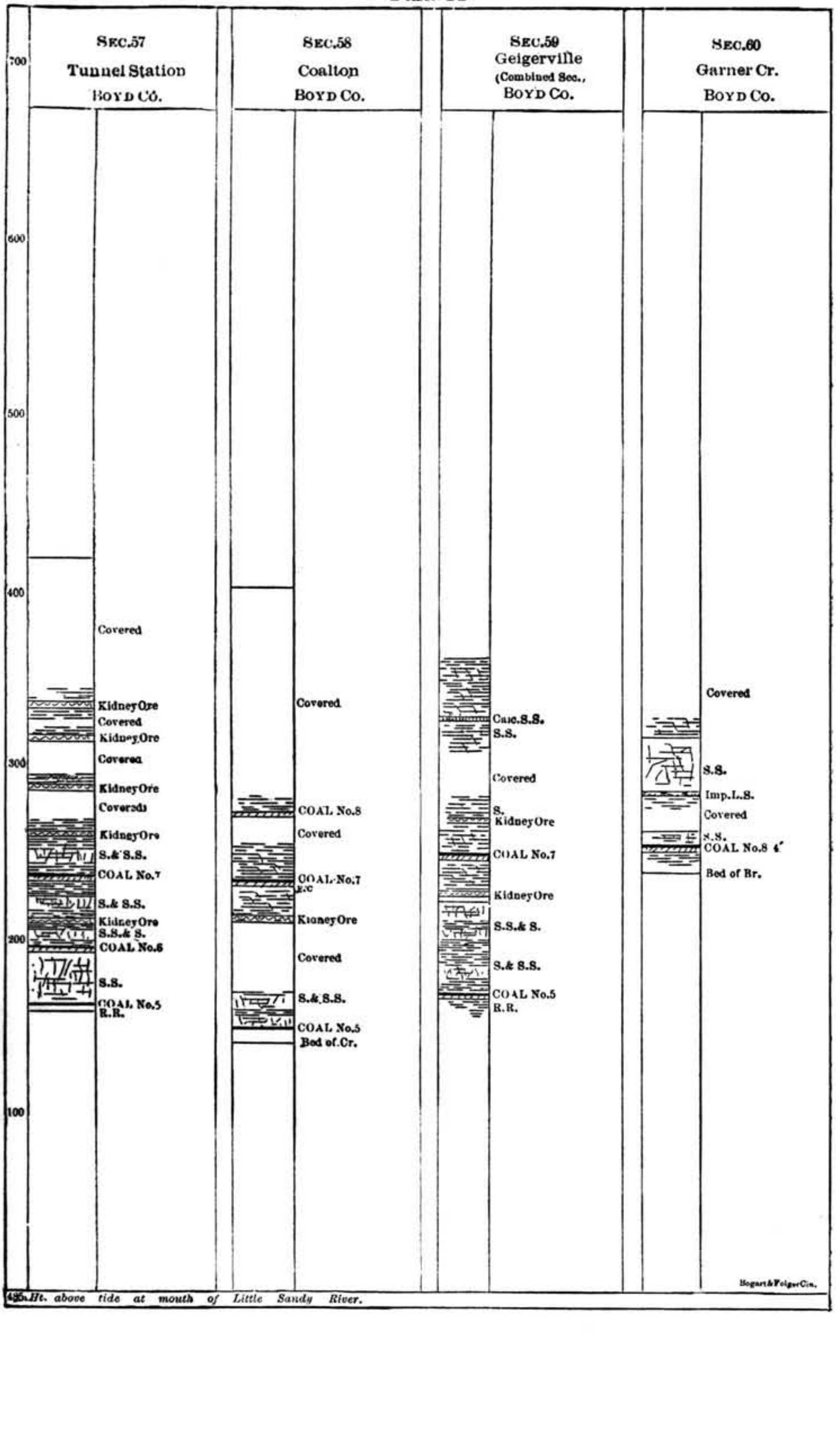

SEC.57
Tunnel Station
BOYD CO.
SEC.58
Coalton
BOYD CO.
SEC.59
Geigerville
(Combined Sec.,
BOYD CO.
SEC.60
Garner Cr.
BOYD CO.
700
600
500
400
300
200
100
Covered
Kidney Ore
Covered
Kidney Ore
Covered
Kidney Ore
Covered
Kidney Ore
S.& S.S.
COAL No.7
S.& S.S.
Kidney Ore
S.S.& S.
COAL No.6
S.S.
COAL No.5
R.R.
Covered
COAL No.8
Covered
COAL No.7
Kidney Ore
Covered
S.& S.S.
COAL No.5
Bed of Cr.
Calc.S.S.
S.S.
Covered
S.
Kidney Ore
COAL No.7
Kidney Ore
S.S.& S.
S.& S.S.
COAL No.5
R.R.
Covered
S.S.
Imp.L.S.
Covered
S.S.
COAL No.8 4'
Bed of Br.
Ft. above tide at mouth of Little Sandy River.
Bogart & Folger Cin.

Plate 17

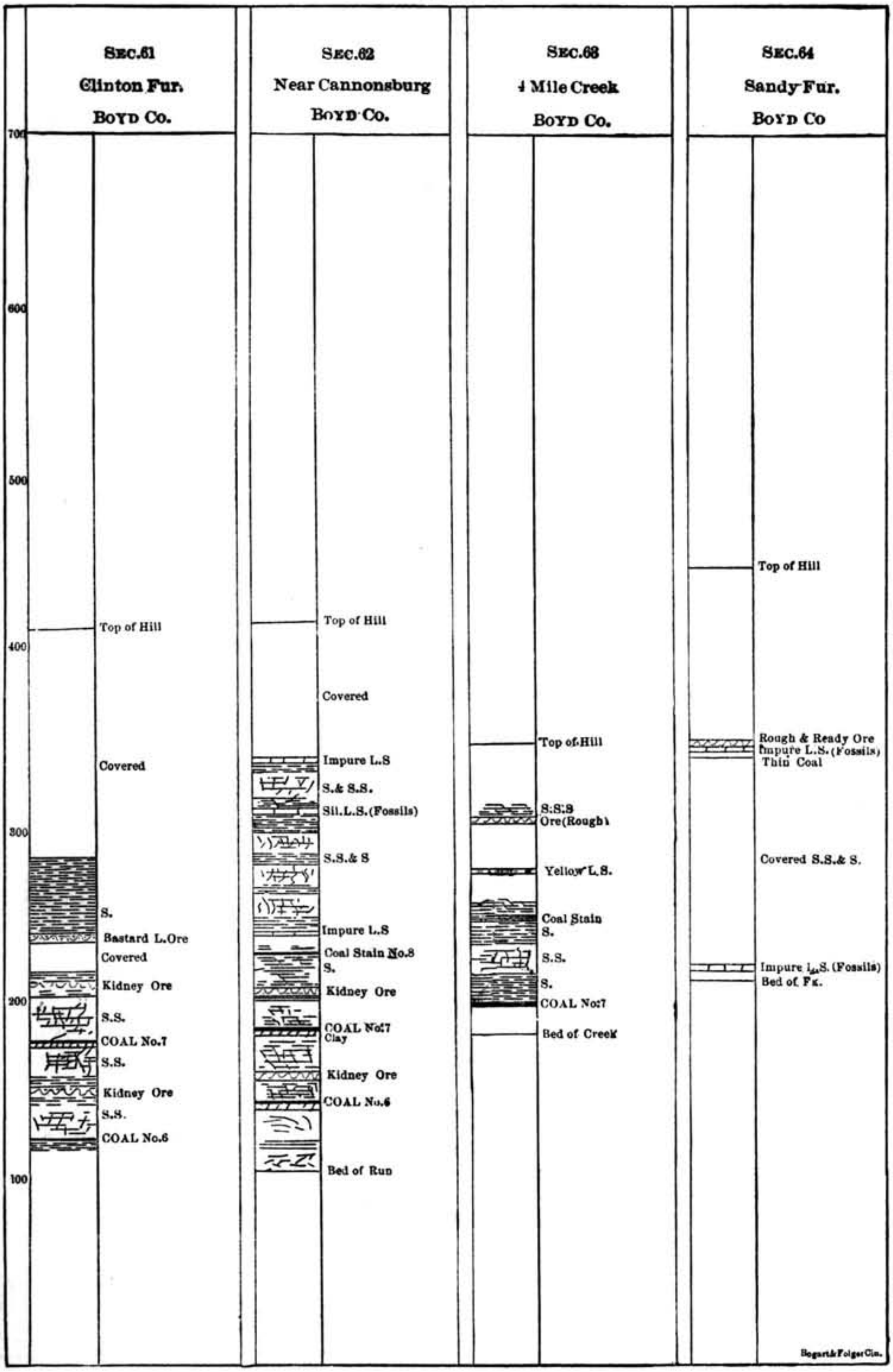
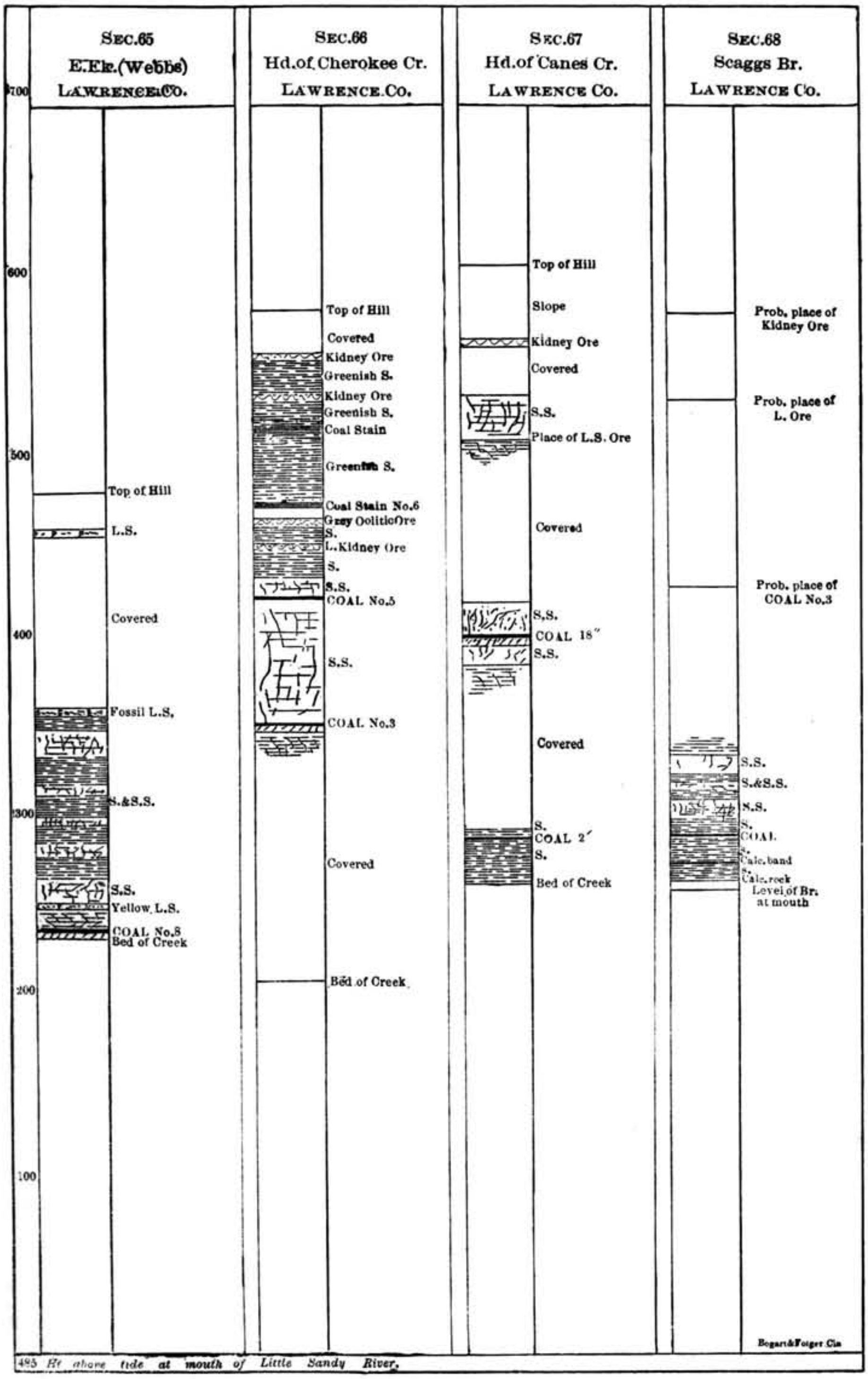

SEC.61
Clinton Fur.
BOYD Co.
SEC.62
Near Cannonsburg
BOYD Co.
SEC.63
4 Mile Creek
BOYD Co.
SEC.64
Sandy Fur.
BOYD Co
700
600
500
400
300
200
100
Top of Hill
Covered
S.
Bastard L.Ore
Covered
Kidney Ore
S.S.
COAL No.7
S.S.
Kidney Ore
S.S.
COAL No.6
Top of Hill
Covered
Impure L.S
S.& S.S.
Sil.L.S.(Fossils)
S.S.& S
Impure L.S
Coal Stain No.8
S.
Kidney Ore
COAL No.7
Clay
Kidney Ore
COAL No.6
Bed of Run
Top of Hill
S.S.S
Ore(Rough)
Yellow L.S.
Coal Stain
S.
S.S.
S.
COAL No.7
Bed of Creek
Top of Hill
Rough & Ready Ore
Impure L.S.(Fossils)
Thin Coal
Covered S.S.& S.
Impure L.S.(Fossils)
Bed of Fk.
Bogart&Folger Cin.

Plate No.18



Sec.65
E.Ek.(Webbs)
Lawrence Co.
700
600
500
400
300
200
100
Top of Hill
L.S.
Covered
Fossil L.S.
S.&S.S.
S.S.
Yellow L.S.
COAL No.3
Bed of Creek
Sec.66
Hd.of Cherokee Cr.
Lawrence.Co.
Top of Hill
Covered
Kidney Ore
Greenish S.
Kidney Ore
Greenish S.
Coal Stain
Greenish S.
Coal Stain No.6
Grey OoliticOre
S.
L.Kidney Ore
S.
S.S.
COAL No.5
S.S.
COAL No.3
Covered
Bed of Creek
Sec.67
Hd.of Canes Cr.
Lawrence Co.
Top of Hill
Slope
Kidney Ore
Covered
S.S.
Place of L.S. Ore
Covered
S.S.
COAL 18"
S.S.
Covered
S.
COAL 2'
S.
Bed of Creek
Sec.68
Scaggs Br.
Lawrence Co.
Prob. place of Kidney Ore
Prob. place of L. Ore
Prob. place of COAL No.3
S.S.
S.&S.S.
S.S.
S.
COAL
S.
Calc.band
S.
Calc.reek
Level of Br. at mouth
Bogart&Folger Cin
485 Ft above tide at mouth of Little Sandy River.

Plate 19

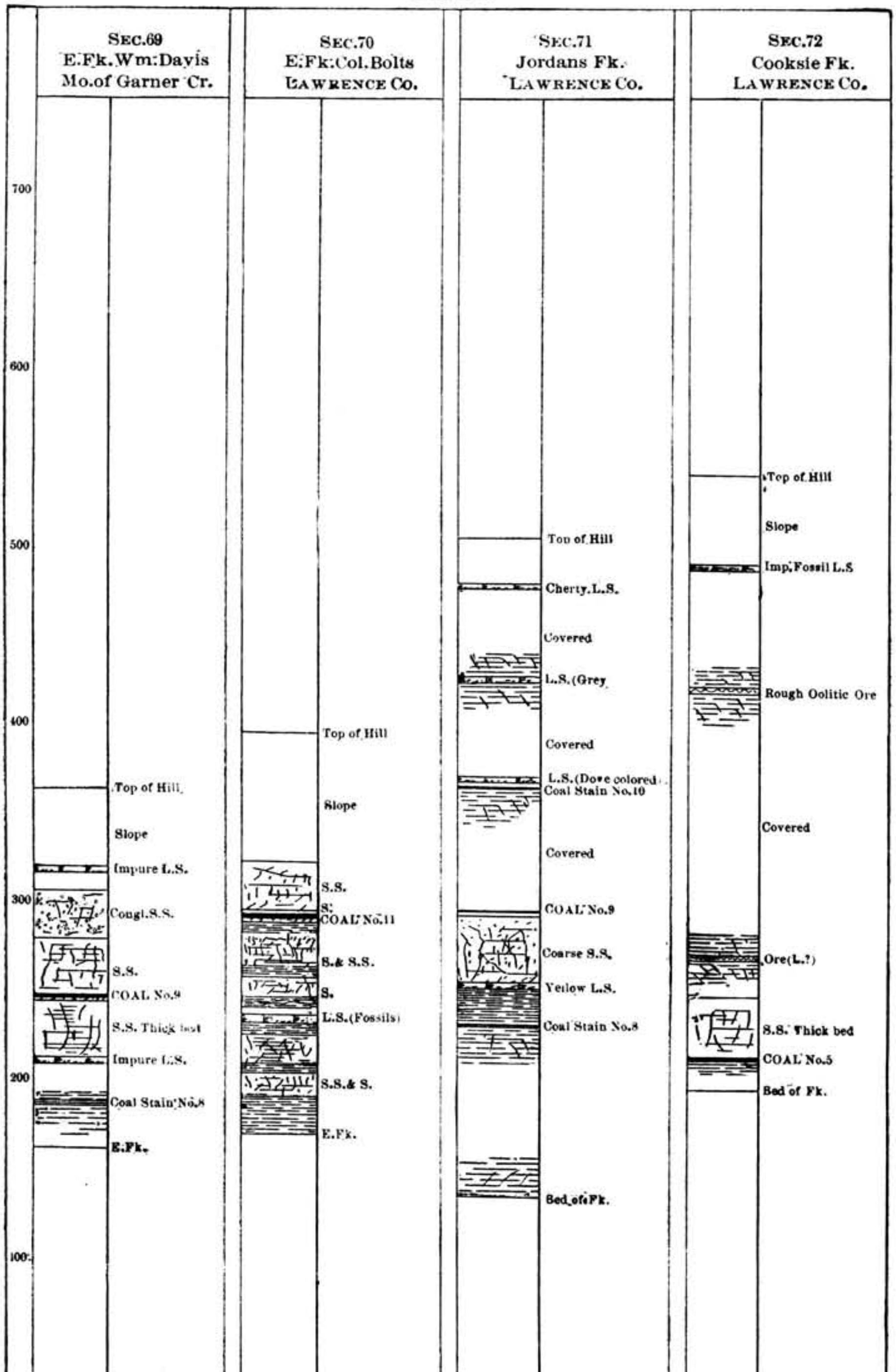

Sec.69
E. Fk. Wm. Davis
Mo. of Garner Cr.
Sec.70
E. Fk. Col. Bolts
Lawrence Co.
Sec.71
Jordans Fk.
Lawrence Co.
Sec.72
Cooksie Fk.
Lawrence Co.
700
600
500
400
300
200
100
Top of Hill
Slope
Impure L.S.
Congl.S.S.
S.S.
COAL No.9
S.S. Thick bed
Impure L.S.
Coal Stain No.8
E.Fk.
Top of Hill
Slope
S.S.
S.
COAL No.11
S.& S.S.
S.
L.S.(Fossils)
S.S.& S.
E.Fk.
Top of Hill
Cherty.L.S.
Covered
L.S.(Grey
Covered
L.S.(Dove colored)
Coal Stain No.10
Covered
COAL No.9
Coarse S.S.
Yellow L.S.
Coal Stain No.8
Bed of Fk.
Top of Hill
Slope
Imp. Fossil L.S
Rough Oolitic Ore
Covered
Ore(L.?)
S.S. Thick bed
COAL No.5
Bed of Fk.
Bogart&FeigerCin.
485 Ht. above tide at mouth of Little Sandy River.

Plate 20

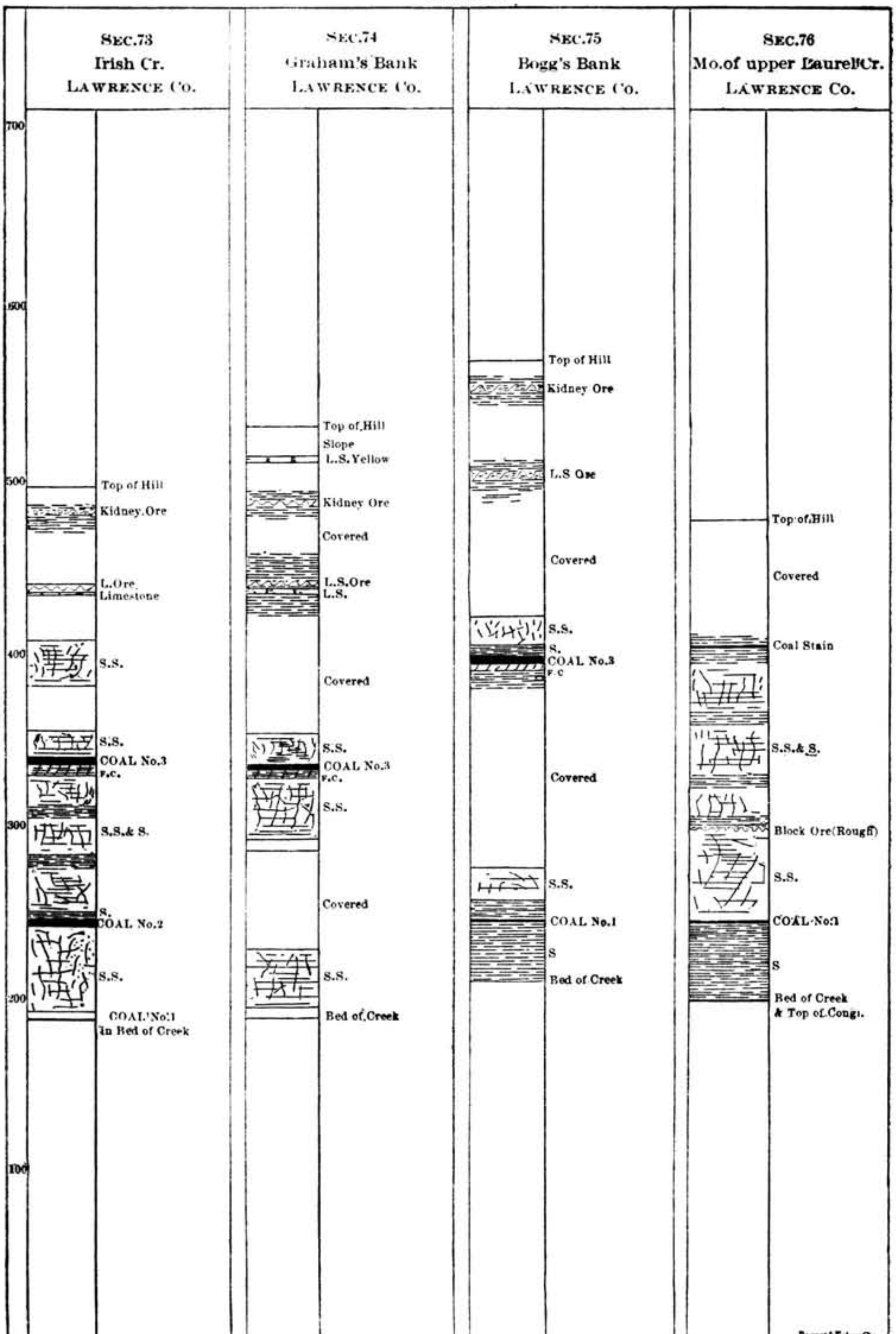

Sec. 73
Irish Cr.
Lawrence Co.
Sec. 74
Graham's Bank
Lawrence Co.
Sec. 75
Bogg's Bank
Lawrence Co.
Sec. 76
Mo. of upper Laurel Cr.
Lawrence Co.
700
600
500
400
300
200
100
Top of Hill
Kidney Ore
L. Ore
Limestone
S.S.
S.S.
COAL No.3
F.C.
S.S. & S.
S.
COAL No.2
S.S.
COAL No.1
In Bed of Creek
Top of Hill
Slope
L.S. Yellow
Kidney Ore
Covered
L.S. Ore
L.S.
Covered
S.S.
COAL No.3
F.C.
S.S.
Covered
S.S.
Bed of Creek
Top of Hill
Kidney Ore
L.S Ore
Covered
S.S.
S.
COAL No.3
F.C
Covered
S.S.
COAL No.1
S
Bed of Creek
Top of Hill
Covered
Coal Stain
S.S. & S.
Block Ore (Rough)
S.S.
COAL No.1
S
Bed of Creek
& Top of Congl.
Bogart & Foiges Co.
485 Ht. above tide at mouth of Little Sandy River.

Plate 21

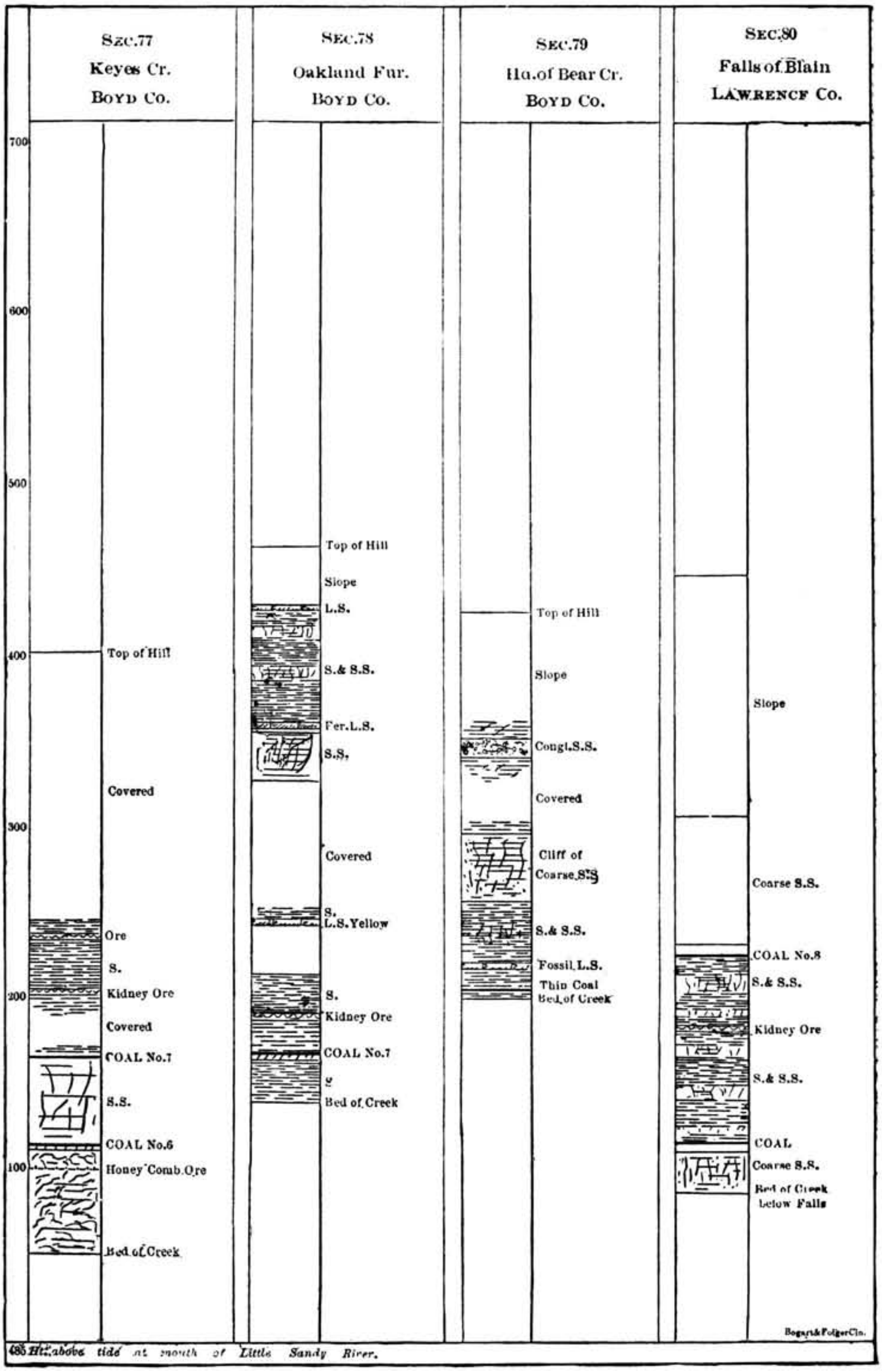

SEC.77
Keyes Cr.
BOYD CO.
SEC.78
Oakland Fur.
BOYD CO.
SEC.79
Ha.of Bear Cr.
BOYD CO.
SEC.80
Falls of Blain
LAWRENCE CO.
700
600
500
400
300
200
100
Top of Hill
Covered
Ore
S.
Kidney Ore
Covered
COAL No.7
S.S.
COAL No.6
Honey Comb.Ore
Bed of Creek
Top of Hill
Slope
L.S.
S.& S.S.
Fer.L.S.
S.S.
Covered
S.
L.S.Yellow
S.
Kidney Ore
COAL No.7
S
Bed of Creek
Top of Hill
Slope
Congl.S.S.
Covered
Cliff of
Coarse.S.S
S.& S.S.
Fossil.L.S.
Thin Coal
Bed of Creek
Slope
Coarse S.S.
COAL No.8
S.& S.S.
Kidney Ore
S.& S.S.
COAL
Coarse S.S.
Bed of Creek
below Falls
Bogart&FolgerCo.
485 Ht. above tide at mouth of Little Sandy River.

Plate No.22

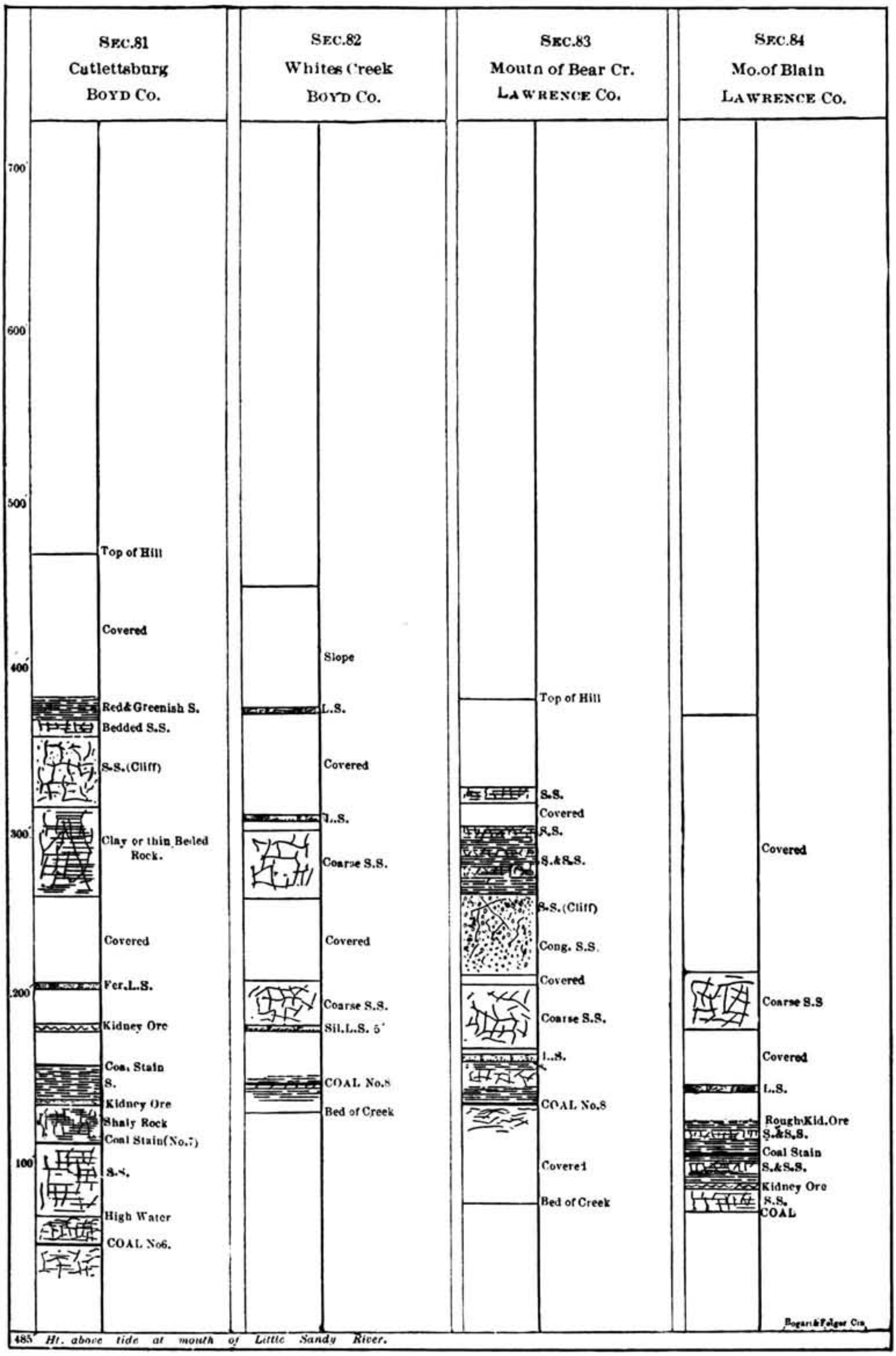
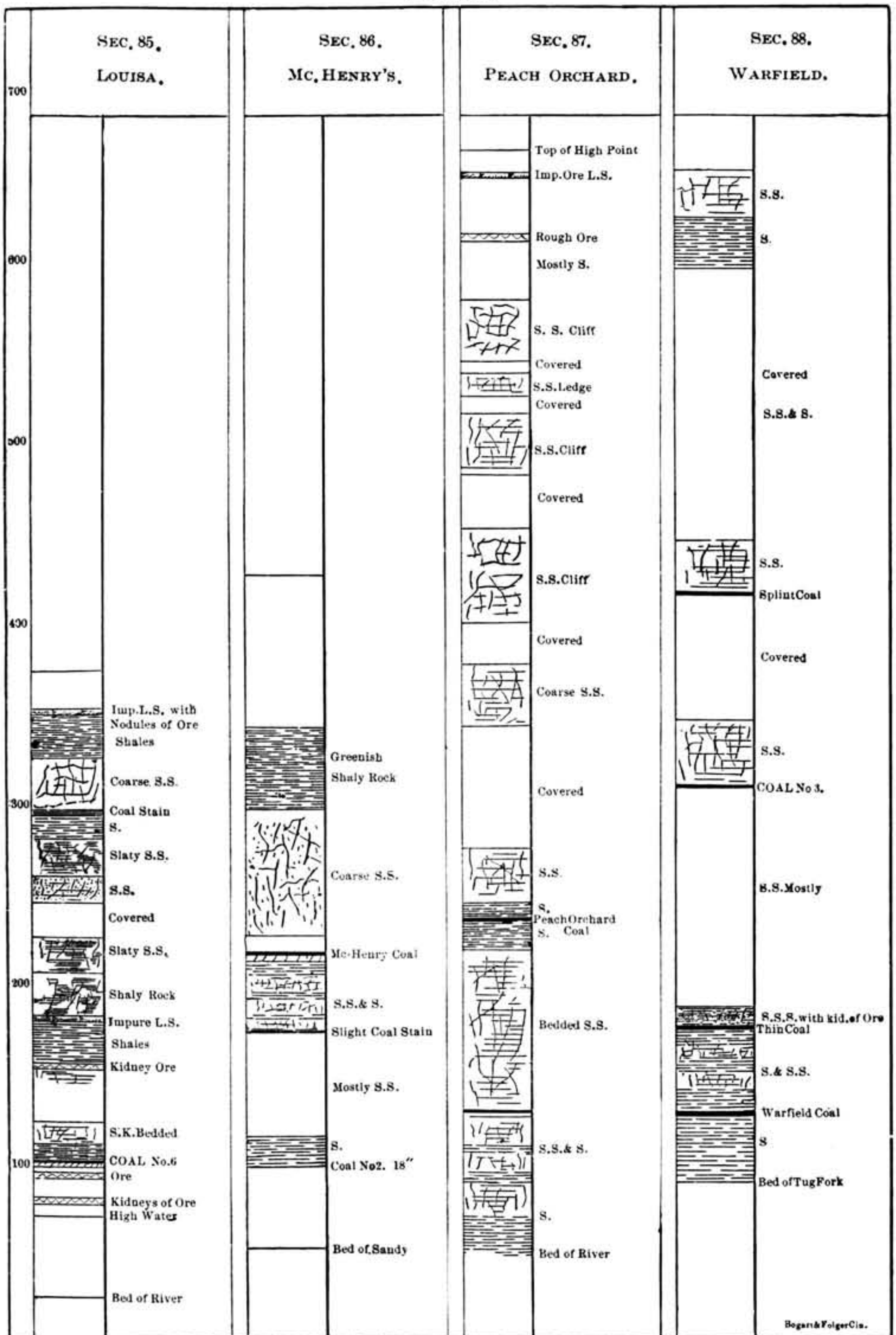

SEC.81
Cutlettsburg
BOYD CO.
SEC.82
Whites Creek
BOYD CO.
SEC.83
Mouth of Bear Cr.
LAWRENCE CO.
SEC.84
Mo.of Blain
LAWRENCE CO.
700'
600'
500'
400'
300'
200'
100'
Top of Hill
Covered
Red& Greenish S.
Bedded S.S.
S.S.(Cliff)
Clay or thin Bedded Rock.
Covered
Fer.L.S.
Kidney Ore
Coa. Stain
S.
Kidney Ore
Shaly Rock
Coal Stain(No.7)
S.S.
High Water
COAL No6.
Slope
L.S.
Covered
L.S.
Coarse S.S.
Covered
Coarse S.S.
Sil.L.S. 5'
COAL No.8
Bed of Creek
Top of Hill
S.S.
Covered
S.S.
S.&S.S.
S.S.(Cliff)
Cong. S.S.
Covered
Coarse S.S.
L.S.
COAL No.8
Covered
Bed of Creek
Covered
Coarse S.S
Covered
L.S.
Rough Kid.Ore
S.&S.S.
Coal Stain
S.&S.S.
Kidney Ore
S.S.
COAL
485' Ht. above tide at mouth of Little Sandy River.
Bogart & Folger Co.

Plate 23.



Sec. 85.
Louisa.
Imp.L.S. with Nodules of Ore
Shales
Coarse S.S.
Coal Stain
S.
Slaty S.S.
S.S.
Covered
Slaty S.S.
Shaly Rock
Impure L.S.
Shales
Kidney Ore
S.K.Bedded
COAL No.6
Ore
Kidneys of Ore
High Water
Bed of River
Sec. 86.
Mc. Henry's.
Greenish Shaly Rock
Coarse S.S.
Mc-Henry Coal
S.S.& S.
Slight Coal Stain
Mostly S.S.
S.
Coal No2. 18"
Bed of Sandy
Sec. 87.
Peach Orchard.
Top of High Point
Imp.Ore L.S.
Rough Ore
Mostly S.
S. S. Cliff
Covered
S.S.Ledge
Covered
S.S.Cliff
Covered
S.S.Cliff
Covered
Coarse S.S.
Covered
S.S.
S.
PeachOrchard
S. Coal
Bedded S.S.
S.S.& S.
S.
Bed of River
Sec. 88.
Warfield.
S.S.
S.
Covered
S.S.& S.
S.S.
SplintCoal
Covered
S.S.
COAL No 3.
S.S.Mostly
S.S.S.with kid.of Ore
ThinCoal
S.& S.S.
Warfield Coal
S
Bed ofTugFork
700
600
500
400
300
200
100
485
Ht. above tide at mouth of Little Sandy River.
Bogart&FolgerCin.

Plate 24.

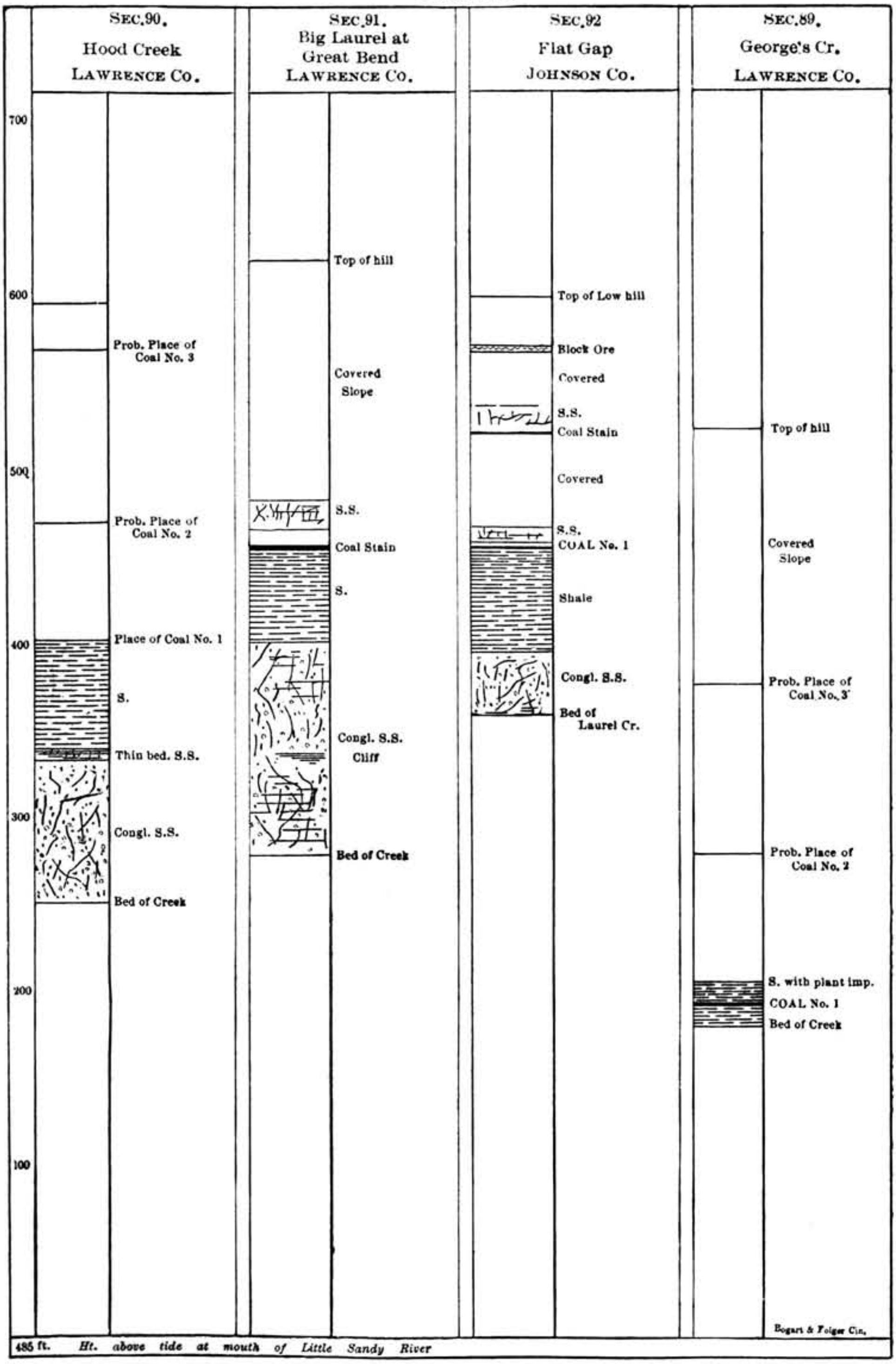
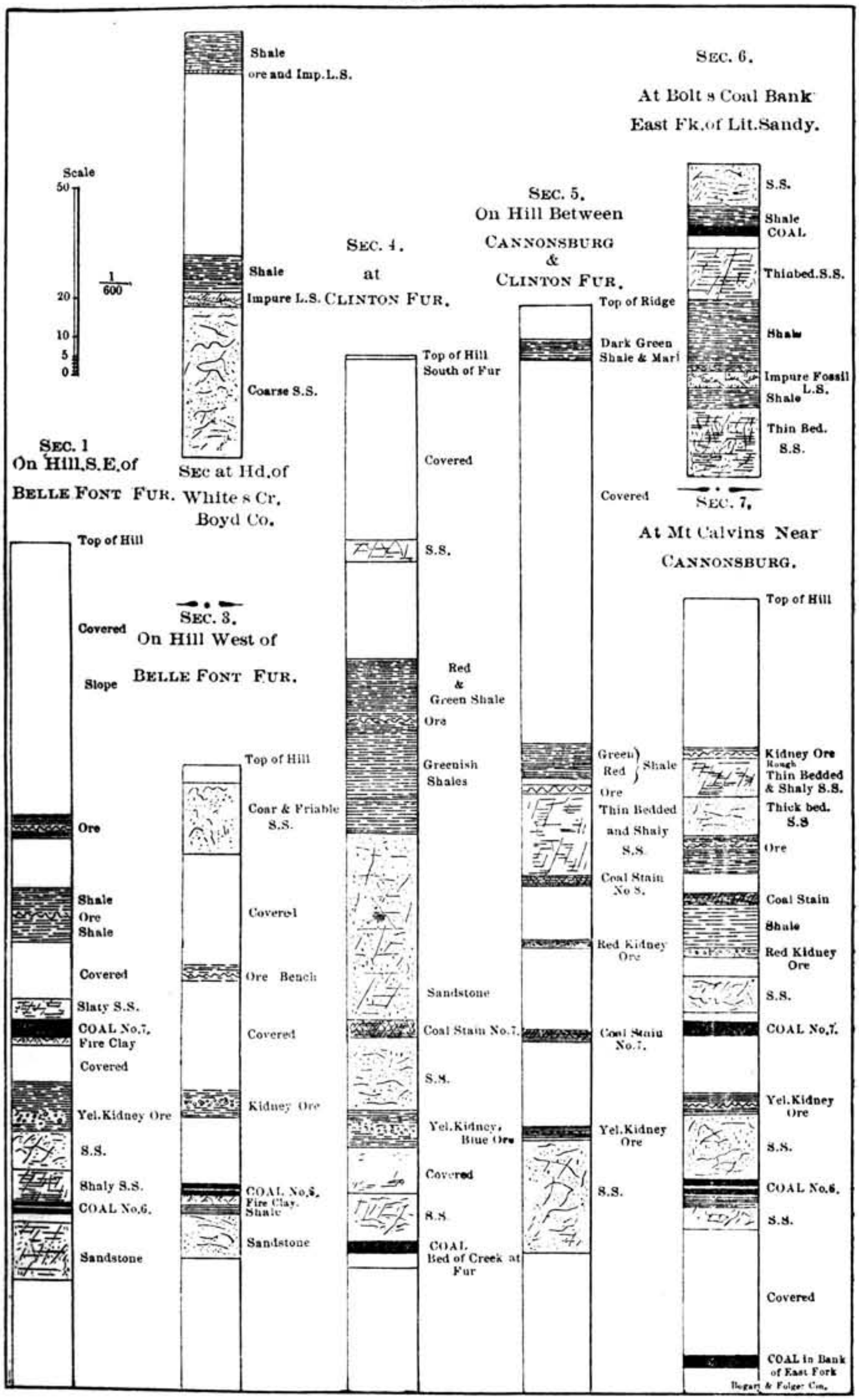

SEC. 90.
Hood Creek
LAWRENCE CO.
SEC. 91.
Big Laurel at Great Bend
LAWRENCE CO.
SEC. 92
Flat Gap
JOHNSON CO.
SEC. 89.
George's Cr.
LAWRENCE CO.
700
600
500
400
300
200
100
Prob. Place of Coal No. 3
Prob. Place of Coal No. 2
Place of Coal No. 1
S.
Thin bed. S.S.
Congl. S.S.
Bed of Creek
Top of hill
Covered Slope
S.S.
Coal Stain
S.
Congl. S.S. Cliff
Bed of Creek
Top of Low hill
Block Ore
Covered
S.S.
Coal Stain
Covered
S.S.
COAL No. 1
Shale
Congl. S.S.
Bed of Laurel Cr.
Top of hill
Covered Slope
Prob. Place of Coal No. 3
Prob. Place of Coal No. 2
S. with plant imp.
COAL No. 1
Bed of Creek
485 ft. Ht. above tide at mouth of Little Sandy River
Bogart & Folger Cin.

Plate 25.



Scale
50
20
10
5
0
1/600
SEC. 1
On Hill S.E. of
BELLE FONT FUR.
Top of Hill
Covered
Slope
Ore
Shale
Ore
Shale
Covered
Slaty S.S.
COAL No.7.
Fire Clay
Covered
Yel. Kidney Ore
S.S.
Shaly S.S.
COAL No.6.
Sandstone
Shale
ore and Imp. L.S.
Shale
Impure L.S.
Coarse S.S.
SEC at Hd. of
White s Cr.
Boyd Co.
SEC. 3.
On Hill West of
BELLE FONT FUR.
Top of Hill
Coar & Friable S.S.
Covered
Ore Bench
Covered
Kidney Ore
COAL No.6.
Fire Clay.
Shale
Sandstone
SEC. 4.
at
CLINTON FUR.
Top of Hill
South of Fur
Covered
S.S.
Red
&
Green Shale
Ore
Greenish
Shales
Sandstone
Coal Stain No.7.
S.S.
Yel. Kidney,
Blue Ore
Covered
S.S.
COAL
Bed of Creek at
Fur
SEC. 5.
On Hill Between
CANNONSBURG
&
CLINTON FUR.
Top of Ridge
Dark Green
Shale & Marl
Covered
Green
Red
Shale
Ore
Thin Bedded
and Shaly
S.S.
Coal Stain
No 8.
Red Kidney
Ore
Coal Stain
No.7.
Yel. Kidney
Ore
S.S.
SEC. 6.
At Bolt s Coal Bank
East Fk. of Lit. Sandy.
S.S.
Shale
COAL
Thinbed. S.S.
Shale
Impure Fossil
L.S.
Shale
Thin Bed.
S.S.
SEC. 7.
At Mt Calvins Near
CANNONSBURG.
Top of Hill
Kidney Ore
Rough
Thin Bedded
& Shaly S.S.
Thick bed.
S.S
Ore
Coal Stain
Shale
Red Kidney
Ore
S.S.
COAL No.7.
Yel. Kidney
Ore
S.S.
COAL No.6.
S.S.
Covered
COAL in Bank
of East Fork
Hogan & Folger Co.

Plate 26.

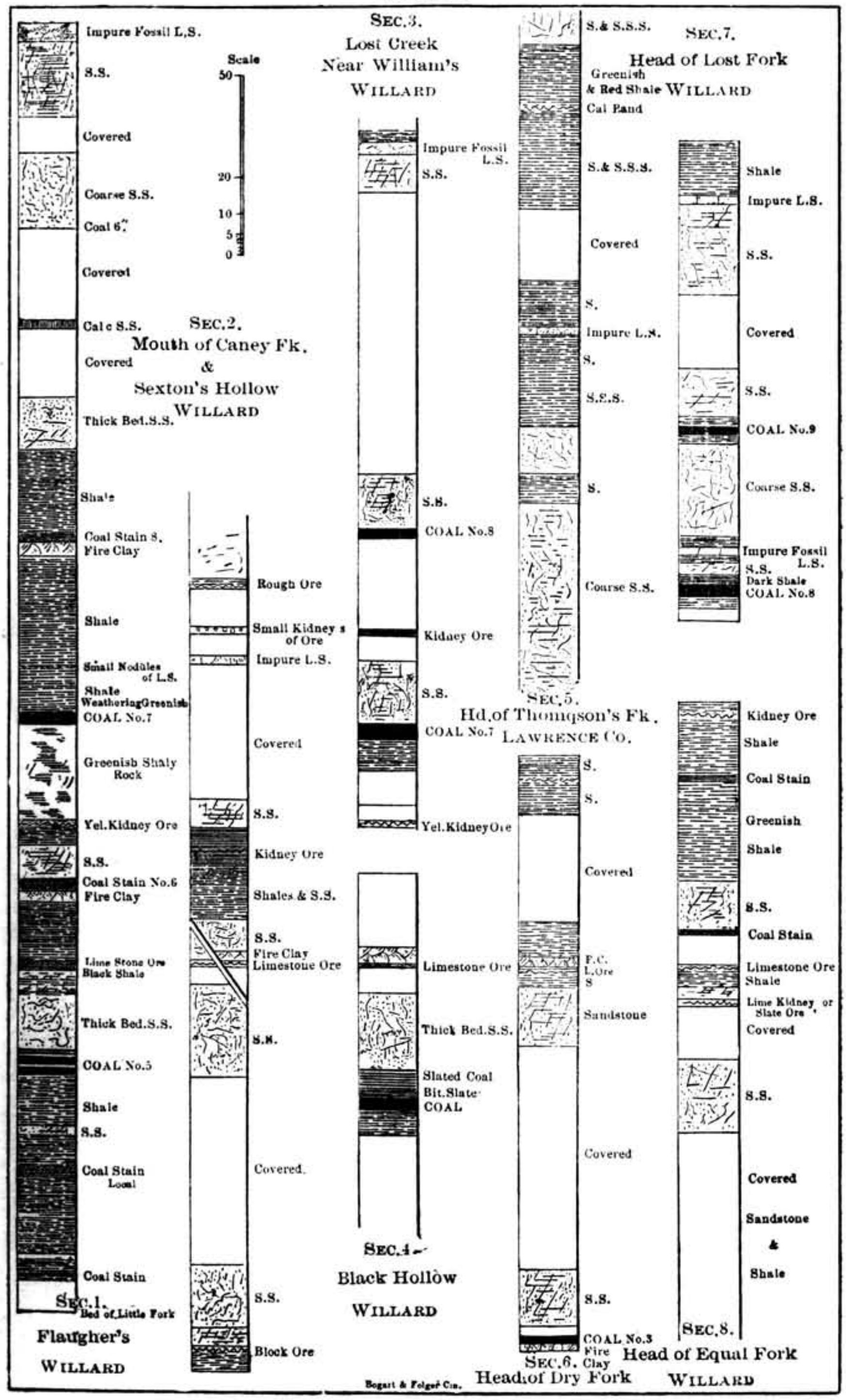
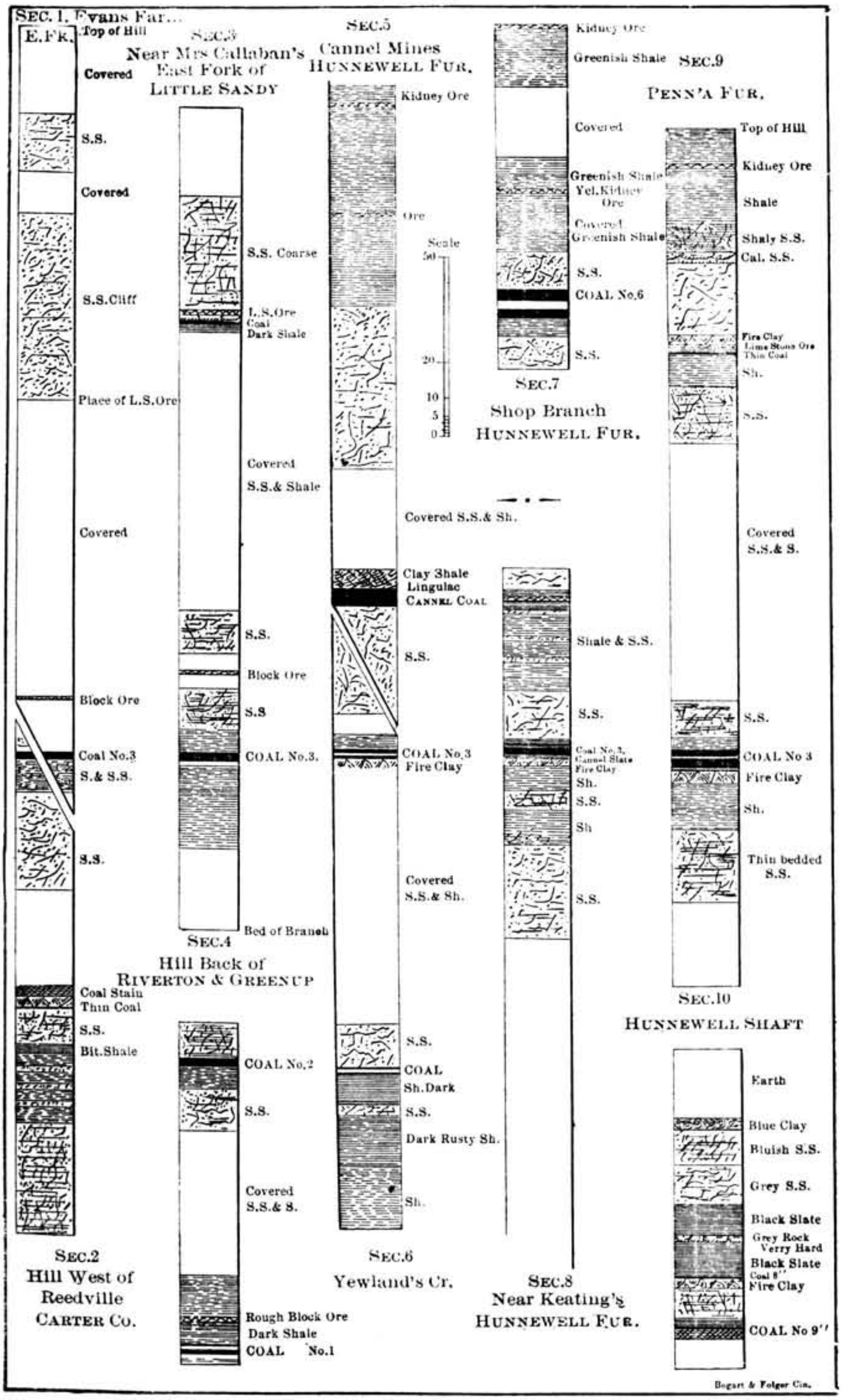
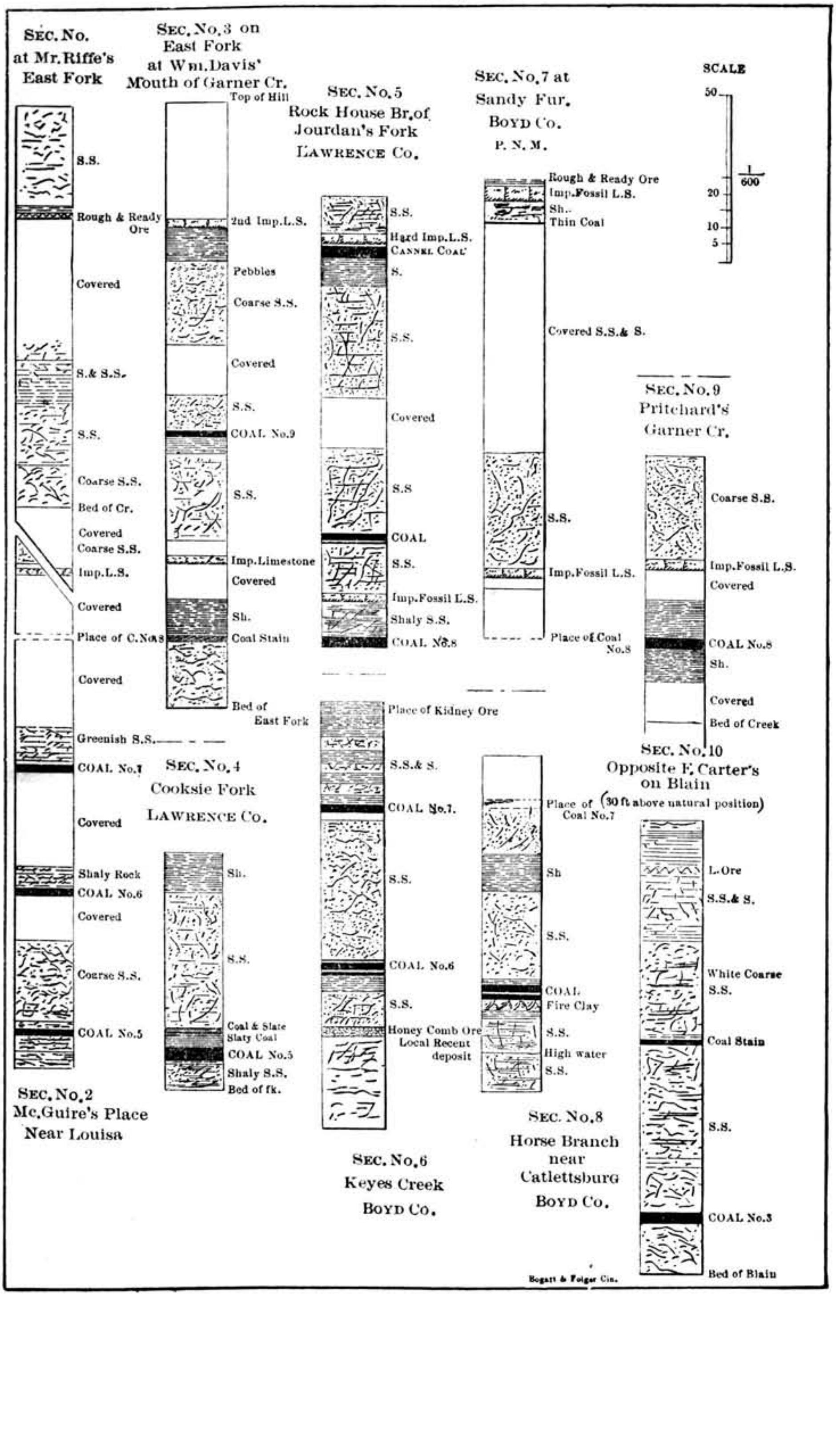

Scale
50
20
10
5
0
SEC.1.
Bed of Little Fork
Flaugher's
WILLARD
Impure Fossil L.S.
S.S.
Covered
Coarse S.S.
Coal 6"
Covered
Calc S.S.
Covered
Thick Bed.S.S.
Shale
Coal Stain S.
Fire Clay
Shale
Small Nodules of L.S.
Shale Weathering Greenish
COAL No.7
Greenish Shaly Rock
Yel.Kidney Ore
S.S.
Coal Stain No.6
Fire Clay
Lime Stone Ore
Black Shale
Thick Bed.S.S.
COAL No.5
Shale
S.S.
Coal Stain Local
Coal Stain
SEC.2.
Mouth of Caney Fk.
&
Sexton's Hollow
WILLARD
Rough Ore
Small Kidneys of Ore
Impure L.S.
Covered
S.S.
Kidney Ore
Shales & S.S.
S.S.
Fire Clay
Limestone Ore
S.S.
Covered.
S.S.
Block Ore
SEC.3.
Lost Creek
Near William's
WILLARD
Impure Fossil L.S.
S.S.
S.S.
COAL No.8
Kidney Ore
S.S.
COAL No.7
Yel.Kidney Ore
Limestone Ore
Thick Bed.S.S.
Slated Coal
Bit.Slate
COAL
SEC.4.
Black Hollow
WILLARD
S.& S.S.S.
Greenish & Red Shale
Cal Band
S.& S.S.S.
Covered
S.
Impure L.S.
S.
S.S.S.
S.
Coarse S.S.
SEC.5.
Hd.of Thompson's Fk.
LAWRENCE CO.
S.
S.
Covered
F.C.
L.Ore
S
Sandstone
Covered
S.S.
COAL No.3
Fire Clay
SEC.6.
Head of Dry Fork
SEC.7.
Head of Lost Fork
WILLARD
Shale
Impure L.S.
S.S.
Covered
S.S.
COAL No.9
Coarse S.S.
Impure Fossil L.S.
S.S.
Dark Shale
COAL No.8
Kidney Ore
Shale
Coal Stain
Greenish Shale
S.S.
Coal Stain
Limestone Ore
Shale
Lime Kidney or Slate Ore
Covered
S.S.
Covered
Sandstone & Shale
SEC.8.
Head of Equal Fork
WILLARD
Bogart & Folger Co.

Plate 27



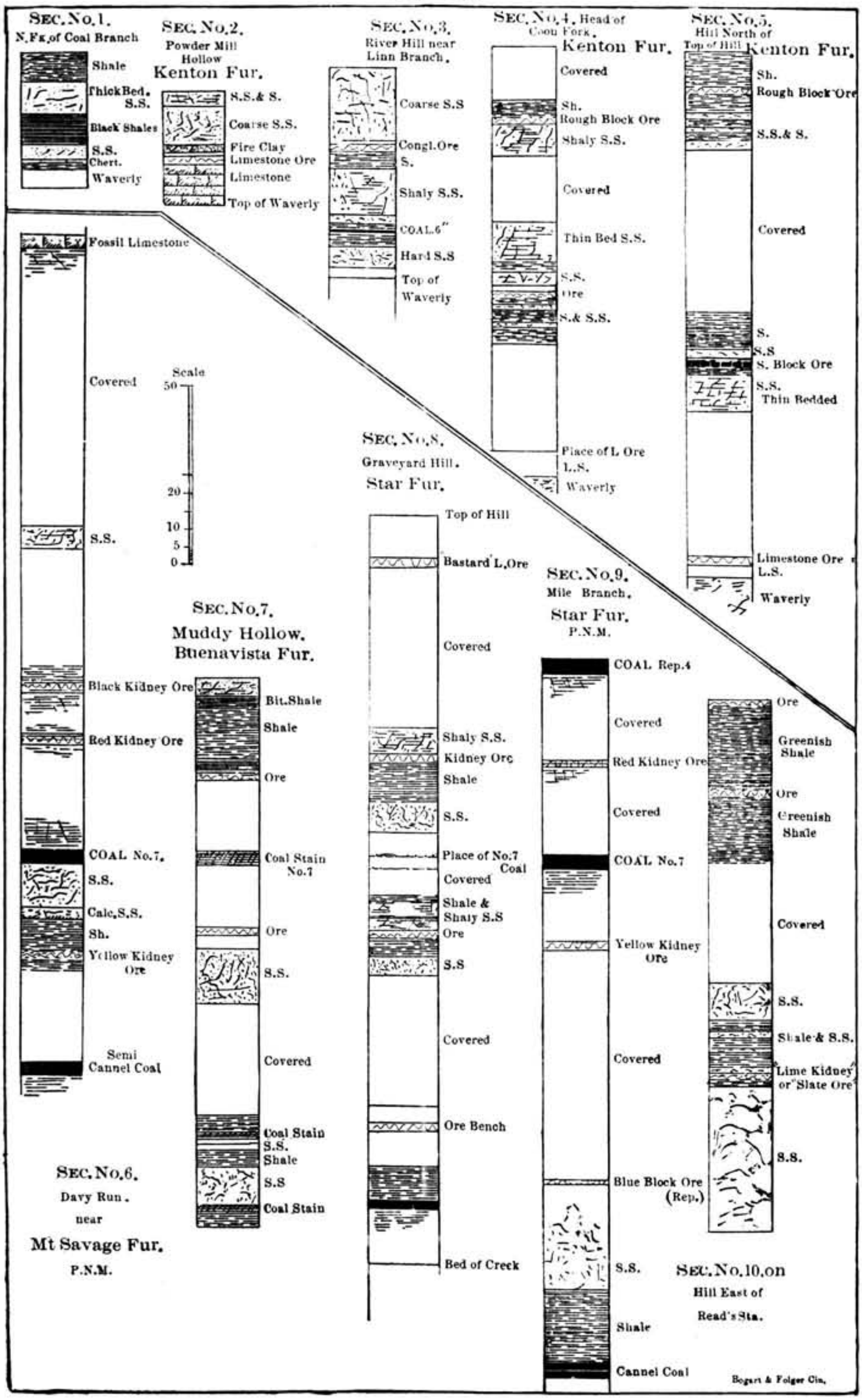
SEC. 1. Evans Far...
E.FK.
Top of Hill
Covered
S.S.
Covered
S.S.Cliff
Place of L.S.Ore
Covered
Block Ore
Coal No.3
S.& S.S.
S.S.
Coal Stain
Thin Coal
S.S.
Bit.Shale
SEC.2
Hill West of
Reedville
CARTER CO.
SEC.3
Near Mrs Callahan's
East Fork of
LITTLE SANDY
S.S. Coarse
L.S.Ore
Coal
Dark Shale
Covered
S.S.& Shale
S.S.
Block Ore
S.S
COAL No.3.
Bed of Branch
SEC.4
Hill Back of
RIVERTON & GREENUP
COAL No.2
S.S.
Covered
S.S.& S.
Rough Block Ore
Dark Shale
COAL No.1
SEC.5
Cannel Mines
HUNNEWELL FUR.
Kidney Ore
Ore
Scale
50
20
10
5
0
Covered S.S.& Sh.
Clay Shale
Lingulae
CANNEL COAL
S.S.
COAL No.3
Fire Clay
Covered
S.S.& Sh.
S.S.
COAL
Sh.Dark
S.S.
Dark Rusty Sh.
Sh.
SEC.6
Yewland's Cr.
Kidney Ore
Greenish Shale
Covered
Greenish Shale
Yel.Kidney Ore
Covered
Greenish Shale
S.S.
COAL No.6
S.S.
SEC.7
Shop Branch
HUNNEWELL FUR.
Shale & S.S.
S.S.
Coal No.3.
Cannel Slate
Fire Clay
Sh.
S.S.
Sh
S.S.
SEC.8
Near Keating's
HUNNEWELL FUR.
SEC.9
PENN'A FUR.
Top of Hill
Kidney Ore
Shale
Shaly S.S.
Cal. S.S.
Fire Clay
Lime Stone Ore
Thin Coal
Sh.
S.S.
Covered
S.S.& S.
S.S.
COAL No 3
Fire Clay
Sh.
Thin bedded
S.S.
SEC.10
HUNNEWELL SHAFT
Earth
Blue Clay
Bluish S.S.
Grey S.S.
Black Slate
Grey Rock
Verry Hard
Black Slate
Coal 8''
Fire Clay
COAL No 9''
Bogart & Folger Cin.

Plate 28.



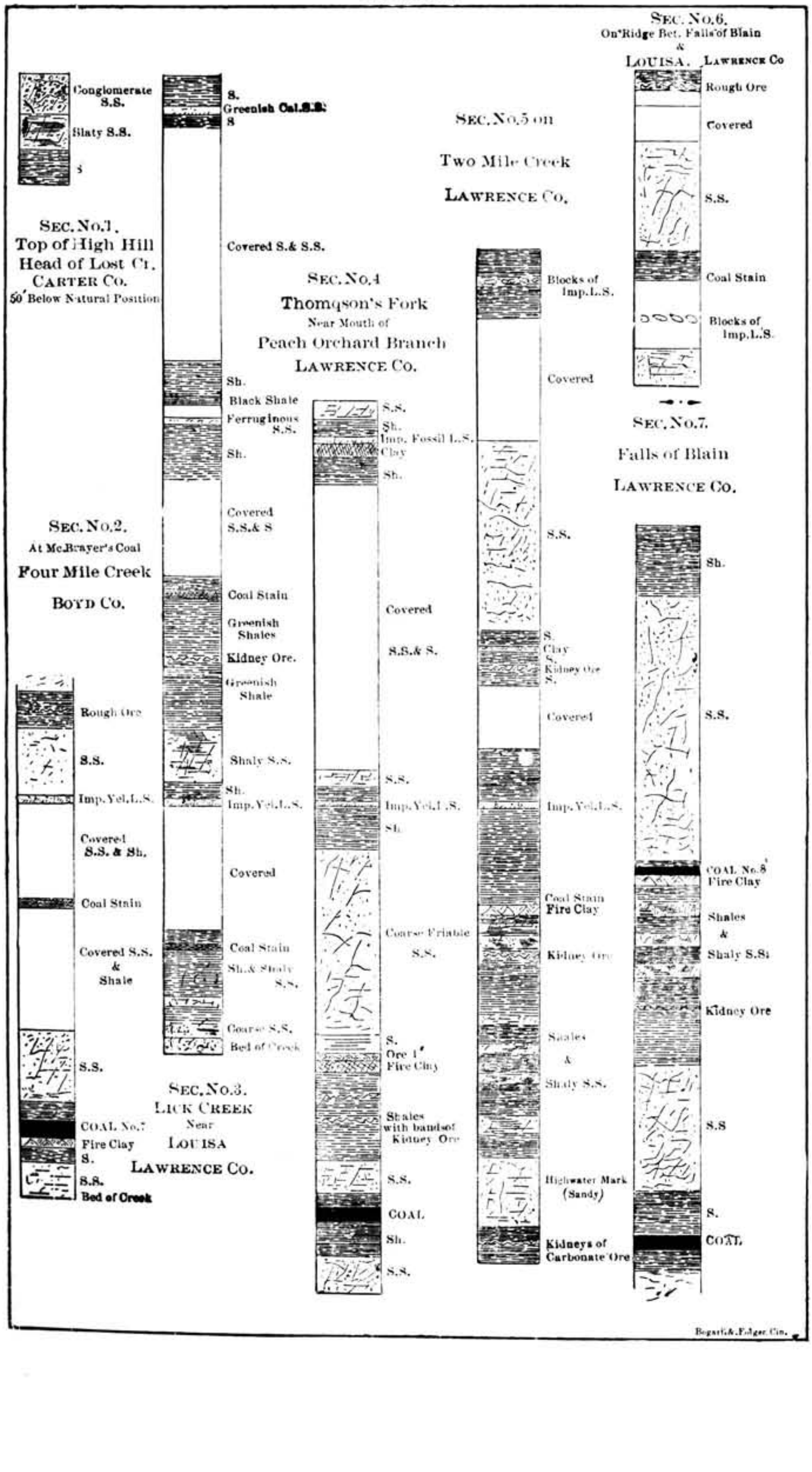
SEC. No. at Mr. Riffe's East Fork
S.S.
Rough & Ready Ore
Covered
S. & S.S.
S.S.
Coarse S.S.
Bed of Cr.
Covered
Coarse S.S.
Imp.L.S.
Covered
Place of C.No.8
Covered
Greenish S.S.
COAL No.7
Covered
Shaly Rock
COAL No.6
Covered
Coarse S.S.
COAL No.5
SEC. No.2 Mc.Guire's Place Near Louisa
SEC. No.3 on East Fork at Wm. Davis' Mouth of Garner Cr.
Top of Hill
2nd Imp.L.S.
Pebbles
Coarse S.S.
Covered
S.S.
COAL No.9
S.S.
Imp.Limestone
Covered
Sh.
Coal Stain
Bed of East Fork
SEC. No.4 Cooksie Fork LAWRENCE CO.
Sh.
S.S.
Coal & Slate
Slaty Coal
COAL No.5
Shaly S.S.
Bed of fk.
SEC. No.5 Rock House Br. of Jourdan's Fork LAWRENCE CO.
S.S.
Hard Imp.L.S.
CANNEL COAL
S.
S.S.
Covered
S.S
COAL
S.S.
Imp.Fossil L.S.
Shaly S.S.
COAL No.8
Place of Kidney Ore
S.S.& S.
COAL No.7.
S.S.
COAL No.6
S.S.
Honey Comb Ore
Local Recent deposit
SEC. No.6 Keyes Creek BOYD CO.
SEC. No.7 at Sandy Fur. BOYD CO. P. N. M.
Rough & Ready Ore
Imp.Fossil L.S.
Sh..
Thin Coal
Covered S.S.& S.
S.S.
Imp.Fossil L.S.
Place of Coal No.8
Place of Coal No.7 (30 ft above natural position)
Sh
S.S.
COAL
Fire Clay
S.S.
High water
S.S.
SEC. No.8 Horse Branch near Catlettsburg BOYD CO.
SCALE
50
20
10
5
1/600
SEC. No.9 Pritchard's Garner Cr.
Coarse S.S.
Imp.Fossil L.S.
Covered
COAL No.8
Sh.
Covered
Bed of Creek
SEC. No.10 Opposite F. Carter's on Blain
L.Ore
S.S.& S.
White Coarse S.S.
Coal Stain
S.S.
COAL No.3
Bed of Blain
Bogart & Folger Cin.

Plate 29.



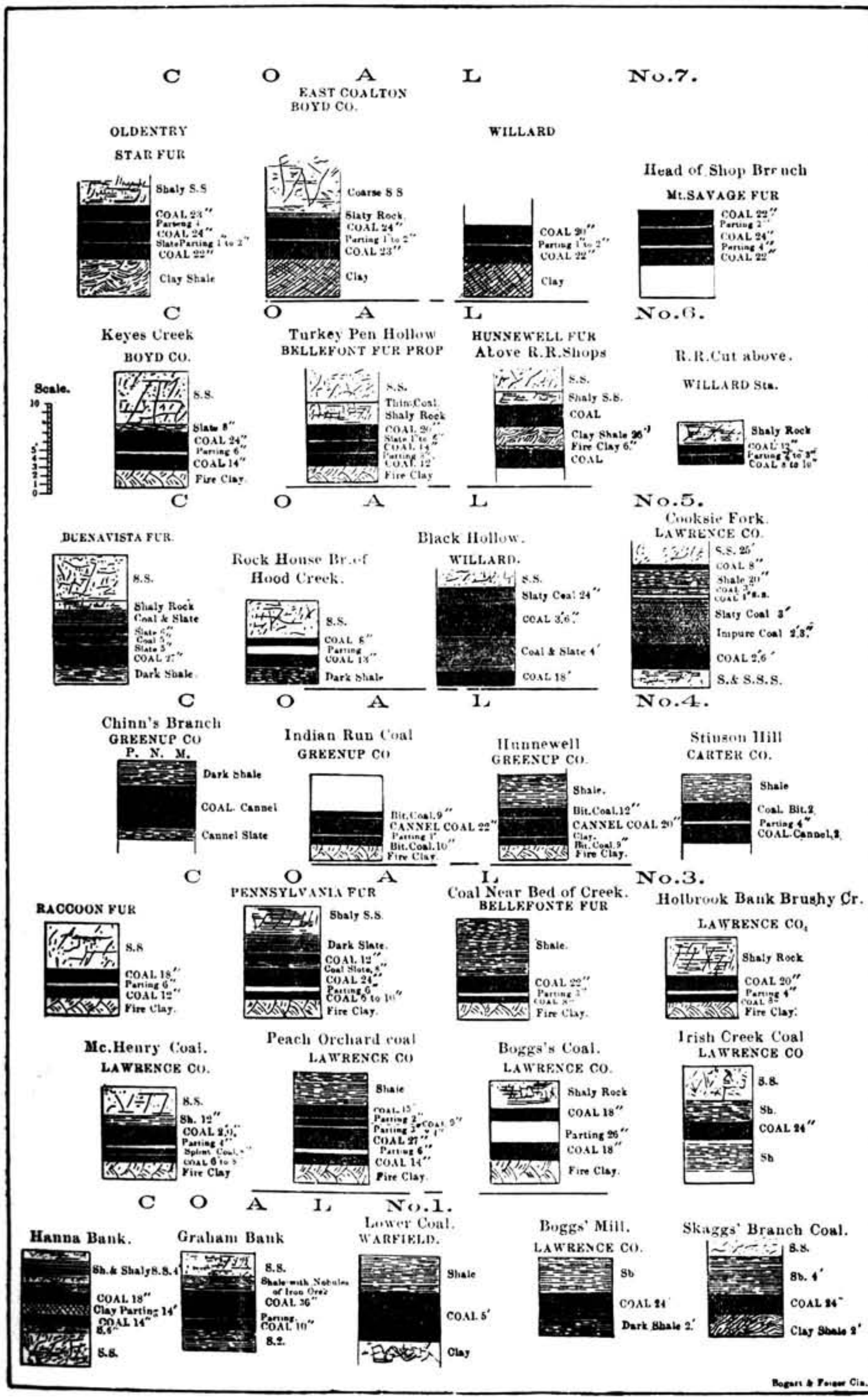
SEC. No. 1.
N. Fk. of Coal Branch
Shale
Thick Bed. S.S.
Black Shales
S.S.
Chert.
Waverly
SEC. No. 2.
Powder Mill Hollow
Kenton Fur.
S.S. & S.
Coarse S.S.
Fire Clay
Limestone Ore
Limestone
Top of Waverly
SEC. No. 3.
River Hill near Linn Branch.
Coarse S.S
Congl. Ore
S.
Shaly S.S.
COAL 6"
Hard S.S
Top of Waverly
SEC. No. 4. Head of Coon Fork.
Kenton Fur.
Covered
Sh.
Rough Block Ore
Shaly S.S.
Covered
Thin Bed S.S.
S.S.
Ore
S. & S.S.
Place of L. Ore
L.S.
Waverly
SEC. No. 5.
Hill North of Top of Hill
Kenton Fur.
Sh.
Rough Block Ore
S.S. & S.
Covered
S.
S.S
S. Block Ore
S.S.
Thin Bedded
Limestone Ore
L.S.
Waverly
Fossil Limestone
Covered
Scale
50
20
10
5
0
S.S.
Black Kidney Ore
Red Kidney Ore
COAL No. 7.
S.S.
Calc. S.S.
Sh.
Yellow Kidney Ore
Semi Cannel Coal
SEC. No. 6.
Davy Run.
near
Mt Savage Fur.
P.N.M.
SEC. No. 7.
Muddy Hollow.
Buenavista Fur.
Bit. Shale
Shale
Ore
Coal Stain No. 7
Ore
S.S.
Covered
Coal Stain
S.S.
Shale
S.S
Coal Stain
SEC. No. 8.
Graveyard Hill.
Star Fur.
Top of Hill
Bastard L. Ore
Covered
Shaly S.S.
Kidney Ore
Shale
S.S.
Place of No. 7 Coal
Covered
Shale & Shaly S.S
Ore
S.S
Covered
Ore Bench
Bed of Creek
SEC. No. 9.
Mile Branch.
Star Fur.
P.N.M.
COAL Rep. 4
Covered
Red Kidney Ore
Covered
COAL No. 7
Yellow Kidney Ore
Covered
Blue Block Ore (Rep.)
S.S.
Shale
Cannel Coal
Ore
Greenish Shale
Ore
Greenish Shale
Covered
S.S.
Shale & S.S.
Lime Kidney or Slate Ore
S.S.
SEC. No. 10. on
Hill East of
Read's Sta.
Bogert & Folger Cin.

Plate 30.



Bogart & Folger Cin.

Plate 31


C O A L No.7.
EAST COALTON
BOYD CO.
OLDENTRY
STAR FUR
Shaly S.S
COAL 23"
COAL 24"
COAL 22"
Clay Shale
Coarse S S
Slaty Rock
COAL 24"
COAL 23"
Clay
WILLARD
COAL 20"
COAL 22"
Clay
Head of Shop Branch
Mt.SAVAGE FUR
COAL 22"
COAL 24"
COAL 22"
C O A L No.6.
Keyes Creek
BOYD CO.
S.S.
Slate 8"
COAL 24"
Parting 6"
COAL 14"
Fire Clay.
Scale.
Turkey Pen Hollow
BELLEFONT FUR PROP
S.S.
Thin Coal
Shaly Rock
Fire Clay
HUNNEWELL FUR
Above R.R.Shops
S.S.
Shaly S.S.
COAL
Clay Shale 36"
Fire Clay 6"
COAL
R.R.Cut above.
WILLARD Sta.
Shaly Rock
C O A L No.5.
BUENAVISTA FUR.
S.S.
Shaly Rock
Coal & Slate
Dark Shale.
Rock House Br. of
Hood Creek.
S.S.
COAL 8"
Dark Shale
Black Hollow.
WILLARD.
S.S.
Slaty Coal 24"
Coal & Slate 4'
COAL 18'
Cooksie Fork.
LAWRENCE CO.
S.S. 25'
COAL 8"
Shale 20"
Slaty Coal 3'
Impure Coal 2'3"
S.& S.S.S.
C O A L No.4.
Chinn's Branch
GREENUP CO
P. N. M.
Dark Shale
COAL. Cannel
Cannel Slate
Indian Run Coal
GREENUP CO
Bit.Coal.9"
CANNEL COAL 22"
Parting 1"
Bit.Coal.10"
Fire Clay
Hunnewell
GREENUP CO.
Shale.
Bit.Coal.12"
CANNEL COAL 20"
Fire Clay.
Stinson Hill
CARTER CO.
Shale
Coal. Bit.2
Parting 4"
COAL Cannel,2
C O A L No.3.
RACCOON FUR
S.S
COAL 18"
Parting 6"
COAL 12"
Fire Clay.
PENNSYLVANIA FUR
Shaly S.S
Dark Slate.
COAL 12"
COAL 24"
Fire Clay.
Coal Near Bed of Creek.
BELLEFONTE FUR
Shale.
COAL 22"
Fire Clay.
Holbrook Bank Brushy Cr.
LAWRENCE CO.
Shaly Rock
COAL 20"
Parting 4"
Fire Clay.
Mc.Henry Coal.
LAWRENCE CO.
S.S.
Sh. 12"
Fire Clay
Peach Orchard coal
LAWRENCE CO
Shale
COAL 27"
Parting 6"
COAL 14"
Fire Clay.
Boggs's Coal.
LAWRENCE CO.
Shaly Rock
COAL 18"
Parting 26"
COAL 18"
Fire Clay.
Irish Creek Coal
LAWRENCE CO
S.S.
Sh.
COAL 24"
Sh
C O A L No.1.
Hanna Bank.
Sh.& Shaly S.S.
COAL 18"
Clay Parting 14"
COAL 14"
S.S.
Graham Bank
S.S.
Shale with Nodules of Iron Ore
COAL 36"
Parting.
COAL 10"
S.S.
Lower Coal.
WARFIELD.
Shale
COAL 5'
Clay
Boggs' Mill.
LAWRENCE CO.
Sh
COAL 24
Dark Shale 2.'
Skaggs' Branch Coal.
S.S.
Sh. 4'
COAL 24"
Clay Shale 2'
Bogart & Feiser Cin.

GEOLOGICAL SURVEY OF KENTUCKY.

N. S. SHALER, Director.

REPORT ON THE GEOLOGY

OF THE

NOLIN RIVER DISTRICT,

EMBRACING PORTIONS OF

GRAYSON, EDMONSON, HART, AND BUTLER COUNTIES,

BY P. N. MOORE.

Part II. Vol. II. Second Series.

79 & 80

INTRODUCTORY LETTER.

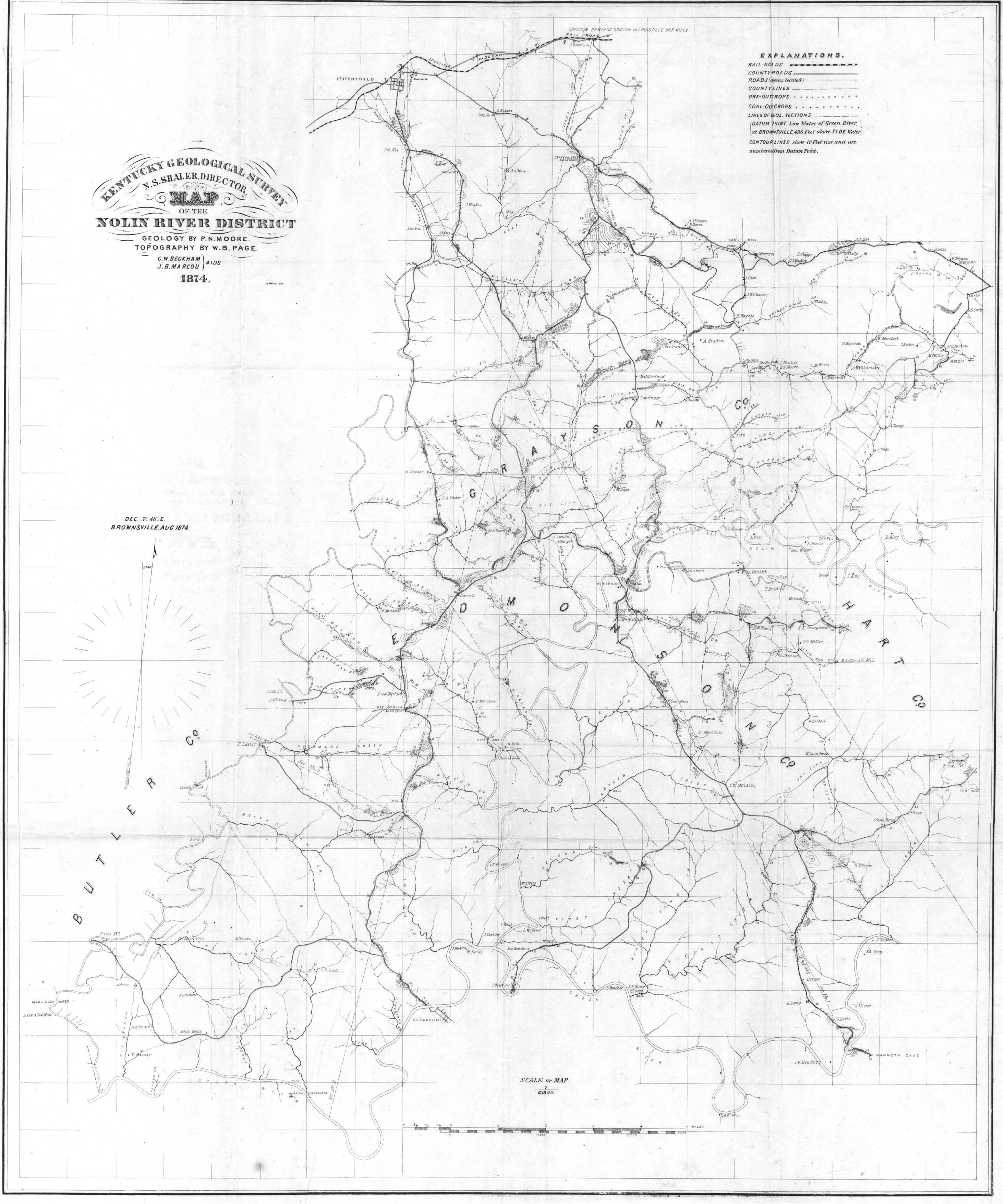
Professor N. S. SHALER, *Director Kentucky Geological Survey:*

I herewith transmit my report upon the geology of that portion of the western coal field between Green river and the Louisville, Paducah and Southwestern Railroad, lying east of Bear Creek. The limits of the work have been determined more by geological and topographical boundaries than by political divisions. It therefore embraces portions of Butler, Grayson, Edmonson, and Hart counties, without including the whole of any of them.

I desire here to acknowledge the valuable assistance rendered to the Survey by Mr. John R. Procter. In addition to his services in the field, Mr. Procter has been of great assistance in preparing the cross-sections which accompany this report. His observations have been extensively used in their construction.

Respectfully submitted,

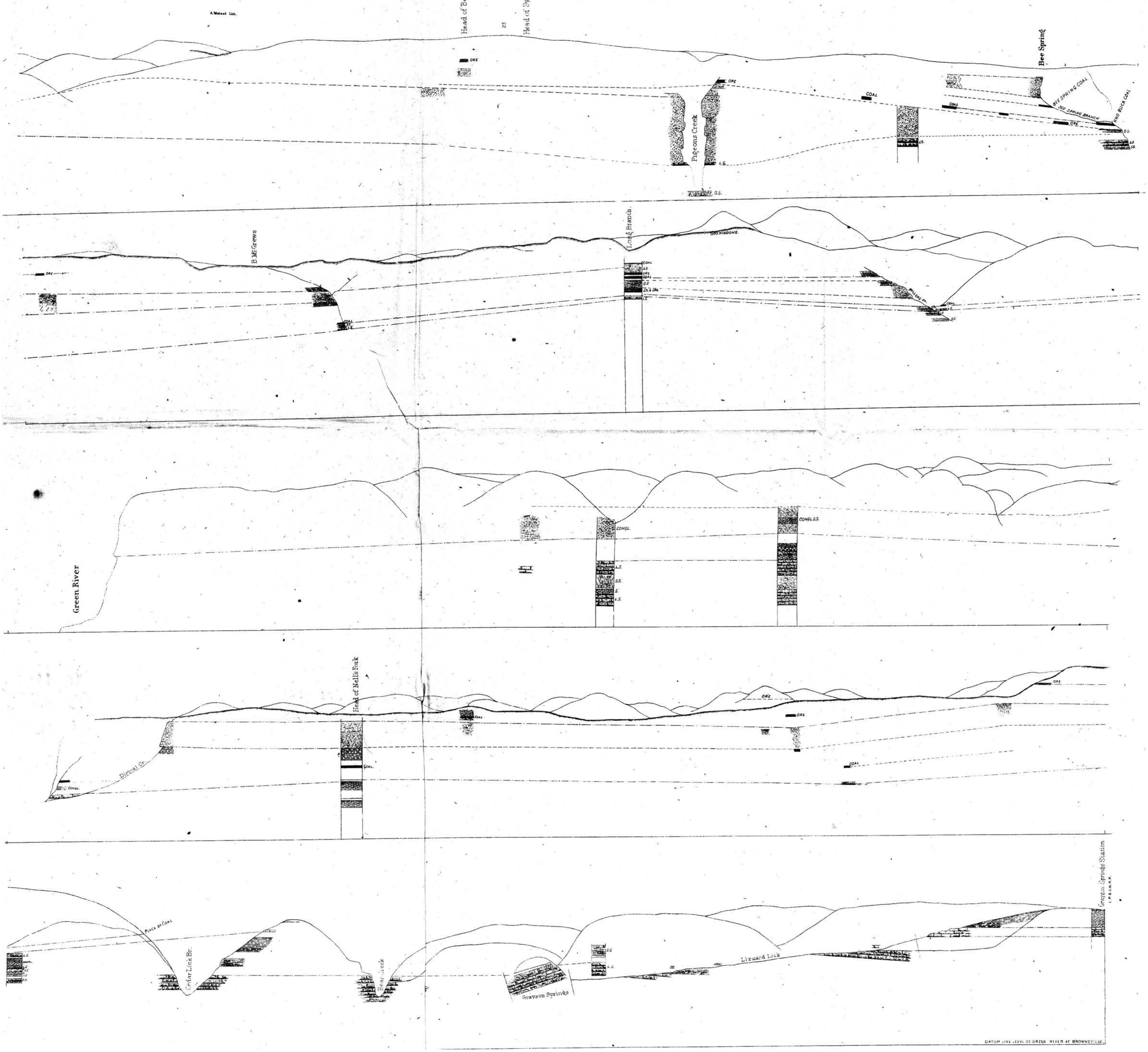
P. N. MOORE, *Assistant.*


KENTUCKY GEOLOGICAL SURVEY
N. S. SHALER, DIRECTOR
MAP
OF THE
NOLIN RIVER DISTRICT
GEOLOGY BY P. N. MOORE.
TOPOGRAPHY BY W. B. PAGE.
C. W. BECKHAM
J. B. MARCOU
AIDS
1874.
EXPLANATIONS.
RAIL-ROADS
COUNTY-ROADS
ROADS (aprox. located)
COUNTY LINES
ORE-OUTCROPS
COAL-OUTCROPS
LINES OF GEOL. SECTIONS
DATUM POINT Low Water of Green River, at BROWNSVILLE, 436 Feet above TIDE Water
CONTOUR LINES show 10 Feet rise and are numbered from Datum Point.
GRAYSON SPRINGS STATION TO LOUISVILLE 66.5 MILES
RAIL ROAD
LOUISVILLE PADUCAH
LEITCHFIELD
GRAYSON CO.
EDMONSON CO.
HART CO.
BUTLER CO.
NOLIN RIVER
GREEN RIVER
BROWNSVILLE
MAMMOTH CAVE
DEC. 5° 48' E.
BROWNSVILLE, AUG 1874.
SCALE OF MAP
1/63360.

CROSS SECTION No.2 FROM Grayson Springs Station TO GREEN RIVER, BY P. N. MOORE & J. R. PROCTER.

SCALE
160 feet to 1 inch Vertical.
1600 feet to 1 inch Horizontal.

A. Meisel Lith.



ON THE GEOLOGY OF THE NOLIN RIVER DISTRICT, EMBRACING PORTIONS OF GRAYSON, EDMONSON, HART, AND BUTLER COUNTIES.

The area covered by the present report consists of that portion of the western coal field, and the immediately surrounding country, which lies east of Bear Creek, between Green river and the line of the Louisville, Paducah and Southwestern Railroad.

SURFACE FEATURES.

This region, for one in which the vertical height of the hills is comparatively so small, affords considerable variety in its topographical features, which have been formed solely by erosive agencies slowly acting upon sedimentary rocks of various kinds, which are comparatively undisturbed, and lie nearly horizontally.

A great variety of forms of topography are presented, which offer fine illustrations of the effect of the different rock formations of a country upon its surface features by the different degrees with which the rocks resist erosion. Resistance to erosion has been alone the determining agency in forming the topography; it has not been appreciably affected by distortions, upheavals, or faults in the strata; for, taking the region as a whole, it is very little disturbed, and the rocks usually retain their original position, lying horizontally or dipping slightly to the west.

There are, it is true, in portions of this region, in the limestones and sandstones of the Chester Group, a large number of small faults, some of which extend up into the overlying coal measures; but they are usually of small vertical extent, rarely measuring more than 50 feet, and they do not seem to have exerted any appreciable effect upon the topography.

There are few prominent hills, but the general surface of the country may be best considered as a plain of considerable elevation, with the variations in height caused by the streams cutting through in different ways. The highest elevations will not exceed 490 feet above low water in Green river, at Brownsville, or 920 feet above tide water, estimating Green river at Brownsville as 430 feet above sea level–a level obtained from the best data at command, which, however, are imperfect. The general level of the country, on the ridges and comparatively flat uplands at the heads of the streams, is from 300 to 400 feet above Green river; while the level of the valleys, which in the lower part of this region are usually quite narrow, is from 200 to 250 feet below the uplands.

The drainage is all into Green river, chiefly through its two principal branches, Nolin river and Bear Creek, although there are a number of small creeks flowing directly into Green river, in the southern part of the region.

To the north, on the ridge which forms the divide between the waters of Rough Creek and those of Nolin river and Bear Creek, and along which the Louisville, Paducah and Southwestern Railroad passes, the surface of the country is level or gently rolling. To the south, it is much more broken, showing high table lands with the streams cut as deep gorges or cañons, with precipitous and often impassable banks, affording remarkably picturesque scenery.

The topography of the northern portion is due to the alternate thin sandstones, limestones, and shales of the Chester Group, which, not offering great resistance to the erosive agencies, are acted upon quite uniformly, giving us even and gentle slopes, except where there is a limestone or sandstone thicker than usual, when the streams cut narrow and gorge-like but shallow valleys, leaving the general surface above the streams still comparatively level and unbroken. On the south, a series of heavy, coarse sandstones, culminating in the massive conglomerate, which is from 100 to 180 feet thick, are the determining rocks, and give us a characteristic topography.

Where the massive sandstone forms the tops of the hills, and is underlaid by friable shales and shaly sandstones, we have for the uplands a nearly level surface, streams narrow and precipitous at the upper part, where each one heads in the sandstone, and wider below, giving occasional valleys which afford good-sized farms of nearly level land. This is the character of the topography over a large portion of this region—of nearly all of that north of Sycamore and Dismal Creeks to the edge of the coal measures. Here a massive, thick-bedded sandstone, ranging from 40 to 60 feet in thickness, lies near the surface, and gives character to the topography. All the streams head in it, or cut their way through it near their heads, where it shows many exposures of its full thickness, in precipitous cliffs.

Further south, the conglomerate sandstone is of great thickness, and the streams are cut in it and the underlying limestone. The result is, that they are little more than narrow but deep gorges for their entire length, with little or no tillable land even near their mouths. The walls of these gorges are often precipitous cliffs from 75 to 150 feet in height. The country is so cut up by streams of this class, that travel is very difficult or impossible, except by following the main ridges or divides between the streams.

Some of the most romantic and beautiful scenery of the State is to be seen on the streams of this region. The well-known Dismal Rock, on Nolin river, at the mouth of Dismal Creek, is but one instance among many. Piney, Pigeon, Bylew, and the other creeks in the heavy conglomerate, present a series of wild and picturesque cliffs which have been rarely seen by appreciative eyes, but are well worthy the attention of the tourist. Were they more accessible, the region would doubtless become a well known and attractive resort. As it is, some of the finest scenery is but a short ride from Mammoth Cave, and can readily be visited from that place.

Nolin river, from Dismal Creek to its mouth, cuts its way through the heavy conglomerate. Its valley, which above had been at some places of considerable width, at once narrows, and at many places is little wider than the bed of the stream; and the banks are so steep that it is with difficulty one can make his way along them. In this distance, at almost every turn, abrupt, precipitous cliffs tower above the stream from 150 to 200 feet high, and some even higher. Among the best known of these are Dismal Rock, at the mouth of Dismal Creek, on the very edge of the thickest conglomerate, Bylew Rock and Whistling Mountain, one on each side of the mouth of Bylew Creek. A sketch of Dismal Rock is given by Dr. Owen in the first volume, first series, Kentucky Geological Reports.

To the east we have the topography determined by the heavy, massive, and cavernous limestone called the St. Louis limestone. It is of great thickness, homogeneous, stratified in heavy beds, with few shaly and friable members. Into this Green river is cut deep, with high precipitous banks, but the tributary streams on the surface are generally few and short. The drainage is chiefly underground through the labyrinthine caverns and crevices with which the limestone is honey-combed. The country is full of sink-holes, funnel-shaped depressions, into which the water flows and disappears. There are many valleys which have evidently been cut out by streams when the level of Green river was much higher than at present. As Green river cut deeper and deeper into the limestone, the tributary streams, having perhaps reached a level where the limestone was more subject to the action of water, left their former beds and sought an exit underground, through the seams and fissures which were gradually enlarged by the solvent action of the water until they form the numerous caves which are so characteristic of that region.

These in their turn were abandoned for other channels, as the river cut still deeper, and the most of them remain comparatively dry. The surface of the country thus underdrained, is fairly pitted with the sink-holes, into which the water runs, and from them gradually drains away through the limestone. Often the sink-holes become filled with clay and earth so that the water remains in them the whole year round. If at any time it is desired to drain them, it is easily accomplished by simply digging down through the clay till the limestone is reached, when the water sinks away at once. By reason of the great abundance of these sink-holes the topography is quite complex and varied, but the chief characteristics have been already stated; they are absence of long streams above ground, and abundance of sink-holes through which underground drainage is facilitated.

GEOLOGY.

We have represented in this region only the rocks of the carboniferous system, in the following divisions:

Carboniferous.	*Coal measures.*
Sub-carboniferous or Mountain Limestone.	*Chester Group.* *St. Louis Limestone.*

The description of these different formations will be given, beginning with the lowest of the region:

THE ST. LOUIS LIMESTONE.

This is the limestone known in the first series Kentucky Geological Reports as the cavernous member of the Sub-carboniferous Group. It is the limestone in which Mammoth Cave and all the similar caverns of that region have been formed. It is usually quite homogeneous in structure, very heavy-bedded, not very fossiliferous, occasionally somewhat earthy in appearance, and shows conchoidal fracture. The cavernous nature of this region is due wholly to the character of this limestone. It is so homogeneous and thick-bedded that such gigantic excavations as Mammoth Cave can be made in it without its crumbling or falling in, and thus filling them up.

The greatest thickness of this limestone which we have exposed within the field under discussion is about 230 feet, which is its height above Green river at Mammoth Cave.

In only a small portion of the field, covered by the accompanying map by Mr. Page, and that on the eastern part, does this limestone come to the surface not covered by other rocks.

The total thickness of this limestone in Kentucky has not been accurately determined. It is, however, much thicker than any exposure in this region, as has been proved by borings made in search of oil some years since. One of these wells, sunk on a branch of Dismal Creek, penetrated to a total depth of 804 feet, of which the last 524 feet is said to have been in solid limestone, and the boring was stopped without reaching the base of it. This gives us a greater thickness of this limestone below the drainage than we have exposed above. It is true that all of this limestone may not belong to the St. Louis Group; the limestone of the lower portion of the well may be a still lower member of the sub-carboniferous system, such as occur in other States, known as the Keokuk or Burlington limestone; but until they have been recognized in this State, it will be accurate enough to consider the whole thickness as belonging to the St. Louis.

THE CHESTER GROUP.

Between the massive St. Louis limestone and the sandstones and shales of the coal measures, there is a series of irregularly and frequently alternated limestones, sandstones, and shales, which mark a period of comparatively rapid and frequent geological changes; a progress toward the conditions which attended the formation of the coal measures, met by frequent returns to those which enable the deposition of a fine-grained crinoidal limestone, such as must have prevailed during the long period of the deposition of the St. Louis limestone.

From paleontological evidence, Mr. C. J. Norwood, Assistant in the Kentucky Survey, has identified this series with the Chester Group of the Illinois geologists. For the evidence upon which the identification is based, see his report.

These rocks immediately underlie the conglomerate at the base of the coal measures, and are exposed in nearly all this region.

Nolin river has its bed in these rocks for the whole distance covered by this report. Bear Creek runs in them from its head to some distance below the mouth of Sycamore Creek. Rock Creek likewise cuts its channel in them from head to mouth. All of the branches of Nolin river, of any size, in the region covered by Mr. Page's accompanying map, have their channels cut in the Chester rocks for the greater portion of their distances. They usually head in one of the sandstones of the coal measures; but the descent is rapid and steep until the Chester limestone is reached, when it becomes much more gentle and regular, and the fall is comparatively slight. The same is true of all the branches of Bear Creek, except Beaver Dam and Gulf Creeks, which, although touching the limestone once in the course of their descent, run in the conglomerate sandstone most of the way, as after these streams have once cut through to the limestone, a rapid dip to the west again carries it underground, and brings the conglomerate down to the bed of the creek once more.

The ridge forming the divide between the waters of Rough Creek and Nolin river and Bear Creek, and along which the Louisville, Paducah and Southwestern Railroad runs, is formed by Chester rocks, which here extend southward three or four miles before they are overlaid by coal measures.

The total thickness of the rocks of this group, as shown along the line of the Louisville, Paducah and Southwestern Railroad, is given by Mr. Norwood in his report as 262 feet. Mr. Norwood's general section of the Chester rocks, along the line of the railroad, as given in his report, is sufficiently accurate in its details for the northern part of the region covered by this report, but as we go south there is a marked change. The great thickness of marly shales, called the Leitchfield marls, and the numerous thin limestones, give place to heavy-bedded limestones and sandstones. This change will be alluded to more in detail hereafter. The thickness of the series, in the region covered by this report, does not vary much from that given by Mr. Norwood. It may be stated in round numbers at 250 feet.

The base of the Chester series, the equivalent of the Big Clifty sandstone of Mr. Norwood's report, is reached at but few places, except on the very eastern portion of the field, on Green river and its immediate branches.

Some wells, which have been already referred to, sunk in search of oil in this region a number of years since, penetrated through the entire thickness of this series and deep into the underlying St. Louis limestone. The records of some of these borings have fortunately been obtained for publication. One of these wells was sunk on a branch of Dismal Creek by Wm. C. Dodge, of Bowling Green, to whom we are indebted for the records. This well was started just below the level of the lowest coal of the neighborhood, and close to the top of the conglomerate, which is here only 25 feet thick.

The following is the record:

	No.		Thickness.	Total depth.
Carboniferous 33 feet	1	Clay	8	8
	2	Black sandstone (conglomerate S. S.)	25	33
Chester series; total thickness 239 ft.	3	Shale	25	58
	4	Limestone	9	67
	5	Shale	15	82
	6	Limestone	34	116
	7	Shale	8	124
	8	Limestone	42	166
	9	"Mud vein" (probably shale)	17	183
	10	Limestone	20	203
	11	Black sandstone	15	218
	12	"Sand and shale"	42	260
	13	Shale	20	280
St. Louis limestone 524 feet	14	Grey limestone (St. Louis limestone)	524	804

The above record is given as it was furnished for publication. The names in parentheses are added by the author of this report.

The horizon at which this well was begun is well ascertained to be the top of the conglomerate.

We have shown by the above section 239 feet of Chester rocks, reckoning the shale between the conglomerate and limestone, as belonging to this group. There is always a large margin to be allowed for error in measurements, and for mistakes in recognizing the material through which the drill is penetrating, as well as the precise point of change from one rock stratum to another, in considering sections obtained by drilling. It is a difficult matter, without the most careful study, to tell exactly what is the material being penetrated by the drill, for the reason that it is usually all finely pulverized, and there is a considerable admixture of material broken down from the sides of the well above by the drill-rods. Nevertheless, when these allowances are made, these records are of great value, and should always be kept. In the case of this well, there may be some errors in the record of the frequently changing strata of the Chester Group, but it is not probable there is any error in the total thickness, or in the measurement of the St. Louis limestone.

Other wells were sunk in this region on Rock Creek and on Brier Creek; but as yet we have been unable to obtain the records. Six wells, in all, were sunk in this region during the oil excitement. The following is the record of one of these sunk by the Kentucky Oil Company, on the Nolin Furnace tract, near Bear Creek, above the mouth of Decker Branch. The records were kindly furnished for publication by Col. Chas. E. Smith, of Indianapolis, under whose direction the well was sunk. The records were very carefully kept in detail, but in the following account they have been somewhat condensed and summarized. The exact geological level of the mouth of the well is not known, but it is evidently not far from the top of the Chester:

No.		Thickness.		Total depth.	
		Feet.	Inches.	Feet.	Inches.
1	Earth	9	. . .	9	. . .
2	Alternate bands of shale and limestone, mostly limestone	12	6	21	6
3	Shale, with thin bands of limestone, mostly shale	14	7	31	1
4	Hard limestone	38	6	74	7
5	Sandstone	20	3	94	10
6	Limestone	46	2	141	. . .
7	Black sandstone	9	. . .	150	. . .
8	"Mud" (probably soft clay shale)	6	. . .	156	. . .
9	"Slate" (probably hard shale)	2	6	158	6
10	Fine-grained sandstone	19	6	178	. . .
11	"Black mud" (probably soft black shale)	20	. . .	198	. . .
12	Black sandstone	6	. . .	204	. . .
13	"Slate rock"	10	. . .	214	. . .
14	Hard limestone (St. Louis limestone)	288	. . .	492	. . .

By the above record, which is, of course, subject to the before-mentioned liabilities of error, we have a thickness of 214 feet of Chester rocks, and 288 of St. Louis. We note here the beginning of the change in the upper part of the Chester to frequent thin limestones and shales, which are so characteristic of this formation further north.

The heavy sandstone, which is the base of the Chester series in the eastern part of this region, seems, as we go west, to disappear and give place to alternate thin sandstones and shales, the shales prevailing. This feature is shown quite conclusively by the two borings given above. Mr. Norwood also reports finding the same character to this rock in the western part of the coal field.

Further north and east, the sandstone occupies its proper place, growing thicker toward the east. Where the Louisville, Paducah and Southwestern Railroad crosses Big Clifty Creek, the thickness is stated by Mr. Norwood at 125 feet. At Mammoth Cave it is from 60 to 70 feet thick; but on descending Green river to the west it rapidly decreases to 40 or 50 feet, and even less. Near the head of Rock Creek it is 50 feet in thickness, but lower down it is only from 25 to 30.

In the region around Bee Spring, in Edmonson county, and for some six to ten miles north, the character of the Chester rocks differs materially from what it is in the neighborhood of Grayson Springs and Leitchfield. In the Bee Spring region, the series consists of three, and sometimes four limestones, with shales and sandstones between, the sandstone prevailing. The limestones, with the exception of the upper, are usually massive and homogeneous, ranging from 15 to 45 feet in thickness, and occasionally thicker. The upper is usually only from two to ten feet in thickness, and is often in several thin bands in shale. The section of the well last given shows this feature very characteristically. This limestone is usually more fossiliferous than the others. Where it is split up into several thin bands, the aggregate thickness is usually greater than when it consists of a single layer.

The two wells, the records of which have just been given, show typical sections of the Chester rocks of this region, as just described.

Further north, around Grayson Springs and Leitchfield, in place of the heavy limestones at the upper part of this series, we have a very changeable series of shales, marls, or marly shales, thin shaly sandstones, and limestones. At Cedar Knob, near Grayson Springs, a thickness of 115 feet of these rocks is seen, and the most of the shales and sandstones are calcareous. The limestone here, which is persistent, is probably the lowest one of the series. It occurs on Bear Creek, near Grayson Springs, and below. It is seen, at the Chapel, 40 feet in thickness. It dips, however, rapidly down stream, and is overlaid by the shales already referred to, which take the place, in this region, of the heavy limestones further south. Above Grayson Springs it rises rapidly.

In the northern and eastern portions of this region the Chester rocks are peculiarly subject to faults. There are almost innumerable small faults of from 10 to 50 feet vertical distance. They are most abundant where the Chester rocks are not overlaid by the coal measures, but in many places they are seen reaching up through the conglomerate. They are so numerous and irregular—not, so far as we can at present see, following any general direction, any line of uplift or downthrow—that they are often very perplexing, and render the taking of accurate sections quite difficult. They are usually local, and, in most cases, seem to be down-throws.

The Grayson Springs issue near a fault of this kind which extends through the lower sandstone and limestone of the Chester Group. The line of this fault undoubtedly determines the position of these medicinal springs which are here in so great number: the waters, from a depth, probably following the line of the fault underground, as they find it the channel of easiest ascent. The number of springs here is great and their value high. For analyses of the waters from these springs, see the report of Dr. Peter.

DIP OF THE CHESTER ROCKS.

The region covered by this report is really a projecting tongue of the coal measures in the form of a basin or trough, in which the rocks have a general dip to the west, while there is also a modified dip from north and south toward the center of the basin or trough. The Chester rocks underlying the coal measures rise to the surface both to the north and south. The northern edge of this basin is the ridge already referred to, along which the Louisville, Paducah and Southwestern Railroad runs. Chester rocks are the only ones exposed for from two to three miles south, when they are overlaid by the coal-measure rocks. They are seen, however, still dipping south and west, on all the streams until Dismal Creek is reached, when the dip begins to change and they gradually rise toward the south, coming to the surface again on the south side of Green river, beyond the field of the map. The rise southward from Dismal Creek cannot be traced accurately in many places, as the upper part of this series is cut away by the heavy conglomerate. We only know that the rise does take place, as we find the rocks much higher to the south, even when the heavy conglomerate overlies them.

By reference to the accompanying cross-section, No. 2, running nearly south from Grayson Springs Station to Green river, the above mentioned facts in regard to the dip will be readily seen. The lower limestone of the series is 30 feet below the railroad at the station, which, by Mr. Page's levels, is 313 feet above low water in Green river, at Brownsville. The rocks descend to the south by a series of small faults until we find the top of the same limestone about 20 feet above Bear Creek, at Grayson Springs, or 150 feet above Green river. This descent is in two and one half miles distance. The top of Cedar Knob, near Grayson Springs, is 330 feet above Green river, with marly shales and limestones of the Chester Group extending to the very top. The descent is quite rapid from this point at first, something near 90 feet per mile, and then more gentle, until at the crossing of one of the branches of Dismal Creek, near Berry's Lick, where the upper Chester rocks reach the lowest point on this section, 110 feet above Green river. The top of a limestone is seen lower than this on Pigeon Creek; but this is where the upper members are missing, having probably been cut away at the time of the deposition of the heavy conglomerate. Near Brownsville we have the highest Chester limestone exposed, 160 feet above Green river. As already stated, the faults seem most abundant on the northern and eastern borders of the region under discussion. In the central region, between Nolin and Bear Creek, faults seem to be very rare. Irregularities in the upper surface of these rocks are, however, very great, especially where the heavy conglomerate rests upon it. These irregularities are well shown along Green river, above and below the mouth of Bear Creek. One half mile above the mouth of that creek the limestone extends 50 feet above the level of the river. At Bear Creek the conglomerate is seen in the river banks, and the limestone near the level of low water. Below Bear Creek, Mr. J. R. Procter reports the limestone at Indian Fort as seen, 40 feet above Green river, while one fourth mile below, it disappears below the drainage; the top of the conglomerate at the same time descending from 235 feet to 125 feet above the river, thus showing undulations equal to or greater than those in the limestone.

In the northern part of this region there are numerous beds of marly shale, which are quite conspicuous, in their frequent outcrop, on account of their bright colors. They range from a dark red to bright yellowish-green. As yet, they have been only occasionally used, in small quantities, for paints. The colors which can be obtained by the use of these earths are fine, and they are capable of yielding an indefinitely large supply. Analyses of these marly shales, from a number of places, by Dr. Peter and Mr. Talbutt, give between four and five per cent. of potash. They would, therefore, if the potash can be rendered soluble, be of the greatest value as fertilizers, especially for exhausted tobacco lands. For the complete analyses, and further information in regard to the value of this material, see the report of Dr. Peter.

THE CHESTER COAL.

At many points near the edge of this region, on Rock Creek, on Nolin river and some of its branches, as high as Roundstone Creek, on Dog Creek and Cub Run, and on Green river, there is found in the rocks of the Chester series a thin coal. This coal has been already referred to in the report of S. S. Lyon, fourth volume, first series Kentucky Geological Reports, as having been found at the head of Rock Creek. It has been observed at so many points that it may be considered as of more than local occurrence. In fact, it seems to be one of the best marked and most trustworthy members of the series. It occurs at the base of a heavy limestone, which is probably the lowest of the series. It has not been seen by the writer of a greater thickness than three inches, hence it is of no economical importance, as it is not of workable thickness. It has served to delude some persons, in times past, into the belief that they might find coal in quantity to pay for working in places where only the Chester rocks occur; but not much labor has been wasted in the search. It usually has from a few inches to two feet of shale between it and the limestone, and rests upon a thin band of fire-clay. The coal is usually quite pyritous and somewhat slaty. The overlying shale is pyritous also, containing casts of stigmariæ in pyrites. The shale contains abundant impressions of various coal-measure plants, the leaves or spines of *Lepidodendron*, *Sphenophyllum cordiates*, &c. It usually immediately overlies a thin shaly sandstone or marly shale, but is not far from the top of the Big Clifty sandstone. The following section, at Mr. Wise's, on the south bank of Green river, near Brownsville, shows the usual association of the coal:

Limestone, probably 35 feet in all, seen only	25	feet.	
Sandstone (partly covered)	40	"	
Limestone	23	"	
Shale	1½	"	
Coal	¼	"	
Fire-clay			1 inch.
Clay shale	3	"	
Sandy shale	1½	"	
Covered	8	"	

Top of sandstone about 30 feet above Green river.

The base of the limestone above the coal is at high-water mark of Green river. The above section is a typical one of the many which have been obtained in which this coal shows. There is little doubt that this limestone, immediately above the coal, is the lowest one of the series, and that the sandstone, at the base of the section, is one of the top layers of the Big Clifty sandstone.

Although of no economical importance, the occurrence of this coal is of much scientific interest, in that it marks the beginning of true coal formation at a period long anterior to the deposition of the true coal measures. The geological changes which its occurrence indicates are also interesting. After the long period of quiet submersion, during which the great thickness of the St. Louis limestone was formed, an era of disturbed waters and rushing currents was begun, and the coarse, massive sandstone at the base of the Chester series was deposited. This rock bears, at many places, a striking resemblance to the conglomerate at the base of the true coal measures, although it has never been found carrying pebbles. As the waters became less disturbed the sandstone grew finer and more shaly, merging at last into a sandy shale, which, as more silt and less sand were deposited, became a fine clay shale, which formed the soil for the plants afterwards converted into coal. Immediately following the deposition of the slight thickness of shale above the coal, a marked and sudden change occurred; a submersion took place in waters in which the abundant crinoids once more began their work of limestone making. The formation of coal, thus interrupted, was not resumed until a thickness of many feet of alternated limestones, shales, and sandstones had been deposited.

THE COAL MEASURES.

As already stated, this region is in reality a basin or trough, forming a projecting tongue of the coal measures, surrounded on three sides by the sub-carboniferous rocks. On the eastern border, this tongue of coal-measure rocks is split in two by the Nolin river, and we have one part capping the ridge between

Nolin river and the branches of Rock and Sinking Creeks, while the other forms the divide between the waters of Nolin and Green rivers, extending further to the east, although the eastern limit of the coal itself is very nearly the same in both.

The boundary of the coal-measure rocks within the field covered by the accompanying map by Mr. Page, is about as follows: beginning at a point on the Leitchfield and Brownsville road, about three miles from Leitchfield, it crosses to Bear Creek, below the mouth of Cedar Lick Branch. From here it continues in an easterly course close to, and on the south side of, Cedar Lick Branch to its head, on the divide between the waters of Bear and Rock Creeks. It then turns a little to the north, and follows the divide between Bear and Rock Creeks, as far north as Grayson Springs. Turning east until Rock Creek is nearly reached, and then south again, it crosses that stream below the mouth of Grindstone Branch, and turns once more in an easterly direction. It continues this course for several miles, once crossing to the north of Grindstone Branch, but for the most part following the ridge between that branch and the Hunting Fork of Rock Creek, and after it passes the heads of these streams, between Sinking Creek and Barton and Laurel Runs. The very eastern extension of it on this outlier, is on a high hill called the "Devil's Backbone," just east of Laurel Run, which is capped with about 50 feet of coal-measure rocks.

Turning a little west of south, the line pursues the divide between Nolin river and the waters of Rock Creek, crosses Rock Creek near its mouth, and Nolin river near the mouth of Dog Creek. It then follows in a southerly course, on the south side of Dog Creek, for about two miles, when it once more turns to the east, along the divide between the branches of Dog Creek and Nolin river, and continues in that direction until it passes beyond the field of the map. The coal measure conglomerate forms the ridge continuously on the divide between the waters of Nolin and Green rivers for several miles beyond the field of the map, and then occurs in disconnected outlying patches nearly to Munfordville. The southern boundary of this projection enters the field of the map at the head of Cub Run. Occasional detached outliers extend to the south, between Cub Run and Ugly Creek, even across Green river; but the boundary of the main body runs east, across the head of Ugly Creek from Cub Run, then turns southeast, crosses Buffalo Creek diagonally with its course, and pursues nearly the same direction until it reaches and crosses Green river below the mouth of Buffalo Creek, passing out of the field of the present report.

The limits of, and the area covered by, the coal-measure rocks, will be much more readily understood by referring to the accompanying geological map, in which the different formations are colored so as to show the area covered by each.

Within the above described limits there is a considerable area, which is described as covered by coal-measure rocks, where no coal will be found. The conglomerate, which is here the first of the coal-measure rocks, covers the surface, but the coal which lies above it, and the upper part of the rock itself, have been worn away by long-continued exposure. It is for this reason that the map was not extended to the eastern limits of the area covered by the conglomerate. Coal may possibly be found on the top of some of the conglomerate-capped hills, beyond the edge of the map; but the probabilities are strongly against it, and if found, it will be in extremely small areas—mere patches as it were.

In the outlier north of Nolin river, coal has been found as far east as the head of Barton's Run, and will probably be found still further east, if sought for in the right place, although it probably does not extend as far as the indicated eastern limit of coal-measure rocks. Reports were heard in regard to coal as far east as the mouth of Roundstone Creek, on Nolin river; but on examination, it proved to be the Chester coal already described.

Between Nolin and Green rivers, coal has been found on Dog Creek, on Longfall, between Brier and Bylew Creeks, and between Bylew and Buffalo Creeks; but it has not been found further east than the heads of these streams, nor is it probable it will be. The conglomerate forms the ridge at the head of these streams, and for a long distance east, and it is so near the surface, that it is probable the coal has been all removed. This is also the case toward Green river, although in the main ridges the conglomerate is covered, so that there is a possibility of finding the coal at many places.

Reference has been made, in the discussion of the topographical features of this region, to two heavy sandstones, which are the prominent agents in the determination of the topography of the coal field. These two sandstones are the most prominent features in the geological structure, and where they prevail a very different succession of rocks is found. They are: the conglomerate at the base of the coal measures, and a heavy, massive, rarely conglomeratic sandstone, which has been called by Lyon, in the fourth volume, first series Kentucky Geological Reports, the fifth sandstone of the millstone grit series–a series of rocks beginning with the St. Louis limestone, which he termed "the cavernous member of the sub-carboniferous limestone," and extending up into the coal measures. It includes, therefore, what is now identified by Mr. Norwood as the Chester series, and the lower portion of the coal measures. This sandstone, which he termed the fifth sandstone, is in this vicinity not the fifth sandstone above the St. Louis limestone, but the fourth. The name, therefore, is for this region incorrect, and will be discarded. In its place it will be called the Bee Spring sandstone, from the Bee Spring in Edmonson county, where it is well shown in its characteristic features.

The principal problems in the geology of this region are in connection with the occurrence of these two sandstones; and for this reason, and to lead to a correct understanding of the stratigraphy, a description will be here given of their character and distribution.

THE CONGLOMERATE.

The first of these sandstones, the conglomerate proper, in the northern part of this region, is usually thin, and often wanting altogether. In the northwestern portion of the field under discussion, on upper Bear Creek and its branches, it is either absent altogether, or present as a coarse, non-conglomeratic sandstone. Where found, it is usually only from 15 to 25 feet thick, though occasionally a little thicker. This is its usual thickness north of Nolin river and east of Rock Creek, and it is well marked by the pebbles it carries. Here, more than in any other part of this region, the conglomerate and the coal-measure rocks above are affected by the faults, which have been referred to as so frequent, in the Chester rocks. South of Nolin river, which is here running nearly west, the conglomerate thickens rapidly. West of Rock Creek, and between Nolin river and Bear Creek, for about fifteen miles south, the conglomerate is not seen, at any place, more than 50 feet in thickness, while it is usually about 25. It is also found of about this thickness east of Nolin river, between Brier, Longfall, and Dog Creeks, not extending, however, near to the heads of any of these streams. The limit of the area, where the conglomerate is of this unimportant thickness, is a line somewhat irregular and broken, extending from Bear Creek, above the mouth of Beaver Dam Creek, in a general east-northeast course, crossing Nolin river at the mouth of Dismal Creek, then across Brier, Longfall, and Dog Creeks, until it passes beyond the field of the map. From this line south to Green river, and beyond, the conglomerate is of great thickness, ranging from 60 to 190 feet. This thickening gives us a very different geological section north and south of the line. It is often very sudden in its occurrence, and seems to be effected by the cutting away of several of the underlying Chester rocks. This is finely shown, in one case, near the mouth of Dismal Creek. Here, upon the west side of Nolin river, is a section exposed, showing two sandstones and two limestones, as follows:

Pebbly iron ore, thickness not seen.	
Covered	3 feet.
Conglomerate sandstone	20 "
Covered	15 "
Sandstone	10 "
Covered	15 "

Limestone	25 feet.
Covered	10 "
Sandstone (not conglomeratic)	25 "
Limestone, not seen at this place, but exposed below	15 "
Covered	20 "
Level of Nolin river.	

On the opposite side of Nolin river, in full view, and not more than one fourth of a mile distant, is exposed the well-known Dismal Rock. This is a vertical cliff of conglomerate sandstone, resting upon the lower limestone of the section just given. The total height, as measured by Mr. Page, is 165 feet, of which the conglomerate forms 130 feet.

The section is as follows:

Conglomerate sandstone	130 feet.
Limestone	35 "
Level of Nolin river.	

The top of this rock, as nearly as can be determined with a hand level, is on a level with the top of the upper sandstone of the section just given. We thus see that the currents which have deposited this rock, have cut away about one hundred feet of the Chester rocks, and deposited in their place the heavy conglomerate sandstone.

This sudden thickening is well shown by cross-section No. 4, from Nolin river to Bear Creek, along Dismal Creek, and down Mill Branch. The thickening at this place, from 25 to 130 feet in one fourth of a mile, is all downwards. At other places it seems to be accompanied by a rise in the top of the conglomerate, as well as by an increase in depth.

A large portion of this region is underlaid by this conglomerate, where it is at its greatest thickness. It forms a great irregular mass, with the line of its greatest thickness extending in a course nearly east-northeast. It forms the divide between the waters of Nolin and Green rivers, on the very eastern border of the region covered by Mr. Page's map. Along this ridge it is very prominent, presenting many bold escarpments, and ranging from 80 to 130 feet in thickness. It does not, however, until within the field of the map, extend in any great width to the north or south. Cane Run, Cub Run, Ugly Creek, and other branches, head in the thick conglomerate, but soon pass through it, and have their valleys altogether in the Chester and St. Louis rocks. As already stated, it extends to the southwest, and crosses Green river below the mouth of Buffalo Creek. Green river cuts its way through it for some distance west of the mouth of Bear Creek. Its limit to the south of Green river has not yet been accurately determined.

From the north line of the coal measures, where the conglomerate is first seen, to the center of its greatest thickness, there is an increase from north to south from 25 to 180 feet. On the southern edge it disappears abruptly, while from 75 to 130 feet thick. There is some thinning in that direction, but it is slight in comparison with that to the north. The greatest thickness known is on the upper part of Dog Creek and its branches. Here it is found as high as 180 feet in thickness. On Piney Branch of Dog Creek there is a single cliff exposure of this sandstone called the "Buzzard Roost," where 160 feet is seen in one face, and 175 feet is the total thickness. The stream here has cut away the base of the sandstone, and formed a rock house of considerable depth and unusual height. The stream here has not cut to the bottom of the sandstone, although the Chester limestone is seen a short distance below. There is in the valley of this branch either a remarkable and rapid dip to the north, from the head of Buffalo and Ugly Creeks, or there is a total thickness of the conglomerate of nearly 275 feet. In less than two miles, going north from the head of Ugly Creek, the distance from the top of the conglomerate on the ridge to the base in the valley is 275 feet. There is, in this distance, room for considerable dip, which probably accounts for the apparent great thickness. The conglomerate has not been found at any point, where the observation was free from possibility of error, of more than 180 feet thickness. Dog Creek cuts its way through the thick conglomerate for nearly its whole length, only emerging from it within the last two miles.

Of the streams flowing into Nolin river, Pigeon and Pine, Bylew, First and Second Creeks cut through it from head to mouth, Beaver Dam and Gulf Creeks, and all their branches, of the tributaries of Bear Creek, do likewise, as also Indian

Creek and the other streams flowing directly into Green river from the north, between Nolin river and Bear Creek.

Bylew Creek cuts longitudinally through the very thickest of the conglomerate, and the result is, that, in its tremendous cliffs and narrow gorge-like valley, as well as the magnificent views which it presents, it is unequaled in this region.

In all the region covered by this thick sandstone, exposures of from 80 to 125 feet in one face are frequent. Its outline is by no means regular, but varies greatly, being full of indentations and projections, so that the direction already given as the line of the axis of greatest thickness is to be understood as approximate only.

The rock has evidently been deposited by very swift-moving currents of water. This is proved by the character of the rock itself, which, where the thickening is rapid and great, as on Nolin river, is composed chiefly of large quartz pebbles, many of them larger than a hen's egg, with barely enough sand to cement them together.

These masses of pebbles have only been found near the bottom of the sandstone, where it is at nearly its maximum thickness, and near the border. The pebbles gradually diminish in frequency as we approach the top, where they usually are found in thin, irregular layers, with a considerable thickness of sandstone between, which is almost or entirely free from pebbles. There is also a gradual diminution in the number of pebbles from the east toward the west and north. At many places on Bear Creek, where the sandstone is still of great thickness, it is hardly conglomeratic at all. It is also noticeable that where the conglomerate is thin, the pebbles are not nearly so abundant. As we approach the northwestern portion of this region the pebbles disappear almost entirely, and the sandstone itself is erratic, sometimes present and sometimes not, and, where present, is recognzied only by its position. I am informed by Mr. Norwood that still further west, along the line of the Louisville, Paducah and South western Railroad, there is no true conglomerate found at the base of the coal measures on the eastern border of the coal field.

This coarse, pebbly sandstone can only have been deposited by very swift currents of water, and only such were energetic enough to wear away the rocks which the conglomerate replaces. From the character of the rock these seem to have acted with the greatest force from the east, or, more probably, from the southeast, as we find the conglomerate thinning, and finally disappearing to the north, while it changes character to the west, while still retaining a considerable thickness. West of Bear Creek there are indications, although the region has not been examined in sufficient detail to make the assertion positively, that the sandstone, instead of dipping beneath the surface entirely, gives place to a great thickness of shales, which occupy nearly the same geological position. Should this, on more thorough examination, prove to be the case, it will furnish additional strongly corroborative evidence of the statements just made in regard to the direction of the currents which deposited the sandstone.

Further than this, in the eastern portion of this region, between Nolin and Green rivers, at the heads of Bylew, Brier, and Longfall Creeks, there is a second strongly marked conglomerate, at a distance of about 30 feet above the lower, with a coal bed between. Further south and southeast the two conglomerates seem to unite. To the northwest the upper conglomerate changes character, becomes rarely conglomeratic, is thin-bedded and shaly at places, and considerably thicker. It seems here to be identical with the Bee Spring sandstone. Between Brier and Bylew Creeks it is full of pebbles, but they rapidly disappear towards Nolin river. This apparent identity is shown in cross-section No. 1, from Leitchfield to Mammoth Cave.

The occurrence of this second conglomerate in the eastern part of this region above a coal, indicates a long-continued action of rapid currents from this direction, continued and repeated after the elevation and change of conditions in the other portion of this region, which accompanied the deposition of the coal. It is worthy of notice that this sandstone changes its character to the northwest much more rapidly than the main conglomerate.

The pebbles of the conglomerate are of quartz, usually white, though occasionally a few are found of rose color or jaspery quartz, but never of any other material.

THE BEE SPRING SANDSTONE.

This sandstone, for all that region north of the line which has been given as the northern limit of the heavy conglomerate, is by far the most prominent member of the geological column. It is most extensively developed between Nolin river and Bear Creek, where it shows abundant exposures of from 50 to 60 feet. It lies near the top of the ridge, and has served to form it into a comparatively even, gently rolling table land. Near the northern edge of the coal-measure rocks this sandstone has changed its position, become thinner, and is difficult of identification. There is also here a change in the position of the coals, as will be shown further on. It is not until about five miles south of the extreme northern border that this sandstone reaches its maximum thickness. It then extends for about seven or eight miles south, varying very little in its thickness until south of Dismal Creek, and on the head streams of the different branches of Sycamore Creek, when it becomes thin, rises rapidly to the south, and finally disappears. The position and character of the sandstone here are somewhat obscure. It is usually covered, and very rarely seen outcropping in position. It is certain that it thins rapidly when it comes to overlie the heavy conglomerate. As the conglomerate thickens this sandstone thins. South of Beaver Dam and Pigeon Creeks it has not been recognized, nor is there any indication of its presence shown by the slopes of the hills.

The thickening of the conglomerate and the disappearance of the Bee Spring sandstone take place within a comparatively short distance—about two miles. The character of the change in the conglomerate can be determined, as it is frequent in outcrop; but all is obscure in the change and final disappearance of the Bee Spring sandstone.

This sandstone north of Bee Spring is usually quite coarse, and, in a few instances, contains small pebbles; but these are rare. It is remarkable for the great number of springs which issue from its base. Most of the streams head in this sandstone, and at almost every branch there is found a spring issuing from its base. Many of these springs are strongly chalybeate.

The sandstone is here coarse at the bottom and somewhat shaly at top, so that the top is frequently covered. When pebbles occur, they are usually small, and lie between the layers of the sandstone.

North of Nolin river and east of Rock Creek this sandstone changes character somewhat, becoming thin-bedded and shaly. It is, therefore, not nearly so conspicuous. Exposures of it are comparatively scarce; but its presence is indicated by the topography. It forms the divide between Nolin river and the branches of Rock Creek, where the top of it is from 325 to 400 feet above Nolin river, rising towards the east.

South and east of Nolin river, between that stream and the line of the heavy conglomerate already given, there is a triangular area, including the field crossed by Brier, Longfall, and Dog Creeks, in the lower portion of their descent, where this sandstone is found, sometimes shaly and sometimes conglomeratic. As shown by cross-section No. 1, from Mammoth Cave to Leitchfield, this sandstone here occupies the same position as the upper conglomerate, and is doubtless identical with it, although north of Brier Creek it is much thicker. It is, however, found conglomeratic between Brier Creek and Mt. Vernon Mill, on Nolin river.

GENERAL SECTION.

As shown in the description of these two great sand-rocks, there are sudden and great changes in the order and thickness of the various rocks of this region, so that for the whole region, a general section cannot be given which will be of any service in accurately indicating the order and thickness of all the rocks. For a large portion of the region, however, in the already described field, where the Bee Spring sandstone has its best and most characteristic development, a general section can be given, which will show with considerable accuracy the order and thickness of the various rocks, as follows:

General section of the coal-measure rocks east of Bear Creek, and north of Beaver Dam and Pigeon Creeks, Edmonson and Grayson counties, Kentucky:

1. Clay shale, with nodules of iron ore	35	to 35	feet.
2. Iron ore, reported thickness	1½	to 1½	"
3. Clay shale	30	to 30	"
4. Iron ore	2	to 3½	"
5. Space, probably filled with clay shale	0	to 20	"
6. Clay shale	15	to 15	"
7. Coal	⅔	to ⅔	"
8. Coarse sandstone, "Bee Spring S. S."	20	to 60	"
9. Sandy clay shale	0	to 20	"
10. Coal	1	to 2	"
11. Shaly S. S. changing to shale	15	to 20	"
12. Space, probably filled with clay shale	15	to 20	"
13. Main Nolin coal	2	to 3⅓	"
14. Fire-clay and shale	3	to 10	"
15. Conglomerate sandstone	15	to 25	"
16. Shale	0	to 25	"
Top of Chester limestone.			

This section applies very well for most of the region between Nolin river and Bear Creek; also for the region between Bear and Rock Creeks, except at the very edge of the coal-measure rocks, where there is some thinning out. It will also answer for a portion of the country east and south of Nolin river.

For the region of the heavy conglomerate it is difficult to give a general section, for the reason that the rocks above are almost always covered. There is rarely more than 100 feet thickness of material overlying the thick conglomerate, although at a few of the highest points it reaches 150 feet. As evidenced by the slopes, this is mostly shale or shaly sandstone. These are also the most prevalent in wasted outcrops, on the hillsides. A complete section of the rocks above the heavy conglomerate has not been obtained anywhere in this region. The nearest approach to this was at Stevens' coal bank, on the west bank of Bear Creek. This section was partly made from statements of Mr. Stevens in regard to the rock passed through in sinking a trial shaft near his entry.

SECTION AT STEVENS' COAL BANK.

Top of hill.		
Covered slope, probably sandstone	35	feet.
Iron ore	½	"
Shale	3	"
Coal (reported)	1⅙	"
Covered	5	"
Sandstone	20	"
Shale	40	"
Sandstone	4	"
Covered (probably shale)	18	"
Coal	3	"
Fire-clay	2½	"
Sandstone (conglomerate)	50	"
Bed of Bear Creek.		

This section shows more sandstone,than is indicated at most places, above the conglomerate.

Between Nolin river and Rock Creek, and in the corresponding country across Nolin, below Dog Creek, the same trouble is experienced in obtaining a complete section, owing to the scarcity of exposures. The conglomerate, here thin, and the Bee Spring sandstone, usually shaly, are here pretty well defined, as also the Nolin coal, resting immediately upon the conglomerate; but the space up to the Bee Spring sandstone is uniformly covered, and it is still a matter of uncertainty whether the coal, which at other places is just below that sandstone, is present or not.

Near the northern limit of the coal-measure rocks, changes are again so frequent that a general section cannot be given, that will be of any service. The Bee Spring sandstone here is thin and shaly when present; as well as the conglomerate, it is difficult of identification. At places the sandstone, which seems to represent the conglomerate, is close down to the Chester limestone, with not more than two or three feet of marly shale intervening; while at other places, within a short distance, it is fifteen feet above the limestone, and a coal occurs between.

There is a well-marked rise in the rocks, from both north and south, towards the head of Canoloway Creek and Long Branch of Bear Creek. This is well shown by cross-section No. 2, south from Grayson Springs Station, and No. 1, from Mammoth Cave to Leitchfield. From here the rocks dip rapidly north for about two miles, and then rise again rapidly, in conformity with the rise of the Chester rocks. The changes in the character of the rocks, here, are somewhat obscure, as is also the equivalency of the coals. If the sandstone last described be the conglomerate, the lowest coal is a sub-conglomerate, without doubt. If, on the other hand, the lower conglomerate has disappeared, and the sandstone above is the equivalent of the Bee Spring sandstone, we have a section which does not differ so greatly from that further south.

The following will serve as an instance of the rapid changes in the rocks of this region: On Miller's Fork of Bear Creek, at the Gravelly Lick, a coal is seen which is only eight feet above the limestone; a little above, the sandstone, 40 feet thick, is seen, with a covered space of 15 feet between it and the limestone, in which space the coal will undoubtedly be found. On the next branch below, to the west, the sandstone is found close down to the limestone, with only about three feet thickness of shale between. About one mile further west, just across Bear Creek, in the Leitchfield road, the coal is exposed about 12 feet above the limestone. Above the coal is a space of 40 feet, mostly filled with shale, and then a sandstone 26 feet thick. In this short distance the coal disappears and reappears, while a thickness of 40 feet of shale comes in below the sandstone.

A fine section is here exposed which shows quite characteristically the many shales, marly shales, and shaly sandstones of the upper Chester Group.

The section is as follows:

Coarse friable sandstone	26	feet.
Covered (probably sandstone)	3	"
Clay shale	8	"
Covered (probably shale)	7	"
Clay shale	22	"
Coal	1½	"
Fire-clay	1	"
Covered	12	"
Wasted sandstone	3	"
Limestone	2¼	"
Shale	1	"
Covered (probably marly shale)	6	"
Green and red marly shale	4	"
Covered	7	"
Greenish shale	3	"
Amount carried forward	106¾	

Amount brought forward	106¼	
Shaly sandstone	2	feet.
Whitish shale	1	"
Covered (probably shale)	16½	"
Green marly shale	5½	"
Yellow crumbling limestone	½	"
Green shale	3	"
Greenish shaly sandstone	2	"
Total thickness	137¼	"

COAL.

By reference to the general section for the region between Bear Creek and Nolin river, north of Beaver Dam and Pigeon Creeks, it will be seen that there are here three coals. The first of these rests close upon the lower conglomerate; the second underlies the Bee Spring sandstone; and the third rests immediately upon it. Of these, the first is the only one which has been found of workable thickness over any considerable area. The second is reported as 30 inches thick at some places; but it has not been seen by the writer of this of over 18 inches thickness, and in most places it is not more than 12 inches. The third coal has not been found of workable thickness; it is usually only from 8 to 12 inches. The first of these coals was called by Dr. D. D. Owen, in the first volume, first series, Kentucky Geological Reports, the Main Nolin coal, a name which, until the numbering of the coals in the western coal field is finally determined upon, will be retained here. It is the equivalent of Coal L of Mr. Norwood's section along the line of the Louisville, Paducah and Southwestern Railroad. These three coals are quite persistent over all that area where the Bee Spring sandstone is characteristically developed.

The normal distance of the Nolin coal above the Chester limestone is from 20 to 30 feet. The second coal is 40 feet above this, and the third 70 feet above the second. These distances are subject to some slight variation, but within the above limited area this is not great. This section holds good to within three or four miles of the northern edge of the coal-measure rocks, where the changes in the general stratification, which have been already referred to, affect also the position of the coal beds.

We have not here, in any one section, more than two coals exposed, and as we approach the border of the coal-measure rocks but one is found. The following section, on Long Branch of Bear Creek, near Eli Decker's, will serve to show the position of two coals:

Coal	1	foot.
Covered	5	feet.
Sandstone, hard and solid	4	"
Sandstone, shaly	6	"
Sandstone, hard	4	"
Covered	13	"
Clay shale	5	"
Carbonate iron ore	½	"
Clay shale	7	"
Coal, thickness not seen.		
Covered	5	"
Coarse sandstone	35	"
Covered	15	"
Top of Chester limestone.		

Between the base of the sandstone and the limestone there is found, at another locality on this branch, a marly shale belonging to the Chester Group. On the next branch north, called Miller's Fork, there is a coal between this sandstone and limestone.

The changes which take place in the rocks here are well shown by cross-section No. 2, from Grayson Springs Station to Green river. East of this region, on Rock Creek, and beyond, it is also difficult to give a general section, as good exposures are comparatively rare, and there are frequent changes in the character of the rocks. But one coal is here known near the border of the coal measures. This, between Rock and Bear Creeks, is usually only from 10 to 20 feet above the Chester limestone. It has been opened for local blacksmiths' use at Thomas Higdon's, on Cedar Lick Branch of Bear Creek; at John Skagg's, on Dice Branch of Rock Creek; at Lec. Higdon's, on Pearson's Branch of Rock Creek; and at numerous other places. The coal frequently carries a bed of iron ore resting upon it. The ore is a very fair quality of limonite, changing to carbonate as it is followed into the hill, and is from five to eight inches in thickness. The coal itself is from 20 to 27 inches thick, and of very good quality.

East of Rock Creek, in the corner between that stream and Nolin river, there has been but one coal recognized. This is usually 20 to 30 feet above the limestone, resting almost immediately upon the conglomerate, with only the intervention of a few feet of shale and fire-clay. At one locality, a place was seen where another coal is said to have been formerly exposed, but it is now covered, and there is no evidence of its existence. If there be a coal here, it is about 50 feet above the first. The rocks are so generally covered that it has been seen at no other place.

The coal resting upon the conglomerate has been very much disturbed, in the ridge between Rock Creek and Nolin, by frequent faults, which are upon both sides of the ridge. The faults seem to be a series of down-throws or step faults, which follow around the main ridge. They are usually of small vertical extent, hardly ever over 50 feet; but there are a number of them, so that we find the coal at very different heights, dipping, apparently, very rapidly towards both streams, but really carried down by the faults. The greatest thickness of this coal seen here, at any place, was 28 inches; but it is reported, at other places, as three feet and over. The Bee Spring sandstone caps the ridge here, and it is probable the coal, close below it, will be found, on searching in the proper place.

Across Nolin river but one coal has been found. This is the equivalent of the Main Nolin coal, with the sandstone above changed to a conglomerate, and the distance between considerably lessened. Near Mt. Vernon Mills, the Bee Spring sandstone is developed very characteristically, about 30 feet above the coal, which is here exposed nearly two feet thick, and the bottom of the coal still covered. Resting upon the coal is an eight-inch bed of iron ore of good quality.

On Long Fall Creek, at the Old Thompson bank, the coal is very near the top of the lower conglomerate; but the overlying rocks are so covered that it is impossible to determine them exactly. Higher up on the creek, the upper conglomerate is found above the level of the coal. The coal here was covered at time of examination, so that its full thickness was not seen, but it is reported to be something over three feet.

As shown by cross-section No. 2, from Mammoth Cave to Leitchfield, the coal rises rapidly toward the southeast. Between Brier and Bylew Creeks, it is found overlying about 70 feet of conglomerate, and close under a second conglomerate 35 feet thick. The coal is near the overlying sandstone, with a covered space of 25 feet between it and the lower. This is the most southern exposure of this coal with the overlying conglomerate. On the head of Bylew Creek, the conglomerate consists of two members, with a covered space between, in which the coal belongs; further south and east, the conglomerate is seen solid from 100 to 180 feet thick, without division. The coal occurs at the head of Mill Branch of Bylew Creek, some distance south of the main stream, resting immediately upon the heavy conglomerate, and with no evidence of the existence of a higher one. There is here an iron ore above the coal, but the thickness of neither ore nor coal was seen. The coal here has risen about 60 feet from where last seen, on the head of Brier Creek. Further west, at the head of Piney Branch of Nolin, the coal is seen, apparently thin, resting close upon the conglomerate, which is 140 feet thick. No coal, except the thin sub-limestone coal, has been found further east, along the main ridge between Nolin and Green rivers, than the head of Brier and Bylew Creeks; nor is it probable that there will be, in any quantity, as the conglomerate is very close to the surface, sometimes not covered at all, and hardly ever with more than 30 feet of overlying material. If the coal is found, it will only be on the isolated hills where there is enough overlying material to protect it.

North of the main dividing ridge, between Dog Creek and Nolin river, coal is found further east than on the main ridge, as the conglomerate is somewhat lower, and there is a greater thickness of overlying material. It will not probably be found, however, a great distance east of Dog Creek, as the rocks rise rapidly in that direction, bringing the conglomerate close to the surface,once more. South of Bylew Creek, between Nolin and Green rivers, there is not a large area where the coal will probably be found, as the conglomerate comes close to the surface, except on the main dividing ridges between Buffalo, Bylew, First, and Second Creeks. Along the ridge which the Houchin's Ferry road follows, there is from 40 to 75 feet thickness of rock above the conglomerate, until within two miles of Green river, so that, here, the coal has probably been protected from erosion. Of the region, therefore, between Nolin and Green rivers, only that part situated between Nolin river, Bylew, and Dog Creeks, from Wolf Branch down, stated approximately, is furnished with a trustworthy deposit of coal. Beyond this, where found, it is only in detached masses.

Between Bear Creek and Nolin river the Main Nolin coal occurs very regularly and of good thickness, from Decker Branch of Bear Creek south to Green river. Until south of Dismal Creek, the rocks preserve nearly the order and thickness shown in the general section. Here the two coals, below the Bee Spring sandstone, are best developed. From Bee Spring Branch of Dismal Creek south, the Bee Spring sandstone begins to grow thin, and gradually disappears; the coal close below it is seen no more, and the main coal rises rapidly to the south with the thickening conglomerate. From here, south to Green river, this coal is seen at many places, resting close to the heavy conglomerate. The character of the overlying rocks has changed, and no further trace of the second coal is seen. At the Stevens coal bank, near the mouth of Bear Creek, on the west side, as shown by the section already given, there is a thin coal 85 feet above the main coal; but this is the first instance where it is clearly shown.

From Decker Branch to Dismal Creek, the main coal is seen exposed in almost every branch of both Nolin river and Bear Creek. South of Dismal Creek, it is seen close to Nolin river, at Watt Merideth's, above the mouth of Pigeon Creek; but it has not yet been seen in the region drained by Pigeon, Pine, or Indian Creeks. If sought for, at its proper place, above the conglomerate, there is no reason why it should not be found on Pigeon and Pine Creeks, as the conglomerate is, at many places, overlaid by a sufficient thickness of rock to protect the coal. Over a larger portion of the area drained by Indian Creek, as well as the other branches of Green river entering near Brownsville, the conglomerate has been so nearly denuded that it is very doubtful if the coal will be found. If found, it will be only on the highest ridges. In the drainage of Bear Creek, as might be expected from the dip of the rocks, the conglomerate is covered much deeper, and the coal occurs more regularly and over a wider area. It is seen on Sycamore Creek, between Sycamore and Beaver Dam Creeks, on Gulf Creek, at numerous old openings on Bear Creek, near Green river, at the Stevens bank, where the coal is now being mined, and on a short branch entering Green river, just above the mouth of Bear Creek.

At none of these places has it been opened for more than local use, except at the Stevens bank. This is the only locality within the field of the present report where the coal has been mined under ground. It is put into boats on Bear Creek, which is here navigable, and carried down Green river. Throughout the rest of this region the coal is only opened by stripping occasional patches for the blacksmiths of the neighborhood. These openings are usually in the beds of streams, where the coal has been found originally washed bare by the stream. From their position these openings fall in or fill with water almost as soon as they are abandoned, and the coal becomes covered, so that it is impossible to see its full thickness. In many cases, therefore, the thickness of the coal bed has to be taken from the report of those who formerly dug the coal. This is a very untrustworthy way, as the thickness is hardly ever measured accurately by the digger, and in reporting it afterwards, the tendency is almost always to exaggeration. The usual thickness of the coal, reported at these places, is from three to four feet. In some cases it is reported at four feet, with a heavy slate parting; but usually no notice is taken of the partings, and the total thickness is reported, as remembered by the digger.

The average thickness of the Main Nolin coal throughout the region just described, where it has been seen by the writer, is three feet. At many places, where it was reported much thicker, it was found, on examination, that a slate parting or very bituminous slate, which often occurs at the base of the coal, had been measured with the coal, thus greatly increasing its thickness.

It is, however, over most of this field, a trustworthy three-foot coal, and, at many places, it shows free from any parting.

The following section at Knob Lick, near Dismal Creek, is fairly typical of this coal over a large region:

Clay shale, bituminous at bottom	3 feet.	
Coal	3 "	1 inch.
Very bituminous slate		4 inches.
Bituminous slate	1 "	

QUALITY.

Of the quality of the coals of this region nothing is accurately known, except of the lowest or Main Nolin coal. The other coals are thin, and so rarely exposed that it is difficult to get fairly representative samples. Moreover, not being of workable thickness, it was not considered as of sufficient importance to warrant any great expenditure of time in endeavoring to procure samples of them.

Of the Main Nolin coal a number of analyses have been made, both from single specimens and from carefully averaged samples.

The following analyses of this coal, by Dr. Peter and Mr. Talbutt, will serve to show its quality:

	1	2	3	4	5	6	7	8	9	10	11
Specific gravity	...	1.305	1.335	1.282	1.345	1.437	1.350	1.367	1.336	1.395	1.346
Moisture	3.40	4.70	4.06	2.30	2.60	4.06	3.60	3.20	3.66	4.14	6.26
Volatile combustible matter	30.66	31.40	33.24	32.10	33.80	32.00	33.00	33.80	35.14	31.52	32.44
Fixed carbon	54.94	52.20	51.70	56.30	53.14	50.84	54.40	52.60	54.26	56.08	53.80
Ash	11.10	11.70	11.06	9.30	10.46	13.10	9.00	10.40	6.94	15.26	7.50
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Coke	65.94	63.90	62.70	65.60	63.60	63.94	63.40	63.00	61.20	65.34	61.30
Sulphur	2.544	1.945	1.67	1.059	2,425	4.938	2.101	2.923	2.706	3.565	1.476

No. 1 is an average sample, taken by myself, of the coal from the Stevens bank, Butler county.

No. 2 is an average sample, taken by myself, of coal from Tar Lick, near Dismal Creek, Edmonson county.

No. 3 is an average sample, by Mr. J. R. Procter, of coal from same locality.

No. 4 is a single specimen from same locality.

No. 5 is an analysis of a single specimen from Knob Lick, Dismal Creek.

No. 6 is an average sample, by myself, from a small outcrop of coal on Mill Branch of Bear Creek. The outcrop from which the sample was taken was so small that it cannot be safely considered as a representative sample.

Nos. 7 and 8 are analyses of single specimens from the same locality.

No. 9 is an analysis of a single specimen from Shoal Branch of Bear Creek.

No. 10 is an analysis of coal from Gravelly Lick, Miller's Fork of Bear Creek. The sample was taken by myself from a very small outcrop, and cannot be considered as an average of the whole bed.

No. 11. Coal from Brushy Branch of Canoloway Creek; average sample by myself.

These analyses, with the exception of Nos. 6 and 10, show a coal of quality which entitles it to rank among the best of Western Kentucky. The superior quality of the lower coals of the western part of the State has been frequently noted, and is well shown by the above analyses of the Nolin coal, the lowest of the series. The coal varies considerably, at different places, in the amount of sulphur present, but is otherwise, usually, a moderately dense coal, which stands exposure remarkably well, and apparently is sufficiently fat to produce a good coke. At some places the coal is so bituminous that the bitumen flows from the base of it, giving rise to "Tar Springs." This is the character of the coal at the Tar Lick, analyses of which have just been given. At some places where the coal shows the most sulphur, the sulphur is present in a layer or parting of pyrites, which is so thick and persistent that it can easily be rejected when mined, and the remainder of the coal left comparatively free from sulphur.

IRON ORE.

The iron ores of this region are abundant and valuable. It is one of the most richly endowed undeveloped localities in the State.

Iron ores are found in association with the rocks of each geological age in this region, but they are by no means uniformly distributed, nor are they of uniform quality. The region is as yet almost wholly undeveloped, and but little pick and shovel prospecting has been done; so that it is in many cases, impossible to tell of the quantity of ore present when outcrops are found. Doubtless the ores which have been seen will be found, on further investigation, to be more extensive than at first supposed, and ore will be found, at many localities, where it has not been discovered, as yet. It is, therefore, not to be considered as evidence against the continuance of an ore, that it has not been seen at certain localities, unless it has been dug for, or the situation is such that, if present, it must have shown in outcrop.

The ores of this region are mostly in stratified beds, conformable to the rocks with which they are associated. The ores are both limonites and siderites, or earthy carbonates. There is, however, an exception to the rule as to the character of deposit just stated. This is found in the lowest ore of this region, associated with the St. Louis limestone. It is found in the surface clays where the limestone has been much eroded. The ore is thinly scattered, at a great many localities, where the St. Louis limestone is the prevailing rock; but within the field, covered by the present report, it is not apparently in any quantity. The deposits are limited and irregular, and seem to have been formed by the segregation of the ferruginous matter, which was disseminated in small quantities, through the limestone, before its erosion. As the limestone was dissolved away, the iron and the silicious matter in the limestone remained unaffected by the agencies which effected the solution of the limestone; the iron separating to itself formed the deposits just described, and the silicious residue formed the surrounding clays. The ore is a limonite, which, in some cases, seems to be the original mineral, and, in others, is derived from pyrites, as is shown or proved by the pseudomorphs of limonite, after pyrite found and by the presence of pyrites in the center of some of the largest pieces of ore. This ore is the geological equivalent of the Cumberland river limonites of the western part of the State, which are so valuable and so well known; but it is by no means as abundant. There are numerous places where this ore shows in quantity sufficient to justify working on a small scale, if there were any market for it, or means of shipment; but it does not show enough, at any one place, to justify a reliance upon it as a basis of ore supply for a furnace. The ore is usually of excellent quality, except when injured by the presence of sulphur; but these cases are comparatively rare. It is rarely ever mixed with chert or flint, and is not often silicious to an injurious extent. There were, formerly, iron furnaces in Hart county, which are said to have used ore which is the same as this, with charcoal as fuel, but they are not now in operation, and nothing definite has been learned in regard to them.

The other ores of this region, found in both the Chester and the coal-measure rocks, are stratified deposits of earthy siderite or carbonate of iron, and limonite or hydrated peroxide of iron, derived from the carbonate. At most places only the limonite has been seen; but it will doubtless be found to change to siderite on following it underground, where there is a sufficient covering to protect it from oxidizing agencies.

At a number of places, ores have been found associated with the rocks of the Chester Group, usually resting upon limestone. On Napper and Saltsman's branches of Bear Creek, there are several exposures of a lean-looking ore, from two to two and one half feet thick. The ore consists of a silicious matrix, inclosing many small nodules of comparatively pure limonite. The ore here rests close under the conglomerate, upon a limestone which is probably the upper one of the series. An analysis was made by Dr. Peter and Mr. Talbutt of an average sample, collected by myself, from an exposure of this ore on Stillhouse Branch, with the following results:

Peroxide of iron	40.798
Alumina	1.293
Lime and magnesia	traces.
Phosphoric acid	1.019
Sulphuric acid	.360
Combined water	7.250
Silica and insoluble silicates	50.030
Total	100.750
Metallic iron	28.519
Phosphorus	.445
Sulphur	.207
Silica	46.760

This shows a high per centage of silica, combined with a low per centage of iron—a combination which renders the ore, for the present at least, of little value.

On Caney Branch of Gulf Creek, one of the lowest branches of Bear Creek, on the farm of Jacob Souders, there is found an ore of excellent quality, a limonite, so far as seen, of remarkable purity. It appears to be in a bed or stratum of about two feet thickness, resting under shales, upon or near the top of a limestone, the exact equivalency of which was not determined, as the exposure was small, and the undulations or irregularities of the strata soon carry it below the bed of the creek, both above and below. The heavy conglomerate sandstone, showing cliffs from 50 to 100 feet high, is seen immediately above the ore; but the base of it is covered, so that the exact distance of it from the ore could not be ascertained; but it is probably not over from 10 to 20 feet. This sandstone comes down to the bed of the creek, both above and below the locality where the ore and the limestone are exposed. The distance within which the limestone is exposed above the drainage is from one third to one half mile along the Creek. The limestone is probably not the upper member of the Chester Group, as it is in the region of the heavy conglomerate, where the upper members of the Chester have probably been carried away at the time of the deposition of the conglomerate. In quality this ore is among the best of this region; and if it can be found to extend over any great area, it will prove one of the most valuable. It has been found outcropping in considerable quantities on the farm of M. Honaker, on Green river, above the mouth of Bear Creek. Enough is here seen to indicate with considerable certainty that this is the same ore, and that it is present in considerable quantity. At numerous other places, traces of this ore have been found, but nowhere else so promising. At other localities, where the Chester are the prevailing rocks, small surface outcrops of ore have been found; but as yet they have not been prospected, and it is impossible to tell anything definite as to the amounts. It is probable that, with careful prospecting, many of these will be found more valuable than now supposed.

The first iron ore of the coal measures rests immediately upon, and, in fact, is often mingled with, the conglomerate. The ore varies largely in its character, but is usually distinguishable by the quartz pebbles which are scattered through it in greater or less quantities.

The exact relation which this ore bears to the coal which rests close to the conglomerate is still a matter of some obscurity. At some places the coal has been seen resting immediately on the conglomerate, and at others the pebbly ore occupies exactly the same position; but a satisfactory section, showing the two together in one hill, has not been obtained. At Watt. Merideth's, on Nolin river, above the mouth of Pigeon Creek, the ore was found on the surface, in a position which indicates that its position is below the coal. The coal was found in sinking a well, and no ore was found above it, thus indicating with certainty that the position of the ore is here below the coal, although it cannot be far. Further southwest, on Beaver Dam Creek, the coal is seen resting almost immediately on the conglomerate, with no room for the ore below, and no sign of its presence above. It is by reason of the uncertainty that attaches to the relative position of ore and coal, that the lines indicating their places have not been carried south of Pigeon Creek, in the cross-section No. 2, from Grayson Springs Station to Green river. Further north, at many places in the region north of the heavy conglomerate, an ore is found resting upon the Main Nolin coal, which, in its turn, rests close to the conglomerate, with no ore between. This ore differs in character from the other; is usually leaner, more porous, thinner, and does not carry any pebbles. Its usual thickness is from six to eight inches, although occasionally thicker. The thickness of the conglomeratic ore is not well shown at many places, but it seems to vary from one to two feet, and occasionally thicker. It is very variable in both quality and thickness, changing suddenly from a nearly pure limonite ore to a ferruginous conglomeratic sandstone, in a very short distance, and making correspondingly great changes in thickness at the same time. The ore, so far as seen, is all limonite. It has not been opened, at any place, far enough to reach the unaltered carbonate.

The following analyses, by Dr. Peter and Mr. Talbutt, will serve to show the quality of this ore:

	1	2	3
Peroxide of iron	55.028	47.724	32.820
Alumina	1.006	2.501	2.356
Brown oxide of manganese	.040	. . . . .	. . . . .
Carbonate of lime	trace.	trace.	trace.
Magnesia	.108	trace.	trace.
Phosphoric acid	.312	.065	.984
Sulphuric acid	.133	.315	.285
Combined water	8.300	8.250	8.330
Silica and insoluble silicates	35.180	41.145	55.180
Total	100.107	100.000	99.955
Metallic iron	35.519	33.407	22.974
Phosphorus	.135	.028	.430
Sulphur	.053	.125	.114
Silica	33.70	39.560	48.960

No. 1 is an analysis of a single specimen of conglomeratic limonite ore from Mrs. Bythe Merideth's, near the mouth of Dismal Creek. Specimen selected by Prof. N. S. Shaler.

No. 2 is an analysis of an average sample, taken by myself, from an exposure of the conglomeratic ore above Thomas Merideth's, on one of the branches of Dismal Creek, from the south.

No. 3 is an analysis of an average sample, by myself, from the ore resting upon the Main Nolin coal, on Mill Branch of Bear Creek.

Nos. 1 and 2 show the conglomeratic ore at its best. It proves to be better in reality than its looks would indicate; and if it can be relied upon to continue of this quality, it will prove a very valuable ore. Of this there is some doubt; but it will doubtless be found of this quality at many other places.

Analysis No. 3 indicates an ore much poorer than it appears to be. The ore here is porous and sandy, but does not, to the eye, appear nearly so silicious as the analysis proves it to be. It is so poor in iron, and so silicious, that for the present, at least, it is of little value. From its position immediately above the coal, this ore could be mined very cheaply if it were sufficiently rich in iron to justify its use.

Near Old Nolin Furnace, on Davis Branch of Nolin river, there is an ore which occurs between the lower conglomerate and the Bee Spring sandstone. Its place is about 30 feet above the conglomerate. This ore is said to have been used in considerable quantities when the furnace was in operation. It is from three to four feet thick where seen, and very lean. There is evidence of considerable digging at the place where the ore was seen. The analysis shows that the ore is very silicious and poor in iron. The sample analyzed was, however, selected from only a very small surface of the ore, which was uncovered for the purpose, and it may have been worse than the average of the bed. The sample was taken to represent the outcrops exposed, as accurately as possible. The ore is quite fossiliferous, being composed at places almost entirely of the shells of fossils, and it varies in quality. It must be, therefore, that the sample was taken from a place where the ore is more silicious than usual, although it was not known at time of sampling. An ore yielding only 19 per cent. of iron could not be profitably worked in the furnace.

The following is the analysis by Dr. Peter and Mr. Talbutt:

Peroxide of iron	27.340
Alumina	5.930
Carbonate of lime	1.090
Carbonate of magnesia	.447
Phosphoric acid	1.068
Water expelled at red heat	12.380
Silica and insoluble silicates	51.230
Undetermined and loss	.515
Total	100.000
Metallic iron	19.138
Phosphorus	.497
Silica	47.360

This ore has not been recognized at any other locality, but occasional thin bands of clay carbonate are found in the shales, between the conglomerate and the Bee Spring sandstone. These are usually of very good quality; but they have never been mined, and little is known as to their horizontal extent. Many surface outcrops of ore have been found through this region, which could not be traced to their position with the means at command. Many of these promise well, and show ore of very good quality; but little can be learned of their quantity without digging. This is especially the case east of Nolin river. Several promising surface outcrops of very good ore have been seen here. One of them, near Wm. Saunders', on Brier Creek, shows limonite of very good quality, which seems to belong on top of the lower member of the conglomerate; but nothing definite as to position or thickness. At another place, near the Mammoth Cave road, about one mile from Mt. Vernon Mill, surface limonite was found in considerable quantity upon the Bee Spring sandstone, which is here conglomeratic, as is also the ore. There are obscure indications that the sandstone consists of two members here, and that the ore belongs between them. It is certain that the position of the ore is not far above the sandstone.

Above the Bee Spring sandstone. is found, apparently, the most regular and promising ore of this region. This is best seen at the old banks, on the Nolin Furnace property, where much ore was formerly obtained for use at the furnace. These banks are on the ridge at the head of Decker Branch of Bear Creek. The ore is 35 feet above the Bee Spring sandstone, which is here characteristically developed, about 50 feet thick, with the two coals below it.

There are two banks near the Brownsville and Leitchfield road, about two miles apart. At the most southerly of these, the ore is reported to be six feet thick, and it was seen between three and four feet in thickness, of which the upper portion was ore of very good quality; the lower was sandy and ochreous. This bank is between three and four miles north of Bee Spring, between Decker and Davis Branches. A little over two miles north of this is a bank, exactly six miles from Bee Spring, which shows ore of very good quality, two feet in thickness. The ore from this bank is reported to have been the best, in quality, of any ever used at Nolin Furnace. It is, in fact, of excellent quality, as shown by analysis No. 3 of the following table. The same ore is found near McGrew's, on one of the streams of Hart Branch of Bear Creek, showing about two feet thick, although no digging has ever been done, here, to expose its full thickness. Further north, the ore has not been distinctly recognized. It probably thins in that direction, and soon disappears altogether, simultaneously with the change in the character of the Bee Spring sandstone.

South of Bee Spring, on the heads of Sycamore and Beaver Dam Creeks, an ore is found 60 feet above the heavy conglomerate, and from 15 to 20 feet above a sandstone which seems to be the thin edge of the Bee Spring sandstone. This ore is somewhat different in character from that last described, but it is not unlikely the same ore. It has only been seen as a limonite, which is oölitic and rather coarse-grained, appearing more silicious than it really proves to be on analysis. It is a "block" ore, occurring in layers, which cleave into rectangular blocks. It is between three and four feet thick where seen, but in the opinion of the writer will probably average near the lower figure.*

*This ore has been distinctly seen in but two places, and in these it exceeds four feet in thickness, by my measurements. N. S. S.

The quality of this ore, and that of the old Nolin Furnace banks, is shown by the following analyses by Dr. Peter and Mr. Talbutt:

	1	2	3	4
Peroxide of iron	52.926	49.906	57.830	48.913
Carbonate of iron	. . . . .	. . . . .	. . . . .	5.735
Alumina	4.792	3.330	6.719	7.125
Brown oxide of manganese	.210	. . . . .	. . . . .	. . . . .
Carbonate of lime	.180	trace.	.290	9.410
Magnesia	.425	trace.	.122	.144
Phosphoric acid	.355	.694	.921	.489
Sulphuric acid	.143	.395	. . . . .	.199
Combined water	10.400	9.320	12.180	8.905
Silica and insoluble silicates	30.580	39.780	21.040	19.080
Total	100.011	100.425	99.102	100.000
Metallic iron	37.048	34.407	40.481	36.526
Phosphorus	.154	.303	.412	.209
Sulphur	.057	.158	. . . . .	.080
Silica	29.160	33.461	14.360	17.820

No. 1 is an analysis of an average sample, taken by Prof. N. S. Shaler, from a bank called the "Federick bank," at the head of one of the branches of Beaver Dam Creek, near where the Little Mountain road leaves the Leitchfield and Brownsville road, Edmonson county.

No. 2 is an average sample, taken by myself, from an exposure of the same ore, near the head of one of the branches of Sycamore Creek, Edmonson county.

No. 3 is an average sample, by myself, of ore from one of the old Nolin Furnace banks, on the Leitchfield road, six miles from Bee Spring, and nine miles from Grayson Springs, Grayson county.

No. 4 is an average sample, selected by myself, from another of the old banks of the Nolin Furnace, about three and one half miles north of Bee Spring, west of the road, at the head of one of the forks of Decker Branch.

These analyses show a good workable per centage of iron in all of the samples, and not enough of any injurious ingredients to affect their value to any extent. The per centage of silica is rather high in No. 2, and phosphorus in No. 3, but it is by no means enough to prevent their use.

These ores, whether they be the same geologically or not, are the most valuable in all this region. They alone promise to furnish a sufficiently reliable supply of ore upon which to base a manufacturing industry. There are many square miles of area over which these ores will, probably, be found. As yet, little prospecting has been done, and the opportunities for observing the variations of the ore, as well as for ascertaining the fact of its occurrence at any locality, are very poor. It has been observed, however, at enough localities to obtain its geological position accurately, and at localities far enough separated, to justify the conclusion that it is of more than local occurrence. It is probable that it will be found, at many places, between the outcrops at present known, where it is now not supposed to exist. Its best development is, of course, in the main dividing ridge between Nolin river and Bear Creek; but it will be found out on the spurs of the ridge between the branches, wherever there is a sufficient thickness of rocks above the Bee Spring sandstone to hold and protect the ore. There are, however, many places on the main ridge, even where the Bee Spring sandstone comes so near the surface, that the ore will not be found. It may be stated as a rule, for the benefit of prospectors, that it will be of no use to look for this ore unless there is at least a thickness of from 40 to 50 feet of rock above the Bee Spring sandstone, where it is characteristically developed, or of 65 to 75 feet thickness above the heavy conglomerate, where that is the prevailing rock. When this rule is borne in mind, it will be very easy to tell, at any locality, whether there is a possibility of finding the ore or not.

South of Beaver Dam Creek no prospecting has been done, although there is a considerable area in which the thickness of rock above the conglomerate is sufficient to protect the ore. In the Brownsville road, about three miles from Green river, there is some ore exposed, which is probably the outcrop of the same, although it has not been definitely determined.

South of the Morgantown road, in the drainage of the small streams flowing directly into Green river, the conglomerate is so near the surface that in but few isolated patches can we expect to find the ore.

The region where this ore will be found is, therefore, approximately, bounded on the south by the ridge at the head of the short streams flowing directly into Green river. Its limit to the north has been already given. East of Nolin river, this ore has not been recognized. Near the river, there are numerous hills which are high enough to hold the ore; but these are not found further than three or four miles from the river.

West of Bear Creek, little work has been done, and little or nothing is known of the existence of the ore in this direction. The field of the ore, already known, is sufficiently large to furnish a reliable supply of ore upon which to base an iron industry.

On the Nolin Furnace property, at the head of one of the forks of Davis Branch, 25 feet above the main ore, is another ore bank, where a sandy ore nearly two feet thick is said to have been obtained for use at the furnace. This is the highest ore of the general section, and has been recognized at no other place. The ore was covered so that not enough of it was seen to judge of its quality.

OTHER ORES.

At several other localities in this region, ores have been observed which have not been given a place in the general section, for the reason that they seem to be local. Some of these show ore of as excellent quality as any in this region. The fact, however, that they have not been found elsewhere, in a region where so little prospecting has been done, is not of itself conclusive that they are local. They may, hereafter, be found to be reliable and extensive deposits.

One of the best known of these occurs on a hill between two branches of Sycamore Creek, about two thirds of a mile west of the Brownsville road. It is called the Procter ore bank. The ore is a limonite, freer from silicious matter than almost any other in this region, but exceedingly fossiliferous. It occurs on the top, and extending some distance down the slope, of an unusually high knob. Some prospecting has been done, but no bed or solid mass of ore has been found; it only occurs in lumps of small size. The character of the ore, and its occurrence in this manner, indicate that it is the remnant of a destroyed stratum or bed of ore, the original position of which was some distance above where it is now found. It was probably a bed of very pure fossiliferous carbonate of iron originally; but the long-continued exposure to oxidizing agencies has converted it into limonite, while the erosive agencies were destroying its identity as a bed. The position of this ore, where found, is considerably above the main bed of ore on Sycamore Creek. The following analysis by Dr. Peter and Mr. Talbutt, from a single specimen, shows the excellent quality of this ore:

Peroxide of iron	76.284
Alumina	2.361
Brown oxide of manganese	.030
Carbonate of lime	.180
Magnesia	.068
Phosphoric acid	1.055
Sulphur	.151
Combined water	12.000
Silica and insoluble silicates	7.951
Total	100.080
Metallic iron	53.399
Phosphorus	.460
Sulphur	.059
Silica	7.660

Another of these ores is shown in the section already given, at Stevens' coal bank. It is the ore above the upper coal, and is about six inches thick. Its quality is shown by the following analysis by Dr. Peter and Mr. Talbutt. The sample analyzed was taken from a very small outcrop of the ore, so that it may not be fairly representative, but it is believed to be as good as the average:

Peroxide of iron	44.974
Alumina	2.391
Carbonate of lime	.643
Magnesia	.234
Phosphoric acid	.535
Sulphuric acid	.158
Combined water	7.700
Silica and insoluble silicates	44.180
Total	100.815
Metallic iron	31.482
Phosphorus	.233
Sulphur	.063
Silica	42.20

On Taylor's Fork of Bear Creek, on a branch entering at M. Ray's, about two miles from Leitchfield, an ore is found, under a heavy sandstone, at a chalybeate spring. The ore is about seven inches thick where seen, and of very good quality, partly limonite and partly the unaltered carbonate. On the opposite side of the branch the same ore is seen, apparently considerably leaner, while the sandstone does not show above. The following analysis by Dr. Peter and Mr. Talbutt, from a sample of this apparently lean ore, shows that it is rich enough in iron to be valuable. The ore on the opposite side of the branch, at the spring, is much richer than this:

Peroxide of iron	44.528
Alumina	1.368
Carbonate of lime	5.590
Carbonate of magnesia	.609
Phosphoric acid	1.074
Sulphuric acid	.151
Combined water	8.940
Silica and insoluble silicates	37.380
Total	99.620
Metallic iron	31.169
Phosphorus	.468
Sulphur	.060

At many other places ores have been found, in greater or less quantities, in surface outcrops; but usually when the quantity was sufficiently great to render them worth attention, the quality has proved to be poor; and *vice versa*, when the quality was good, the quantity was so small that, without further prospecting to prove the extent greater, they have not been deemed worthy of mention. Beyond the field of the map, west of Bear Creek, near Green river, in Butler county, a number of these ores have been examined. They are mostly bands of clay carbonate, in the heavy shales which overlie or replace the conglomerate. The ores do not seem to be continuous, but are independent beds at various levels. Some of these are of very fair quality, but thin, ranging from three to six inches in thickness. The most promising outcrop was found at John Hudson's, on the Young's Ferry road, about two miles from Green river, where is a bed of carbonate of iron fourteen inches thick, of which the following is an analysis by Dr. Peter and Mr. Talbutt, from an average sample, taken by myself:

Carbonate of iron	29.914
Peroxide of iron	17.945
Alumina	3.583
Carbonate of lime	12.036
Carbonate of magnesia	3.677
Phosphoric acid	.467
Sulphuric acid	.380
Silica and insoluble silicates	28.040
Water and loss	3.957
Total	100.000
Metallic iron	27.041
Phosphorus	.204
Sulphur	.152
Silica	25.260

This ore, by roasting, can be brought to yield over 30 per cent. of iron, while the considerable per centage of lime present will render it an easy working ore.

In the old Brownsville and Leitchfield road, on the first high hill west of Bear Creek, about four miles from Leitchfield, on land belonging to John Higdon, is a bed of ore, partly limonite and partly carbonate, resting on the shales near the top of the hill. The ore is about eight inches thick, and of excellent quality, as the following analysis, by Dr. Peter and Mr. Talbutt, of an average sample, taken by myself, shows:

Carbonate of iron	16.598
Peroxide of iron	42.761
Alumina	4.994
Carbonate of lime	2.840
Carbonate of magnesia	2.904
Phosphoric acid	1.017
Sulphuric acid	trace.
Silica and insoluble silicates	20.830
Water and loss	8.056
Total	100.000
Metallic iron	37.945
Phosphorus	.444

Near the mouth of Hunting Fork of Rock Creek, a small outcrop of excellent ore was found, not far from the top of the Chester limestone; but it was seen in only one locality, and it is not certain if it be a reliable deposit. Its quality is equal to that of any in this region.

On Grindstone branch of Rock Creek, a fossiliferous limonite was found, but proved to be so lean that it is probably of little value.

This closes the list of ores in this region which have been deemed worthy of description. Most of them have been seen at but few outcrops, and may have been judged to be local from insufficient evidence. There is, however, in a large portion of this region a trustworthy supply of ore, sufficient to sustain a number of furnaces. Most of the region is covered with timber suitable for charcoal, which can be obtained at a small cost, and sometimes for the cutting. Of stone-coal there is an abundant supply of good quality, which can be mined cheaply and easily. It will, however, probably be best to coke it, if it is desired to use it for the manufacture of iron. Limestone for flux is also abundant in nearly every stream. The region furnishes, therefore, all the requisites for the manufacture of iron in quantities sufficient, and at prices low enough, to produce cheap iron. The most serious disadvantage which it has, and the one which has prevented its development hitherto, is lack of transportation facilities. The distance from the Louisville, Paducah and Southwestern Railroad to the nearest valuable ores is from ten to twelve miles, while on the south, it is about six miles from Green river to the ore banks best known at present. This distance is from the river at Brownsville, above the head of slack-water navigation, although, for perhaps half the year, boats of light draught can ascend to Brownsville. The building of a dam across Green river, below the mouth of Bear Creek, would give slack-water navigation to Brownsville, and render Bear Creek navigable to small boats, so that access could be had to the ores.

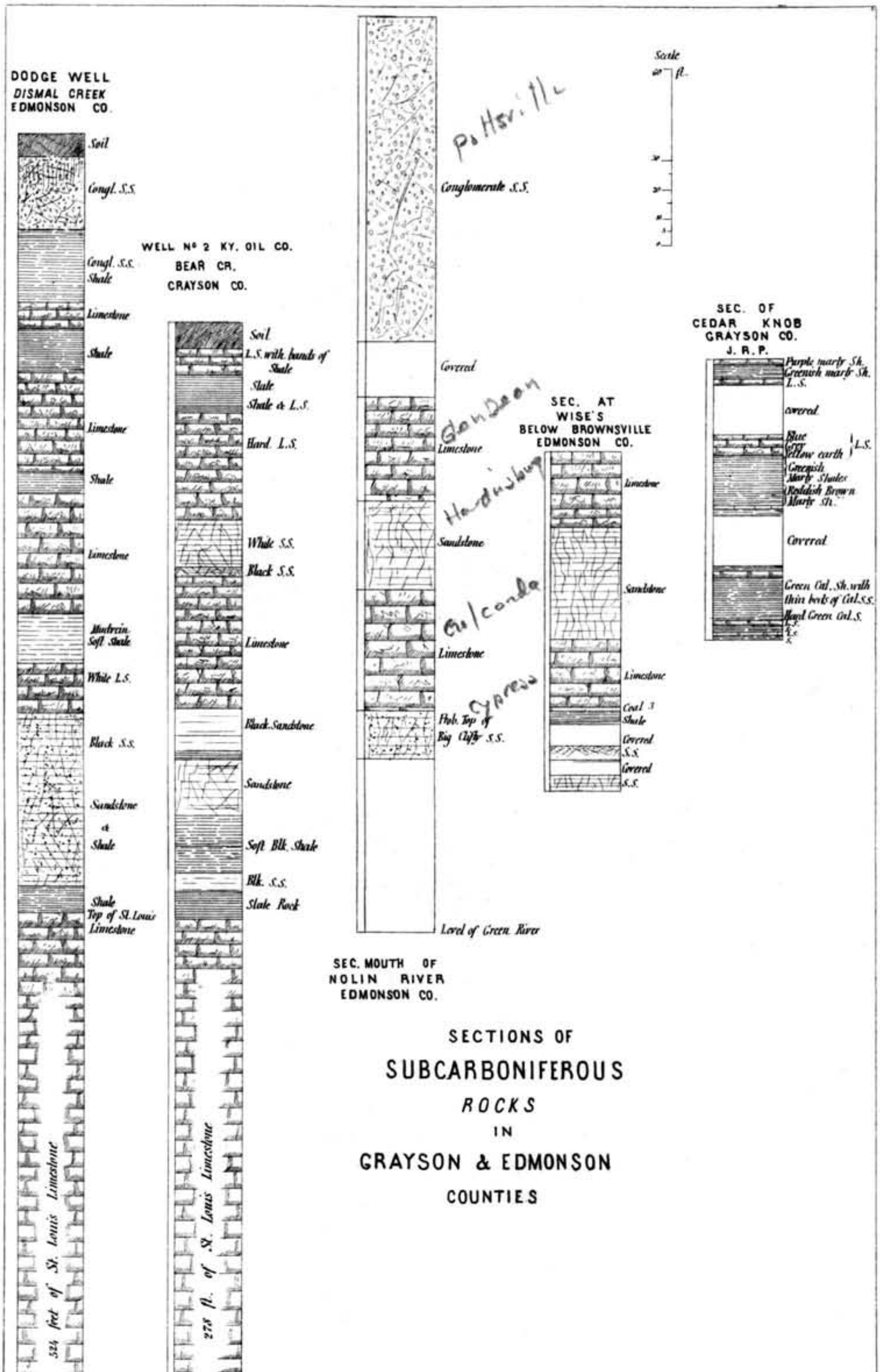
The necessity of wagoning iron to the railroad, involves so great an expense per ton that it is probable stone-coal iron could not now be made, in this region, at a profit; but a high grade of charcoal iron, either cold or hot blast, as it is a more valuable product, could stand a greater expense per ton for transportation and yet yield a profit.

The Nolin Furnace, which has been frequently referred to, was compelled to suspend operations largely from this cause. It was built in 1844 or 1845, near the mouth of Davis Branch of Nolin river, in Edmonson county. It ran three or four years, and then suspended operations. It has never since been started. The only means of getting out the iron was to run it down Nolin river in keel-boats, at time of high water—a method so uncertain and irregular in its operation that it, in addition to the limited capital of the owners, proved fatal to the enterprise. The furnace used charcoal for fuel, and made only cold blast iron. The iron made was of excellent quality. In the last days of its operation the furnace was run almost exclusively with the ores from the banks above the Bee Spring sandstone, on the ridge between Nolin river and Bear Creek.

A piece of pig iron made at this furnace was obtained, and analyzed by Dr. Peter and Mr. Talbutt. The following is the analysis:

Iron	94.287
Graphitic carbon	3.100
Combined carbon	.700
Silicon	.493
Phosphorus	1.029
Sulphur	.012
Total	99.611

The iron is a fine-grained, cold blast iron of great strength. The noticable feature of the above analysis is the small per centage of silicon and the high per centage of phosphorus. The strength of the iron is due to the low per centage of silicon; for with the ordinary amount of silicon present, added to the phosphorus, the iron would be very brittle. The phosphorus is higher than is usually possible without making a cold-short iron. The amount of phosphorus in this iron shows that nearly all of that ingredient in the ore is reduced, and passes into the pig. This furnishes an additional reason for smelting these ores with charcoal, as with that fuel, silicon and other impurities are not so liable to be reduced, and alloy with the iron, to its great injury.



SECTIONS OF

SUBCARBONIFEROUS

ROCKS

IN

GRAYSON & EDMONSON

COUNTIES

GEOLOGICAL SURVEY OF KENTUCKY.

N. S. SHALER, DIRECTOR.

REPORT

UPON THE

AIRDRIE FURNACE AND PROPERTY,

MUHLENBURG COUNTY, KENTUCKY,

BY P. N. MOORE.

PART IV. VOL. II. SECOND SERIES.

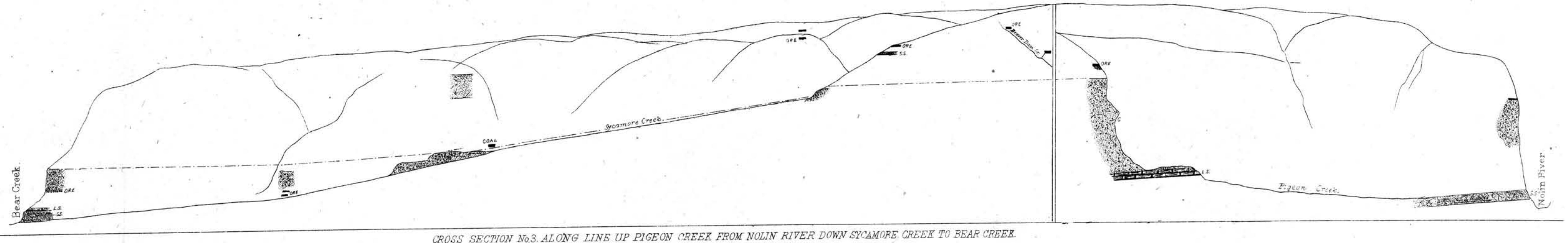
INTRODUCTORY LETTER.

Professor N. S. SHALER, *Director Kentucky Geological Survey:*

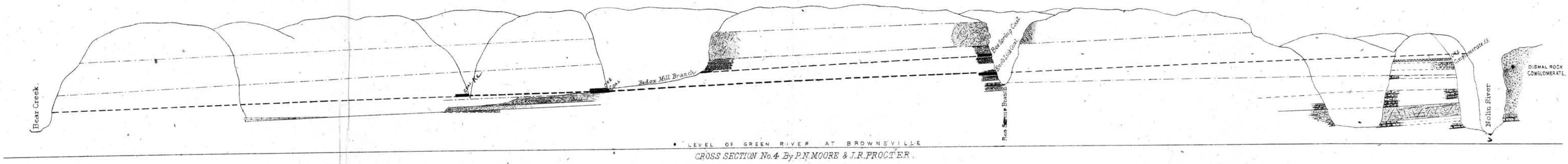
SIR: In accordance with your instructions, I made, during the past summer, an examination of the Airdrie Furnace and property, with a view to ascertain something of the resources of the estate, the causes of the former non-success of the furnace, and to suggest, if possible, the means whereby it can be brought into successful operation. The time at my command did not suffice for a careful geological examination of the whole property, and my attention was therefore given only to that portion in the immediate neighborhood of the furnace. It is to this that the furnace must look for its supply of fuel for a long time to come, and, as on examination it proved sufficiently rich in coal to place the matter of a sufficient supply beyond reasonable doubt, little attention was given to any other part of the property.

P. N. MOORE, *Assistant.*

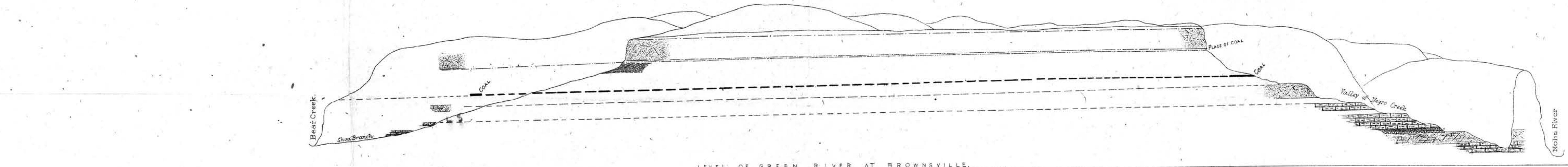
LEXINGTON, KY., December, 1874.



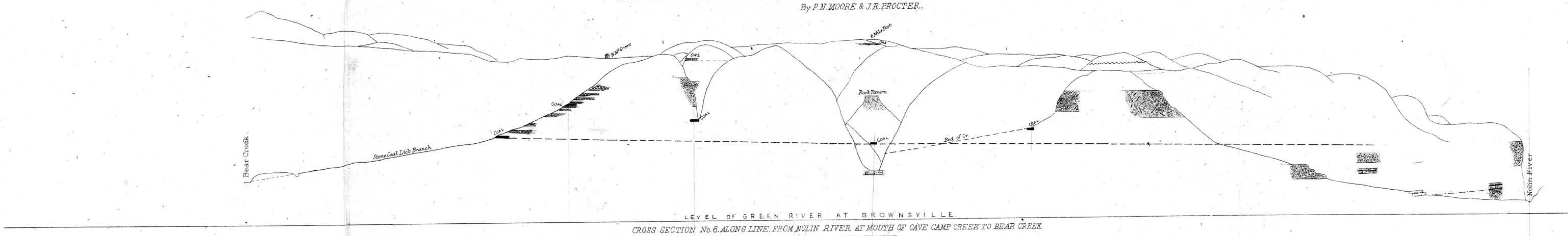
CROSS SECTION No.3. ALONG LINE UP PIGEON CREEK FROM NOLIN RIVER DOWN SYCAMORE CREEK TO BEAR CREEK.
By P.N. MOORE & J.R. PROCTER.



CROSS SECTION No. 4. By P.N. MOORE & J.R. PROCTER.



CROSS SECTION No.5. ALONG LINE, FROM NOLIN RIVER AT MOUTH OF NEGRO CREEK TO BEAR CREEK AT MOUTH OF SHOAL BRANCH.
By P.N. MOORE & J.R. PROCTER.

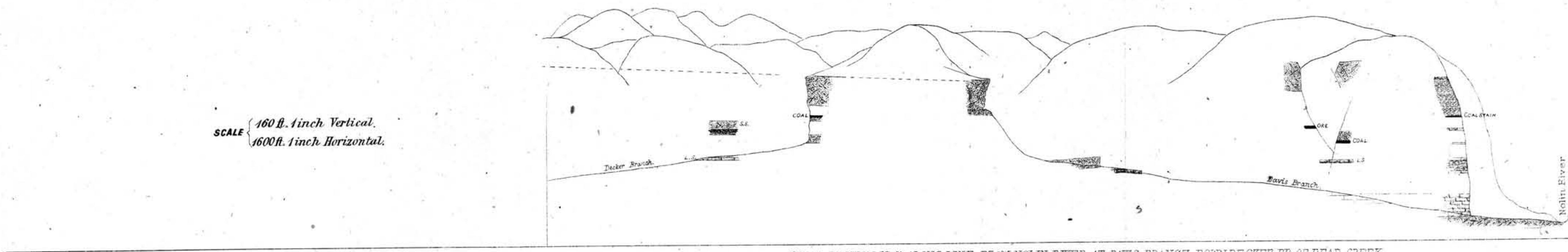


CROSS SECTION No. 6. ALONG LINE, FROM NOLIN RIVER AT MOUTH OF CAVE CAMP CREEK TO BEAR CREEK.
By P.N. MOORE & J.R. PROCTER.

CROSS SECTIONS TO ACCOMPANY THE REPORT OF P. N. MOORE on the EDMONSON COAL AND IRON DISTRICT.

A. Meisel, Lith. Boston.

SCALE { 160 ft. 1 inch Vertical. 1600 ft. 1 inch Horizontal.



CROSS SECTION No.7. ALONG LINE, FROM NOLIN RIVER AT DAVIS BRANCH DOWN DECKER BR OF BEAR CREEK.
By P.N. MOORE & J.R. PROCTER.

REPORT UPON THE AIRDRIE FURNACE AND PROPERTY, MUHLENBURG COUNTY, KY.

SITUATION.

Airdrie Furnace is situated near the village of Paradise, Muhlenburg county, Kentucky, on the bank of Green river, one hundred and thirty miles above its mouth, eighty-five miles below the head of slack-water navigation at Bowling Green. It is also four miles above Rockport, where the Louisville, Paducah and Southwestern Railroad crosses Green river, a stream which furnishes slack-water navigation for two hundred and fifteen miles, at nearly all times of the year, to boats drawing four feet of water; and during the greater portion of the time is navigable for boats drawing six feet.

There are but two locks between Airdrie Furnace and the Ohio river, and these are of a size uniform on Green river—one hundred and forty-five feet long by thirty-six feet wide.

THE FURNACE.

The furnace was built in 1855–'56. It has an iron shell stack, resting upon a masonry base, twenty-six and a half feet square by twenty-one feet high. The outside diameter of the shell is twenty-three feet.

The internal dimensions of the furnace are as follows: height fifty feet, diameter of bosh seventeen feet, height to bosh twenty-four feet (bosh cylindrical for six feet), diameter of throat eleven feet. The hearth is four feet high (elliptical in shape), seven feet four inches by (about) five feet.

The furnace is entirely open-topped, having no facilities for saving the gases, and requiring separate firing for both boilers and hot-blast.

There are two hot-blast ovens of the old-fashioned pistol-pipe pattern, with thirty-four pipes in each oven, ten curved pipes on each side, with seven straight at each end. The pipes are eight feet long, elliptical in cross section, nine by eighteen inches, with diaphragm through the center of each.

There are four boilers, each forty inches in diameter by twenty-eight feet in length, each boiler having two flues. The engine is vertical, with direct connection between the steam and blast cylinders, and also connected with a heavy walking beam and fly-wheel, the walking beam working with a counterpoise at one end.

The steam cylinder is twenty inches in diameter, and nine feet stroke; the blast cylinder six feet ten inches in diameter, stroke same as steam cylinder.

The engine-house is a splendid stone structure, built of a fine free stone, which occurs at the furnace. Everything about the furnace is constructed in the most thorough and durable manner.

The top of the furnace is about the level of the No. 11 Coal, to be hereafter described, and the ore and coal from the No. 12 seam were brought to the furnace mouth through a tunnel cut in the No. 11 Coal.

The engine is in good order and well preserved.

The furnace proper stands perfectly sound, and could, in a very brief time, be put in condition to go into blast; but among the buildings attached thereto the lapse of the many years since they were in use has not been without its effect, so that repairs to both buildings and hot-blast apparatus will need to be made before they can be used again.

THE PROPERTY.

The Airdrie Furnace property consists of about 17,000 acres of land in Muhlenburg county, Kentucky. This land is not all in one body, but lies in various sized lots, ranging from 500 to

5,000 acres. The greater portion of the estate lies within a short distance of the furnace; but one tract of about 5,000 acres—the old Buckner Furnace property—is about five miles from Greenville, the county seat of Muhlenburg county, and fifteen miles from Airdrie. Upon this tract, if all reports be true, there are extensive beds of iron ore, as well as some of the lower coals, one of which, said to be four feet thick, was mined and coked for use at the old Buckner Furnace. The situation is such, however, being five miles from the railroad at Greenville, that for the present, at least, the minerals of this tract cannot be rendered available.

We come then to the examination of the property adjacent to the furnace. A geological section showing the number and position of the coals here is given in the third volume of the Kentucky Geological Reports, first series, page 24.. This section was obtained in sinking a shaft at the furnace, and the measurements are therefore probably much more accurate than those usually obtained by boring. In reproducing the essential parts of the section, and describing the coals, the numbers assigned to them in the first series Geological Survey Reports will be used provisionally, for the reason that they are best known by these numbers, and that, although they have been discarded by the present Survey, the final nomenclature has not yet been decided upon.

We have, then, at this place the following coals:

I. Coal No. 12, two feet thickness of clear coal, then two feet of brashy coal. Resting upon this is a bed of slaty carbonate of iron, which sometimes contains a small amount of carbonaceous matter, and is called a Black-band iron ore. This ore ranges from four to fourteen inches in thickness, with an average of perhaps five or six. Its chemical constitution will be referred to hereafter.

II. Twenty-one feet below Coal No. 12, resting immediately under a hard, blue limestone, is Coal No. 11, six feet thick, in three members, each about two feet in thickness, with a parting of one to two inches of pyritiferous shale between each member. This coal is about sixty-five feet above Green river.

III. Below the level of Green river, and eighty-four feet under Coal No. 11, is Coal No. 9, five feet thick. This is the same coal as that mined so extensively for the Louisville market along the line of the Louisville, Paducah and South-western Railroad. Little is known of its quality here, but it is safe to suppose that it does not vary greatly from that along the railroad.

IV. There are one or two thin coals below this, but it is not until a depth of three hundred and forty-one feet below No. 9 is reached that another coal of workable thickness occurs. This is called No. 5 by Dr. Owen, and is three feet six inches thick. If the report of the miners who sunk the shaft, and of others who were employed at the furnace, is to be believed, this coal is of most excellent quality. A drift was run, and considerable coal taken out and used under the boilers with great success.

We see, therefore, that there are here, including the No. 12 Coal, which can be profitably worked with the overlying iron ore, no less than four coals of workable thickness.

QUALITY OF THE COAL.

Of the quality of No. 5 and No. 9 Coal at this place, we of course know nothing, for it was impossible to obtain samples for analysis. Samples of the No. 11 coal were obtained from the mine at Paradise, adjoining the Airdrie property. They were taken with great care from a number of rooms in the mine, in order to obtain as nearly an average as possible, representing the coal as actually mined and shipped. It is a brilliant black, firm coal, with comparatively little fibrous coal or mineral charcoal. It cleaves readily into large rectangular blocks in mining. There is considerable pyrites mingled with it in an increasing ratio from the top to the bottom, the upper member carrying the least. A sample was taken from each member. The following analyses are by Dr. Peter and Mr. Talbutt, chemists of the Survey:

ANALYSES OF NUMBER ELEVEN COAL, PARADISE MINE.

	Upper.	Middle.	Bottom.
Specific gravity	1.274	1.326	1.331
Moisture	3.60	4.10	4.20
Volatile combustible matter.	38.70	35.90	36.10
Fixed carbon	53.70 } coke 57.70	53.60 } coke 60.00	50.50 } coke 59.70
Ash	4.00	6.40	9.20
Total	100.00	100.00	100.00
Sulphur	3.158	4.394	4.573

It will be seen from the above that while an extremely good coal in the matter of freedom from water and ash, yet there is a very considerable per centage of sulphur present. It is, however, an excellent household and steam coal, and is held in high repute wherever it has been tried. Large quantities are sent from the Paradise mines to Bowling Green, where it is used for domestic purposes and by the railroad, and it is there rated higher than any other coal from Green river.

The No. 12 *Coal.*—As it was in the expectation of using this coal raw for fuel that the furnace was built, and as it was actually so used during the short campaigns of the furnace, it became a matter of considerable importance to obtain a perfectly average representative sample for analysis.

The attempt to obtain such a sample was only partially successful. The old entries by which the coal was worked have fallen in, so that it was impossible to get at the face of the coal where a sample from a number of places could be taken.

A shaft was, therefore, sunk through the coal near one of the entries, and an average sample taken. Another was taken from a pile of several thousand bushels which lies at the mouth of one of the old drifts, where it has been exposed to the weather for seventeen years. Although these must both represent the coal with a certain degree of accuracy, yet at both places it had been to a certain extent exposed to the weather, and may have absorbed water and parted with some sulphur.

The fact that the coal is quite "fat," however, containing much bituminous matter, tended to preserve it from the action of the weather. In the interior of the pile of coal at the entry many pieces were found only very slightly affected by its protracted exposure.

It is a deep black coal, showing little pyrites, and quite bituminous, too much so apparently to be successfully used alone raw in the blast furnace. Of the following three analyses the first was made by Dr. Peter, and published in the fourth volume of Kentucky Geological Reports, first series, page 230. Of the character of the sample and by whom taken I am ignorant. The second and third are by Dr. Peter and Mr. Talbutt, from average samples taken by myself. The second is the weathered coal from the stock-pile; the third from bottom of shaft near entry No. 4.

ANALYSES OF NUMBER TWELVE COAL, AIRDRIE FURNACE.

	I.		II.		III.	
Specific gravity	1.593		1.332		1.278	
Moisture	7.06		4.70		3.60	
Volatile combustible matter	30.84		30.60		31.40	
Fixed carbon	58.70	coke 62.10	58.80	coke 64.70	58.50	coke 65.00
Ash	3.40		5.90		6.50	
Total	100.00		100.00		100.00	
Sulphur	0.789		1.455		1.438	

A remarkable resemblance will be noticed between analyses two and three, showing that they have weathered very similarly; but the coal of No. 2 has absorbed more water and lost some of its volatile combustible matter. They show this to be a coal of very good quality, with neither sulphur nor ash sufficient to seriously injure it. It is so bituminous that it did not work well raw in the furnace, and after three unsuccessful trials it was decided to use it coked. A large amount of coke, several thousand bushels, was made; but the furnace was never started again, and it now lies on the stock bank, some of it good looking coke yet, after the rain and snows of seventeen years have fallen upon it. It is difficult to tell what the quality of it was when first made, and a sample taken from this pile does not fairly represent the coke that can be made from the coal; but it was regarded as matter of sufficient interest to be worth an analysis. I accordingly selected from the least weathered of the coke a sample for analysis, which is here given. The coke was made in open heaps, and therefore is not as firm and dense as it would be if coked in close ovens:

Moisture expelled at 212°	7.50
Moisture expelled at red heat	4.20
Fixed carbon	82.90
Ash	5.40
Total	100.00
Sulphur	0.642

The composition of the ash is as follows:

Silica and silicates	4.32
Alumina, oxide of iron, and manganese	.48
Lime	.33
Magnesia	.18
Phosphoric acid	.08
Total	5.39

As was to be expected, the coke has absorbed a very considerable per centage of water; but the amounts of both sulphur and ash are small.

THE IRON ORE.

Above the No. 12 Coal, already referred to, is a hard, dense, slaty carbonate, often containing fern leaf impressions between its cleavage planes. The amount of bituminous matter shown by analysis is small, and probably adheres to it from the associate shale and coal. It contains occasional specks of pyrites large enough to be easily seen by the unassisted eye. Its appearance is decidedly against it, and it seems to be much leaner than it really is.

The same difficulty was experienced in obtaining a fair average sample of the ore as with the No. 12 Coal. A sample was obtained from the same shaft, sunk to reach the coal near the old No. 4 entry, but it was so near the surface that the ore had been altered to a limonite. At this place, too, it seemed to be less silicious than usual, and the average, of course, was taken from only a limited amount of ore. Another sample was taken from a pile of unroasted ore lying near the mouth of the entry, where it has been exposed to the weather for seventeen years.

Still another sample was taken from a large pile of roasted ore, which had undergone a like period of exposure since roasting. In all of these there is a possibility that the ore is a little richer in iron and more free from sulphur than will be found to be the case when it is reached at a place where it is wholly unaltered; for the exposure to the air has a most beneficial effect in peroxidizing the iron and removing the sulphur.

The analyses by Dr. Peter and Mr. Talbutt are as follows:

	1.	2.
Peroxide of iron	63.048	59.810
Alumina	5.290	2.972
Brown oxide of manganese	.090	.720
Carbonate of lime	.680	. . . . .
Lime	. . . . .	2.263
Magnesia	.930	4.270
Phosphoric acid	.147	.223
Sulphur	.044	.065
Combined water	12.430	.206
Silica and insoluble silicates	17.250	29.880
Total	99.909	100.409
Specific gravity	3.246	3.652
Metallic iron	44.133	41.867
Phosphorus	.064	.097

No. 1. Ore from bottom of shaft near No. 4 entry.

No. 2. Roasted ore from the stock-pile, weathered seventeen years since roasting.

The above ores are both altered from the carbonate; one by the slow natural process of oxidation, the other by the process of roasting.

The analyses of the carbonate ores:

	1.	2.
Carbonate of iron	47.810	59.344
Peroxide of iron	9.054	4.180
Alumina	5.205	2.290
Carbonate of manganese	.797	2.017
Carbonate of lime	3.740	3.390
Magnesia	7.180	7.149
Phosphoric acid	.179	.428
Sulphur	.094	.246
Carbonaceous matter and water	8.788	4.071
Silica and insoluble silicates	17.010	16.280
Total	100.099	100.609
Potash	.....	.286
Soda	.....	.322
Specific gravity	3.376	2.959
Metallic iron	29.418	31.598
Phosphorus	.078	.186

No. 1. Average sample from the stock pile, where the ore had weathered seventeen years.

No. 2. Analysis by Dr. Peter, published in volume three, page 337, of the first series Kentucky Geological Reports, of "Black-band ore, roof of upper coal, Airdrie Furnace."

From the foregoing analyses the following conclusions are drawn:

First. The No. 11 Coal, while a fine domestic and steam-producing fuel, contains too much sulphur to be used in the manufacture of iron, without a previous preparation by washing and coking.

That this could be successfully done there is little doubt. The strength and density of the coke might not be equal to the best, but it would be a fuel of fair quality; such as could, it is believed, be used successfully in the manufacture of iron.

Second. The No. 12 Coal is an excellent fuel, on account of its small per centages of sulphur and ash; but the former experience of the furnace seems to prove conclusively what the appearance of the coal indicates, that it is too fat to use raw in the furnace, and should be coked. The amount of sulphur is so small that the coal can be coked without previous preparation, to free it from sulphur, and it will probably produce a superior coke; this, however, can only be demonstrated by actual trial on a large scale.

Third. The ore contains enough iron and is sufficiently free from injurious mixture to be safely used to a certain extent; but it will probably prove necessary to use other ores with it.

It is not unlikely, as already stated, that the analyses represent the ore as somewhat better than it really is, and that it will be found on trial, when used alone, to make a low grade of iron. There is, furthermore, the fact that, while both the coal and ore have to be mined together in order to be cheaply obtained, the output of coal for a given area will be more than twice as much as is required for the reduction of the ore from the same area, assuming from the general testimony that the coal will average two feet in thickness and the ore six inches. Of the coal, with a specific gravity of 1.33 and a thickness of two feet, each acre of land will contain 3,300 tons of 2,240 pounds each.

Of the ore, with a specific gravity of 3.25, and six inches thick, each acre will contain 2,015 tons. The ore will probably not yield in the furnace more than an average of twenty-eight or twenty-nine per cent., thus requiring for the production of one ton of iron three and a half tons of the raw ore. For the reduction of this amount of ore only from two to three gross tons of coal will be required, probably not exceeding an average of two and a half tons.

The coal from one acre of land will, therefore, be sufficient for the reduction of more than two and a fifth times as much ore as is produced from the same area. The necessity, then, of looking elsewhere for a partial ore supply is evident.

The situation of Airdrie Furnace is one remarkably favorable for the facilities with which ores from a number of regions can be cheaply laid down at the furnace. It can command, at very reasonable rates for freight, the following ores:

(*a*) Coal measure ores from Green river valley.
(*b*) Limonites from the Cumberland river region.
(*c*) Specular ores from Missouri.

(*a*) Coal measure ores from the Green river valley. There are, in a large number of places in the valley of Green river, ores of workable thickness and apparently considerable area; but they are as yet generally undeveloped, and frequently so far from the river or other means of transportation that they cannot be rendered available without the expenditure of considerable sums to provide such means of transportation. To this class belong the ores of the Buckner Furnace tract, already referred to. These must some day be developed and used at the furnace; but for the present they are inaccessible. They comprise both slaty carbonates or Black-band, and fossiliferous ores.

One locality was visited where is an exposure of eight or ten inches of the Black-band ore, and a sample for analysis selected. The ore from which it was taken had been exposed to the weather for thirty years or more.

The following is the analysis by Dr. Peter and Mr. Talbutt:

Carbonate of iron	42.950
Peroxide of iron	29.618
Alumina	2.454
Carbonate of manganese	1.083
Carbonate of lime	2.490
Carbonate of magnesia	4.828
Phosphoric acid	.083
Sulphuric acid	1.596
Carbonaceous matter and loss	5.868
Silica and insoluble silicates	9.030
Total	100.000
Metallic iron	36.916
Phosphorus	.036
Sulphur	.638

In Edmonson county, on the north side of Green river, between Bear Creek and Nolin river, is an extensive and valuable deposit of oölitic ore; but it is, where best developed, some six miles from Green river, and it cannot be hauled to the river cheaply enough to compete with ores from other places lower down. It is of excellent quality, and can be mined quite cheaply, and, if accessible, would be one of the most available ores. I append analysis, by Dr. Peter and Mr. Talbutt, of ore from a bank at the head of Beaver Dam Branch of Bear Creek. Average sample by Prof. N. S. Shaler:

Peroxide of iron	52.926
Alumina	4.792
Brown oxide of manganese	.210
Carbonate of lime	.180
Magnesia	.425
Phosphoric acid	.355
Sulphur	.057
Combined water	10.400
Silica and insoluble silicates	30.589
Total	99.934
Metallic iron	37.048
Phosphorus	.155

In Butler county, near the mouth of Little Reedy Creek, from one and a half to two miles distant from Green river, on the James E. Taylor farm, is a deposit of ore which shows at the outcrop three feet thick. It was only seen at one place, and little or nothing is known of its horizontal range. It has never been worked. An average sample was taken by Mr. J. R. Proctor, who first discovered it, and analyzed by Dr. Peter and Mr. Talbutt, with the following result:

Peroxide of iron	48.049
Alumina	8.171
Brown oxide of manganese	.140
Carbonate of lime	.540
Magnesia	.195
Phosphoric acid	.345
Sulphuric acid	.473
Combined water	9.750
Silica and insoluble silicates	31.900
Total	99.563
Metallic iron	33.634
Phosphorus	.150
Sulphur	.189

It is a silicious, somewhat oölitic limonite, altered from the carbonate; and as it occurs in shales, with a high hill above it, it will probably be soon found as the blue carbonate.

Its situation is such that it can be very cheaply placed in boats, on the slack-water of Green river, about seven miles above the lock at Woodbury. Should it be found, on closer examination, to retain its thickness, and extend over a considerable area, it can be mined very cheaply.

A reasonable estimate of its cost at the furnace, provided the above conditions hold, would be:

	Per ton.
Mining and royalty	$1 75
Hauling to river and loading on barges	75
Freight on Green river	1 25
Unloading at furnace	25
Making the total cost	$4 00

Two of these items, the freight on Green river and the hauling to the river, might be considerably reduced. It is probable that three dollars or three dollars and fifty cents would be a minimum cost at the furnace.

In Muhlenburg county, on Mud river, on land belonging to Jeremiah M. Hope, is a deposit of ore which, over a limited area, shows the unusual thickness of twelve to fifteen feet. The ore is exceedingly fossiliferous, partly a limonite and partly an unaltered carbonate. The upper portion of the ore is somewhat lean and silicious; the middle and lower portions of the bed are of fine quality.

The following analyses by Dr. Peter and Mr. Talbutt show the character of the ore:

	1.	2.	3.
Peroxide of iron	46.866	60.492	18.374
Carbonate of iron	.....	.....	26.643
Alumina	5.930	7.075	6.548
Brown oxide of manganese	.103	.360	a trace.
Carbonate of lime	2.535	1.980	13.430
Magnesia	1.073	1.550	5.698
Phosphoric acid	.179	.083	.211
Sulphur	.059	.074	.074
Combined water	9.550	12.530	6.792
Silica and insoluble silicates	33.530	15.560	22.230
Total	99.825	99.674	.....
Metallic iron	32.806	42.344	27.136
Phosphorus	.077	.032	.092

1. Sample, not carefully averaged, of limonite from the upper portion of the deposit.

2. Average sample of the limonite of the lower and middle portions of the deposit.

3. Average sample of the blue carbonate ore of the lower part of the deposit.

This ore seems to be in a regularly stratified deposit, but it only retains its unusual thickness over an area of perhaps 1,200 square yards. It is found at another locality, one third of a mile distant, on the opposite side of the ridge, two and a half feet thick.

The distance of the principal deposit from the head of slack-water, on Mud river, is four miles. Over this distance the ore would have to be wagoned, at a probable cost of one dollar and fifty cents per ton. The distance from the head of navigation, on Mud river, to Airdrie, by water, is about twenty miles, and in that twenty miles one lock to be passed. The cost of freight would be about seventy-five cents per ton. The ore can be mined quite cheaply, as very little stripping will be required for some time. One dollar and twenty-five cents will probably be sufficient to cover the cost of mining and royalty. The cost of this ore would therefore be:

	Per ton.
Mining and royalty	$1 25
Hauling to river	1 50
Freight to Airdrie	75
Unloading at furnace	25
Total	$3 75

By the purchase of the deposit and the use of their own barges by the owners of the furnace, this cost might be reduced to three dollars, or even less.

In Muhlenburg county, near Greenville, on the farm of Mr. Dabney Martin, some three miles from the Louisville, Paducah and Southwestern Railroad, is a bed of quite pure limonite ore. It is only eight inches thick, but is so situated that it could be mined over a large area, as the stripping above it would not be deep. It is of excellent quality. The analysis is as follows:

Peroxide of iron	69.546
Alumina	3.914
Brown oxide of manganese	.230
Carbonate of lime	.480
Magnesia	.921
Phosphoric acid	.115
Sulphur	.086
Combined water	11.250
Silica and silicates	12.730
Total	99.272
Metallic iron	48.882
Phosphorus	.050

This ore would cost, delivered on the cars at Greenville, three dollars per ton; freight from Greenville to Rockport, one dollar and fifty cents; hauling and freight from Rockport to Airdrie, fifty cents—making the cost of the ore at the furnace five dollars per ton, a price which renders its use at present out of the question.

(*b*) Limonites of the Cumberland river region. The ores of this region are too well known to need especial description. They are cherty limonites found in the clays on the sub-carboniferous limestone, in unstratified and irregular but extensive deposits. They vary greatly in quality at every deposit, and great care is required in mining to prevent the cherty ore from becoming mixed with the better quality. They yield from thirty-five to fifty per cent. of the iron, and even higher when free from chert. There are numbers of these deposits in Lyon county, close to the line of the Louisville, Paducah and Southwestern Railroad. I visited some of these and obtained samples for analysis:

	1.	2.	3.	4.
Peroxide of iron	59.370	70.518	66.117	69.412
Alumina	1.622	.045	1.064	not est.
Brown oxide of manganese	.090	.190	.170	.170
Carbonate of lime	.170	.090	.090	.140
Magnesia	.100	a trace.	a trace.	a trace.
Phosphoric acid	.179	.275	.434	.313
Sulphur	.212	.045	not est.	a trace.
Combined water	8.400	9.850	9.800	9.550
Silica and insoluble silicates	30.000	18.910	22.330	20.500
Total	100.053	99.923	100.005	100.085
Metallic iron	41.559	49.363	46.282	48.588
Phosphorus	.077	.120	.189	.144

These ores are all from the old Suwanee Furnace lands, in Lyon county, and the samples were taken to represent, as nearly as possible, the average character of the ore of each deposit, chert and all. All of the ore could be picked so as to give a much better average, and it would be necessary to do so in shipping.

No. 1. Ore from "Big Showing" bank, Suwanee Furnace property, Lyon county.

No. 2. Ore from bank close to the furnace, Suwanee Furnace property, Lyon county.

No. 3. Ore from bank at railroad cut, Suwanee Furnace property, Lyon county.

No. 4. Ore from Iron Mountain bank, Suwanee Furnace property, Lyon county.

It would be safe to estimate that these ores can be relied on to yield forty-five per cent. of iron, where properly sorted before shipment.

These deposits are situated about eighty miles from the crossing of Green river at Rockport.

Parties stand willing to-day to deliver these ores on the cars at two dollars and fifty cents per ton. The Louisville, Paducah and Southwestern Railroad will transport, in small quantities, from Lyon county to Rockport for one dollar and fifty cents per ton, and will take large quantities at much less rates. It is probable that on a regular contract the rates would not exceed one dollar or one dollar and twenty-five cents per ton. The expense of loading into barges at Rockport, towing to Airdrie (four miles) and unloading, should not exceed fifty cents per ton. By the erection of a proper chute or tip at Rockport this could be reduced nearly one half.

Assuming the maximum rates for freight, the cost of Lyon county ore at Airdrie would be:

	Per ton.
Ore delivered on cars	$2 50
Freight to Rockport	1 25
Handling and towage to furnace	50
Total	$4 25

This could be reduced by making large contracts and some expenditure for a dock at Rockport; but this estimate, like all the others, is made on a basis of the purchase of the ore without the investment of any capital. With such investment, four dollars per ton would safely cover the cost of a ton of ore at the furnace.

(*c*) The specular ores of Missouri. These well-known ores are known under two classes, the Iron Mountain ore and the Central Missouri ores. There is not a great deal of difference in their quality. They are all rich, yielding from sixty to sixty-seven percent of iron. The Iron Mountain ore has a little the largest percentage of iron, and is of the most uniform quality. It averages sixty-five to sixty-seven per cent. of iron; the Central Missouri ores from sixty to sixty-five. Iron Mountain ore is now worth in St. Louis seven dollars per ton; Central Missouri ores, six dollars. These ores can be brought in barges directly from St. Louis to the furnace, or they can be shipped to Evansville by rail, and from there to the furnace in barges. In either case, the cost for transportation from St. Louis should not exceed two dollars and fifty cents to three dollars per ton; thus making the cost of the Missouri ores nine dollars and fifty cents to ten dollars per ton at the furnace for Iron Mountain ore, and eight dollars and fifty cents to nine dollars for Central Missouri.

THE AVERAGE COST PER TON OF IRON

for each of the two classes of ore available to Airdrie Furnace, based on the foregoing estimates, which are certainly large enough in each case to be almost called maximum estimates, would be:

3 tons Green river ore, at	$3 75	per ton	$11 25
2¼ tons Cumberland river ore, at	4 25	"	9 56
1½ tons Iron Mountain, at	10 00	"	15 00
1⅔ tons Central Missouri, at	9 00	"	15 00

The Cumberland river ores, therefore, are considerably the cheapest that can be obtained at present without the outlay of considerable additional capital.

Their richness is such as to add another considerable advantage to them over ores with a less per centage of iron, for they are proportionately more economical to use in the furnace, as they require less fuel for their reduction.

In a time of ordinary prosperity of the iron market, any of the other ores can be profitably and successfully used.

Limestone for use as flux will have to be brought from upper Green or Barren river. It occurs at many places there in heavy deposits immediately on the bank of the stream, and can be quarried and placed in barges very cheaply. It is probable that seventy-five cents per ton will cover the cost of the limestone at the furnace.

The limestone required will not exceed twenty-five per cent. of the ore used, and may be less, as the Black-band ore, although lean, contains a considerable proportion of lime and other bases and will partly flux itself. There is a limestone four to five feet thick forming the roof of the No. 11 coal; but it is somewhat earthy, and at places quite sulphurous. It was tried during the former campaign of the furnace, but soon abandoned, and its place supplied with limestone from the mouth of Gasper Creek, on Barren river. This, as will be seen by the following analysis, is a nearly pure limestone of excellent quality:

Alumina and oxide of iron	0.917
Carbonate of lime	93.020
Carbonate of magnesia	2.088
Phosphoric acid	.243
Sulphuric acid	.604
Silica and insoluble silicates	2.760
Water and loss	.368

We have shown the number of alternatives possible to the furnace in the matter of an iron ore supply: let us look for a moment at the corresponding advantages for fuel.

Suppose No. 12 Coal should prove too thin to work, and the No. 11 not of as good quality as needed. The great shaft stands open, the boiler, winding drum, and engine for operating it are ready to be put in operation, in a short time, to give access to the two coals below the drainage. Suppose on trial neither of these proves a suitable fuel for iron making; Airdrie Furnace is only twenty miles by water from the well-known Mud River mines, the coal from which is among the best (if not the best) in the Green River country. That this will make iron raw, there is little doubt. A barge load of it was taken to St. Louis a few years since and tried very successfully in one of the Kingsland (now Vulcan) Company's furnaces. These mines are on slack-water, and can be reached from Airdrie at all times of the year.

The excellent quality of coal can be seen from the following analysis by Dr. Peter and Mr. Talbutt. The sample was a carefully taken average from all parts of the seam by myself:

MUD RIVER COAL.

Moisture	3.80	
Volatile combustible matter	32.70	
Fixed carbon	58.00	Coke 83.50.
Ash	4.90	
Sulphur	1.929	
Specific gravity	1.221	

Yet another alternative remains to Airdrie Furnace. Its situation on the bank of Green river is such that it can be cheaply and easily supplied with charcoal in case the manufacture of charcoal iron should be desirable.

Large portions of the valley of Green river are an almost unbroken forest, both above and below the furnace. Timber for the manufacture of charcoal can be purchased along the river at very small prices, and sometimes can be had for the clearing. This can either be rafted to the furnace, and there made into charcoal in ovens, or it can be charred on the ground and carried to the furnace in barges. In either case it can be furnished there cheaply enough for the manufacture of charcoal iron at a profit in the ordinary stage of the market.

We see, therefore, that Airdrie furnace is so fortunately situated as to be able to command, at reasonable prices, at any of which, in the ordinarily prosperous condition of the iron market, iron can be made at a profit:

Ore from four different regions.

Coal from four different beds at the furnace.

The Mud River coal.

Charcoal.

Such advantages as these, it can be truly said, are unsurpassed, and they render it certain, beyond reasonable doubt, that, with proper management, Airdrie Furnace can be made one of the most successful in the country.

Having thus considered in detail the resources of this property, and seen the remarkable advantages it possesses for obtaining fuel and cheap and varied supplies of ores, the question naturally presents itself: why, then, with all these advantages, was the furnace no more successful on its former trial? This is a serious and important question, for the reproach of failure laid against an enterprise of this kind outweighs many advantages.

Into the answer a number of reasons enter, and to render them properly understood it will be necessary to go into the history of the former campaign of the furnace in some detail, and to refer to the management of the enterprise in language which is unmistakable, although it may seriously reflect upon the business sagacity of some persons once connected with it who are no longer living. It should be premised that the information upon which the following account is based was obtained partly from the books of the furnace and partly from men who were on the ground, connected with the furnace in various capacities.

The enterprise seems to have been conceived by its proprietor in a spirit in which benevolence, national pride, and the desire for a profitable investment, were strangely mingled. Being a Scotchman, and having some knowledge of iron manufacture as practiced in Scotland, he not unnaturally believed men of that nationality to be the most competent and desirable persons to conduct establishments for iron making.

He therefore committed from the beginning the serious mistake of employing almost exclusively newly-arrived foreigners, men who, however competent at home, were without any knowledge of American prices and metallurgical practice, or experience with American ores and fuel.

Having found what was firmly believed to be the equivalent of the celebrated Scotch Black-band iron ore, and an associate coal which it was thought could be used raw in the furnace, he proceeded to erect a furnace modeled after the Scotch pattern. He brought over large numbers of Scotch miners and furnace men, and employed them almost exclusively; giving them to understand, it is reported, that it was to improve their condition, rather than in hopes of great returns, that he had made the investment. He employed as superintendent and manager an uneducated, dissipated Scotchman, a man wholly unfit to fill so important and responsible a position, and to him he gave almost entire charge of the whole enterprise, often not visiting the property for months at a time.

Under such conditions, it is no wonder that there was mismanagement, and that ill-advised expenditures were made.

For three years, while the slow process of development was going on, the furnace and machinery erected, entries driven, and the great shaft, five and a half by eighteen feet, sunk to a depth of four hundred and thirty feet in search of a mythical ore (known to exist fifteen miles distant and nowhere between), the proprietor continued uncomplainingly to increase his investment.

At last the furnace was started. It ran a few days very unsuccessfully, producing iron of a poor quality and in small amount, when an accident to the boiler compelled it to be blown out.

Repairs were made in due time and the furnace again started. The working was no better than before, and the iron not improved in quality or quantity. In twenty-two days from the time of starting the saddle-plate of the walking-beam broke, disabling the engine and compelling the furnace to be shoveled out. Again it started, and again, after a short run, no more successful than the last, an accident happened to the engine, the cast-iron shaft of the fly-wheel broke, and once more the furnace was shoveled out.

In all three of these unfortunate campaigns the furnace was not in blast altogether more than six weeks or two months.

After the last blast the manager concluded that the coal did not work well raw, and so made a large amount of coke from it to be tried at the next blast, but the next blast never came; the proprietor's patience was exhausted; he stopped operations entirely, discharged his men, and shut up the mines and furnace.

Since that time (November, 1857) the furnace has never been in operation. The No. 11 Coal has been worked largely for shipment to the Southern market, but beyond that the property has been lying idle and unproductive.

The closing of the furnace at that time was a mistake no less serious than some committed in starting it. The manager was beginning to learn, by the only method by which a so-called practical, uneducated man can learn—his own dear-bought experience—that American ores and fuel are not exactly like the Scotch, and that different practice is required for their treatment. Had he been allowed to go on, using coke for fuel, it is not unlikely that his next campaign would have proved much more successful.

It can be truly said that the furnace has never been subjected to a fair trial. A total campaign of six weeks or two months, divided into three short blasts, affords no fair basis for judgment as to the merits of furnace, fuel, or ore.

The iron made at the furnace was of notoriously poor quality. In order to ascertain to what cause this was due, three samples were procured from the iron remaining at the furnace, the analysis of which, by Dr. Peter and Mr. Talbutt, are herewith appended. The samples are all from a grade of iron variously known as silver gray, burnt iron, or glazed pig. It was impossible to procure samples of any other grade of iron. It is a fine-grained, light-colored iron, extremely weak and brittle.

The analyses are as follows:

	I.	II.	III.
Iron	86.645	85.863	86.842
Graphitic carbon	.900	.400	.780
Combined carbon	2.080	2.570	2.070
Silicon	7.704	7.747	8.614
Manganese	.571	.696	.355
Aluminum	.202	.274	.136
Calcium	.072	.112	.112
Magnesium	.035	.017	.056
Sulphur	.127	.227	.173
Phosphorus	.253	.509	.122
Total	98.589	98.415	99.260

Slag undetermined.

It will be seen that the proportion of sulphur and phosphorus is quite high in No. II, but it is probable that the poor quality of the iron is due more to the excessive amount of silicon than to any other cause.

The attempt was made to produce a No. 1 foundry iron by working the furnace hot, and the result was, that with a hot working of the furnace much silicon was reduced with the iron, and rendered it very brittle or "cold-short." Had the manager been content to burden his furnace for a "mill iron," working colder, it is probable the product would have been of much greater strength, although, as already stated, it is not unlikely that the Airdrie ore worked alone will always have a tendency to produce a low grade of iron. Hence, the necessity for some supply of ore from other sources.

That Airdrie Furnace, with some alterations and proper management, can be made to produce iron of good quality, and at a very low price, there is little doubt. In order to this, however, it will be advisable to considerably alter and modernize the furnace. It should be raised ten to fifteen feet in height, in order to give it dimensions better adapted to economical working, and a closed top and down-takes to carry the waste gases to boilers and hot blast added. The position of the boilers will have to be altered, the smoke-stack raised, new hot-blast ovens erected, or the present ones changed, and a new casting-house built. It will be also advisable to erect coking-ovens; and, in case the No. 11 Coal is used, washing machinery will be required in addition.

The total amount required to make all the needed changes, open the mines, and put the furnace in operation, will not exceed $60,000.

These changes made, Airdrie Furnace can produce iron, considering its nearness and cheapness of transportation to market, for a less price per ton than any other furnace in Kentucky.

We have already shown the cost at which ore and limestone can be supplied at the furnace. We have now to consider the cost of fuel, when we will have the material in hand to prove the above statement.

Mining the coal and the ore together, the No. 12 Coal can be mined for one dollar per ton, the ore for one dollar and seventy-five cents.

Allowing fifty cents per ton as the cost for handling and mine expenses, &c., we have the cost of the coal one dollar and a half per ton. Three tons of coal will make two tons of coke, at a cost for coking of fifty cents per ton. Allowing the large consumption of two tons of coke to the ton of iron, and using one and one eighth tons of Cumberland river ore to one and three fourths tons Airdie ore, the cost per ton of pig iron at the furnace would be:

Two tons of coke, at $2 75 per ton	$5 50
One and three fourths tons of Black-band ore, at $1 75 per ton	3 06
One and one eighth tons Cumberland river ore	4 78
Roasting two and three fourths tons of ore, at twenty cents per ton	55
Two thirds of a ton of limestone	50
Labor and superintendence	3 50
Sundries	1 00
Total estimated cost per ton	$18 89

The iron can be put in market for from two dollars to three dollars per ton additional. Even supposing all the odds against the furnace, and that the iron produced is of a low grade, yet there would be a profit in it, even in the present fearfully depressed condition of the iron trade.

The demand of the future is for cheap iron. The days of high-priced iron have gone, not to return for months to come, if ever; and, in the struggle for existence, only those furnaces which are favorably located and carefully managed can survive. For such as can produce iron economically and cheaply, there will always be a profitable market, and only for those.

To this class Airdrie Furnace certainly belongs.

GEOLOGICAL SURVEY OF KENTUCKY.

N. S. SHALER, Director.

TOPOGRAPHICAL REPORT

OF THE

NOLIN RIVER DISTRICT,

BY WILLIAM BYRD PAGE.

Part V. Vol. II. Second Series.

189 & 190

INTRODUCTORY LETTER.

Professor N. S. SHALER, *Director Kentucky Geological Survey:*

SIR: I herewith submit the following report upon the topography of the Nolin River district:

In accordance with your instructions of June 3d, 1874, designating for field work the country from Green river north towards the Ohio, and the object the delineation of the eastern outcrop of the western coal field, field work was commenced on the 10th of June, 1874, and continued without intermission until the 24th of December of the same year. In connection with this work, a meridian line was established at Brownsville; stones were placed in the line, and the declination of the magnetic needle determined. A map showing this line, and the position of the stones, was placed on record at the court-house at Brownsville.

A map of an Indian fort near Honaker's Ferry, on Green river, was also made.

The map of the Nolin River district was drawn upon a scale of six inches to the mile, to be kept as a record, and reduced for publication to one inch to the mile.

In the field work, material aid was rendered by Messrs. C. W. Beckham and J. B. Marcou, to whom an acknowledgment is due for their energy and interest during the prosecution of the work.

Upon leaving the field, the office work was commenced and continued until the map was prepared for publication.

Very respectfully,

WM. BYRD PAGE.

TOPOGRAPHICAL REPORT OF THE NOLIN RIVER DISTRICT.

The topographical survey of this section extends northward from Green river to the Louisville, Paducah and Southwestern Railroad, and from Bear Creek, on the west, eastward to the Mammoth Cave, including the lower portion of Green river. The extent of area mapped is about three hundred square miles. This area includes portions of Edmonson, Grayson, and Hart counties, and the county towns of Brownsville and Leitchfield. The Mammoth Cave and Grayson Springs and its railroad station are also shown.

THE METHOD OF THE SURVEY.

The following is an outline of the method pursued in mapping this section: The road from Brownsville to Grayson Springs Station was selected as a base line. This road was surveyed with transit and chain, and over the transit line a profile of the road was made with a water level. This line served as a base for the compass work, and, as far as possible, the surveys were closed to it. The profile enabled the barometric work to be checked. Barometric observations were made upon all the compass lines, and from these observations contour lines were shown upon the map.

DRAINAGE.

The drainage of this section is entirely to Green river, and in a southward direction, making this area a portion of the northern water-shed of the river.

The principal channels of drainage are Nolin river and Bear Creek.

The surface rock, the character of which determines the shape and relative positions of the contours, is, over much of the surface, sandstone. This is shown in the table-land structure of the area in the western portion mapped. The limestone structure, which is flatter and of more irregular form, is confined chiefly to the eastern portion of the district, and to the valleys or bottom lands of the rivers and creeks. Where the shales come to the surface there are characteristic knobs. The thickness of the sandstone gives an additional variety to the features of the country. The height of the table-land will average about 350 feet,* and will vary from 250 feet to 500 feet, the general level rising toward the east. The more important portions of the country will be described in detail.

The head branches of Bear Creek drain the country southward from the railroad, from east of Grayson Springs Station to west of Leitchfield. About four miles from the road, these streams meet at a level about 200 feet below the road.

Lizard Lick Branch, heading at the Springs Station, empties into Bear Creek at Grayson Springs. Here the level of the creek is 175 feet below the railroad.

These branches have no precipitous cliffs or falls, but regular and gradual slopes, mostly covered, and, as they approach Bear Creek, widen into flat bottom lands. From Grayson Springs the general course of Bear Creek is south southwest, and its length, to the mouth, is 41 miles. It is tortuous in its entire length. In air-line, the distance is 22 miles from the Springs to the mouth of Bear Creek. The total fall of the creek in this length is 130 feet. The table-land ridges between Bear Creek and Nolin river and its branches may be considered as spurs of the ridge upon which the Louisville and Paducah road, near the Springs Station, is built. These ridges extend to Green river. At the railroad the ridge is about 325 feet in height above Green river. Where first shown on the map, it is crossed by the road from Grayson Springs to Morrison's Ford, on Rock Creek. Its extreme height at this road is 350 feet. One mile south it is crossed by another road from Grayson Springs to Rock Creek. Here

*Vertical measurements are given in feet above low water of Green river, which datum is 436 feet above the level of the sea.

the streams of Bear and Rock Creeks head close to each other, and cut down the ridge to a height of 300 feet. One mile further, at the junction of the Grayson Springs, Mammoth Cave, and Brownsville roads, the ridge attains a height of 340 feet, and is divided by Canoloway Creek. This creek is about six miles in length; its slopes are gradual and mostly well covered. The branches from the southwest show exposed cliffs. The total fall of this creek, from its head to Nolin river, where it empties, is 310 feet.

The spur of the ridge, upon which is the Mammoth Cave road, preserves its height evenly for some miles. The creeks, as they drain either side of the table-land ridge, show, by their precipitous drop of about 60 feet, the character and thickness of the surface rocks. Three miles from Nolin river the ridge is cut down, and the branches on either side head to the saddle. The ridge to the river gains its original height only at intervals.

The spur of the ridge, upon which is the Bee Spring and Brownsville road, extends in a southerly direction towards Green river. Its height varies considerably, although the same character of table-land exists. Five miles from Grayson Springs, where the Leitchfield road is, the ridge attains its greatest height of 400 feet. Just to the east of this point is a knob about 40 feet higher than the road. From this point to Bee Spring, a distance along the ridge of 10 miles, the height varies from 390 to 270 feet. From Bee Spring the ridge rises to 370 feet, at the Little Mountain road, 3 miles south of the spring.

From here to the southward, although the surface is without apparent change, the creeks indicate, in many points, remarkable alterations. Pigeon, Pine, and Indian Creeks, draining into Nolin and Green rivers on the east, and Beaver Dam and Gulf Creeks of Bear Creek on the west, after a short, gradual, covered slope, break over the heavy conglomerate sandstone in perpendicular cliffs. These cliffs vary in height from 60 and 70 to over 100 feet. From the bottoms of the creeks they rise almost vertically on either side. Here is seen the

Rock-House structure, where the lower portion of the sandstone has receded and the upper part makes a roof, giving good shelter and room. The rock-houses vary much in size; the dimensions of one measured were 100 by 40 by 60 feet.

East of Rock Creek appears the first general erosion of the sandstone, the sandstone table-land structure being replaced by the flat but irregular limestone type of topography. The ridge between Rock Creek and Nolin river has been protected, and remains capped with sandstone. This ridge attains a height, in places, of nearly 500 feet. The lowest gap in the ridge is between Hunting Fork of Rock Creek and Laurel Run of Nolin river. Its height is 300 feet. The ridge towards Rock Creek will average in height from 350 to 400 feet. This ridge does not extend further north than Sinking Creek. This creek is so named because it has no outlet above ground. The bed of the stream has no continuous slope towards the mouth, but a rise of 20 or 30 feet in one or more places. To the northward of Sinking Creek the area remains flat. The country between Nolin and Green rivers presents several curious features of topography. The structure is of the sandstone type and partly of the thickened conglomerate sandstone variety.

The streams head to a common point, which is about 480 feet high. The descent to the bottoms of the creek is very precipitous, and from the bottoms the cliffs extend along almost the entire length of the creeks as vertical walls.

To the valley of Bylew Creek there are said to be only three approaches. In the valley the arable land is of some extent. The heights of the vertical cliffs were measured in several places, and are given below. Bylew and Piney Creeks cut through the thickest of the sandstone, and the cliffs in these creeks are almost unbroken in their wall-like appearance. In some places the cliffs will measure 180 feet. Buzzard's Roost, on White Oak Fork of Dog Creek, is a picturesque overhanging cliff of 160 feet in height. This peculiar structure is confined to the following creeks: First Creek and Gulf on the south, Pigeon, the mouth of Dismal, Piney, and the western branches of Dog Creek on the north, the western branches of Dog and Buffalo Creeks on the east, and on the west extending to Gulf and Beaver Dam Creeks. The heights of the cliffs were measured in a few places on Green and Nolin rivers. At the mouth of Indian Creek, on the north side, the cliff is 198 feet in height; at the mouth of Nolin river, on the western bank, 175 feet; at the mouth of Second, 209 feet, and Dismal Rock, opposite the mouth of Dismal Creek, is 164 feet in height.

LINES OF ACCESS.

The nearest railroad is the Louisville, Paducah and Southwestern. This road skirts the northern boundary of the country. Grayson Springs Station is distant from Louisville 65½ miles. A branch line from this road 15 miles in length would place, at the road, the coal and iron together with the timber and other produce of this section. The probable routes would present no peculiar difficulties. The ridge extending from the road to Green river has been described in detail as a practical route for the road, and the map has been worked closely along the probable line. This will enable the route to be chosen without much expense of preliminary surveying. Should it be advisable that the road pass Grayson Springs, Lizard Lick Branch presents suitable slopes, and the approach to the ridge could be made by the School-house Branch of Bear Creek. This route would not lengthen the road appreciably.

To the southward of this section of the country is the Louisville and Nashville road, 8 miles south of Green river, and 7 and seven eighths miles south of the Mammoth Cave, by railroad survey. A branch road into this section of the country would give an abundant supply of coal to this road, at a most convenient point, midway between the termini of the road.

RIVERS.

This section has great advantages in the facilities which its rivers will afford. Green river, as shown in this area, is about 200 feet wide, a deep stream, rarely freezing, and with slight fall per mile. Slack-water exists already within the limits of the map, and the distance by the river to the Ohio is 283 miles. The highest lock on the river is near the mouth of Barren river, 19 miles below the mouth of Bear Creek.

Slack-water facilities could be given to this section at small expense. This would also affect Nolin river and Bear Creek. Mt. Vernon Mills, on Nolin river, would be brought within the limits of slack-water, and within the reach of a market for the valuable timber which it offers.*

WATER POWER.

The country has superior advantages in this respect. The volume of flow in the rivers will be mentioned later. Springs are numerous, and may be divided into two classes—limestone springs and those flowing from the sandstone. The former are large in volume, with comparatively small fall; the latter are smaller in volume but more numerous, and are in such relation to the vertical cliffs as to have effective falls of considerable height. Both classes of springs represent power, and are susceptible of use. Upon the map is shown the quantity of running water of many of these springs; the quantity for twenty-four hours is given, and from the contours the effective fall in any distance can be determined.

The volume of some of the springs may be mentioned here. At Grayson Springs one spring measured 30,000 gallons. On Slab Run and Barlow's Run are two springs, measuring about 40,000 gallons each. On Beaver Dam Creek is a mill dependent on a spring for its supply; the effective fall is about 30 feet. A spring at the mouth of Nolin river has an effective fall of 90 feet, and was flowing, when measured, about 70,000 gallons. Used, as it is at present, for a mill, about half the power is lost. Dog Creek should be mentioned as furnishing a considerable supply of running water. Its banks are suitable for high dams. The mills on the creek represent good power. A spring near Nolin at Broad Ford, higher on the

* See water power at dam, as given below.

river than shown on the map, measured over 4,000,000 gallons. The volume of flow of Nolin was measured in May, 1875; it was then said to be below its average for the year, exclusive of freshets. The volume was over 8,000 cubic feet per minute, which is equivalent to 15.1 horses' power per foot of fall, or for the dam, 7 feet in height, at Mt. Vernon Mills, there was represented 108 horse-power. The river has measured, at other times, when considered just beyond its usual flow, 48 and 68 horse-power per foot of fall.

Green river, when gauged in May, 1875, was about 10 feet above its ordinary summer level. The volume was measured at the Brownsville ford, and amounted to 430,000 cubic feet per minute. This volume does not give an idea of the average flow, as the river was much beyond its ordinary stage.

For irrigation, the water of the streams and branches can be made of service. In many cases it can be led around the slopes by natural flow; or where there is enough water it can be pumped, by water power, to a desired height and led over the land. The water of heavy rains, causing the subsequent heavy wash, which, in the bottom lands of the creeks, are so destructive, could, with small expense, be so held back and spread upon the land, that it would leave upon it the rich soil in suspension, the benefits of which would be considerable. The difference between head-water and back-water rises is well understood on the river bottoms; the former washing the soil, and taking off fences, &c., the latter, on the contrary, depositing on the lands submerged the sediment in suspension, the value of which is shown in the succeeding crops. The construction of dams for the purposes of slack-water will tend to increase the chances for back-water rises.

ROADS.

The roads of this section have never been improved to any extent. The ridge roads are generally good, the sandstone making excellent road-beds. The roads in the bottom lands, upon the limestone or shales, are easily cut, and often heavy. The difficult parts of the roads are the slopes to and from the bottom lands to the table-land ridges. In some cases these slopes are well selected, but they do not receive work in sufficient amount. Portions of the roads are frequently changed, and generally to unsuitable ground. This is often done for the benefit of a single individual to the detriment of the public, the only advantage being the saving a single line of fencing. If this is not remedied, the country will be much injured. No portion of a road should be changed without an examination being made by competent authority from a plan and profile of the original and of the proposed road. Many of the worst features noticed were due to these changes to unsuitable ground.

ESTABLISHMENT OF A TEST-MERIDIAN AT BROWNSVILLE.

In connection with the survey of this section, the direction of a meridian was determined and marked by stone monuments. The magnetic declination was also ascertained. The monuments were placed (165) one hundred and sixty-five feet apart.*

These monuments were intended as a check upon the errors of the instruments used for land surveys; the distance between them to test the accuracy of the chain. The discrepancies in the length of chains are often as much a source of error as the inaccuracies of the compass. The monuments are accessible to the surveyors of the several adjacent counties. With little trouble the compasses and chains in use by the surveyor could be tested and the discrepancies recorded. This would not only check compass and chain in use for each survey, but in a few years a table of the variation of the declination, so necessary in the re-survey of old lines, could be made. Although these points may not be considered as very important at the present time, they will become indispensable as the lands of the State increase in value, and subdivisions become necessary.

*The length, 165 feet, is equivalent to 5 half-chains. The half-chain (33 feet) is used in this section of country.

The monuments were placed in the Brownsville court-yard, and covered for protection. A plan showing their position was placed upon record at the Brownsville court. The points on the monuments are marked by copper bolt and cross-lines.

This section of country, from its proximity to two important lines of railway, and with its natural advantages of water transportation, demands, and will in a short time find, a market for its produce and mineral wealth.

GEOLOGICAL SURVEY OF KENTUCKY.

N. S. SHALER, DIRECTOR.

REPORT OF A RECONNOISSANCE

ON THE PROPOSED LINE OF RAILWAY FROM

LIVINGSTON STATION TO CUMBERLAND GAP.

BY C. J. NORWOOD.

PART VI. VOL. II. SECOND SERIES.

PRELIMINARY NOTE.

The following report of Mr. C. J. Norwood is published in advance of the completion of the work of which it forms a part. It is the intention of the Survey to complete at least three sections from the Cambrian or Cincinnati axis, continued into the valley of East Tennessee or Virginia, in order to show the internal sections of the rocks of this part of the State and their connection with the lower-lying rocks of the region to the eastward. These sections will, taken together, not only give a basis for the better understanding of this district, but will aid in furnishing data for the study of the dynamic geology of the Appalachian Mountain system, as far as it is displayed in this region.

Mr. Norwood has been compelled to touch upon several of the important questions concerning the structure of the mountains in the neighborhood of Cumberland Gap. These matters are receiving the earnest attention of the Survey, but will require years for their mature consideration. Within a year I hope to extend the section given herewith so as to show the general resources of the country between Cumberland Gap and the railway connection of East Tennessee. This work will, however, be done without cost to the Geological Survey, by the aid of the Harvard Summer School of Geology, which holds its sessions in connection with the parties of the Survey.

A considerable amount of information, especially upon the questions of a theoretical nature, referred to in this report, will be found in the biennial report of the Director of the Survey for 1875, which is now in press, and should appear simultaneously with the volume of which this forms a part. A special report concerning the iron ores of Cumberland Gap will be found in the fourth volume of reports (second series). Other reports on the timber resources, the soils, &c., of this district, are in preparation.

This report alone is, however, sufficient to show that any transportation route along this line will command a great area of available mineral resources.

N. S. SHALER.

INTRODUCTORY LETTER.

Professor N. S. SHALER, *Director Kentucky Geological Survey:*

DEAR SIR: I herewith submit a report of a reconnoissance made along the path of the survey for a railway, extending from Livingston Station to Cumberland Gap, made, according to your instructions, in August, 1875.

Respectfully,

C. J. NORWOOD.

REPORT OF A RECONNOISSANCE ON THE PROPOSED LINE OF RAILWAY FROM LIVINGSTON STATION TO CUMBERLAND GAP.

I.

For the purpose of obtaining a somewhat better knowledge of the structure and of the general value of part of the region through which the "Knoxville Branch" of the Louisville and Nashville Railroad has been projected, some examinations were made along a line reaching from Cumberland Gap to Livingston, following near the path of the railroad survey. The distance traversed was about 70 miles, and the time occupied in the work was less by a few days than a fortnight; so that, upon the whole, the work should be regarded as only a "detailed reconnoissance;" and the accompanying section for this report is to be accepted only as a preliminary delineation of the relations of the beds in this district.*

The survey for the railroad, beginning at Livingston, crosses the Rockcastle river at a point about half a mile above Fishtrap ford, and thence, whenever possible,passing along valleys, takes its way to London, in Laurel county. From London it was carried to Flat Lick, Knox county. Two available routes were surveyed to Flat Lick. One of them passes within less than a mile of Barbourville, following the State road which leads from London to Barbourville as closely as the topography will allow, and thence up the right bank of the Cumberland river to Flat Lick. The second route follows the State road leading from London to Barbourville to within six miles of the latter town, then, turning to the southeast, it follows up

*It is to be remarked, that a large number of the heights were determined by *uncorrected* barometrical (Aneroid) measurements, and the results are, therefore, subject to future revisions.

—one of the tributaries of Collins' Fork of Goose Creek, to Payne's Cross Roads, whence it follows along the "old State road" to Flat Lick; thence it follows up the Cumberland river, passing through Pine Mountain at the Pineville Gap, to the mouth of Patterson's Branch, about three and a half miles above Pineville, whence the course is turned towards the south, and the survey carried up Patterson's Branch and up Cannon Creek, past Rocky Face, between that mountain and the first Log Mountain, to the valley of Yellow Creek; up which it is carried to Cumberland Gap. It seems unnecessary to discuss the relative merits of the two routes that have been suggested from London to Flat Lick, as the question is one which may be best left to the consideration of the engineers who made the survey. Whether or not the route approaching nearest to Barbourville is to be commended before the other, because of the facilities which will be afforded to the town instead of the country further east, is a matter best left to the judgment of those better informed as to the probable amount and value of the domestic exports of the two regions.

The geological examinations were more particularly made along a line passing through Barbourville; but it is proper to state, that, measured by economic resources, there is little if any difference, between the region along the Barbourville route and the region along the route which carries by the way of Payne's Cross Roads.

II.

The general structure of the region examined is made up of beds belonging to the coal measures. Some of the lower rocks have been brought up by faults.

At Cumberland Gap lower beds are brought to the light on the east side of the Cumberland Mountain by the great uplift that caused the mountain; and at Pineville, beds as low down as the Devonian black shale are brought up in the Pine Mountain fault. The region included between Pine Mountain and

Cumberland Mountain is suggestive of a number of problems that yet await a satisfactory solution.

It has been suggested that the country between the two mountains is virtually a great synclinal valley, with masses of nearly horizontal rocks piled over its greater part;* the two mountains, the Cumberland, with its beds dipping towards the northwest, and the Pine, with its beds inclining towards the southeast, forming two sides of the valley; and that the two uplifts are of nearly the same age.

Another interesting and important matter concerning the region between the Cumberland and Pine mountains, is the apparent change in the physical structure and order of the beds of the coal measures and the number of coal horizons, when it is compared with the region on the north side of the Cumberland river. It seems that the coal horizons decrease in number towards the northwest.

The thickness of the coal measures in mass seems also to be diminished towards the northwest, suggesting that towards the south or southeast the surface was gradually depressed, and that upon this inclined surface the deposits were laid down in approximately horizontal layers.

In other words, there seems to have been a deepening of the floor of deposit towards Cumberland Gap, when the beds were laid down.

Each bed added to the mass in the valley, so to call it, would certainly have entered into the total thickness of the strata, but when extended towards the rising ground, it would have not only lost in thickness as it advanced towards the summit, but gradually encroached on the old surface, and, passing beyond the limits of the immediately preceding deposition, formed of itself the sole covering of the original surface. And thus the thickness of the coal measures would have become less and less as the summit of the rising ground was neared. In fact, there seem to be many things in common, in their position and extent, between the carboniferous

*See the biennial report of N. S. Shaler for 1876, now in press.

beds in this district and deposits that are laid down on the sloping shore of a sea. See the figure in the following plate.

The fact of the increase in the thickness of the carboniferous deposits towards the southeast, and the probability of this being due to the conditions just described, have considerable bearing on the questions concerning the age of the Cincinnati axis, and the relations existing between the eastern and western coal fields of this State. Should the suggestions offered by the condition of the deposits in the region covered by this report be confirmed, there is little room to doubt that the two coal fields are, for the most part, entirely distinct.* The results obtained by examinations made in the vicinity of Manchester, Clay county, and along the road leading from that town to Fish-trap ford, Laurel county, very clearly show an increase in the thickness of the measures towards the southeast. An approximative estimate for the increase towards Manchester, in a distance of 33 miles, gives 700 feet or more as the amount of thickening in that direction alone, there being in that region a thickness of about 1,100 feet or more of beds between the horizon of the visible top of the Wild Cat Mountain conglomerate and the sub-carboniferous series, against 350 feet between the same limits on Wild Cat Mountain.

The accompanying plate of grouped sections exhibits the thickening of the beds towards Cumberland Gap with tolerable clearness.

III.

In consequence of the lateral changes undergone by the deposits, the region examined has been divided into three distinct areas, and a special grouping of the beds made for each area.

The first division includes, with the exception of the Yellow Creek valley, the area included between the Cumberland and

*This should be taken as the individual opinion of the writer. I shall hereafter endeavor to show that the eastern and western coal fields were connected during a part of their history. N. S. S.

Pine mountains, and may, for convenience, be designated as the Log Mountain area. All the knowledge now had concerning the structure of the Yellow Creek valley is largely conjectural, as, so far as I am aware, very few absolute facts concerning the beds underlying its surface were obtained.

My personal study of the valley was so limited that no suggestions of value were obtained concerning its structure; any discussion of the questions concerning it is, therefore, deferred or left to the consideration of those whose explorations may be more thorough.

There is, therefore, a gap of three miles or thereabouts left in the work—it being that space reaching from Log Mountain to Cumberland Gap.

As the structure of Cumberland Mountain was studied in more detail by other officers of the Survey, and under more favorable conditions than were possible for me, only a few general notes are given. The mountain is essentially the remnant of a great fold, which, extending in a northwestwardly course, thrust up the rocks from the southeast. By denudation, the larger part of the eastern slope of the uplifted mass has been removed, leaving the east side of the mountain to front Powell's valley, as a nearly bare face of the basseting edges (in the direction of the strike line) of beds that are tilted towards the northwest, and which make the northwest slope of the mountain.*

On the west side we have deposits of the coal measures only, but on the east the section shows beds from the coal measures to the Silurian, inclusive, as enumerated in the following statement, which represents the order in the beds descending from the pinnacle to Powell's valley:

1.	Conglomerate and associated sandstones and shales of the coal measures.	
2.	Shale, olive green in color, and sandy	75 feet.
3.	Limestone of the Chester Group, in massive beds. In its upper part it is grey and coarse-grained, changing, however, to a drab, close-grained, rather knotty limestone at the middle and towards the base, having, also, much hornstone scattered through it. The upper beds yield the larger part of the organic remains	30 "

*For a fuller discussion of the structure of this mountain, see the biennial report of N. S. Shaler for 1876.

4. Limestone, in dark colored and argillaceous, rather fragile beds. Upon weathering, the rock breaks apart and becomes granular. This bed is the principal deposit of the typical Chester fossils. *Athyris Royissii*, *Spirifer Leidyi*, *Productus elegans*, several *Pentremites*, *Retepora lyra*, and *Archimedes* are found. The lower part of this division forms a distinct bench, having a gently sloping surface, such as is usually characteristic of shale and limestone. This bench marks the junction of the Chester rocks with the St. Louis limestone . . . . 30 feet.
5. Massive limestone of the St. Louis Group. The lower part of the limestone is grey and oölitic. This is soon succeeded by a greyish to light drab, faintly oölitic to rather dense limestone. At the base of the mass, as it nears the Waverly, the rock becomes silicious; a feature which is also apparent in some of its upper members. Some parts of the limestone are formed of hard calcareous nodules,bound together with a softer calcareous material, and as the weathering of the rock tends to dissolve out the softer material, the face of the limestone often has a pitted appearance. The collection of organic remains from this limestone is very meagre; in it are included *Productus mesialis*, *Prod. cora*, *Spirifer Keokuk*, *Spr. pseudolineatus*, and *Retzia Verneuiliana*. Thickness about . . . . . 400 "
6. Waverly Group, consisting of silicious shale, having hard bands and some beds of nodular chert, about . . . . 155 "
7. Devonian shale, about. . . . . 100 "
8. Silurian, sometimes forming foot hills, sometimes on the main slope.

The bench, caused by the partial disintegration of the lower part of No. 4, forms of itself a well-marked line of junction of the Chester with the St. Louis Group. The more trustworthy means, however, of identifying the top of the St. Louis Group is by the fossil contents of its upper bed. At from one to three feet below the top of the group *Productus mesialis* and *Spirifer Keokuk(?)* are found to be rather abundant, especially the *Productus*, and to extend in a horizontal line with considerable regularity. The highest horizon to which these fossils extend may be considered as about the upward limit of the St. Louis Group.

There is a marked difference in the character of the subcarboniferous rocks in this region and those further west. In the western part of the State, the Chester Group is composed of a series of beds of limestone, shale, and sandstone, while in this region sandstone is entirely absent. The absence of the sandstone is especially noticeable, to one acquainted with the group, in its westward extension. In Western Kentucky there are from two to four beds of it, one of them being of special importance as marking the base of the Chester Group.

It varies from 60 to 250 feet in thickness, and has been designated in volume 1 of the reports of the present Survey (new series) as the Big Clifty sandstone.

Although there are marked variations in their texture, the change in the general physical character of the St. Louis beds is not so great as in the case of the Chester Group. The St. Louis beds further west are easily divisible into two great members, viz: the upper or grey limestone division, in the upper part of which is a bed of sandstone and some shale, and the blue or geodiferous limestone division. Here, however, such vertical divisions are not noticeable. The absence of the mud beds and sandstones in the Chester series here, shows the beds to have been rather deep-water accumulations. Further west, however, there are many evidences, not only of shallow-water depositions, but of frequent local currents in various places, which have rearranged the material already laid down.

Of course the few observations at hand do not justify an attempt at an elaborate comparison of the sub-carboniferous group, as it may occur over any considerable area in this part of the State, with its western equivalents; but the greatest apparent difference is probably in the points already given.

As the study of the structure of Cumberland Mountain, and the various other matters of interest pertaining to it, was made the work of other officers of the Survey, further discussion concerning it is omitted.

A preliminary grouping of the beds is all that can be given at present for the ground between Cumberland Mountain and Pine Mountain that is covered by this report.

Observations made by others in the country lying somewhat to the south and southwest of the line of this section tend to show that quite a considerable thickness of beds, including, perhaps, a dozen more coals, is to be added to the summit of the section to make it complete. In Canada Mountain alone there are about 15 beds of coal; the thickness of the section exceeds the one obtained along the immediate line of the railroad survey by some 1,100 feet. Canada Mountain is one of the high peaks of the Log Mountains, the summit rising to about 3,075 feet above the sea.

The highest peak, Brysen, reaches to a height of 3,225 feet above the sea level, and holds about the same number of coal beds that are found in Canada Mountain—about seven more than are found along the immediate path of the railroad survey.* The nearest point in Canada and Brysen mountains at which the coals found in them may be reached from the railroad is, in Canada Mountain, about two and a half miles, and in Brysen Mountain, about eight miles from the road. There may, however, be points nearer than these at which coal may be obtained.

Without purposely trespassing on the ground of others further than the exigencies require, it is deemed advisable to present the following analyses, made by Dr. Peter and J. H. Talbutt, of samples of coal collected by other officers of the Survey from some of the beds in Bell county, lying within striking distance of the railroad line. This is especially desirable, as circumstances did not favor the collection of samples from the coals lying along the immediate path of the proposed railroad.

More elaborate descriptions of the coal beds from which the samples were taken will appear in the proper report.

*Two or three coal horizons that were discarded in the general section, because of their limited extent, are not taken into consideration.

COMPOSITION.	Col. J. G. Eve's. Fork Ridge, near Stony Creek. A. R. C.	Hignite Branch, upper bed. A. R. C.	Hignite Branch, middle bed. A. R. C.	Hignite Branch, lower bed. A. R. C.	Little Clear Creek, fifteen feet above bed of creek. A. R. C.	Little Clear Creek, in the bed of the creek. A. R. C.	Fork Ridge, near Stony Creek, four feet above cannel bed. A. R. C.	Barnett's Ridge, average sample. J. H. T.	Barnett's Ridge, from the portion sent to market. J. H. T.
Number	1.	2.	3.	4.	5.*	6.	7.	8.†	9.
Moisture	1.00	1.80	2.04	2.96	1.02	1.76	1.26	1.36	1.50
Volatile combustible matter	43.60	35.50	36.64	35.28	37.76	38.90	33.96	35.80	37.94
Fixed carbon	47.80	52.20	58.02	59.40	48.22	52.54	55.42	59.54	58.40
Ash	7.60	10.50	3.30	2.36	13.00	6.80	9.36	3.30	2.16
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100 00
Sulphur	.590	.956	.736	.420	1.670	2.027	2.772	.975	1.038
Specific gravity	1.262	1.346	1.290	1.277	1.360	1.325	1.344	1.282	....

* In shales first above the conglomerate?
† On a branch of Clear Creek, where it empties into Big Yellow Creek, six miles north of Cumberland Gap. The bed is 40 inches thick.
All samples marked A. R. C. were collected by Assistant A. R. Crandall. All samples marked J. H. T. were collected by Assistant John H. Talbutt.

The Cannel coal of Col. Eve's property* is somewhat remarkable in having the amount of volatile combustible matter and the amount of fixed carbon in nearly equal proportions.

Viewing the coal in its general character, it is found to be an admirable heating fuel. The amount of ash is small, the amount of water to be expelled is inconsiderable, and the proportion of sulphur is quite small. The amount of volatile combustible matters, however, is less than that contained in the best of gas cannels, although the amount in this case exceeds that contained in the average qualities of bituminous coals by from two to seven per cent., and would make the coal of value as a gas enricher.

The bituminous coals are, most of them, so far as the analyses prove, very good. In two or three of them the amount of ash is quite high, especially in that from Little Clear Creek,† which contains thirteen per cent. of earthy materials; but in the most cases the amount of ash is quite small.

*See analysis No. 1.
†See analysis No. 5.

The small proportion of sulphur in some of the coals is especially worthy of notice. It is to be remarked also, that nearly all of them exceed the *average* of Kentucky coals in the amount of fixed carbon they contain. About the best, in all respects, of the bituminous coals is the "lower bed" on Hignite Branch. The amount of fixed carbon (59.40 per cent.), and the small per centages of ash and sulphur (ash 2.36 per cent.; sulphur .420 per cent.), make it a very desirable coal, should it be found convenient to work it.

Indeed, an impartial comparison of the analyses of these coals with analyses made of those from Pittsburgh gives very favorable results for the Kentucky coals. So far as the analysis proves, the best of Pittsburgh coal is little, if any, superior to the Hignite Branch middle and lower bed, and the Barnett coal.

Following are analyses of samples of Pittsburgh coal:

	No. 1.	No. 2.
Moisture	2.00	1.397
Volatile combustible matter	29.70	30.133
Fixed carbon	65.30	65.050
Ash	3.00	3.260
Total	100.00	100.000
Sulphur	0.055	.1598
Specific gravity	1.291	1.2747
Analyst	R. Peter.	W. R. Johnson.

No. 1 is a selected specimen—a hand specimen. See page 363, volume 1, Kentucky Geological Reports, old series.

No. 2 cannot be considered an average analysis either; the probability is that the sample was better than the average.

IV.

The following statement exhibits the preliminary grouping of the beds in the "Log Mountain area."

It may, for the sake of convenience, be called general section No. 1:

1. Sandstone	55 feet.	
2. Sandy shale, mostly	60 "	
3. Covered, occasional outcrops of sandstone	50 "	
4. Sandstone	10 "	
5. Concealed, mostly sandstone?	90 "	
6. Sandstone	20 "	
7. Concealed, mostly sandstone?	40 "	
8. Shale, bluish-drab, and ochreous towards the base	45 "	
9. Coal VIII, may be called the Buckeye Lick Coal. It varies from three and a half to four feet in thickness, and occasionally has a parting of one inch or more at about twenty-five inches from the bottom	4 "	
10. Clay and shale	20 "	
11. Sandstone. The upper and lower parts are usually in thin beds, but the middle is massive	75 "	
12. Covered, possibly with a coal bed concealed	28 "	
13. Sandstone	96 "	
14. Coal VII*b*		6 inches
15. Shale	15 "	
16. Coal VII*a*		8 "
17. Sandstone, merging into shale below	40 "	
18. Cannel and bituminous coal overlaid by semi-cannel slate, some of which contains *Lingulæ*. Coal VI	1 "	10 "
19. Sandstone and shale	35 "	
20. Coal V. This varies in thickness from one foot to nine inches	1 "	
21. Sandstone and shale; the lower part is frequently all shale	70 "	
22. Coal IV	1 "	1 "
23. Shaly sandstone carrying four horizons of coal, all lying near together and classified as Coal IV*a*	65 "	
24. Coal III; varies in thickness from twelve to sixteen inches	1 "	4 "
25. Sandstone	20 "	
26. Coal II*b*		8 "
27. Shale	10 "	
28. Coal II*a*	1 "	
29. Shale; varies in thickness from twenty to thirty feet	30 "	
30. Coal I; varies in thickness from two to four feet	4 "	
31. Shale, dark blue and ochreous	50 "	
32. Conglomerate. Base of section.		

As remarked hitherto, this section is to be regarded only as a preliminary grouping of the beds, and is put forward with some diffidence. The limited study of the district, for which it has been arranged, left some of the problems, including the question concerning the relative persistency of some of the beds and their lateral changes in thickness, in a not very satisfactory condition. In making up the section certain coal horizons were necessarily discarded in favor of others, although it was not entirely clear which had the greater range.

In such cases the thickest beds were always retained. It was also found necessary to shorten up the distance between one set of beds or to lengthen it out between others to make the average. Hence the general section represents only as nearly an average of the number of beds and their distances apart as it was possible to arrive at with the comparatively few observations taken. To do this it was necessary to reduce the number of coal horizons to which numbers may possibly be applied. There are, without doubt, as many as twelve, perhaps fifteen, coal horizons to be found in the space included in the general section; but of these there are probably not more than eight or ten to which distinctive numbers may be rightfully given, and the question can only be decided by a detailed study of the region, and not by a reconnoissance. What thickness a coal should have to be considered "workable" depends, of course, altogether upon the surrounding circumstances. In some regions a thickness of 18 inches is regarded as not too small, while in other coal districts 3½ feet is considered as the least thickness in which mining may be profitably carried on. The matter is governed by the general thickness of the coal beds in the region, their nearness or remoteness to transportation facilities, and their quality.

In this region, taking into consideration the quality of the coal, a thickness of 30 inches may be considered as workable when the bed is near to transportation facilities. Under this arrangement there are about three beds that may be considered as workable. These are Coals I, VI, and VIII. Coal No. VI is, so far as known, only 22 inches thick, but its mixed character (being part bituminous coal and part cannel coal) makes it as valuable as a coal 30 inches thick, and it may with propriety be classified as a workable bed. There may be other beds than these that will prove workable upon further search. With two exceptions, all of the coals were seen only as outcrops, and very frequently they were represented merely by stains or by a soft smutty material, so that there is no reason to suppose that any of them will prove thicker when found under better conditions. The total thickness of the eight coals, so far as the section shows, is from 15 feet 3 inches to 16 feet 1 inch, of which two coals (Nos. I and VIII) form nearly one half. This is a small aggregate thickness for such a number of beds and 900 feet of other materials, although it exceeds that of the coal deposits in some regions by several feet. In 1,317 feet of upper coal measures, in Missouri, there are eight beds of coal aggregating in thickness to only 4 feet.

In the bank, Coal VIII appears to be of first-rate quality. The cannel of Coal VI also bears a good appearance. The cannel is probably equivalent to the cannel bed on Col. J. G. Eve's land, an analysis of which will be found on a preceding page.

As stated in the first part of this report, the path of the work between Pine and Cumberland Mountains lies in part along one flank of the Log Mountains and in part, as it enters the valley of Yellow Creek, along two detached mountains, known as Rocky Face and Dark Ridge. For the sake of convenience, the structure of each mountain, or that part of it which serves our purpose, will be considered separately.

DARK RIDGE.

This seems to be really an irregularly shaped spur or ridge striking out from Cumberland Mountain. Its form is peculiar, the figure being swelled in the middle and the main body connected with Cumberland Mountain by a narrow neck, from which flow down branches of Clear Creek on the north, and of Little Yellow Creek on the south. The ridge seems to have formerly been a connecting link between the Cumberland and Log Mountains; remaining so until it was cut away from Log Mountain by Yellow Creek. Unless it be that the neck which connects it with Cumberland Mountain is an exception, the beds in this ridge are virtually horizontal. It is very probable that in the neck mentioned the beds do have the same inclination, or nearly the same inclination, as the Cumberland Mountain mass, although this is not at all a settled question. It has been suggested that the Cumberland

Mountain is simply a great fold,* and that the beds forming its mass pass under the horizontal strata lying to the northwest without interruption. In such a case we may expect the bedding of the nearest rocks of Dark Ridge to conform with the slope of the Cumberland beds. But for this to be true—that is, for the Cumberland beds to pass without break beneath those of Dark Ridge—necessitates a rather sharper upward bending of them than we see, as horizontal rocks are found as near as three miles of Cumberland Gap, and a considerable less distance from the base of the mountain. Another suggestion has accordingly been made, to the effect that, somewhere in the ground lying between the base of the mountain and the first locality of horizontal rocks, there was a break in the beds when Cumberland Mountain was uplifted, and that the western edge of the disturbed mass was raised some uncertain distance above the undisturbed rocks further west. At present it is difficult to determine which of the two suggestions is true; at the most, they are scarcely more than mere conjectures, being valuable only as *possible* solutions of the problem, and only available, therefore, as suggestions to be proved or disproved.

The first observation of immediate interest on Dark Ridge was on Mr. John Colson's land, three miles west from Cumberland Gap, on the southern slope of Brush Ridge, a spur of Dark Ridge.

A coal stain 12 inches thick was noticed. Near by the outcrop a drift has been opened in the coal bed; but as the mine had been idle for some time the roof had given way and filled up the entry, so that the thickness of the coal seam could not be determined.

Just what bed the coal is, in the general order of numbers used in the General Section, is not clear, but it seems to be, without doubt, one of the lower beds. It is not improbable that it is No. II^a or II^b. A coal estimated to be three feet thick is reported to lie high up in the ridge, on Mr. Colson's

*See the biennial report of N. S. Shaler for 1876, volume III, second series, Kentucky Geological Survey.

land, about one mile and a half from this point. The coal is presumed to be No. VIII, as that coal is known to occupy a place in the surrounding high land, and is the only one of such considerable thickness to be found among the upper strata in this locality.

Figure A in the following plate shows a longitudinal section of the rocks in Dark Ridge and the shape of the surface contour of the ridge line from the north end of the ridge, where Yellow Creek sweeps round to the east (passing between Dark Ridge and Rocky Face), to a point about one quarter of a mile south of the pinnacle.

The point indicated as the pinnacle is the highest point on the ridge, and is 900 feet above the level of Yellow Creek at Esquire Boffman's house, which lies at the foot of the ridge, about half a mile south from the pinnacle. The figure is drawn from a stepped survey, and, taking into consideration the smallness of the scale, serves as a fairly good representation of the influence that the structure of a mountain, under certain conditions, has upon its surface features.

The section of the beds in the ridge, in descending order from the pinnacle to Esquire Boffman's, is as follows:

1. Partially covered. Sandstone is seen at the top and outcropping at various levels	55	feet.
2. Shale	60	"
3. Partially covered. Sandstone is exposed at various levels	50	"
4. Sandstone	10	"
5. Mostly sandstone	150	"
6. Shale	45	"
7. Coal VIII	4	"
8. Sandstone	90	"
9. Concealed: shale?	35	"
10. Sandstone	40	"
11. Shale	10	"
12. Concealed	45	"
13. Shale	30	"
14. Sandstone	25	"
15. Concealed: shale?	20	"
16. Mostly shale and soft, thinly-bedded sandstone	220	"
Total	879	"

This takes to the water line in Yellow Creek. The sandstone No. 8 is the most prominent stratum in the structure of the ridge. Being, as a whole, harder and more homogeneous in structure than the other beds, it has resisted weather waste more successfully, and now stands out as a distinct band among the rocky layers. For this reason it forms a fairly trustworthy guide in tracing the extension of the coal (No. 7) along the ridge. The coal is indicated by a flat, miry bench upon the top of the sandstone, which is caused by the coal having wasted away upon exposure, while its under-clay, being tough and to a certain extent water-proof, has simply softened somewhat and spread out over the flat surface of the sandstone.

BUCKEYE LICK.

There is only one locality on the western slope of Dark Ridge where, so far as known to the officers of the Survey, Coal VIII has been opened for working.* This is at Buckeye Lick, in the neighborhood of Esquire Boffman's house. The ownership of the land upon which the opening was made was, at the time the examinations were made, the subject of litigation; the names of the parties were not satisfactorily obtained. With so little inducement offered by the surrounding country, very little mining has been done at the place. In fact, using the word in its usually accepted sense, no mining has been done. All the coal used was for domestic purposes, and was wagoned away in small quantities. When the locality was examined the seam was covered by debris, so that no measurements of its thickness could be made at the time of inspection; but, from a trustworthy source, it was learned that the bed, when last measured, showed a thickness of four feet, including a clay parting. The clay band is one inch thick and parts the coal into two members, the lower member being 25 inches thick. As will be noticed hereafter, this is a larger thickness by several inches than the coal shows at another locality lying to the southwest. A somewhat careful examination of the approaches to this coal deposit satisfies me that it may be easily reached from the railroad; and the expense for

* Reference is here had to that part of the ridge which extends from about half a mile south from Esquire Boffman's to the north end, where Yellow Creek cuts through to the east.

mining and preparing ways of carriage to the road will not be so great as at first seems probable.

By following up the little valley of a small stream flowing down from the ridge past Esquire Boffman's house, cars may be carried pretty well up towards the coal, and then, by the usual apparatus used for lowering coal down an inclined plane, the coal may be sent down to the car from the mine at a comparatively small cost. An investment of five or six thousand dollars should give the mine a very fair start.

Dark Ridge is supposed to contain a coal bed at a level below that at Buckeye Lick; its presence, however, was not proved.

ROCKY FACE.

This mountain presents for discussion a number of interesting questions, some of which it seems best to leave for the future.

In form the mountain is a rather irregularly figured line of elevation, extending for about two miles in a northwardly direction. Towards the south end a short blunt spur reaches out to the southeast for a short distance. For about two thirds of its length the course of the ridge line is nearly straight, but towards the south end it makes a curve, first to the east and then to the west, so that the south end is in line with the north end. The course of the main line of the crest is represented by figure 1 in the following plate.

The southern end of the mountain is made by Yellow Creek, which flows round from Dark Ridge and cuts off further southern prolongation of the mountain, and then turns to the north and flows down on the east side of the mountain, between it and the Cumberland range, to the Cumberland river.

Along the west face of the mountain Cannon Creek flows down to the north for about one mile and a half, then, rounding rather sharply to the east, passes in front of the north end and empties into Yellow Creek as it flows past the east face of the mountain.

It will be seen that the mountain is almost completely surrounded by water—that it rises up from the small valleys like a high island.

This curious feature in the flow of the streams—making first to the east for a certain distance and then turning to the north, as they do—is accounted for when the structure of the mountain is examined.

The general course of the mountain is north 60° east. The precise position that it holds relatively to Dark Ridge has not been determined; but if it were prolonged in the direction of that ridge it seems that it would pass to the east of the larger part of it, there being a possibility that it was connected with it towards Cumberland Mountain. It is not at all certain, however, that such was the case. As very little is known concerning the geographical features of the ground lying in that direction, any conjectures—for they are merely conjectures—concerning that question are of little value.

Rocky Face, like Pine Mountain, is a fault mountain, but it is an imitation of that mountain on a comparatively small scale. The amount of throw amounts, perhaps, to not much more than nine hundred or a thousand feet. The main mass of the mountain, so far as known, is a conglomerated sandstone, corresponding to the "Upper(?) Conglomerate" of Cumberland Mountain, which has been thrust up from the west and the beds tilted at various angles of dip towards the east, with shale beds towards the base. The average dip of the mass is about 27°, course north 70° east, the strike bearing south 20° west.

As intimated, the dip is not of the same amount at all places on the mountain, nor is the direction of the strike, although that is more uniform than the amount of dip.

About midway the length of the mountain the beds are found inclining at angles varying from 40° to 45°, and then towards the north and south at angles ranging from 15° and 20° to 32°, the course of the dip varying from south 60° east to nearly due east.

These variations in the amount of dip has, of course, modified the form of the crest line wherever a change occurs. Thus a dip of 45° produces a very sharp and narrow crest, almost impassable, with the sides of the mountain too steep to be ascended. This is well illustrated at one place where the crest is scarcely more than 18 inches wide for quite a distance, and the sides of the mountain merely steep uncovered masses of sandstone. An angle of 32° also gives a sharp ridge and steep sides to the mountain, while an angle of 15° gives an entirely different form to its outline.

Figure 2 of the following plate shows the form of the summit of the mountain at a place where the dip amounts to 15°. This figure having been drawn from careful notes made for this especial purpose, may be considered as a fair sample of the form of mountain crests, like in composition to Rocky Face and formed under like conditions.

Figures 3 and 4 show the shape of the mountain in mass at two other localities; one where the dip is as much as 45°, and the other where the beds have the average dip of 27°.

The changes in the amount of the dip of the beds and in its direction are curious, and at first seem inexplicable; but as the mountain is studied as a whole the cause becomes plainer.

In descending the northern slope of the mountain the beds are found to flatten out, and finally to pass under the horizontal rocks of the hills lying immediately to the north, and without any plain evidence of a dislocation. Then, passing towards the southern end, we find the rocks approaching horizontality in that direction, towards Yellow Creek, although they are still tilted at a steep angle—about 10°.

From this we plainly see that the mountain is due to a sharp thrust which fractured the beds for only a comparatively short distance north and south, at the same time raising them some nine hundred or a thousand feet above their original level for the length of the crack. When the ends of the crack are reached, the beds are, of course, found to lie at their true level and to retain their general horizontality. It accordingly follows, as a natural sequence, that the steepest angle of inclination of the beds is to be found about midway the length of the fracture, while towards the ends it decreases at various rates.*

The descent of the conglomerate at the north end of the mountain, to pass beneath the horizontal beds in the opposite hills, and the gradual flattening out of the mass, are distinct features in the structure of the mountain. A fracture extends across the mountain in the direction of the dip at the point where the commencement of the northward descent of the sandstone is most perceptible. At one time it was thought likely that this crack indicated that the fall of the mass towards the north was of a later date than the general uplift, but later observations tend to show that it occurred at the time of the uplifting, and acted as a relief to the strain on the beds.

Whether or not the beds are entirely unbroken in their extent across the valley, as would seem to be the case, is not quite clear, as, although there is not yet sufficient evidence gathered to lead us to believe in the existence of a fracture in the Cannon Creek valley, it is unsafe to assume that there was not a crack, accompanied by a slight uplifting of the mass, on the southern side.

Figure 3 in the following plate is a rude representation of part of the western face of the north end of the mountain, showing the fracture in the conglomerate and the descent of the rock towards Cannon Creek.

The presumption is that the beds flatten out from the south end also; but this is yet an unsettled question: all we know is, that, as the southern termination of the mountain is approached, there is a considerable lessening in the amount of the dip of the beds.

The causes tending to bring Yellow and Cannon Creeks to the east, at the points where they make the turn, and then to again change their course and direct them towards the north, are interesting.

*These facts are in accordance with the general results obtained by the several officers of the Survey who preceded me in their examinations of the ground.

To a large degree they have been influenced by the position of the beds as well as by the character of the material through which they flow. Yellow Creek, when flowing by Dark Ridge, is resisted by horizontal rocks on all sides, and accordingly cuts its way towards the north (having already an impetus in that direction) rather than towards any other point. Passing on to Rocky Face, however, it found horizontal rocks only on the north and west, those on the east being tilted towards the east. This arrangement of the beds changed the ratio of resistance, making it less on the east; in which direction the stream accordingly cut its way—the position of the beds being such as to greatly favor the work.

The Yellow Creek valley on the east side of the mountain is to a certain extent a synclinal one, coursing northwardly; accordingly, when the stream had eaten through the mountain, and entered what is now the valley, it received another check in its course, and was turned towards the north.

The same influences, with perhaps some small differences of detail, were brought to bear in directing the course of Cannon Creek. We find here, therefore, a fine illustration of the bearing that the composition and position of the hard materials underlying a district have in directing the course of its waterways.

THE LOG MOUNTAINS.

The Log Mountains, or rather those parts that come within range of the path of the reconnoissance, owe the larger part of their interesting features to their economic value. They are, it is true, monuments to the sculpturing power of water, and offer in their various parts instructive lessons in the study of the action of running water on variously composed materials; but beyond that there is, with one exception, but few points of interest attached to their merely stratigraphical conditions.

In their stores of economic materials they are of immense value, and have in that respect far more interest attached to them than any part of the region hitherto discussed.

Unlike the mountains hitherto discussed, these mountains had their origin in the eroding effect of water, and not in any great movement of the rocky masses. In general the beds which enter into their structure—notably sandstones and shales—are comparatively horizontal.

A list of the beds making up that part of the mountain examined has already been given, and is designated as "General Section A."

The total number of coal beds indicated in it are eight; but this does not include all that are to be found beneath the surface.

At some points there are a number of what may be called local beds crowded together that were not included. As stated on a previous page, however, the precise character of these beds has not been determined, hence they are only provisionally excluded.

Of the eight beds enumerated, about three are certainly workable, while others have not been sufficiently exploited to prove their character.

The thickest bed is also the highest one, and the one ranking next to it in thickness is the lowest. This arrangement, upon the whole, is a very convenient one, as it gives greater scope to mining possibilities than when the workable beds are all close together.

Coal VIII has been opened on Saw-mill Ridge, near the first summit, at the head of Jack's Branch, which is one of the many small mountain streams making down to Yellow Creek. The land on which the coal has been opened is the subject of litigation—the respective claimants being Messrs. Boffman and Tinsley.

The coal where tested is 2 feet 8 inches thick; but there seemed to be some reason to presume that, as the bed is followed under a more solid surface, its thickness may increase to at least three feet.

The following statement is a section of the beds in the ridge in descending order from near the level of Coal VIII to Mr. Arthur McTee's house:

1. Slope covered with fragments of sandstone.			
2. Sandy shale	10	feet.	
3. Coal VIII	3	"	8 inches.
4. Concealed	20	"	
5. Sandstone; thinly laminated	55	"	
6. Concealed; a coal horizon reported at the top	173	"	
7. Sandstone	10	"	
8. Shale; ochreous	20	"	
9. Shale; very dark blue	10	"	
10. Black slate containing *Lingulæ*			6 "
11. Coal (VI?)	1	"	10 "
12. Concealed	85	"	
13. Sandstone	30	"	
14. Shale; sandy	25	"	
15. Coal, reported (IV)	1	"	1 "
16. Concealed; shaly sandstone?	10	"	
17. Shaly and bedded sandstone and shale	65	"	
18. Concealed	3	"	
19. Shaly sandstone	10	"	
20. Shale in hard bands; ochreous and blue	7	"	
21. Coal III	1	"	
22. Sandy shale; yellow and dark blue	20	"	
23. Coal II			7 "
24. Shale and sandstone	10	"	
Total thickness of beds	570	"	8 "

The coal No. 11 is regarded as No. VI, which, in other localities, is in part a cannel of apparently good quality. It is only 22 inches thick, but the surrounding circumstances are such that it may prove of practical value.

Coal I is probably below drainage in this locality, lying about on a level with the bed of Yellow Creek.

By a properly devised system of inclined planes, the coal towards the summit of the ridge may be worked with comparative ease; and the lower bed, Coal I, reached by shallow shafting.

As previously stated, the beds in this part of the range are nearly all horizontal. But south from Mr. McTee's, at a point where the State road begins to enter the Yellow Creek Valley, a low hill, serving as a sort of foot hill for the mountain, has been formed of beds that are nearly vertical. The place is represented on the profile section as being about 3½ miles from Cumberland Gap. Figure A on the profile is drawn on a natural scale of 200 feet to the inch, and serves as a tolerably fair representation of the position of the beds.

It should be stated, however, that the measurements were not made with as much accuracy as was really desirable, but were mostly estimated. The following is accordingly an approximate statement of their arrangement, beginning on that side of the hill looking towards Cumberland Gap:

A. Thin-bedded sandstone	36	feet.	
B. Sandstone and shale	180	"	
C. Semi-cannel coal, about	1	"	7 inches.
D. Sandy shale	108	"	
E. Coal	?	"	
F. Sandstone shale.			
G. Coal	?4	"	

The thickness of the several coal beds is especially uncertain, as they are naturally in a crushed and powdery condition at their outcrops. They are nearly vertical, and seem, most of them, to be distinct from those seen in the mountain. The causes tending to arrange the beds thus, and the question concerning their original place, are problems not yet satisfactorily solved. From the condition of the rocks exposed in the face of the mountain as the ones in question are approached, however, we are helped to a suggestion, that, as a probability, seems to have some merit.

As may be seen in the graphic section, the strata begin to rise towards the south, at about one mile and a half beyond Mr. McTee's house, and continue to ascend thus for nearly half a mile; then, in less than an eighth of a mile, the dip is reversed, and the beds slant towards the south, thus forming a small anticlinal at about half a mile beyond Esquire Boffman's house.

The point at which the beds are nearly vertical is not quite half a mile beyond where the crest of the anticlinal is presumed to be.

Now, by extending the lines of all the beds towards the south, we find what appears to be some relation between those in the foot hill, so to call it, and those in the main mountain; we find it suggested that the most northwardly coal in the foot hill, the four-feet bed, is the Buckeye Lick seam (Coal VIII), and that the others are higher than any of the coals enumerated in the General Section. It would then follow that the foot hill is a downthrow from the northwest, and that these displaced beds originally held a position at least 400 feet above their present position. At the best, however, the whole matter resolves itself into a conjecture. Although there are reasons for regarding the suggestions given as the most probable solution of the question—among which may be mentioned the failure to find the same order in the strata towards the north, it is possible that the beds may belong towards the base of the section, the thickest coal being Coal I, and that their position may bear some relation to the Rocky Face fault—the beds having been pushed up in this position at the same time that that mountain was formed.

Near Mr. Frederick Barner's, on the northeast spur of Log Mountain (the "second Log"), which forms the divide between the waters of Yellow Creek and Cannon Creek, there are a number of coal horizons visible. Following is a statement of the number of the beds and their order. The section was obtained along the old Pineville road, beginning at the pinnacle of the mountain on the north, and descending to the valley of Yellow Creek, at the point where the old road coincides with the one now in use:

1. Mostly covered space. Outcrops of sandstone are occasionally seen	275 feet.	
2. Sandstone in an indurated mass, which forms a prominent bench	25 "	
3. Sandstone in rather thin beds; is in alternately hard and soft strata	25 "	
4. Nearly all soft sandstone; probably merging into sandy shale towards the base	35 "	
5. Shaly sandstone and sandy shale	5 "	
6. Indurated sandstone band	3 "	
7. Areno—argillaceous shale	2 "	
8. Coal stain having a clay parting, thus: *a*. Coal, 3 inches; *b*. Clay, 2 "; *c*. Coal, 1 "		6 inches.
9. Under-clay	5 "	
10. Sandstone; disintegrates in spots; full of hard concretions of sandstone	10 "	
11. Indurated sandstone, with occasional shaly layers	25 "	
12. Coal divided by a clay seam, thus:* *a*. Coal, 3 inches; *b*. Clay, 2 "; *c*. Coal, 3 "		8 "

* This may not be precisely in place.

13. Shale		5 feet.	
14. Sandstone and shale; the shale predominating		5 "	
15. Coal			4 inches.
16. Shale having sandstone nodules distributed through it		5 "	
17. Coal stain	1½ inches		
18. Indurated sandy shale	1½ "		
19. Coal stain	½ to 3 "		
20. Indurated clay	6 "	2 "	4 "
21. Coal stain	2 "		
22. Hard, ochreous sandy shale.	6 "		
23. Coal	6 to 8 "		
24. Sandstone; thin bedded; weathers into thickly laminated shale		10 "	
25. Coal; local?		1 to 1 "	2 "
26. Sandstone; shaly at top		20 "	
27. Coal covered by a thin slate			8 "
28. Bluish and ochreous shale		10 "	
29. Coal stain			1 "
30. Sandstone and sandy shale, the shale somewhat ochreous.		25 "	
31. Concealed		15 "	
32. Coal I, outcrop (said to measure 4 feet)		2 "	

The lowest coal, No. 32 of the section, has been opened at several places on Mr. Frederick Barner's place and in the vicinity.

The coal crops out in the road by Mr. Barner's, showing a thickness of two feet; but Mr. Barner states that he measured the coal with a carpenter's "square" at two of his pits, and in each case the thickness was four feet. At the time the examinations were made, the pits were filled with water. The section was made near Mr. Barner's house, and may be considered as a representative one, for the height that it reaches, of that part of the mountain extending from Mr. Arthur McTee's (just north of Saw-mill Ridge) to the ford of Cannon Creek, opposite the west face of Rocky Face.* There are, perhaps, a number of minor changes in that distance—five miles—but not enough is known of the details to warrant a discussion of them.

Passing from Mr. Barner's towards Cannon Creek ford, beds are sometimes seen that are tilted at small angles, usually towards the west, as the road approaches the line of the Rocky Face fault. The precise nature and extent of these disturbances, however, is not known; although their position

*It must not be forgotten that these sections are to a great extent preliminary.

suggests that they have a limited extent, and are merely the ends of the horizontal beds that were bent upwards somewhat when the great fracture occurred and Rocky Face was elevated. There are many other matters not only of economic value, but of special interest to the geologist, that are left undiscussed for want of sufficient data.

From Cannon Creek ford to Pineville examinations were made along two routes; one lying along the path of the railroad survey, and the other following the common road. The latter route crosses directly over one spur of the mountain known as the "third Log," leading from the valley of Cannon Creek to the valley of Clear Creek; whereas, the former one follows down the valley of Cannon for about one mile from the ford; then over a low gap to Patterson's Branch, and down that to the Cumberland river; passing thence, along the foot of the mountain, to Pineville.

As the horizontality of the beds is preserved well up to Pine Mountain (in the gap of which Pineville is situated), no new points of interest are offered in the structure of the ground passed over. All that section lying between Rocky Face and Clear Creek seems to be one mass of horizontal, or nearly horizontal, rocks. We begin, however, to note a diminution in the number of coals as we travel northwest, the number of beds evidently being less in the district lying towards Pine Mountain than in the section extending towards Cumberland Mountain, in the direction of Tennessee.

The following statement may be accepted as an approximately correct General Section, for the height that it reaches, of the beds in the region under consideration:

1. Sandstone	15 feet.	
2. Covered	85 "	
3. Sandstone	10 "	
4. Concealed	20 "	
5. Sandstone	120 "	
6. Concealed. Coal VIII may be present	13 "	
7. Mostly sandy shale	100 "	
8. Coal VII^c?	trace.	
9. Sandstone	80 "	
10. Coal VII^b		6 inches.
11. Shale	15 "	

12. Coal VIIa		8 inches.
13. Sandstone	40 feet.	
14. Coal VI divided thus:		
a. Cannel coal . . . . 12 inches; *b.* Bituminous coal . . 9 "	1 "	9 "
15. Sandstone and shale	35 "	
16. Coal V		9 "
17. Sandstone	130 "	
18. Coal IV?	1 "	4 "
19. Shale, about	120 "	
20. Conglomerate sandstone and shale beds.		

It will be noticed that out of the eight coals held in the mountain lying to the southeast, only five or six are represented here. Coal VIII was not seen, but there is a probability that it will be found in the space indicated by No. 6 in the above statement.

Just where bed 18 of the section belongs, in the order of numbers applied to the coals, is somewhat conjectural still. It is provisionally placed as coal IV, although it may be any of the numbers down to No. I, provided that their associate beds have changed. There are some circumstances, however, which favor the probability of its being No. IV rather than any other number. This being true, we here have our first suggestions as to the manner in which the coal beds decrease, the absence of the beds I, II, and III showing that the diminution is regularly from the bottom upwards, which would be in exact accordance with the idea advanced in the first pages of this report, viz: that there was a *downward* increase in the general thickness of the coal-bearing series towards the southeast, and also in the number of coal beds.

Whether it be true or not, however, that the coals diminish *regularly* from the bottom upwards, it is evident that they do disappear towards the northwest, which still favors the idea just referred to.*

Coal has been opened at a few places within easy reach of the wagon road; but, as in the case of the other districts, the openings are few and in a poor condition for examination—there being no industry in the region whereby constant mining could be sustained.

* This is the general result of the observations made by the officers of the Survey in this district.

On the path of the railroad, as it leaves Cannon Creek ford and makes toward Pineville, there is but one place of opening in any of the coals, so far as was learned.

At Mr. Hugh Browning's, just back from the Cumberland river, about three miles above Pineville, a compound bed of cannel and bituminous coal has been "faced out," and another coal bed discovered below.

Following is a section of the beds seen in the branch flowing down from the cannel bed to the river:

1. Sandy shale and sandstone	20 feet.	
2. Argillaceous sandy slate		10 inches.
3. Bituminous slate		4 "
4. Drab and ochreous argillaceous slate	1 "	
5. Cannel slate		1½ "
6. Cannel coal . . . . 1 foot 7. Bituminous coal . . 9 inches } VI	1 "	9 "
8. Sandy shale and thin-bedded sandstone	51 "	
9. Thinly laminated sandstone and shale	10 "	
10. Concealed	5 "	
11. Coal stain; slided? Coal V	1 "	
12. Concealed	35 "	
13. Shaly sandstone and sandy shale; mostly the latter	50 "	
14. Concealed	5 "	
15. Shaly sandstone and sandy shale	20 "	
16. Concealed to the Cumberland river, at a low stage of water	30 "	

The coals of No. VI are apparently very good in quality, and are easily accessible from the river. At a cost of perhaps not more than five thousand ($5,000) dollars, the necessary machinery may be purchased, and the ground be prepared for profitable mining on a large scale. These coals may, doubtlessly, be found in the Log Mountains for some distance both up and down the river from Mr. Browning's, wherever the elevation is sufficient to reach their horizons.

PINE MOUNTAIN.

This mountain is a true fault mountain, the slant of the uplifted rocks being towards the southeast, forming as it were one rim of a wide synclinal valley.

The fault, which is a clean fracture, courses about N. 60° E., and forms the northwest face of the mountain.

At Pineville, in the immediate vicinity of which the mountain was examined, the average amount of the dip of the beds is about 30°, and the course about S. 30° E. Towards the base, on the northwest face, the amount of the dip is of course greater, and towards the southeast it is less than the average.

The amount of throw of the fault has not been determined with perfect accuracy, but it is apparently at least 2,700 feet; more than twice the height of the mountain, which measures 1,100 feet for its average and 1,200 feet for its maximum height, above the river near Pineville.

Upon comparing the heights of the several mountains, it is found that Pine Mountain is one of the lowest in the region. Rocky Face and Pine Mountain, both of them true fault mountains, have about the same altitude.

Following is a table of comparative heights determined by barometrical observations (mercurial), the sea level being used as a datum for measurements:*

Cumberland Mountain; the Pinnacle	2,500 feet.
Brysen Mountain	3,225 "
Canada Mountain, on Log Mountain	3,030 "
Moore's Peak, on Log Mountain	2,413 "
Signal Point, on Log Mountain	2,138 "
Saw-mill Peak, on Log Mountain	2,024 "
Rocky Face	1,900 "
Pine Mountain	1,950 "
Powell's Valley, Tennessee	1,300 "
Yellow Creek Valley	1,100 "
Cannon Creek, at the ford, about	1,000 "

For convenience, a list of comparative heights, with reference to the Cannon Creek ford, has been calculated with approximate accuracy, and is given:

Cumberland Mountain; the Pinnacle	1,500 feet.
Pine Mountain	950 "
Rocky Face	900 "
Yellow Creek Valley	100 "
Powell's Valley	300 "

By these tables we see that Pine Mountain, although more distinctly prominent than some others, mainly because of its form, is really one of the least considerable. For instance, it is only 50 feet, or thereabouts, higher than Rocky Face,

*These heights are not, all of them, free from possible error; if one exists, however, it is inconsiderable. I have to thank Wm. Byrd Page, Esq., Topographical Assistant, for most of the data from which the table was compiled.

while it is several hundred feet lower than a number of the mountain peaks forming the group known as the Log Mountains. Moore's Peak, the highest point in the group, which lies between Pine Mountain and Rocky Face, rises 463 feet above Pine. The mountain is cut by the Cumberland river at Pineville, the river making in a northwestwardly course towards Barbourville, after following down its northwest face for a short distance. The causes tending to affect the river, so that it preserves its bearing towards the northwest after having passed through the mountain, instead of closely following the line of the fault, as the circumstances would lead us to expect it to do, are as yet unexplained.

The sketch on the following plate serves to convey an idea, somewhat vague though it may be, of the geographical conditions in the immediate vicinity of the gap.

Straight Creek, it will be seen, follows the line of the fracture closely, and of itself distinctly marks the break.

Clear Creek also follows its part of the mountain closely, so that on a good map of these streams the trend of the mountain is indicated with close accuracy by the course of the streams.

The fault making this mountain is a very clear one. Immediately on the northwest side of the Cumberland river, only a short distance from the foot of the mountain, the beds are nearly if not quite horizontal, and of themselves show no evidences of a disturbance; on the southeast side of the mountain, the beds overlying those forming its structure slope gradually away and soon regain their horizontality.

The following is a statement of the beds that enter into the structure of the mountain:

1. Conglomerate sandstones and shales	1,580	feet.
2. Shale	160	"
3. Concealed	35	"
4. Sub-carboniferous limestone	320	"
5. Covered space	30	"
6. Waverly beds	150	"
7. Covered space; may be Waverly in part	55	"
8. Covered space with a nearly flat slope	110	"
9. Outcroppings of Devonian slate	70	"
10. Concealed space to the river	300	"

These measurements were made by angles, and were subjected to several tests; hence, for the kind of work in hand, they may be considered as fairly accurate.

On the northwest side of the mountain a low sharp spur, so to speak, reaches out from the base, about which centres a considerable amount of interest. The spur is indicated in the profile section by the letters A and B. At about 300 feet from the place where the last outcrop of Devonian shale is seen, and at an altitude of about 275 feet above the river, a large mass of hard, closely-grained, somewhat quartzose sandstone (some 35 or more feet thick) is seen, resting in almost vertical beds, having, however, a slight inclination towards the northwest—a direction directly opposite the course of the dip of the main mass of the mountain. The original position of the rock is quite obscure, so far as any examinations yet made would show. There are two methods by which to account for its position, neither of which, however, are more than mere conjectures. Apparently the most plausible suggestion is, that it is a member of the conglomerate series, which was bent upwards when the mountain was raised: this would indicate the line of fracture as being between this mass and the main mountain. Another suggestion, but against which the northwardly inclination of the rock is opposed, is, that the sandstone has its place in the upper series of beds included in the Niagara period. *

It does not seem desirable, however, to spend further space in conjectural explanations concerning it.

The Pine Mountain fault, as it is usually termed, may prove of considerable money value to the region in which it lies.

In the series of rocks coming next below the black shale of the Devonian group, in this section, are beds of remarkably fine and soft hematite iron ore, known as the "dyestone ore" in Tennessee and Alabama, where, perhaps, it has its best development, or as the Clinton ore in other localities. This ore is brought up by the Cumberland Mountain fold, so that it

* Further study may prove both of the propositions untenable; showing instead that it is merely a large mass that has broken away from some of the sandstones now forming the summit of the mountain.

is easily reached in the ground lying on the opposite side of the mountain from Kentucky. A number of measurements were made at that place by Mr. P. N. Moore, for the purpose of determining the distance between the first ore (there are three beds) and the Devonian shale, and will be found in his report on the iron ore deposits of that region. Unfortunately none of his results are at my command at present; but, from subsequent observations made at another locality, I think it safe to compute the distance at something less than 300 feet. It is not improbable, then, that the lift of the beds in Pine Mountain has also been sufficient to bring the ore, at least the upper bed, within comparatively easy mining distance from the base of the mountain. It, at all events, would be worth searching for by extending a drift into the mountain, starting it a little above drainage. It is a matter certainly of sufficient importance to warrant a judicious outlay of money in prosecuting a close search for the ore. Dr. Safford, State Geologist to Tennessee, records the fact that the ore is brought up by the fault further to the southwest, so that the westward extension of the ore is clearly proved.*

FROM PINE MOUNTAIN TO BARBOURVILLE.

Following the course of the State road, the beds are pretty generally horizontal, and all lie above the conglomerate. The observations made between the two places—over a distance of sixteen miles—were very imperfect, the weather being quite stormy, which so affected the barometrical observations as to render them nearly useless. It is believed best, therefore, to defer any discussion of the region until more accurate observations may be made, and the notes already taken be perfected. Several exposures of coal dirts were seen, some of which may prove valuable. There are also some workable beds that are opened; but, as in other cases, they are not wrought for any but domestic purposes.

Coal is opened on the land of Mr. Ely, Mr. Joseph Smith, and of Mr. John Tuggles. The latter place is about one mile

* For a discussion of the question of the existence of this ore at this point, see the biennial report of N. S. Shaler for 1875, Kentucky Geological Survey, second series, volume III.

and a half beyond Mill Branch. The coal is 26 inches thick, is overlaid by a sand rock, and is about 180 feet above the low part of the road near by. The coal is probably not so high above Barbourville. It is not improbable that there are other coal openings on the route than those mentioned.

FROM BARBOURVILLE TO LONDON.

Beyond Barbourville we seem to get further changes in the rocks, the sandstones giving way to shales or vice versa, and the whole mass becoming thinner.

On Mr. W. F. Costellow's land, up Smoky Creek Fork of Richland Creek, and about two miles from Barbourville, on the London road, a coal has been opened which is probably the equivalent of the coal of Mr. John Tuggles. The coal is quite hard and made up of alternating laminæ of fibrous and hard glossy black coal. Its thickness will average about 24 inches. The proportion of iron pyrites in the coal is apparently small, and altogether its quality seems to be very fair.

This bed is the main coal of the region. It is overlaid by a sandstone and underlaid by sandy shale. At about 50 feet below it darkish shale occurs, and forms a very prominent feature in the order of the beds.

At Mr. Archibald Britton's spring-house, about three miles beyond Barbourville, a coal is found that may prove equivalent to Mr. Costellow's; apparently, however, it is from 20 to 30 feet below that bed. About one quarter of a mile beyond Mr. Britton's another coal is seen, which shows a thickness of 16 inches; it is overlaid by 10 or more feet of shaly sandstone. This is at Smoky Gap, and the coal is about 75 feet above Costellow's. The following preliminary general statement of the section, for the region between Barbourville and Laurel river, will serve to show the relative positions (as they are now understood) of the most prominent coal beds:

1. Shale	25	feet.
2. Sandstone (the Wildcat Mountain conglomerate?)	35	"
3. Coal	½	"
4. Sandstone	75	"
5. Coal stain	1¼	"

6.	Sandstone	90	feet.
7.	Coal (V? of the Log Mountain section)	1⅓	"
8.	Shale and sandstone; the shale in the upper part	77	"
9.	Coal (IV? of the Log Mountain section) 2 feet to	2½	"
10.	Shale, dark blue and ochreous	95	"

At Mr. James Britton's a coal equivalent to Mr. Costellow's has been wrought. It is 25½ inches thick, and is covered with 10 or more feet of sandstone, with the dark shale seen near Barbourville underlaying it.

Beyond that fork of Richland Creek which drains the country between Mr. Britton's and Mr. Wm. H. Brafford's is a coal stain probably equivalent to the Smoky Gap coal. The positions of the several coal horizons may be determined from the graphic section accompanying this report, however, and it is not considered necessary to offer further notes on them at present.

Passing on to London, the rocks seem to wedge out, as may be seen in the preliminary horizontal section, and the coal beds decrease in number between the dark blue shale of Barbourville and the Wildcat Mountain conglomerate, if the geolgy has been rightly interpreted.

Following is a statement of the beds at and in the vicinity of London:

1.	Sandstone, the conglomerate of Wildcat Mountain	20	feet.
2.	Mostly concealed	75	"
3.	Sandstone and shale	25	"
4.	Coal stain	½	"
5.	Shaly sandstone and shale	30	"
6.	Coal (IV? of the Log Mountain section), 21 inches to	3	"

The Coal No. 6 is presumed to be, probably, identical with Mr. Costellow's. It is opened in a small valley just west of the town, and has been worked by stripping. The openings, or most of them, have been made on Mr. John C. Brown's land. The land near by, which is hill land, is owned by Messrs. C. Pitman, Jarvis Jackson, and W. L. Brown.

The Wildcat Mountain conglomerate covers the hills around London, and extends thence to Wildcat Mountain. The six inches of coal at London (No. 4 of the section) thickens to 15 inches at half a mile beyond the town, and may prove valuable in other parts. It is probably identical with the 15 inches of coal at section 34, on the horizontal section.

At two miles beyond London the lower coal seam (No. 6 of the section) has been opened and wrought on Mrs. Evelyn Brown's land. The coal is two feet ten inches thick, and apparently of good quality. The coal dips slightly north 75° west.

The same bed has been opened on Mr. Pitman's land, half a mile beyond Mrs. Brown's, where it measures three feet four inches, and three feet; and at Mr. Allison Woods', about one mile and a quarter beyond Mrs. Brown's, where it is said to measure between three and four feet in thickness.

At about five and a half miles beyond London the pink and drab beds of the Wildcat Mountain conglomerate come to view, and form the most prominent features of the upper part of the section on to Wildcat Mountain.

At a point about six miles from the Rockcastle river ford, a coal stain two inches thick is seen at 35 feet below the base of the sandstone; and at 95 feet below the base of the sandstone a coal bed has been opened which may prove equivalent to that at Mrs. Brown's. A short distance beyond that point three inches of coal, apparently corresponding to the first bed above Mrs. Brown's, is exposed.

At about half a mile further the descent is made into the valley of Hazel Patch Creek, a stream emptying into the Little Rockcastle river. Nearly everything is covered by debris on the hillside, occasional outcroppings of shale and sandstone being all that may be seen.

In the valley, about five miles from the Rockcastle river ford, two (possibly more) openings have been made in coal, but they are now filled up. The coal is one foot or more thick.

Whether this coal is in place or not is still a question. It seems to be undoubtedly equivalent to the Livingston coal; but within a less distance than three miles it is found at a level 120 feet below that of the Livingston bed; and, what is more remarkable, it is topographically 70 feet below the top of the sub-carboniferous beds which are exposed on the opposite side of Wildcat Mountain, as may be seen in the graphic section. It is a question that merits study, and is one that it is preferred shall be left open for a while, although it would now seem that the coal is not in its true place, but has been lowered either by a great slide or a cave fault.

WILDCAT MOUNTAIN.

With the study of part of this mountain, the work of the reconnoissance was ended.

The structure of the mountain is simple. The mass is virtually a pile of nearly horizontal beds which have been fashioned into its present form by water. The summit of the mountain (that part of it which was examined) is made of a soft disintegrating pink and drab and light colored conglomerated sandstone. It is very questionable whether this rock belongs to the series lying near or at the base of the coal measures as they appear further to the south. There seems to be much reason to presume that it is entirely distinct from the Pine Mountain and Cumberland Mountain conglomerates; that it occupies a higher geological level. The observations made so far tend to give such an impression; and if this should prove true, those conglomerates would be represented by the lower conglomerate of this mountain, which, at most, is not over 30 feet in thickness. Following is a statement of the order in the beds on the northwest side of the mountain, descending to the ford of the Rockcastle river:

1. Conglomerate; massive in its upper members and soft, but becoming harder towards the base and in thin beds	120	feet or more.
2. Mostly concealed, seems to be mostly bluish-drab sandy shale	10	"
3. Hard sandstone	5	"
4. Dark stain, possibly a coal mark?		
5. Dark and drab argillaceous and argillo-sandy shale	25	"
6. Mostly covered	10	"
7. Drab and dark shale	10	"
8. Argillo-sandy shale, bluish and drab in color, 30 to	20	"
9. Sandy shale, merging below into shaly sandstone	10	"
10. Sandstone, massive	10	"
11. Sandy shale	15	"
12. Hard sandstone in three or four beds, the top bed being filled with *Stigmariæ*	10	"

13. Drab to grey sandy shale and shaly sandstone; the top layer is filled with *Stigmariæ*	20 feet or more.		
14. Coal		9 inches.	
15. Shaly sandstone and sandy shale	5 "		
16. Coal, slaty		7 "	
17. Hard sandstone, from fire clay, filled with *Stigmariæ* rootlets, about,	2 "		
18. Drab clay	2 "		
19. Coal: the "Livington Coal"	1 "	6 "	
20. Drab and yellowish shale	5 "		
21. Dark blue shale, merging into blue and yellowish shale with kidneys of iron ore	5 "		
22. Covered	5 "		
23. Sandstone disintegrating in certain parts, particularly towards the base. Ferruginous "boxes" occur in the upper and larger part. The conglomerate	10 "		
24. Concealed	30 "		
25. Marly olive green shale of the Chester group	5 "		
26. Limestone, 6 inches to	1 "		
27. Calcareous greenish-drab, somewhat marly shale	6 "		
28. Limestone	1 "	6 "	
29. Shale	4 "		
30. Massive limestone of the St. Louis group (?) to the river ford	45 " or more.		

The Coal No. 19 is the bed wrought at the several mines at Livingston, in Rockcastle county, and is considered to be of very good quality. It is probably also equivalent to the Pine Hill coal, which is much esteemed for general purposes, and is used, it is believed, at Crab Orchard for gas-making.

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KENTUCKY GEOLOGICAL SURVEY

N. S. SHALER, Director.

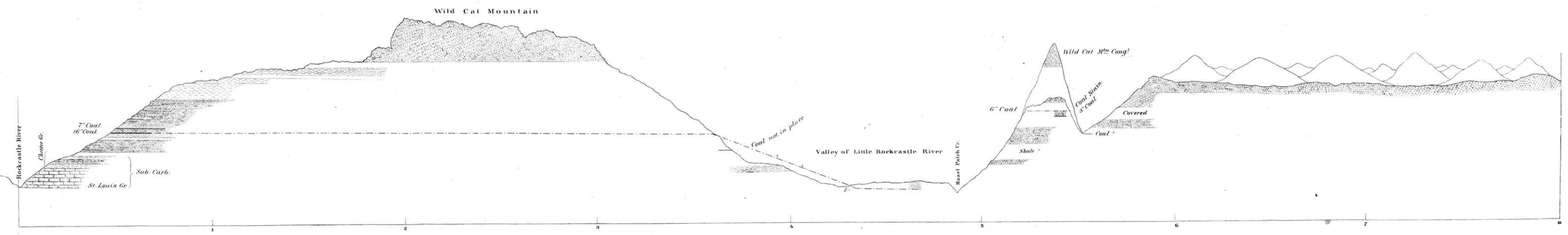
PRELIMINARY SECTION FROM YELLOW CREEK VALLEY TO LIVINGSTON STATION.

BY

CHARLES J. NORWOOD.

1876.

VERT. SCALE, 200 ft.= 1 inch. HORIZONTAL SCALE, 2000 ft.= 1 inch.



GEOLOGICAL SURVEY OF KENTUCKY.

N. S. SHALER, DIRECTOR.

A RECONNOISSANCE REPORT

ON THE

LEAD REGION OF HENRY COUNTY,

WITH SOME NOTES ON

OWEN AND FRANKLIN COUNTIES,

BY CHARLES J. NORWOOD.

PART VII. VOL. II. SECOND SERIES.

PRELIMINARY LETTER.

Professor N. S. SHALER, *Director Kentucky Geological Survey:*

DEAR SIR: I herewith submit to you a report of a reconnoissance made in the lead district of Henry county, during the month of May, 1875.

I trust that it may be found of service to all interested.

Respectfully yours,

CHARLES J. NORWOOD.

LEXINGTON, KY., December 1st, 1875.

A RECONNOISSANCE REPORT ON THE LEAD REGION OF HENRY COUNTY, WITH SOME NOTES ON OWEN AND FRANKLIN COUNTIES.

I.

HISTORY OF THE MINES.

The existence of lead in Henry county is not a recent discovery. It is a well-assured fact that the deposits attracted attention as far back as 1815, and perhaps even at an earlier time.

There is a legend current that silver also was found; this, however, is simply another instance of that delusion so common to all mineral districts, or even in regions having no metalliferous deposits. Those who tell the tales are, usually, thoroughly honest in their belief, however great may be their mistake. The story concerning the silver of this county grew from the fact that, some thirty-five or forty years ago, a family bearing the name of Knight, which lived on Drennon Creek, and occupied a cabin on the land then belonging to a Mr. Minor (now the property of Mr. S. Loudon), conducted themselves in such a manner as to bring them under suspicion of secretly coining money.

The story is, that persons journeying in the neighborhood at night would see bright lights in the house even at midnight, the house being so illuminated by flames, which were supposed to issue from a furnace, as, at a distance, to appear "all ablaze." The Knights, however, received warning of the traveler's approach from their dog, and the house would be darkened before it could be reached.

Finally, suspicion increasing against them, they were driven from the county. After their departure several parts of money moulds were found where they had been secreted in the woods, and, as the relater believed, near their old cabin.*

This was accepted as conclusive proof that Knight had been engaged in making *silver* money, and that the silver was found in the immediate neighborhood.

So far as the supposition that Knight coined money is concerned, the legend is doubtless correct; that it was *silver* money, however, is not so well proven.

It seems simply to have been an instance of counterfeiting, the place being selected for the operation on account of its seclusion.

The absurdity presented by the statement that the metal was silver should be apparent to any one. Had it been that metal, it would have been a mere waste of labor and ingenuity for Knight to have done the coining, as the silver could have been exchanged at the Government Mint for its worth in dollars already coined.

This matter has been given greater prominence than would have been due to it were it not that many, both in and out of the county, have an abiding faith in the existence of a "silver lode" in the county, and entertain notions of searching for it.† All search for the metal will prove futile, and it is simply an utter waste of time and of money to prosecute it.

The oldest "digging," so far as could be ascertained, is on Mrs. Eliza Ann Green's farm, about two and a half miles eastwardly from Franklinton and eight miles from Lockport. Excepting a number of fragments of limestone which are scattered near by, all signs of the digging have disappeared, the excavation having become filled level with the surface with debris washed down from the hillside. A few years ago, however, the pit was only partially closed, sufficient yet remaining open to show that the opening was about 10 feet square. Mrs. Green states that the pit was opened about 60 years ago, before the place was cleared, the land then belonging to

* It is said that a man named Margo also coined money.

† Indeed, I noticed in one of our county papers, published in May of the present year, a letter from a gentleman professing strong belief that a silver lode is to be found in Henry county, and to a certain extent urging that it be searched for.

a Mr. Cook. It is presumed that the digging was done by the settlers in order to procure lead for domestic use. This is, doubtlessly, the correct view of the matter. Other pits were subsequently opened in the region at various times to procure the mineral.

In 1823 or 1824 a Mr. Suckett opened a pit on Jas. Roberts' place, where the "Silver and Spar" mines are now located; it was merely a "prospect hole," and nothing of consequence was done. This pit, so far as could be learned, stands next in age to that on Mrs. Green's land.

The next record we have of any mining was in 1825 or 1826, at which period a Mr. Ficklin mined on Big Twin Creek, in Owen county, at Flannigan & Hunter's Mill. A period of 10 years then succeeded in which no new developments seem to have been made.

In 1836 Messrs. Perkins and Little (from Shelby county, it is believed) erected a furnace on the site of the present "Silver and Spar" mines, and smelted a small amount of lead. The works were on quite a modest scale, and were operated for only a short time.

Three years later, in 1839, two men, Messrs. Barbour and Waggoner, had a pit sunk to a depth of about 50 feet on the McCrell place, in Owen county, then known as Meach's bottom.

About fifteen years ago, perhaps not quite so long, quite an excitement prevailed for a while concerning the lead deposits, and considerable was done in the way of either buying or leasing lands for mining purposes. After a few excavations were made, however, the excitement died away, or rather slumbered to be renewed at intervals up to the present time, when it has, perhaps, attained its greatest degree of energy.

For an interval, however, extending from 1839 or 1840 to 1865, no openings of much consequence were made. No regularly organized plans were formed for working the deposits until about 1865 or 1866.*

*This is in accordance with what information could be gathered at the time. Much trouble was experienced in the effort to get at the history of the mining operations, as many of those who were supposed to know had, with the exception of Mr. Raser (to whom I am indebted for much of this sketch), very imperfect memories as far as regards this matter.

About the year 1865 a company from Wisconsin opened pits on farms belonging to Mr. Wallace and Mr. Roberts, near Lockport, and also leased or bought the right to mine on the farm of Mr. Aris James, which is about one mile in a westwardly direction from the village. A larger amount of work was done on the latter place than on the farm of either Mr. Wallace or Mr. Roberts. Nothing of consequence resulted from it, however, and after a number of shallow pits had been excavated, the spot was abandoned, and has so remained to this time.

At about the same period an organization known as Stewart & Company gained possession of the openings on James Roberts' place ("Roberts' Landing"), hitherto mentioned. They were succeeded by Parker & Company, a Philadelphia company, who in turn were succeeded by the present owners.

Not, however, until within the past two years has any mining been done on an extended plan. In 1873, or about that time, a company, incorporated under the name of the "Silver and Spar Mining Company," assumed charge of the mines—or more properly diggings—at Roberts' Landing, as already intimated.

Little work was done, however, until about one year ago—in the spring and summer of 1874—since which time the work has been carried forward with considerable rapidity. These mines are the only ones properly deserving the name in the county. In 1874 a shallow pit was dug in near proximity to Drennon Lick by Messrs. Hardin and Hurl; but very little more was done than sinking the shaft.

This brings the history of the mining down to the present year, during which period, at least not anterior to June 1st, when the region was examined, no new openings have been made.

Although somewhat incomplete as a detailed history, this sketch is believed to be as nearly correct and comprehensive as can now be obtained.

The several localities already mentioned are treated of in more detail on succeeding pages; and, in addition, a number of diggings that are not mentioned here are discussed.

As a matter of interest and of instruction it would be well to have a trustworthy account of the amount of money that has been expended on the lead deposits of this county from 1815 to 1875, without the return of a dollar of *actual* profit; unfortunately, however, no data for this computation can be had.

II.

GEOLOGY OF THE LEAD REGION.

The sub-structure of this lead region is formed of Upper Cambrian rocks, their precise age, however, being somewhat obscure.

Fossils that in other States are considered typical of the Hudson River and of the Trenton Groups are here found together, and ranging almost throughout the series. The paleontological evidence would point to the identity of these rocks with both of the groups above named, but the mingling of the forms prevents the location of any definite line of separation. They certainly are, in part, of the same age as the Cincinnati Group, and the most pleasing solution of the question regarding their age is to consider them equivalent in part to the Hudson River Group, merging into Trenton beds below.

Dr. Newberry, in volume 1, part 1, of the "Final Geological Report on Ohio," gives as his reason for retaining the name "Cincinnati Group" (given by Meek and Worthen) for the series of limestones and shales of which the rocks in this district form a part, that the group is equivalent both to the Hudson River and Trenton Groups, of New York, and not, as some have believed, because the term "Hudson River Group" was a misnomer; later investigations prove it to have been correctly applied.

As the rocks in this district are, without doubt, near the base of the Cincinnati Group, they probably include, towards their base, beds equivalent to the Galena limestone of Illinois. It may, therefore, be provisionally accepted, until more definite knowledge is gained concerning them, that the rocks in this district include equivalents of the *Galena limestone*, with *Hudson River* beds at the top.

Professor Whitney's description of the *Galena limestone* (which lies next below the Cincinnati Group) is as follows: "The *Galena limestone*, as usually developed, is a rather thick-bedded light grey, or light yellowish-grey dolomite, distinctly crystalline in texture, and usually rather granular, although occasionally quite compact. The coarse-grained portions frequently contain small cavities of irregular shape, which are often lined with minute crystals of brown spar. In its chemical composition this rock is quite homogeneous; it is almost a pure dolomite, since the various analyses which have been made show it to contain only from two to five per cent. of substances insoluble in acid (clay and sand), while the remainder is a mixture of carbonate of lime and magnesia, in the proportion necessary to form dolomite (carbonate of lime 54.35, and carbonate of magnesia 45.65 per cent.), with one or two per cent. of the carbonate of the protoxide of iron, which becomes gradually peroxidized on exposure to the air, and traces of the alkalies, chlorine, and sulphuric acid. * * * The upper layers of the Galena limestone are usually more regularly and thinly bedded than the middle and lower. * * At the very summit of the formation the rock is quite shaly and argillaceous, indicating a passage into the Cincinnati Group above. * * The middle portion of the Galena limestone is usually very heavy-bedded, crystalline, and marked by an abundance of flints arranged in parallel layers. * * * The maximum thickness of the Galena limestone, where none of it has been removed by denudation, is from 250 to 275 feet."

The limestone, which in this region is supposed to be the equivalent of the Galena limestone, does not answer to the foregoing description in every respect. An analysis, made in the laboratory of the Survey, of samples taken from near the Silver and Spar mines, shows its composition to be as follows:

Carbonate of lime	95.770
Carbonate of magnesia	1.378
Alumina, iron, etc.	1.060
Silicious residue	.980
Total	99.188

It will be seen that these samples do not even approach a dolomite in composition, as the proportions of the carbonates of lime and magnesia are not such as are required to form this substance. This analysis cannot be used as a representative one, as it is not made from an averaged collection of samples. Nevertheless, it is undoubtedly true that the amount of magnesia in the rock is quite small. It is, however, of comparatively little importance, except as a matter of scientific interest, whether or not the rock is the equivalent of the Galena limestone. It at least occupies the place in this lead region that the Galena limestone holds in the lead district of Illinois, whether that limestone has thinned out in this direction or simply changed in its composition.

The group of rocks in this region is made up of a series of limestones and shales in the upper part, with a series of massive limestones at the base.

The total visible thickness of the whole section is between 325 and 375 feet.*

The shales preponderate greatly towards the summit, the limestone beds being thin and scarce. For this region the group has been locally divided into the "Shale and Limestone" division, which, without doubt, is part of the Cincinnati Group, and the "Massive Limestone" division, which may, in part, correspond to the Galena limestone.

The thickness of the first named division is at least 160 feet, and of the massive limestone about 125 feet, the base of which is not visible. The accompanying plate represents

*This is probably not the total thickness for the county; the upper series may be thicker by 50 to 75 feet, possibly more, than was seen in the region under study.

sections made at and near Lockport, which may be taken to represent typical ones of the entire region.* It may include certain rocks seen near Drennon Lick; but their place is yet unsettled; and for all practical purposes it matters little whether or not they are included.

A detailed description of the strata making up the sections is here given.

Section 1, made on the Franklin and Flat Creek road, descending toward Lockport to Six Miles Creek.

1.	Drab shale and limestone. The limestone is in beds of two to six inches in thickness, sparsely scattered through the shale. The top beds abound in *Strophomena alternata*, *Zigospira modesta* (?), and corals	50 feet.
2.	Drab shale with a few limestone beds. The limestone at the top is mostly drab, earthy, and somewhat sandy, and in thin layers. *Leptaena sericea* (?) and corals are found, the latter being quite abundant. This division differs principally from No. 1 in the great preponderance of the shale over the limestone. About the middle, for 30 feet, there is scarcely any limestone. Towards the base, however, the limestone increases, some of the beds measuring six inches in thickness.	75 "
3.	Drab shale and limestone. The limestone beds are coarse in texture and bluish grey usually, and are filled with *Leptaena sericea* and *Orthis emacerata* (?). The downward limit of the *Leptaena* is about five feet above the base of this division	40 "
4.	Limestone with some shale. Some of the limestone beds are 12 inches thick. Gasteropoda make their appearance in this division, and mark it as the "Gasteropod Beds;" they are *Cyclonema bilix*, *Bellerophon bilobatus*, *Pleurotomaria lenticularis* (?), *Murchisonia bicincta*, etc., associated with *Strophomena alternata*, *Zigospira modesta*, *Anodontopsis* (?), and an *Orthoceras*	35 "
5.	Nearly all limestone with some shale partings. Organic remains are mostly corals and *Zigospira modesta*	30 "
6.	Limestone abounding in *Rhynconella capax*, and containing great numbers of *Zigospira modesta* at the middle. "*Rhynconella capax* bed"	10 "
7.	Grey and bluish heavy-bedded limestone. *Strophomena alternata* is abundant in most of the layers, and especially at the bottom. The rock also contains what appears to be a small specimen of *Orthis subquadrata*, and also one of *Orthis lynx*? To Six Miles Creek	85–90 "

Another section was made on the Pleasureville road, on the hill back of Lockport, which differs somewhat from the foregoing in its upper members. It is No. 2, and as follows:

1.	Reddish-brown shale, somewhat marly, with a few beds of drab sandy limestone scattered through it	5 feet.
2.	Coarse, bluish-grey limestone and a little drab shale	25 "

* The section representing the beds at the Silver and Spar mines should be opposite the lower part of the section No. 2. Its position on the plate is due to a mistake.

3.	Shale and limestone	20	feet.
4.	Limestone and shale, mostly coarse limestone	5	"
5.	Shale, with some limestone	15	"
6.	Shale, with a little limestone at the base	45	"
7.	Shale and limestone, limestone predominating in the lower 5 feet	25	"
8.	Shale and limestone. The limestone beds are usually drab colored, and sandy in composition. Some are blue at the interior but drab outside, and a few of the beds are dark grey in color and coarse-textured. These are so abundantly filled with *Leptaena* as to fit them to be called the "*Leptaena beds*"	35	"
9.	Coarse limestone and shale, mostly limestone abounding with purple shells of *Orthis emacerata ?*	5	"
10.	Limestone and shale	20	"
11.	Nearly all limestone. About five feet of the upper part is made of shale. The gasteropod beds of section No. 1 are included in this number	55	"
12.	Limestone, the *Rhynconella capax* bed	2	"
13.	Grey sparry limestone	4	"
14.	Grey limestone, containing much calcite, contains remains of *Strophomena* shells replaced by calcite; also corals, and fragments of Crinoid columns. *Strophomena alternata* is quite abundant at about the middle of the bed	15	"
15.	Hard, sparry limestone; color, bluish grey to light grey; lies in beds of from three inches to six inches or one foot in thickness, and is crossed by numerous seams of calcite. The rock is filled with *Strophomena alternata*, which was the only fossil found	3	"

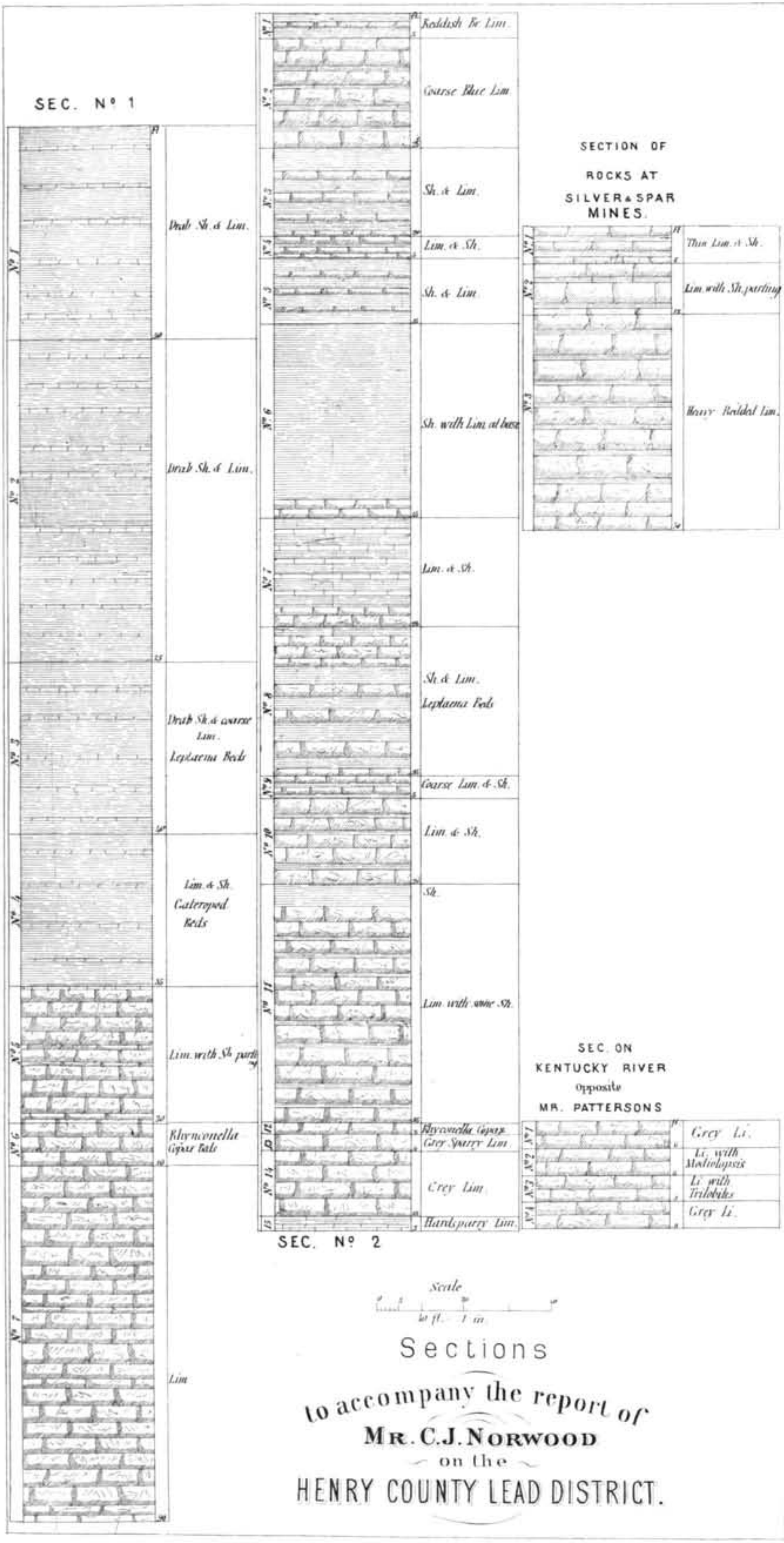
The lead deposits here are in numbers 14 and 15.

On the Kentucky river, opposite "Little Mountain," near Mr. Patterson's house, the following section was obtained. The measurements were approximated:

1.	Grey crystalline limestone, with aragonite filling the shrinkage cracks	6	feet.
2.	Blue limestone, containing gasteropods, several specimens of a *Modiolopsis*, and a few trilobite plates	5	"
3.	Ashy blue earthy limestone abounding in trilobites, and with aragonite filling the cracks and joints	5	"
4.	Grey limestone, lumpy on the surface	8	"

Ambonychia radiata, *Strophomena alternata*, and trilobites, probably belonging to the genus *Asaphus*, were found in addition to those fossils mentioned above.

The rocks in this lead region are nearly horizontal, although from Frankfort down the Kentucky river to a point below the mouth of Drennon Creek there certainly is a fall of the beds in a northwardly direction. At Frankfort a limestone is exposed near the water's edge, which is below any in this district.



Sections to accompany the report of MR. C. J. NORWOOD on the HENRY COUNTY LEAD DISTRICT.

III.

SOME GENERAL NOTES ON MINERAL DEPOSITS.

It is deemed advisable, for the benefit of those unfamiliar with ore deposits, to give some notes on their various forms before entering into the discussion of those in this region. Among the classes of ore deposits are numbered veins, segregations, impregnations, and ore beds. The only form, however, found in this district, so far as I am aware, is to be classed among the veins.

Veins have been divided according to their texture, position, and extent into—

1. True veins;
2. Gash veins;
3. Segregated veins;
4. Bedded veins;
5. Contact veins; and,
6. Lenticular veins.

Among these many modifications are found; and all authors do not adopt precisely the same form of classification.

Lenticular veins may more properly be termed lenticular vein-masses, as they are the fillings of cavities which, lentiform in shape, terminate in all directions—thinning out as it were. They, however, often seem to be a local widening of fissures of some considerable extent. They may be either vertical or parallel with the stratification of the country rock; or, in fact, they may have any direction.

Contact veins are those inclosed between dissimilar formations, and separate the formations from each other.

Bedded veins traverse the country parallel to its stratification, and are only distinguishable from beds by their occupying a fissure, having been introduced into the rock since it was laid down, and not at the time of its deposition.

Segregated Veins or Segregated Deposits.—The latter term is the more acceptable, as all the mineral deposits placed under this heading do not have the character of *veins*.

Segregated deposits are those accumulations of minerals, or ores brought together in cavities, limited in their extent on all sides.

Sometimes these cavities have such forms that they resemble veins; but as a rule they are the result of erosion, either in the direct washing out, from the surface down, of cavities in the rock, or by undermining, or a wearing away of the bed in some other manner, and are not due to a fracturing of the rock. In size they vary from a few inches to many yards in width, and are of all forms, from the vein-like to that of the "cave" and "pot" deposits.

In some instances this class of mineral deposits are doubtlessly due to replacement; but, usually, the matter is introduced from above. It is probable that there are few such deposits which have not been introduced from the exterior. Some segregated deposits have distinct selvages, are frequently crystalline in texture, and, when vein-like in form, their character is not always to be recognized at first view.

The two following forms of veins are so well defined in Whitney's "Metallic Wealth of the United States" that I avail myself of his descriptions.

Gash veins "hold an intermediate position between segregated and true veins. Like the latter they occupy pre-existing fissures; but these are of limited extent, and not connected with any extensive movement of the rocky masses. They are usually confined to a single member of the formation in which they occur, terminating below, when a marked change in the lithological or mineralogical character of the rock takes place.

"Lateral branches will usually be found in connection with the main fissures, which may or may not be nearly vertical, according to circumstances; but whatever their position, the two sets of cracks will be nearly at right angles with each other, and will possess the same character in regard to their mineral contents, although one set will generally predominate over the other greatly in extent."

As Professor Whitney states, this class of veins occupy fissures that are never the direct result of "extensive movements of the rocky masses." But that there are instances in which the formation of the fissures have been, to a certain extent, influenced by such movements, is true beyond doubt.

FIG. 2

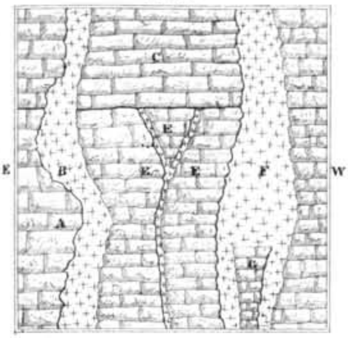


FIG. 3

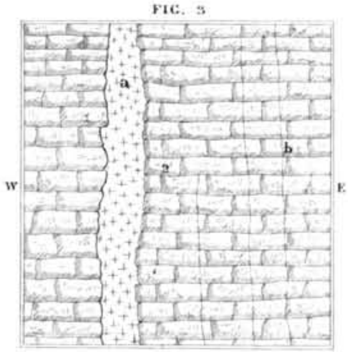


FIG. 1

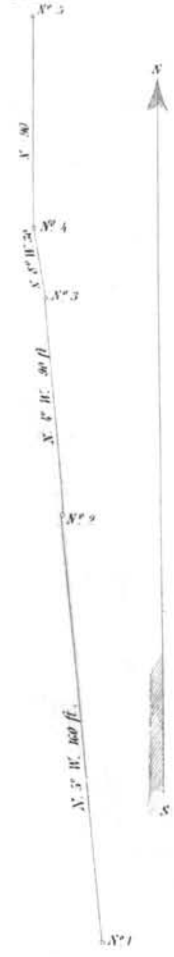


FIG. 2

A *Limestone*
B *Baryta*
C *Limestone*
D *Baryta*
E *Limestone*
F *Baryta*
G *Limestone*

FIG. 3

1 *Limestone wall on the West*
2 *Limestone with vertical craks*
a *Baryta The Lode*
b *Vertical crak in the East side of Shaft*

Scale Fig. 2 & 3
50 inches

Sections

to accompany the report of

MR. C. J. NORWOOD

on the

HENRY COUNTY LEAD DISTRICT.

Gash veins are due to a shrinkage of the rock in which they occur, and are, therefore, simply the filling matter of shrinkage cracks brought about by various agencies.

True veins are indefinitely deep fissures, which have, to some certain extent, been filled with minerals or ores; "or, in other words, an aggregation of mineral matter, accompanied by metalliferous ores, within a crevice or fissure which had its origin in some deep-seated cause, and may be presumed to extend for an indefinite distance downwards.

"True veins are almost universally admitted by geologists to have originated in 'faults' or dislocations caused by great dynamical agencies connected with extensive movements of the earth's crust, and for this reason they are believed to extend indefinitely downwards, an assumption which is supported by facts, since no well-developed and defined vein has ever been found entirely terminating in depth.

"Gash veins, on the other hand, as before remarked, occupying fissures which have resulted from shrinkage of the rock, cannot be expected to extend into strata of different character from that of the bed in which they originated.

"The linear extent of true veins is very various in different instances. Some of the longest known have been traced many miles; but, usually, even if they extend for so considerable a distance, they are not found to be impregnated with ore through the whole of their course."

IV.

CHARACTER OF THE DEPOSITS.

So far as they have been explored, the lead deposits of Henry county lie in approximately vertical fissures, which occur in the "Massive Limestone" division of the Upper Cambrian rocks of this district. The lead, in the form of cubic crystals of galena, sometimes accompanied by small quantities of zinc sulphide (the black blende), is held in a gangue of dense baryta. The metal is sprinkled, apparently indiscriminately, through the baryta, and the quantity varies greatly at different parts of the lode. The vein-stone is not always wholly of baryta. In some instances it is a mixture of baryta and calc. spar and some earthy, limy matter; and cases were noticed where calc. spar, in the form of large crystals, formed the larger portion of the vein.

No instance was observed where a vein showed a distinct selvage; the vein-stone was always found to completely fill the fissure, lying in direct contact with the limestone walls.

So far as my observations extend, there is always a set of fissures traversing the rocks in a nearly due north and south course. Extending from these are other cracks; but they are quite variable in their direction and extent. They are found coursing towards nearly every point of the compass, having, however, a more decided bearing towards the southeast.

The main fissures, however, do not extend in a decidedly straight line by any means. They, in fact, make many turns, proceeding in a series of offsets—in a zig-zag manner. This feature in the fissures alone goes far towards determining their origin and character.

They show, undoubtedly, that the fissures are simply the result of shrinkage cracks, such as exist in many limestones similar in composition to these; and that they were chiefly due to the same causes that produced other such cracks. Originally they had, perhaps, little more length or breadth than the lateral crevices now extending from the fissures.

It is reasonably to be presumed that the beds, varying in texture, shrank unequally, thus distributing the cracks somewhat irregularly and without connection with each other. This is a feature not at all uncommon in limestones having the composition of those in this region. It may, in fact, be noticed in the rock bed of any stream in this district, and the view presented there will give a very fair idea of the original form of what are now the lead-bearing fissures.

The widening of these shrinkage cracks, their connection with each other, thus producing one continuous fissure, and their northwardly course, is, in all probability, largely due to one cause.

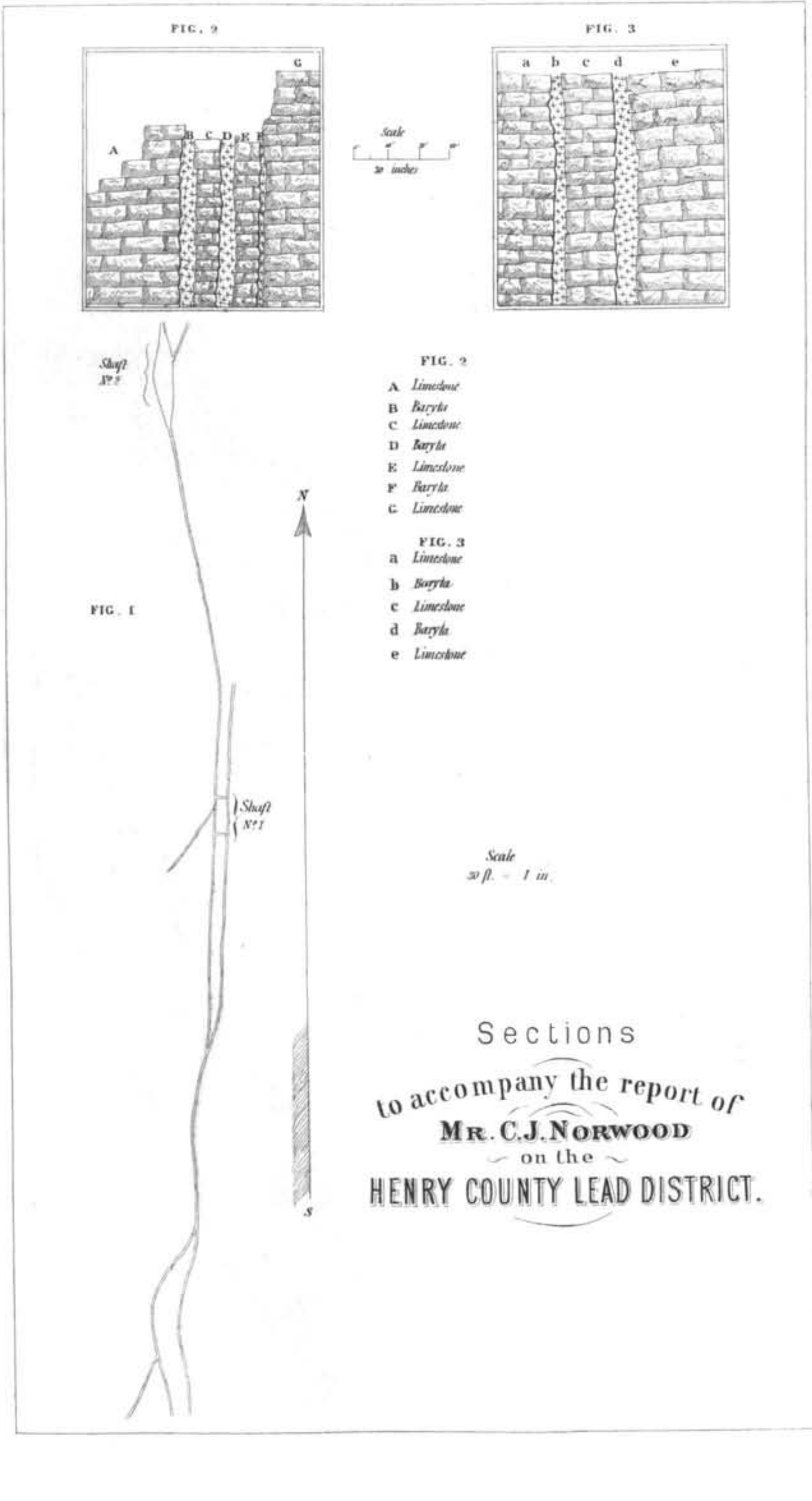


FIG. 2
A
B C D E F
G
FIG. 3
a b c d e
Scale
30 inches
Shaft No. 2
FIG. 2
A Limestone
B Baryta
C Limestone
D Baryta
E Limestone
F Baryta
G Limestone
FIG. 3
a Limestone
b Baryta
c Limestone
d Baryta
e Limestone
N
FIG. 1
Shaft No. 1
Scale
30 ft. = 1 in.
S
Sections
to accompany the report of
MR. C. J. NORWOOD
on the
HENRY COUNTY LEAD DISTRICT.

The key to the explanation is probably found in the course of the great uplift of Upper Cambrian rocks, known as the Cincinnati axis, in which the fissures occur.

This uplift has a northwardly trend, and, according to Dr. Newberry's views, the rocks seem to have been elevated quite gradually. This elevatory process, although too slow to produce any great fractures, would certainly have a tendency to disjoint the beds, and, the beds having already been fissured to a certain extent, the pressure on them would find relief in the widening and connecting together of those previously-formed cracks, thus making the irregularly trending fissures we now see.* It is not improbable that the chemical changes which were in force when the minerals now filling the fissures were brought towards them, also bore a part in their formation; but it is probable that this was a subsequent, and, we may say, locally modifying operation, the open spaces having first existed as shrinkage cracks, towards which the minerals were carried by their solvents.

To put the explanation in simpler form, we have merely to consider that the fissures are *primarily* due to shrinkage cracks (such as are common to nearly all limestones that are at all earthy in their composition), and that the force by which they were widened, and their form was, to a large degree, caused by the uplift, the rocks being so broken by the pressure as to connect the cracks, and the fissures thus caused a decided course. The angles of the broken parts would soon have been removed by friction.

If this is accepted as a correct account of the origin of the fissures, it is not difficult to understand why we find a prominent set of fissures extending to the north and south, while those to the east and west are of minor importance.

The fact is not disregarded that in some of the lodes there seem to be evidences of friction on the vein matter, striated surfaces not being uncommon in it, as if the fissures had been filled before the uplifting of the rocks began. There are, how-

* It will be seen that I do not take this view of the formation of these veins, but attribute the fissures to contraction of the rocks due to chemical changes. See preceding report.

N. S. S.

ever, a number of as equally important points which are to be considered that conflict with any supposition that the fissures were filled before the rocks were raised. Had such been the case, the vein matter would show faults and be fractured in many places, which is not found to be its condition. It must also be borne in mind that there is no reason to suppose that the beds were raised to their present position, and so remained without disturbance. On the contrary, just the opposite case is the most presumable; *i. e.*, that they have been gently elevated and lowered at more than one period. Indeed, the friction surfaces (if such they be) on the baryta gangue seem to indicate little, so far as the origin of the fissures are concerned.

The fissures are irregular in their downward as well as in their linear extent. A plummet dropped from one side of a fissure falls but a short distance before it encounters the other side.

This is not a matter of dip in the fissure, but of unevenness in the surface of the walls; descending to where the plummet first struck, and lowering it again, it strikes the opposite wall in a short distance, and so on.

These downward ziz-zags seem to be caused by the limestone lying in successive beds. With each distinct layer there is usually a decided change in the downward direction of the fissure, a condition which should be expected.

After all is summed up concerning them, the fissures seem to be simply large cracks in the rocks, differing materially from those commonly met with in massive limestones only in their size and extent, and from the very nature of their origin cannot have great depth.

Indeed, it is very presumable that when the base of the massive limestone is reached, the fissures will terminate.

As may be inferred from the above, the lead does not occur in true veins, but lies in what may be termed *gash* veins.

There seems to have been some law impelling the deposits to appropriate the fissures running a northwardly course.

This is especially the case with those veins of any considerable width.

Leaders, so to term them, frequently split off from the larger vein and penetrate the country for a short distance in various directions, the course, however, usually bearing towards the north.

In one instance a deposit of lead was visited, which, if what could be gathered concerning it is true, is enclosed between the horizontal layers of the limestone—in a matrix of baryta.

Although no more than a single instance, it, if true, demonstrates the possibility of there being more than one class of deposits in the region.

V.

ORIGIN OF THE LEAD.

Many theories have been constructed in the attempt to reach the history of veins, and explain the origin of metalliferous deposits.

Of the number, however, only three bear application, and these are (*a*) by injection from below; (*b*) by infiltration from above; and (*c*) by elimination from the enclosing rocks, which is termed lateral secretion.

By the first method only such veins as trap dikes (if they can with propriety be termed veins) were formed. The metals sometimes accompanying them, although apparently coexistent with the trap, have been shown to have been extracted from the strata enclosing the vein, and do not in any way militate against the first statement.

By the second method many of our metalliferous deposits that are the fillings of cavities, and not veins proper, have been formed. The seams of calcite and other common minerals frequently found traversing the rocks are due to such infiltrations.

By the third method the larger number of veins, especially in metamorphic rocks, have been formed.

The theory of injection was at one time held to be true, by some authors, for all true veins, and there may yet be some who accept it.

In view, however, of the contradictory conditions presented by the veins themselves, the theory has come to be abandoned by the better class of mineralogists, and that of lateral secretion adopted.

The filling of the fissures has been the result, according to their situation, either of heated vapors ascending from below permeating the strata, and carrying the minerals to the open spaces, and depositing them as veins, or by solutions from above, charged with solvents, extracting the matter from the beds through which they percolate. Water is of itself a powerful solvent, and under certain conditions that may be conceived of, this power may be greatly augmented. Many of our metalliferous accumulations are due to the solvent power of water, either terrestrial or subterranean, and not from heated vapors.

The chemical operations, however, differed of course, according to the character of the minerals acted upon; and in these chemical changes it is very presumable that a certain amount of heat was generated, which would greatly facilitate the elimination of the various minerals.

Although it has attracted the attention of scientists for many years, the chemistry of metalliferous veins is not yet thoroughly understood, though considerable light has been thrown on the subject in late years, and some system obtained from the many complications that surround them.

The lodes in this district may be regarded as the result of lateral secretion, the minerals having been gathered from the enclosing rocks.*

The lead in the lodes is frequently found clinging to the walls of the fissure; but in the greatest number of cases, where present at all, it is disseminated in cubes pretty generally throughout the baryta, being more abundant, however, in that part of the gangue lying towards the wall.

* For further discussion on this point see preceding reports.

The lead is in all cases connected with the wall, usually in a continuous line of crystals, and is the oldest mineral.

The baryta is deposited over and around the lead crystals, thus giving the ore the appearance of a conglomerate. In some cases the direct connection of the cubes seems to have been broken, and the baryta completely surrounds the crystal. These cases are quite rare, however—much more so than a casual inspection of the ore would seem to show.

A careful inspection of any of the ore will show that, although apparently distributed quite irregularly through the gangue, the lead is in strings of crystals, the cubes either touching or with but little space between them. This apparent disorder in the arrangement of the crystals is due to the way the mass happens to be fractured, and in blasting it the ore is broken in such irregular fragments that it is difficult to obtain a piece showing the proper arrangement of the metal.

In some of the ore the lead crystals seem to have been removed here and there, their place being indicated by cavities of the same form as the removed crystals.

The origin of the calcite is easily explained, being due to the action of carbonic acid on the limestones; but the origin of the baryta is not so clear. That it also was derived from the limestone seems presumable, however, from the fact that in one piece a well preserved cast of a fossil (*Zigospira modesta*) was found, which also seems to give a clue to its original source.

The relative ages of the minerals are probably to be represented thus:

$$\left.\begin{array}{l}\text{1. Lead.}\\ \text{2. Zinc.}\end{array}\right\}\text{Pyrites.}$$

3. Calc. spar.
4. Barytes.
5. Calc. spar.

Occasionally the zinc is found in the limestone.

DOWNWARD LIMIT OF THE LODES.

Accepting the theory that the source of the galena is in organic accumulations, we would not look for the metal in sand rock (in any appreciable quantity or unless placed under conditions that are not supposed to exist in this region), as it is of inorganic origin, there having been, in this case, no organic matter to have collected the metal in the first place.

We would, also, for the same reason, be suspicious of other rocks bearing little evidence of organic structure, excepting highly metamorphosed limestones, of which we have no examples in the region under discussion.

The metal as it now exists undoubtedly was derived from the strata enclosing the fissures. It may have come, in part, from higher strata, but it is believed to have had its most productive source in the massive limestones lying below, as the strata above the massive limestones are mostly made up of shale beds, in which organic matter was rare.

The lead is not, therefore, believed to be present in any considerable quantity either in the higher strata (the thin limestones and shale beds), or in the beds next below the massive limestone that are different lithologically or chemically from that limestone.

As a consequence, we may expect to find the downward limit of the galena wherever a distinct change in the character of the beds occurs.

At just what depth this will occur I have at present no means of determining. It is not unlikely, however, that the downward extent of the lode reaches to no more than 300 feet, if so much.

VI.

DESCRIPTIONS OF SPECIAL DEPOSITS.

There seem to be quite a number of lodes crossing this region. At least three, probably more, occur in Henry county, and others are found in Franklin and Owen counties. Without a finished map of the region it is impossible to precisely locate each lode.

One lode crops out in a ravine on Mr. Wallace's land, near Lockport. Two prospect shafts were opened there and sunk for about eight feet. No mining was done. The vein courses north, 3° east.

Figure 2 in plate II represents the north end of one of the shafts.

A indicates the country rock; B, a baryta vein five inches wide; C, limestone six inches wide; D, a baryta vein five inches wide; E, limestone six to nine inches wide; F, a baryta vein one and a half inches wide; G, limestone—the country rock.

It will be noticed that the vein is split into three divisions.

Figure 3 in the plate represents the south end of the same shaft.

A indicates the country rock; B, a baryta vein three inches wide; C, limestone, corresponding to the limestone C in figure 2, fifteen inches wide; D, a baryta vein five and a half inches wide.

The baryta vein indicated by D in figure 3 is a continuation of the one marked B in figure 2, and is the main vein; and the baryta indicated by B in figure 3 is a continuation of the vein which is five inches wide in figure 2.

The vein measuring one and a half inches in width is merely a small crack filled with baryta for a short distance.

The baryta is dense, and, most of it, white and somewhat granular, with Galena sparingly distributed through it.

Not much more than five per cent. of the ore seen at the pits is lead, or, in other words, one ton (2,000 pounds) of the ore will, on an average, yield about 100 pounds of metal.

In one piece of the baryta a fossil shell was found in a very fair state of preservation.

By following these veins towards the south they are found to diminish in width, and little fissures or "shoots" strike off from them. The course of the veins also becomes irregular.

Shaft No. 2 is a few yards north of the above mentioned one, and is on the same vein as that indicated by B in figure 1. This shaft is sunk in a lozenge shaped "opening" in the vein about three and a half feet wide at the widest part. The average width of the vein is about five and a half inches.

This locality furnishes a very good example for study in determining the character of the lodes in this lead region.

Figure 1 in the plate represents the ground plan, for a short distance of the lode, and gives a fair idea of the manner in which the veins progress throughout the region.

About three fourths of a mile westwardly from Lockport, near the old "still," there are signs of a digging, which, it is said, was done to procure lead. According to tradition, lead was taken from the hole; there is, however, no outcrop of the lode near by, if one does exist. Baryta, however, is to be seen on some of the fragments of limestone scattered in the vicinity. The rock abounds in *Rhynconella capax* and *Zigospira modesta*, and probably lies at the same geological level as bed No. 6 in section 1.

Another admirable illustration of the character of the lead deposits is presented on the farm of Mr. Aris James, about one mile south, 50° or 60° west of Lockport, south of Six Miles Creek.

A company from Wisconsin did considerable digging at this place, there being in all some five or six pits opened. The smallness of the returns, however, caused the work to be abandoned.

One shaft was put down to the depth of 40 feet, the width of the vein being about 20 inches at the bottom.* When the shaft was commenced the vein was only 6 inches wide near the surface, thus widening towards the bottom. It is not probable that it will increase much more in width. The course of the vein is north, about 5° east.

Figure 1 in the following plate gives the relative position the shafts have with each other. As may be observed from the position of the shafts, the course of the vein varies. It is possible, however, that some of the pits were sunk on what are merely branches of the main lode. Pit No. 4 was the only one in which any satisfactory examination could be made.

* This is in accordance with a statement made by Mr. James. When it was visited the pit was not in a condition suitable for examination.

Figures 2 and 3 of the accompanying plate exhibit views of the north and south ends of it. In figure 2, A is the limestone wall; B, 1½ to 2 inches of baryta, thinning out towards the top; C, limestone limiting the upward extension of the baryta in the limestone E; D, ¼ inch of baryta; F, the main baryta vein, which is alternately 3 inches and 4½ inches in width towards the bottom, but thinning to 3 inches at the top; G, limestone extending downwards for 15 inches and then wedging out.

In figure 3 the vein occupies the northwest corner of the pit (as indicated by *a*), and is from 3 to 5 inches wide. The limestone (2) has vertical cracks in it, as shown in the figure, but they seem to be destitute of baryta. On the extreme east (*b*) a thin thread of baryta follows the wall from the south. The vein here courses nearly due north and south. Scarcely any galena was seen in the baryta at these diggings.

This lode is distinct from the one seen at Lockport; and, as a matter of convenience, may be designated as the *James Lode.*

On Mrs. Fanny Wait's farm, about two miles above the mouth of Flat Creek, in Franklin county, some search for lead has been made. A lode certainly crosses the property; but the width could not be determined, as loose soil covered it.

Fragments of baryta holding lead were found over a considerable linear distance, the course of the line along which they were found bearing about north.

Mr. Wait states that one piece of ore, very fully charged with galena, was picked up on the property about 15 years ago and weighed about 100 pounds.

On Alexander Hardin's place, at Drennon Lick, a prospect pit has been opened and sunk down for a few feet and some ore obtained. From all that could be gathered concerning the place, it seems that the ore occurred as a sheet of baryta, 2 feet thick, extending in a plane parallel with the bedding of the limestone, and not as a vertical vein. It is possible, however (and I may say even probable), that there is some misunderstanding about the place, as my informant did not seem to have a clear knowledge of the matter himself, and water in the pit prevented the making of a personal examination.

Very little galena was seen in the ore piled near the pit, and it does not seem probable that the locality will ever prove of much importance in a mining point of view. The limestone is coarse in texture, of a dark bluish grey color, and contains *Strophomena alternata*, *Zigospira modesta*, and a shell resembling *Rhynconella capax*.

Mr. Alexander Hardin and Mr. Samuel Herl opened the pit in the spring of 1874.

On Mrs. Eliza Ann Green's place, about 2½ miles below Franklinton, towards Drennon Lick, and 8 miles below Lockport, there are signs of a former digging for lead. It was done about 60 years ago, however, and little is known concerning the place at this day.

Fragments of coarse limestone, apparently the debris resulting from sinking the pit, were found. They were abundantly filled with *Orthis lynx*, and also contained *Zigospira modesta*, and an *Orthoceras*. No ore was seen.

THE "SILVER AND SPAR MINES." *

These mines, as stated on a preceding page, are the only ones, properly designated as such, in the county. They are apparently on the same lode as that which crops out at Lockport. They are, for the most part, open to daylight, consisting of two open ditches. One is about 50 feet deep at its deepest part, and follows the lode in a north and south direction for about four hundred yards. The other, which was intended to simply test the lode, extends into the hill for about 70 feet. Part of the ditch in which mining was in progress has been covered (for the better security of the miners), thus making it to resemble a tunnel.

* Examined May 20, 1875. I am indebted to W. H. Leatherman, Mine Superintendent, for all information that could not be obtained by personal observation.

A shaft was sunk down 50 feet below the present level of the gangway (May 20, 1875), which is about 50 feet below the surface where the initial digging was done, thus making one hundred (100) feet as the total depth to which the lode was followed.

The general character and texture of the lode, as seen in the shaft, was not to be distinguished from that in the ditch.

Mr. Leatherman states that it would "sometimes almost disappear, and then form an 'opening' or come into a pocket, and then again assume its usual width."

The lode is worked by underhand stoping. The ore was reached at about 18 inches from the surface, and continued to fill the crevice all the way down.

The richest ore, according to the statement of W. H. Leatherman, was obtained in the first 10 or 15 feet of descent of the lode.

The vein averages about 15 inches in width, which varies from 12 to 18 inches. Occasionally the vein is quite thin, but there are also places where it is 2 feet wide.

The gangue is usually massive baryta, white, and quite dense in texture; but some parts are made up of calc. spar, baryta, and a little fluor.

The galena is distributed through the vein-stone in cubes ranging from the size of a small pea or mere specks to those measuring a quarter of an inch or a little more in diameter, and generally extends through the baryta as a string of crystals.

A little zinc sulphide is mingled with the lead and spar, but the amount is small.

The baryta frequently fills narrow cracks (so-called feeders) extending from the main fissure which holds the lode. It also makes irregular seams in the limestone.

The average yield of lead is estimated to be about 10 or 11 per cent. of the ore.

The following is a statement of a section of the beds at the working place:

1. Thin-bedded limestone and shales. The limestone is usually dark grey. Many of the beds are abundantly filled with *Orthis testudinaria?* and *Zigospira modesta.* Others contain large numbers of *Bellerophons*, *Murchisoniæ*, *Pleurotomariæ*, and a few corals . . . . 8 feet.
2. Dark-grey limestone passing into dark-bluish grey and then blue limestone. Occurs in beds divided by shale. The shale contains great numbers of corals, but of only one or two species. Occasional masses of baryta, probably connected with the vein below, are seen . . . . 12 "
3. Heavy-bedded bluish-grey limestone. Fossils are found in the upper 10 to 15 feet, including *Rhynconella capax*, *Zigospira modesta* and *Orthoceras*, etc. . . . 50 "

At the north end of the ditch, where it terminates, there is a swell in the thickness of the baryta, the vein being 2 feet wide. This is local.

Figure 1 in the accompanying plate represents the course of the vein for 75 feet at the north end of the ditch.

At the north end crystals of baryta are frequently found lying next to each wall, the body of the vein, however, being dense, massive, white baryta. The crystals, however, are usually irregularly placed and frequently are in lumpy masses attached to the massive spar; apparently showing that part of the vein has been dissolved, and then assumed the crystalline form when precipitated.

Figure 2 in the accompanying plate represents a portion of the vein, showing one of its crooks, with a short vein of baryta in the space left by the elbow, and nearly in line with the lode.

At the test ditch the width of the lode does not seem to be more than 5 or 6 inches, and the baryta splits and seems to pursue two fissures, the limestone between, however, usually being of small thickness.

The sides of the wall where the baryta rests are rough and lumpy, having about the same degree of smoothness that water would produce by flowing through the fissure for a time.

Instances were noted where the baryta extends into horizontal cracks or divisions of the limestone. It was also noticed that the lode is frequently split vertically into two, three, or more divisions, the surfaces of the sundered parts having a smooth, slightly grooved appearance, somewhat resembling slickensides. The limestone walls occasionally seem to show the same feature, but a close inspection determines the effect to be due to a thin film of baryta coating the rock.

The following is a section of the beds at this place:

1.	Limestone in thin beds with shale partings	5 feet.
2.	Bluish-grey limestone in thin beds, with partings of shale. Some of the upper beds abound in *Murchisoniæ* and *Bellerophons*. A little calc. spar and baryta occur in the irregular cracks in the beds; they do not, however, seem to be in any way connected with the vein-matter below	8 "
3.	Blue shale holding a little calc. spar and baryta, which, however, are not in direct connection with the body of the lode. This seems to be the stratum limiting the upward extension of the lode	2 "
4.	Bluish-grey massive limestone, carrying the lead lode	12 "

At the time when these mines were visited, the following gentlemen composed the board of directors: Mr. W. H. Merriwether, President; Mr. Wm. F. Bullock, jr., Secretary and General Manager,* and Messrs. George Ainsley, James Folsen, and James Loomis, with W. H. Leatherman as the Mine Superintendent.

Not much mining was doing at the time, and neither the smelter nor crushing mill was in operation.

The furnace is built on the reverberatory plan, and is quite defective in its construction; it is undoubtedly true that an amount of lead is lost in smelting which would be saved by a properly constructed furnace.

The pigs turned out are of two sizes, weighing 80 and 120 pounds respectively. The day yield of the smelter could not be ascertained. The capacity of the crushing mill is about 20 tons daily. The amount of ore which it is possible for a single miner to raise in a day has been estimated as being half a ton, or (at 10 per cent. of lead) about 100 pounds of lead. It seems probable, however, that this is too large, or that the yield of lead is placed at too high a per centage, as the conditions observed at the mines and the history of the mining do not indicate such returns.

These mines, as an experiment, have been about as complete in their operations as it seems desirable should be tried on the lead deposits of this county, and the result has been, to say the least, not encouraging.

*Mr. Bullock died at the mines May 21st, 1875.

The conditions are as favorable here for testing the richness of the ore and value of the deposits generally as are to be found at any point in the region, and they do not seem to indicate that much profit will result from any further prosecution of the work in the county.

At Michael McAlester's, about one half of a mile east of the Silver and Spar Mines, a shaft was sunk down for 21 feet on a lode running parallel with that at the mines. Water nearly filled the pit. The vein was said to be 7 inches wide; a width of 4 inches could be distinguished at the top. But little lead was noticeable in the baryta.

At Mr. Patterson's, on the bank of the Kentucky river, near "Little Mountain," is a place reported to afford lead ore. An examination of the place, however, failed to verify the report. It seems to have arisen from the fact that the rocks contain vertical seams of aragonite (a form of carbonate of lime). It is possible, of course, that the precise spot indicated by the report was not found; but this does not seem probable. The section of the beds here has been given on a preceding page.

TWIN CREEK MINES.*

At Hunter's Mill, in Owen county, two shafts have been sunk on a lode which varies in width from 12 to 16 inches. The position that the lode holds relatively to those examined in Henry county could not well be determined, as no good map of the country was at hand, and it was not considered necessary to trace the lodes out in detail.

Each shaft was filled with water, and could not be descended for the purpose of making examinations. But a fair view of part of the vein was obtained in a shallow pit dug on the bank of Twin Creek near by. The vein-stone is baryta, having occasional masses of calcite through it, and is rather fully charged with galena. The lead is not altogether confined to the baryta, but in places clings to the country. Short fissures extending from the main one are filled with the same material as that composing the lode. Only a small part of the vein is shown

*Examined May 25th, 1875.

at this opening. The deepest shaft is said to reach to 76 feet. At 54 feet down the vein is said to have measured 22 inches.

In the new shaft, what was supposed to be another vein 2 inches wide, was observed at 3 feet from the main one; this, however, is probably merely a shoot from the larger one.

Digging was commenced at this place, if my information is correct, in 1867. In 1869 a simple log furnace was erected, and, for such means, considerable lead was run out. The returns from the smelter were estimated at 33 per cent. This, however, indicates an ore much richer than the actual conditions seem to justify.

So far as would be indicated by the small part of the vein seen, the deposit appears to be workable for a limited time. It must be borne in mind, however, that these surface indications are frequently deceptive; for, as hitherto stated, the lead is frequently bunched in the lode, lying rather compact in the baryta for a certain distance, both vertically and horizontally (the ore yielding as high as 60 per cent. of lead), while again the lode will be quite lean for a distance exceeding that of the rich portion.

A very interesting analysis of a piece of the baryta follows:*

Sulphate of baryta	80.31
" strontia	17.05
" lime	.34
Oxide of iron	.15
Silica	.29
Loss, etc.	1.86
Total	100.00

Mr. Peter remarks, concerning the analysis: "The strontia sulphate may be a little too high, at the expense of the lime sulphate." Opportunity was not given him to repeat the analysis. The per centage of strontia is quite high.

It may be remarked, in conclusion, concerning this lead region, that the inducements offered by it for mining are

*Made by Mr. Alfred M. Peter, in the chemical laboratory of the Survey.

undoubtedly, to a large degree, fictitious. It is true that the lodes have been exploited only to a comparatively small extent, but the work has been sufficient to demonstrate the unlikelihood of any profit being gained by prosecuting it further. The character of the deposits do not justify the belief that the ore will become richer as the lode descends, and even should such be the case, its downward extent, being limited, would not justify the expense necessary to carry on the plan of mining required.

There may come a time when such deposits as these may be worked with profit, but at present that day seems in the distance.

In consideration of the baryta, which is so largely used now for the adulteration of white lead, it is possible that a white lead works might be located here with a chance for profit;* but any mining for the lead alone will be apt to prove disastrous.

*I understand that this has been done at one of the mines in Fayette county.

GEOLOGICAL SURVEY OF KENTUCKY.

N. S. SHALER, DIRECTOR.

ON THE ORIGIN

OF

THE GALENA DEPOSITS

OF THE

UPPER CAMBRIAN ROCKS OF KENTUCKY,

BY N. S. SHALER.

PART VIII. VOL. II. SECOND SERIES.

ON THE ORIGIN OF THE GALENA DEPOSITS OF THE UPPER CAMBRIAN ROCKS OF KENTUCKY.

The deposits of galena in the Cambrian district of the State differ in some important regards from those which have been observed in the sub-carboniferous limestone, although there is in both cases a general agreement in the circumstances of occurrence. In both cases these deposits are limited to true fissure veins of a peculiar type. In both regions they occur in limestones only, and are not observed in the overlying silicious and argillaceous rocks. The associated minerals in both cases are substantially the same, though differing in their proportions and general appearance. We are driven by the facts to the conclusion that all these veins have been formed by infiltration of water charged with the substances that form the vein matter, the cavity of the vein having been first developed by a movement of the rocks in which it is found. There are, however, differences of character between the galena veins of the Livingston district and those of Central Kentucky that compel us to make a strong line between them. As is shown by the report of Mr. Norwood (see reports Kentucky Geological Survey, first volume, new series), the veins in the Livingston district very often give indications of abrupt faulting, and, in some cases at least, of several successive vertical disturbances acting in the same spot. There seems to have been a good deal of irregularly acting dislocating force in this region, which did not result in the formation of distinct mountain curves, but expended itself in the numerous sharp breaks that have disturbed all this district.

I am inclined to attribute many of these veins of the Livingston district to this faulting action, combined with the shrinking of the whole rock system from the loss of heat and other changes.* The result was the formation of fissures of possibly great depth, the walls of which gaped apart, remaining perhaps closed near the surface, where there was perhaps only a small contraction, or, possibly, none at all. The next stage of the process seems to have been the infiltration of waters charged with carbonate of lead in solution, and its deposit by crystallizing action within these cavities. Subsequent changes brought about still further movements of the same character as those that formed the cavity at first, and through them the original deposits were often curiously broke up and mingled with other materials.

In the Cambrian district, particularly in Henry county, the tendency to faulting seems to have been much less than in the western field. All the crevices I have seen do not show any distinct vertical movement of the wall rocks, but seem to have been formed by lateral dislocation alone. It is not easy to determine the causes of this shrinkage in the mass of rock throughout this region, but the evidence of its occurrence is tolerably clear at all points. It is manifested in every line of the section by the breakage of the mass of rock into vertical crevices, which have become to a greater or less extent filled with clay and other substances. At some points these crevices indicate a reduction of at least one fifteenth of the horizontal dimensions of the rock mass. Generally these shrinkage

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*I am inclined to think that the general absence of mineral deposits in all the well-defined faults which I have seen in Kentucky is strong presumption against the occurrence of extensive mineral deposits in such breaks within this Commonwealth. The Pine Mountain fault, one of the most extensive and readily observable in the whole Appalachian district, has not yet given a trace of metallic deposits. The same is the case with the Kentucky River faults. In the case of the lode near Smithland, Livingston county, that on which the Royall mines are situated, there seems good evidence of a fault. With this evidence from other fissures, I should feel it necessary to examine with care for evidence as to the time of formation of the fault itself as distinguished from the vein stuff. These deep-reaching contraction fissures naturally form lines of weakness, along which faults would propagate themselves in case the rocks were submitted to a breaking strain tending to form such disruptions. In the case of the Royall mines and other openings on the fissure just referred to, this question would have little practical value, inasmuch as the vein stone at that point may be reasonably expected to extend quite through the Waverly rock, as well as the sub-carboniferous limestone, on account of the calcareous character of the former rock in its western extension.

Without taking up the history of these dislocations of Kentucky in detail—a matter which will be reserved for use of the special memoirs on the geology of the State—it may be worth while to say that all the facts as yet collected point to the conclusion that all the faults, in Eastern Kentucky at least, are of a comparative recent origin, probably dating from a time long after the action of the forces concerned in making the deposits in the galena veins.

cracks extend only through a foot or two of the beds in a continuous way, the different beds yielding at different points, so that nothing like a continuous crevice is found. On the other hand, from point to point, we have these continuous deep-reaching fractures with separation of the walls, which to my mind are certain indications of a contraction that has extended through a great thickness of beds, and differs only in the magnitude of its action from the small crevices so abundantly found throughout the rocks.

The deep-reaching crevices of considerable width seem most abundant where the small open joints are rare. In Campbell and the adjoining counties, where the limestone abounds in these open joints, I have never found an ore-bearing crevice; while in the counties within the Cambrian district, along the Kentucky river, where the rock is peculiarly free from small joints, these wide ore-bearing fissures are frequently found. We may, therefore, reasonably conclude that both these forms of fissuring are due to the same contraction of mass, and that some local conditions, possibly the difference in the massiveness of the beds, determine which shall be the type formed in any particular region.

The cleanness of these fractures, and the absence of all evidence of violence, is to my mind sufficient evidence that these fractures have not been attended by any wide-reaching movements. The fossil shells on the rock are often cut in two with perfect neatness, their broken edges being not in the least shattered or rubbed as they would have been had there been any such collision of the sides as is sure to occur where there has been true faulting. This is not the place for an exhaustive inquiry into the nature of the forces that have brought about this change in mass; but some idea of the nature of the forces involved is necessary to the comprehension of the condition under which the vein-stones that fill them have been formed.

There can be no doubt that this region was once buried under several thousand feet of strata, which have been worn away during the time since the emergence of the region from the sea. During the time these beds lay deep buried there was an accession of heat which may well have amounted to several hundred degrees of Farenheit. This expansion must have done much to pack the rocks together, and to bring about chemical changes attended by a loss of volume. When, therefore, the continued loss of heat, caused by the wearing away of the old rock covering, had greatly lowered the temperature, the tendency of the rock to contraction would be considerable. As against pressure rocks are tolerably elastic, but to tension they are much less so, and rend apart easily under its action; so that any considerable loss of heat would not be required in order to account for these deep-reaching rifts. A change of not over one hundred degrees Farenheit would be sufficient to cause the formation of a considerable number of rifts, probably as many as occur in this region.

The possibilities are that these rifts began to form with the first considerable decrease of temperature, and increased in width as time went on and cooling advanced. As will be seen from the figures in Mr. Norwood's report, there is a very general tendency of these veins to be grouped in the shape of two or three gashes placed near to each other. The immediate partitions are often thin walls, yet undisturbed by any violent movements. This affords another evidence of the tranquil nature of the movements involved in their production. It will also be seen that there is no evidence whatever of a vertical movement of the rocks on either side of the fissure. The beds lie at equal heights in both walls, and every feature of fault veins is quite wanting. We are therefore compelled to hold to the opinion that these veins are the product of shrinkage of the rocks.

Having now briefly discussed the formation of the fissures in which these deposits occur, it remains for us to examine the methods of accumulation of the deposits contained within them. This inquiry, though touching on the domain of abstract theory concerning the genesis of such veins, is necessary to any proper understanding of their character, and of the prospects of their downward extension.

The old view that attributed the formation of mineral veins to the ejection from a reservoir of molten matter of mineral substances, which penetrated along the passages leading towards the surface, has been quite abandoned as a usual explanation to be assigned to such phenomena. In its place has grown up the conviction that most veins are formed in essentially the same fashion as is the stalactitic material that accumulates in caverns, viz: by the deposition of matter dissolved by water in one part of its course through the crust of the earth and laid down at another.

The belief of metallurgists and others who have most studied the history of metals is, that the original condition of those substances was that of extensive dissemination, and that this local accumulation has been the result of actions that have come about in the changes of temperature, &c., taking place since the deposition of the beds containing the deposit.

Until within a few years this opinion, very general in its outlines, has been the accepted view as to the origin of metallic deposits. It will be seen that it is imperfect, in that it does not sufficiently explain the curious limitation of certain species of metals to certain geological formations.

In 1862 a decided advance towards a clearer theory was made in the report of J. D. Whitney on the lead district of Wisconsin, in which the ground was distinctly taken that the process of formation of mineral veins went on in something like the following manner, viz: First, the dissolving out from the rocks of the earth of the mineral substances which were originally widely distributed therein, and their transportation to the waters of the sea. Second, the precipitation of these materials by the action of the decaying organic life on the sea floor, which, as we know, is capable of effecting such work. Third, the concentration of these materials through the action of the various processes that build up the veins. The following extract from the work of Prof. Whitney will serve to show the fashion in which this was suggested by him. On account of the close general resemblance of the geological condition of the upper Mississippi lead region to the Kentucky lead district, I have, by permission of the author, made extensive extracts from his report.*

These important suggestions remained practically unconsidered and without addition until many years after their publication. In a course of unpublished lectures given by Professor Raphael Pumpelly at Harvard University in 1869–'70, the idea of the cöoperation of the secretive power of organic life in the series of actions leading to the formation of mineral veins was suggested and extensively discussed, though from a somewhat different point of view. For the first time the capacity of organic species to separate metals from the sea water and build them into their structure was publicly suggested as a means whereby the fixing of metals in strata could be brought about. In this process of concentration Professor Pumpelly gave great weight to the action of marine currents in accumulating masses of sea weeds and other organic substances on particular parts of the sea floor, and so leading to deposits in great part made up of the remains of animals which might contain some one metal in considerable quantities. By permission of Professor Pumpelly this lecture is published in the second appendix to this report.

In 1870 Dr. T. Sterry Hunt brought the matter to the notice of geologists in an extended discussion of the action of organic life in the localization of mineral substances. We seem to have here, as in many other cases in the process of scientific progress, the coincident and independent discovery of a series of facts by two observers, each working in ignorance of the other's researches. The first public announcement of this discovery was made by Professor Pumpelly; but priority, as determined by actual publication, is clearly to be awarded to Dr. Hunt.

The researches that have been made into the composition of sea water and of sea weeds has gone far to support this hypothesis as to the function of marine organic life in the

*See Appendix No. I, taken from a "Report of a Geological Survey of the Upper Mississippi Lead Region, by J. D. Whitney, Albany, N. Y., 1862."

making of mineral deposits. There can be no reasonable doubt that all the substances which have been detected by chemists have their place in the universal solution of the sea. The presence of silver, gold, copper, and other metals in the sea water is evident on a concentration of its contents. Some of these substances exist in considerable quantities. The assertion even been made that the silver of the sea will amalgamate with the copper employed in sheathing ships, so that old copper long exposed to the moving sea may be worked for its silver won from the water. The idea prevails that this separation of silver by the copper takes place more rapidly on the west shore of South America than in any other region.

The researches of Forchhamer and others on the composition of marine invertebrate animals and plants long ago showed that there is a considerable amount of metallic substances laid up in the structure of marine forms, which, on their death and decay, would be laid down with the accumulating sediments of the sea floor. It is my impression, as above remarked, that this important function of organic life in the production of mineral deposits was first suggested by Professor Pumpelly in his lectures above referred to, of which no printed report was ever made. It is important to notice, however, that, as long ago as 1858, Dr. T. Sterry Hunt began a series of investigations as to the action of organic life in the deposition of various substances, such as carbonate and phosphate of lime, &c., which had been built into their structures, that led naturally to the inquiry into the important action of marine life in the deposition of metallic substances. A discussion of this important hypothesis will be found in the assembled papers of Dr. Hunt.*

It does not come within the province of this report to attempt an exhaustive inquiry into this question of the origin of these lead deposits of the upper Cambrian. From the suggestions already given, it will be seen that this balance of opinion among the best informed chemists and metallurgists inclines to the conclusion that organic life is closely concerned

*See Appendix No. III at the end of this report.

in the localization of the metallic deposits, at least in the little changed rocks, such as compose all our Kentucky formations, and that in this work the action takes place in two ways: *Firstly*, by the taking into the organic structure of the metallic substances which pass into the sea bottom on its decay. *Secondly*, by the effect of the gases, particularly the sulphuretted hydrogen, released by decay, in precipitating the metallic substances dissolved in the sea. The practical operation of these processes is somewhat as follows: The fixed, and to a certain extent the swimming, animals of the sea, taking this or that substance in their growth, deliver it up at their death to certain tracts of the ocean bottom, and in their decay take continually more of these substances into imprisonment in the accumulating sediment.

As this power of separating metallic substances varies in different species, it therefore differs in different sections of the ocean floor and in different periods in the earth's history. If this theory be true, then, other things being equal, we should expect to find that those formations which indicate the existence of abundant organic life on the sea floor where they are being deposited would be the most likely to furnish considerable quantities of metals. Such, in fact, we find to be the case wherever these deposits have been worked under similar conditions to those existing in the region we are now considering. The evidence cannot be safely regarded as affording a basis for definite and final assertion; but there can be no reasonable doubt that, in going downwards into rocks containing little evidence of organic life, we have reason to fear that we shall pass out of the richest part of a galena vein and into leaner territory. Some of the metal derived from the rock where it was deposited will, doubtless, often work downwards into the fissure when it runs in sandstones or other rocks where life has never been abundant. But this must be, in a good degree, accidental, as the deposit generally takes place at the point where the metal-charged waters oozed through the walls of the fissure. There is little reason to suppose that there could be more of the metallic substance in the sandstone or shale beds than in the limestone beds. Another reason to fear the unprofitable nature of galena veins in sandstone beds would be from the contraction of the fissure, owing to the change of rock. We have seen that the most of the veins found in Kentucky are the product of contraction or shrinkage taking place in the stratified rocks. This form of vein is always characterized by very variable width, and is likely to widen in the limestones and to contract in sandstones and shales.

The general character of the deposits of ore in the mineral veins of Kentucky may be the better understood when we consider some of the facts of distribution of these veins. The blue or Cambrian limestone abounds in these veins, especially in its upper part, where the organic life has left abundant fossil record of its existence. The equivalents of the Niagara series, rather carboniferous, have little trace of lead. The black or Ohio shale is almost without mineral beds of any importance; the same may be said of the Waverly series in Eastern Kentucky, where we find sandstones and argillaceous limestones rarely penetrated with lead-bearing rocks. When, however, we come up to the sub-carboniferous limestone, then, again, we find the lead-bearing veins in great abundance. Now when, as in Central Kentucky, we follow the line over which the carboniferous limestone has retreated, we are struck with the fact that, where it has been worn away from the lower lying beds, the Waverly and black or Ohio shale, these beds from which the carboniferous limestone has been stripped away, are characterized by the want of mineral veins, as above set forth. We have no reason to doubt that the limestone that once overlaid these beds was as well marked by its mineral veins as are the areas which still exist. We are, therefore, led to believe that these veins we find in the sub-carboniferous limestone do not extend into the subjacent sandstones and shales. It should, however, be distinctly noticed that this difference depends not upon the geological position of the rock, but on its mineralogical character; and that where, as in Western Kentucky, the Waverly series takes on in the sandstone or shale beds than in the limestone beds. Another reason to fear the unprofitable nature of galena veins in sandstone beds would be from the contraction of the fissure, owing to the change of rock. We have seen that the most of the veins found in Kentucky are the product of contraction or shrinkage taking place in the stratified rocks. This form of vein is always characterized by very variable width, and is likely to widen in the limestones and to contract in sandstones and shales.

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The following figure will show, in a diagrammatic way, the apparent condition of the Kentucky series of rocks. It should be understood that this figure is intended as an illustration of an opinion rather than as a graphic representation of the facts:

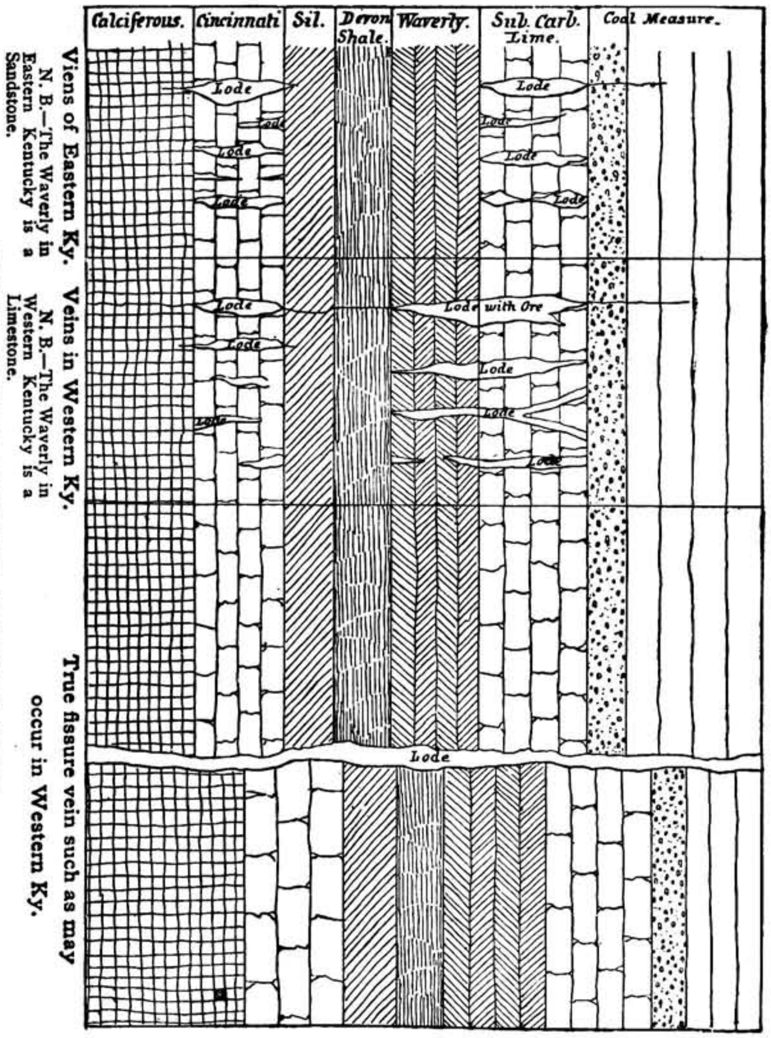


DIAGRAM SHOWING RELATIONS OF MINERAL VEINS

It will be noticed that this diagram indicates generally vertical fissures with tolerably regular walls, all clearly the work of a contraction of the mass. On examining Professor Whitney's work, "The Lead Region of the Upper Missouri," it will be seen that there have been extensive deposits of the lead and associated substances in ordinary caverns in that region—a large part of the workable deposits coming from beds that have been formed in caverns rather than as fissures. Possibly some of the lead deposits of Western Kentucky, occurring in the carboniferous limestones, may also be regarded as occupying caverns rather than fissures; but at this time I am quite convinced that the evidence is rather against this view and in favor of the theory that this class of deposits has never, in this region, been found in caverns excavated by water. I have carefully observed many such underground channels, both in the Cambrian and Sub-carboniferous limestones, with a view to ascertaining whether any such deposit is now going on, with the definite result that not a trace of such action is observable at the present time. I am satisfied that the uppermost caves in Kentucky date back at least a million of years,* and that they were probably in existence during the middle Tertiary period; yet in none of them is there the least trace of the deposition of lead. It seems to me that this fact clearly proves that the formation of these veins is most explicable by the supposition that they were segregated while the rocks were subjected to conditions of heat that do not now exist in them. At the same time it must be said that their mechanical condition forbids the supposition that they have ever been subjected to any very high temperature.

To sum up in brief the general condition of our Kentucky vein metals, we may make the following propositions, viz:

1st. That the fissures or veins in which they occur have generally been formed by the shrinkage of the rocks in which they are found, and not by the deeper-seated causes which form fault veins.

*See Antiquity of the Caverns and Cavern Life of the Ohio Valley, Memoirs Kentucky Geological Survey, volume I, part I, 1876.

2d. That these fissures, dependent for their origin on the peculiarities of constitution of particular beds, cannot safely be expected to continue indefinitely downwards below the level of the beds in which they are seen.

3d. That the absence of metallic veins in the sandstones that were originally overlaid by limestones, which limestones are vein-bearing, is a corroboration of the view that these veins are limited to the limestone rocks.

4th. That the general presence of metalliferous veins in the limestones of the State, and their general if not universal absence in the sandstones, is a strong proof of the truth of the theory that assigns to organic life the function of separating these metals from the sea and laying them down in the stratified rocks.

5th. That the cycle of change of metals, as, indeed, of all substances, is as follows: Dissolved from the earth by the water, which is aided in its work by its contained gases and heat, they find their way to the sea; then the organisms living in the waters or on the bottom, select the substances according to their peculiar organic laws; built into the growing deposits of the sea bottom, they become part of the earth's crust, and come again within the action of those forces that work them into their concentrated state, or, mayhap, wash them again into the sea, and so repeat the eternal circle.

In the appendix to this report I have, by permission of the authors, reprinted extracts from the writings of Professors J. D. Whitney and Raphael Pumpelly and Dr. T. Sterry Hunt, thus bringing together all the important contributions known to me that bear on this question.

The reader is requested to bear in mind that the views above suggested, though they seem to satisfy the facts better than is usually the case in geological theories, must not be taken as matters of final demonstration. There can be no doubt that the balance of probabilities is greatly in their favor, and that they may fairly be made the basis of a judgment by those who seek even the least light where else would be only darkness.

With reference to the economic bearing of these conclusions above set forth, little needs be said. The economic side of the problem is not greatly affected thereby, save in the conclusion that few of our lead deposits, if any, may reasonably be expected to be continuous to great depths or to improve in descending. The reports of Dr. Peter make it plain that all our lead ores are singularly poor in silver; in no case has enough been found to warrant extraction. With careful mining some of the lodes will possibly pay for working; but there can be no doubt that at least half a dozen other sources of mineral wealth within the State promise a better return for capital and enterprise. Already there has been a large amount of money expended in the opening of lead ores in the State; probably not less than half a million dollars has been spent in such workings. Very little lead has been marketed. I doubt whether four hundred tons have ever been obtained from all the workings put together, and but two or three openings can now be said to be promising in their appearance. I feel, therefore, compelled to say, that however single ventures may turn out, the prospect of the industry to the Commonwealth is by no means good.

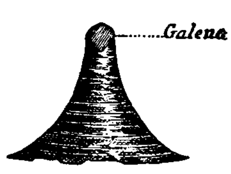
APPENDIX I.

[From a Report on the Upper Mississippi Lead Region by Professor J. D. Whitney, reprinted by permission of the Author.]

"In view of all these facts, we consider it as a matter settled beyond all possibility of doubt, that the lead deposits of the Northwest must have been introduced into the fissures from above, and by precipitation from a solution. In reference to this last clause, we have not thought it necessary to adduce any evidence to disprove the theory of the igneous origin of the ore, or of its having been brought up from below, either by sublimation, or by actual injection. Since, however, both of these ideas have been maintained by different persons writing on the region, although every fact seems to be entirely opposed to any hypothesis of igneous action, it may be proper to sum up as concisely as possible the evidence in favor of aqueous deposition.

"1st. The generally recognized aqueous origin of the sulphurets: deposits of sulphurets of iron and other metals are frequently produced accidentally or intentionally in the chemist's laboratory, by the decomposition of solutions containing the metals by sulphuretted hydrogen.

"2d. The occurrence of the sulphurets of lead and iron in the lead region, in forms which they could not have assumed, except as deposited from a solution—as in the form of casts of fossils, and in connection with stalactites and stalagmitic masses of calcite. An instance of this kind is to be seen in the Wheatley collection at Union College, and is shown in the annexed wood-cut, which represents a large stalagmite, with a small mass of galena on the end of it, in a position which it would be difficult to imagine it to have reached, except in solution, dropping from above, exactly as the rest of the stalagmite was formed. Instances have been mentioned



Stalagmite with Galena

to me by the miners (I have not met with such myself) of stalagmites made up of alternating layers of galena and calc. spar. The replacement of organic forms by galena is not infrequent, and that by pyrites is very common; blende has never been met with in this relation, so far as is known.

"3d. The impossibility, absolute and entire, of the introduction of the ore into the crevices from below, either as a molten mass or in the form of a sublimate: this point has been already sufficiently insisted on. It is inconceivable that any one at all familiar with chemistry, or mining geology, should have ever imagined the possibility of the igneous origin of these ores.

"If, then, we inquire by what agent the sulphuretted combinations of the metals now found so abundantly disseminated through the lead region could have been deposited in their present position, we need not look far for an answer, since there is but one agent capable of effecting it, namely sulphuretted hydrogen gas. This decomposes nearly all metallic solutions, and precipitates the metals in the form of sulphurets, provided the resulting sulphuret is one insoluble in the medium in which the decomposition takes place. If, then, the metals zinc, lead, and iron were present, in solution, in the oceanic waters at the time of the deposition of the lead-bearing strata, or if the strata became impregnated with these metallic substances, by the infiltration of waters charged with their salts through them, then all that would be needed to produce a deposition of the sulphurets would be a source of sulphuretted hydrogen gas, slowly disengaged in or beneath the rocks permeated by the metalliferous solutions.

"That the oceanic waters were highly impregnated with metalliferous salts during the early geological periods seems not improbable, from the fact that the lower formations are those which contain the largest deposits of ores: these are found both in the unaltered sedimentary rocks, and in those which have undergone metamorphism. The palæozoic strata, and especially the Lower Silurian groups, all over the world, are emphatically the great store-houses of the metals. The azoic rocks, on the contrary, are poor in ores, with the exception of such as have been introduced into them by direct igneous or intrusive action. Thus, in this country, for instance, the lowest series of strata, or those deposited, so far as the evidence goes, before the appearance of organic life on the globe, are but scantily supplied with any of the metals except iron, which occurs in this geological position in the oxidized form, and in mountain masses. The Lower Silurian rocks, on the other hand, either in their unaltered state, as at the West, or as metamorphosed in the Atlantic States, are the seat of active mining operations for a variety of metals.

"It will be argued, of course, that, the crust of the earth being thinner during the earliest geological periods, thermal springs conveying metalliferous solutions could more easily have found their way to the surface in regions broken up by faults and dykes, so that the abundance of ore deposits would be due rather to the facility of access from below, than to the pre-existing condition of the oceanic waters above. But in regions like those of the Mississippi Valley, where there are no dykes or intrusive masses of igneous matter, and where the formations have been so slightly disturbed, since their deposition, as to make it exceedingly improbable that the ores they contain could have been introduced from below, we are driven to the necessity of presupposing their existence in the oceanic waters, either during the deposition of the metalliferous formation, or after it had taken place.

"That the appearance of the first considerable deposits of metalliferous ores in the Northwest should be closely connected with the introduction of animal life in profusion in that region, seems an important fact, which should be carefully considered in this connection. In all the thick mass of the Potsdam sandstone, from 300 to 500 feet in vertical development, there are nothing more than the merest traces of ores, and none of lead or zinc, so far as known. The insignificant deposits of iron and copper in this sandstone are exclusively in the oxidized form. In the Lower Magnesian limestone, which is next above, and whose lithological character is in every respect as favorable for the deposition and retention of metalliferous substances as is that of the lead-bearing rock above, we have only a few irregular deposits of galena, in the upper part of the formation, so that there is a thickness of 600 to 800 feet of stratified rocks above the azoic, which is almost absolutely barren of metallic ores. It is not until we rise into the Blue limestone that noteworthy quantities of any of the metals are found, and it is precisely here that the evidences of organic life begin to be abundant; portions of this group of strata are almost exclusively made up of the remains of animals, and these are nowhere more abundant than in the immediate vicinity of some of the heaviest deposits of the ores of lead and zinc. In the Lower Magnesian, the only traces of fossils yet discovered are in the upper portion of this rock, while the Potsdam sandstone is, except in a few extremely circumscribed localities, completely destitute of animal or vegetable remains. The same is true of the Upper sandstone, which is alike characterized by the entire absence of any traces of organic life or of metalliferous ores.

"It is hardly possible, in view of these facts, not to recognize a general law connecting the absence of the mineral deposits in the non-fossiliferous portions of the stratified groups with their abundance in those which contain organic remains. Whether we suppose the metalliferous solutions to have originated below, and to have been conveyed upwards by thermal springs, or whether we suppose them to have been contained in the waters of the ocean, we are, in either case, equally dependent on some conditions connected with the rocks themselves to account for the deposition or non-deposition of the metalliferous ores in the rocks in question. In the first named case, we should have to account for the zinc and lead solutions having been conveyed through rocks of precisely the same lithological character as those above in which deposition really did take place, without leaving a trace of their presence; in the other view, we should be called on to give a reason why no precipitation from the oceanic waters took place, while either the silicious or dolomitic strata were depositing, with a thickness of several hundred feet. To suppose that the ore-depositing springs could have passed through so great a vertical range of rock without a portion, at least, of the metallic substances having been left behind, we must assume that there was some cause to favor deposition present in the upper strata which was absent in the lower.

"The agent, then, which we conceive to have been efficient in producing the deposits of the metals which are found in the region in question, was the organic matter of the Blue limestone and the lower beds of the galena; which, either by its reducing action, while undergoing decomposition, acted on the sulphates of the metals held in solution in the surrounding waters, and converted them into sulphurets; or, still more directly, generating sulphuretted hydrogen from the sulphur which they themselves contained, furnished the necessary material for the precipitation of the metals as sulphurets.

"It has been demonstrated by repeated experiments, as well as by observation of natural phenomena, that organic substances undergoing decomposition in solutions impregnated with the sulphates of the metals cause a precipitation of the metal in the form of a sulphuret. The immense quantity of pyrites found in connection with all the coal beds of the West may be here referred to as evidence of this kind of chemical action. No other combination of iron than the sulphuret is found in the coal beds, and it is hardly possible to find a fragment of coal, however small, which has not some of this substance attached to it, or intersecting it in thin plates and veins. As we have in the strata of the Blue limestone the most fossiliferous portion of the whole series of rocks, many beds of it being made up almost exclusively of fragments of shells, we are not at a loss for organic matter, and it is especially in the neighborhood of the productive openings, in those districts where the mining is done in the Blue limestone, that the fossils are most abundant. Thus, at the Crow Branch diggings, the stuff thrown out from the pipe-clay opening is a mass of shells, many of which have been themselves converted into pyrites. The same is true of the openings in this geological position near Mineral Point.

"The immense number of remains of marine plants, which we have spoken of in a previous chapter as occurring in the lower and upper beds of the Galena limestone, may here be adverted to, in connection with the investigations of Forchhammer,* who has shown that many sea-weeds contain a large amount of sulphuric acid, the quantity in one instance being equal to 8.5 per cent. of the weight of the dried plant. He mentions that, in the vicinity of Copenhagen, the disengagement of sulphuretted hydrogen from the decomposing sea-weeds on the coast is often so great as to blacken the silver in the houses, at a considerable distance. Here, then, we have an ample source of sulphur to enter into combination with the iron and other metals contained in the sea-water in which the Galena limestone was deposited, which rock we conceive to have been made up in no small degree of the remains of this class of plants. No one can deny that we have, in the conditions set forth above, a *possible* means for the production of the deposits of the metals which have been described in the preceding pages. And as we conceive it to have been clearly shown that all other modes of deposition were impossible—that is to say, requiring conditions which have not existed in the lead region—we are forced to accept the theory advanced above, which is essentially that advocated by the author of this report six years ago, in the 'Metallic Wealth of the United States.'

"There are many points requiring farther elucidation, in connection with the formation of the lead-bearing crevices and openings; but it will be necessary to defer the consideration of them to another occasion, as this report has already swollen to an unexpected size.

"One or two conditions we may touch briefly upon before closing this section. The first is, the probable reason why the east and west crevices are so much more open, through a

*See Bischof's Lehrbuch der Chemischen und Physikalischen Geologie, i, 925; and Report of the British Association for 1844.

large part of the lead region, while the norths and souths are, to a considerable extent, filled with sheet ore, as has been previously set forth. We explain this by referring to the gradual opening of the east and west crevices by an uplift of the region along an east and west axis: one or more undulatory movements of the strata, if effected in this direction, would necessarily tend to open the fissures running in the same direction as the axis of upheaval. The fissures being thus expanded, so as to give a passage to the system of under-ground drainage, they would become worn out into such shapes as we find them to have at present, while the norths and souths, remaining much more tightly closed, would show this effect in a less marked degree, as is the case in the lead region generally.

"Another question which will naturally be asked in reference to the views advanced above, is this: why, if the metalliferous solutions from which the ore deposits of the lead region were thrown down were diffused through the oceanic waters, there was not a precipitation of the metallic sulphurets over every part of the valley of the Upper Mississippi? or why is the productive mining ground confined to a limited area, while over a vast extent of country, for all that can be seen on the surface, there is no reason why equally important deposits should not exist?

"To this we reply, that we believe it would be found that, were the earliest highly fossiliferous formations everywhere exposed, they would be found to a considerable extent impregnated with the sulphurets of lead, zinc, iron, &c.; and in proof of this we refer to the fact that the Silurian, and especially the Lower Silurian rocks, are much more metalliferous than any other series of strata occupying the same area and with the same thickness. But these are not commonly exposed, being almost everywhere covered by other groups. Where metalliferous ores do exist in the upper strata, nothing forbids the belief that they may have been derived from previously deposited masses below, carried up in solution by thermal springs or otherwise. If the original conditions under which the ores were deposited in the lower rocks were not favorable to their segregation in large masses—as was the case in the lead region, where the rock was intersected by numerous fissures—then the deposition would take place in a more diffused manner, and we might have a mass of strata impregnated with ore, in small particles, which would thus be liable to oxydation, and would easily be dissolved out and transferred to the upper strata by thermal springs rising through them from beneath.

"To recapitulate as briefly as possible. The oceanic waters, during the earliest geological epochs, may have been, and very probably were, impregnated with metallic salts, although not to such an extent as to prevent the development of organic life. When this development took place, if the circumstances were otherwise favorable, by the reducing action of the decaying organic matter entombed in the strata, or by that of plants containing sulphuric acid, the metalliferous combinations in the surrounding waters were decomposed, and the metals precipitated as sulphurets. These were collected by segregation in masses of considerable size, when the rocks had the necessary lithological character, and when crevices, fissures, or cavities existed, in which these masses could find room for their formation. When this was not the case, the strata were impregnated with metalliferous substances, which were diffused through the mass of rock, and which may afterwards have afforded an almost inexhaustible magazine of material to be drawn upon for the formation of mineral veins and other deposits in the overlying rocks.

"It is believed that with the adoption of these views some facts may be explained, with regard to the occurrence of ores in mineral veins and other forms of deposit, which have not hitherto been well understood: the subject will be farther discussed, however, in another place, as a sufficient space in this report has already been occupied with theoretical views."

APPENDIX II.

[From the Origin of Metalliferous Deposits by Dr. T. Sterry Hunt.]

"There are about sixty bodies which chemists call elements; the simplest forms of matter which they have been able to extract from the rocky crust of our earth, its waters, and its atmosphere. These substances are distributed in very unequal quantities, and in very different manners. As regards the frequency of these elements in nature, neglecting for the present those which constitute air and water, and confining ourselves to the solid matters of the earth's crust, there are a few which are exceedingly abundant, making up nine tenths, if not ninety-five hundreds, of the rocks so far as known to us. The elements of which silica, alumina, lime, magnesia, potash, and soda are oxides are very common, and occur almost everywhere. There are others which are much rarer, being found in comparatively small quantities. Many of these rarer elements are, however, of great importance in the economy of nature. Such are the common metals and other substances used in the arts, which occur in nature in quantities relatively very minute, but which have been collected by various agencies, and thus made available for the wants of man. It is chiefly of the well known metals, iron, copper, silver, and gold, that I propose to speak; but there are two other elements, not classed among the metals, which I shall notice for the reason that their history is extremely important, and will, moreover, enable us to comprehend more clearly some points in that of the metals themselves. I speak of phosphorus and iodine.

"You all know the essential part which the former of these, combined as phosphate of lime, plays in the animal economy, in the formation of bones; and how plants require for their proper growth and development a certain amount of phosphorus. Ordinary soils contain only a few thousandths of this element, yet there are agencies at work in nature which gather this diffused phosphorus together in beds of mineral phosphates and in veins of crystalline apatite, which are now sought to enrich impoverished soils. Iodine, an element of great value in medicine and in the art of photography, is widely distributed, but still rarer than phosphorus; yet it abounds in certain mineral waters, and is, moreover, accumulated in marine plants. These extract it from the waters of the sea, where iodine exists in such minute quantities as almost to elude our chemical tests. (See the Appendix, page 237.)

"There are probably no perfect separations in nature. We cannot, without great precautions, get any chemical element in a state of absolute purity, and we have reason to believe that even the rarest elements are everywhere diffused in infinitesimal quantities. The spectroscope, which we have lately learned to apply to the investigation alike of the chemistry of our own earth and of other worlds once supposed to be beyond the chemist's ken, not only demonstrates the very wide diffusion of various chemical elements here on the earth, but shows us that very many of them exist in the sun. If we accept, as most of us are now inclined to do, the nebular hypothesis, and admit that our earth was once, like the sun of to-day, an intensely heated vaporous mass; that it is, in fact, a cooled and condensed portion of that once great nebula of which the sun is also a part, we might expect to find all the elements now discovered in the sun distributed throughout this consolidated globe. We may speculate about the condensation of some of these before others, and their consequent accumulation in the inner parts of the earth; but the fact that we have all the elements of the solar envelope (together with many more) in the exterior portions of our planet, shows that there was, at least, but a very partial concentration and separation of these elements during the period of cooling and condensation. The superficial crust of the earth, from which all the rocks and minerals which we know have been generated, must have contained, diffused through it, from the earliest time, all the elements which we now meet with in our study of the earth, whether still diffused, or accumulated, as we often find the rarer elements, in particular veins or beds.

"The question now before us is, how have these elements thus been brought together, and why is it that they are not all still widely and universally diffused? Why are the compounds of iron in beds by themselves, copper, silver, and gold gathered together in veins, and iodine concentrated in a few ores and certain mineral waters? That we may the better discern the direction in which we are to look for the solution of this problem, let us premise that all of these elements, in some of their combinations, are more or less soluble in water. There are, in fact, no such things in nature as absolutely insoluble bodies, but all, under certain conditions, are capable of being taken up by water, and again deposited from it.*

"The alchemists sought in vain for a universal solvent; but we now know that water, aided in some cases by heat, pressure, and the presence of certain widely distributed substances, such as carbonic acid and alkaline carbonates and sulphides, will dissolve the most insoluble bodies; so that it may, after all, be looked upon as the long-sought-for alkahest or universal menstruum.

"Let us now compare the waters of rivers, seas, and subterranean springs, thus impregnated with various chemical elements, with the blood which circulates through our own bodies. The analysis of the blood shows it to contain albuminoids which go to form muscle, fat for the adipose tissues, phosphate of lime for the bones, fluorides for the enamel of the teeth, sulphur, which enters largely into the composition of the hair and nails, soda, which accumulates in the bile, and potash, which abounds in the flesh-fluid. All of these are dissolved

*It is well known that many chemical compounds, when first generated by double decomposition in watery solutions, remain dissolved for a greater or less length of time before separating in an insoluble condition. The solubility of recently precipitated carbonate of lime in water holding certain neutral salts, as already described (*ante*, page 149), is a fact in the same order. In this connection may also be recalled the great solubility in water of silicic, titanic, stannic, ferric, aluminic, and chromic oxides when in what Graham has called their colloidal state. There is reason to believe that silicates of insoluble bases may assume a similar state, and it will probably one day be shown, that, for the greater number of those oxygenized compounds which we call insoluble, there exists a modification soluble in water.

in the blood, and the great problem for the chemical physiologist is to determine how the living organism gathers them from this complex fluid, depositing them here and there, and giving to each part its proper material. This selection is generally ascribed to a certain vital force, peculiar to the living body. I shall not here discuss the vexed question of the nature of the force which determines the assimilation from the blood of these various matters for the needs of the animal organism, further than to say that modern investigations tend to show that it is only a subtler kind of chemistry, and that the study of the nature and relation of colloids and crystalloids, and of the phenomena of chemical diffusion, promises to subordinate all these obscure physiological processes to chemical and physical laws.

"Let us now see how far the comparison which we have made between the earth and an animal organism will help us to understand the problem of the distribution of minerals in nature; how far water, the universal solvent, acting in accordance with known chemical and physical laws, will cause the separation of the mixed elements of the earth's crust, and their accumulation in veins and beds in the rocks. The subject is one of great importance to the geologist, who has to consider the genesis of the various rocks and ore-deposits, and the relations, which we are only beginning to understand, between certain metals and particular rocks, and between certain classes of ores and peculiar mineralogical and geological conditions. It is at the same time a vast one, and I can now only give you a few illustrations of the chemistry of the earth's crust, and of the laws of the terrestrial circulation, which I have compared to that of the blood distributing throughout the animal frame the elements necessary for its growth. The analogy is not altogether new, since a great French geologist, Elie de Beaumont, has already spoken of a terrestrial circulation in regard to certain elements in the earth's crust; though he has not, so far as I am aware, carried it out to the extent which I now propose to do in my attempt to explain some of the laws which have presided over the distribution of metals in the earth.

"The chemist in his laboratory takes advantage of changes of temperature, and of the action of various solvents and precipitants, to separate, in the humid way, one element from another; but to these agencies, in the economy of nature, are added others which we have not yet succeeded in imitating, and which are exerted only in growing animals and plants. I repeat it; I do not wish to say that these latter processes are different in kind from those which we command in our laboratories, but rather that these organisms control a far finer and more delicate chemical and physical apparatus than we have yet invented. Plants have the power of selecting from the media in which they live the elements necessary for their support. The growing oak and the grass alike assimilate from the air and water the carbon, hydrogen, nitrogen, and oxygen which build up their tissues, and at the same time take from the soil a portion of phosphorus, which, though minute, is essential to the vegetable growth. The acorn of the oak and the grass alike become the food of animals, and the gathered phosphates pass into their bones, which are nearly pure phosphate of lime. In like manner the phosphates from organic waste and decay find their way to the sea, and through the agency of marine vegetation become at last the bony skeletons of fishes. These are, in turn, the prey of carnivorous birds, whose exuviæ form on tropical islands beds of phosphatic guano. A history not dissimilar will explain the origin of beds of coprolites and of some other deposits of mineral phosphates. [By whatever means the phosphates have been first concentrated, it appears from the recent studies of Sollas that the so-called coprolites of the green-sand in England result from a petrifaction of sponges by dissolved phosphates, and similar observations have been made by Edwards with regard to the guano of the Chincha Islands.]

"But again, these plants or these animals may perish in the sea and be buried in its ooze. The phosphates which they have gathered are not lost, but become fixed in an insoluble form in the clayey matter; and when, in the revolutions of ages, these sea-muds, hardened to rock, become dry land, and crumble again to soil, the phosphates are there found ready for the wants of vegetation.

"Most of what I have said of phosphates applies equally to the salts of potash, which are not less necessary to the growing plant. From the operation of these laws it results that neither of these elements is found in large quantities in the ocean. This great receptacle of the drainage from the land contains still smaller quantities of iodine; in fact, the traces of this element present in sea-water can scarcely be detected by our most delicate tests. Yet marine plants have the power of separating this iodine, and accumulating it in their tissues, so that the ashes of these plants are not only rich in phosphates and in potash-salts, but contain so much iodine that our supplies of this precious element are almost wholly derived from this source, and that the gathering and burning of seaweed for the extraction of iodine is in some regions an important industry. When this marine vegetation decays, the iodine which it contains appears, like the potash and phosphates, to pass into combination with metals, earths, or earthy phosphates, which retain it in an insoluble state, and in certain cases yield it to percolating saline solutions, which thus give rise to springs rich in iodine.

"In all of these processes the action of organic life is direct and assimilative, but there are others in which its agency, although indirect, is not less important. I can hardly conceive of an accumulation of iron, copper, lead, silver, or gold, in the production of which animal or vegetable life has not either directly or indirectly been necessary, and I shall begin to explain my meaning by the case of iron. This, you are aware, is one of the most widely diffused elements in nature; all soils, all plants, contain it; and it is a necessary element in our blood. Clays and loams contain, however, at best, two or three hundredths of the metal, but so mixed with other matters that we could never make it available for the wants of this iron age of ours. How does it happen that we also find it gathered together in great beds of ore, which furnish an abundant supply of the metal? The chemist knows that the iron, as diffused in the rocks, exists chiefly in combination with oxygen, with which it forms two principal compounds: the first, or protoxide, which is readily soluble in waters impregnated with carbonic acid or other feeble acids; and the second, or peroxide, which is insoluble in the same liquids. I do not here speak of the magnetic oxide, which may be looked upon as a compound of the other two, neutral and indifferent to most natural chemical agencies. The combinations of the first oxide are either colorless or bluish or greenish in tint, while the peroxide is reddish-brown, and is the substance known as iron-rust. Ordinary brick-clays are bluish in color, and contain combined iron in the state of protoxide, but when burned in a kiln they become reddish, because this oxide absorbs from the air a further proportion of oxygen, and is converted into peroxide. But there are clays which are white when burned, and are much prized for this reason. Many of these were once ferruginous clays, which have lost their iron by a process everywhere going on around us. If we dig a ditch in a moist soil which is covered with turf or with decaying vegetation, we may observe that the stagnant water which collects at the bottom soon becomes coated with a shining, iridescent scum, which looks somewhat like oil, but is really a compound of peroxide of iron. The water as it oozes from the soil is colorless, but has an inky taste, from dissolved protoxide of iron. When exposed to the air, however, this absorbs oxygen, and the peroxide is formed, which is no longer soluble, but separates as a film on the surface of the water, and finally sinks to the bottom as a reddish ochre, or, under somewhat different conditions, becomes aggregated as a massive iron-ore. A process identical in kind with this has been at work at the earth's surface ever since there were decaying organic matters, dissolving the iron from the porous rocks, clays, and sands, and gathering it together in beds of iron-ore or iron ochre. It is not necessary that these rocks and soils should contain the iron in the state of protoxide, since these organic products (which are themselves dissolved in the water) are able to remove a portion of the oxygen from the insoluble peroxide, and convert it into the soluble protoxide of iron, being themselves in part oxidized and converted into carbonic acid in the process.

"We find in rock formations of very different ages beds of sediments which have been deprived of iron by organic agencies, and near them will generally be found the accumulated iron. Go into any coal region, and you will see evidences that this process was at work when the coal-beds were forming. The soil in which the coal-plants grew has been deprived of its iron, and when burned turns white, as do most of the slaty beds from the coal-rocks. It is this ancient soil which constitutes the so-called fire-clays, prized for making bricks which, from the absence of both iron and alkalies, are very infusible. Interstratified with these we often find, in the form of ironstone, the separated metal; and thus from the same series of rocks may be obtained the fuel, the ore, and the fire-clay.

"From what I have said it will be understood that great deposits of iron ore generally occur in the shape of beds; although waters holding the compounds of iron in solution have, in some cases, deposited them in fissures or openings in the rocks, thus forming true veins of ore, of which we shall speak further on. I wish now to insist upon the property which dead and decaying organic matters possess of reducing to protoxide, and rendering soluble, the insoluble peroxide of iron diffused through the rocks; and reciprocally the power which this peroxide has of oxidizing and consuming these same organic matters, which are thereby finally converted into carbonic acid and water. This last action, let me say in passing, is illustrated by the destructive action of rusting iron bolts on moist wood, and the effect of iron stains in impairing the strength of linen fibre.

"We see in the coal formation that the vegetable matter necessary for the production of the iron-ore beds was not wanting; but the question has been asked me, where are the evidences of the organic material which was required to produce the vast beds of iron-ore found in the ancient crystalline rocks? I answer that the organic matter was, in most cases, entirely consumed in producing these great results; and that it was the large proportion of iron diffused in the soils and waters of these early times, which not only rendered possible the accumulation of such great beds of ore, but oxidized and destroyed the organic matters which in later ages appear in coals, lignites, pyroschists, and bitumens. Some of the carbon of these early times is, however, still preserved in the form of graphite, and it would be possible to calculate how much carbonaceous material was consumed in the formation of the great iron-ore beds of the older rocks, and to determine of how much coal or lignite they are the equivalents.

"In the course of ages, however, as a large proportion of the once diffused iron-oxide has become segregated in the form of beds of ore, and thus removed from the terrestrial circulation, the conditions have grown more favorable for the preservation of the carbonaceous products of vegetable life. The crystalline magnetic and specular oxides, which constitute a large proportion of the ores of this metal, are almost or altogether indifferent to the action of organic matter. When, however, these ores are reduced in our furnaces, and the resulting metal is exposed to the oxidizing action of a moist atmosphere, it is again converted into iron-rust, which is soluble in water holding organic matters, and may thus be made to enter once more into the terrestrial circulation.

"There is another form in which iron is frequently concentrated in nature, that of sulphide, and most frequently as the bisulphide, known as iron-pyrites. This substance is found both in the oldest and the newest rocks, and like the oxide of iron, is even to-day forming in certain waters and in beds of mud and silt, where it sometimes takes a beautifully crystalline shape. What are the conditions in which the sulphide of iron is formed and deposited, instead of the oxide or carbonate of iron? Its production depends, like these, on decaying organic matters. The sulphates of lime and magnesia, which abound in sea-water, and in many other natural waters, when exposed to the action of decaying plants or animals, out of contact of air, are, like peroxide of iron, deoxidized, and are thereby converted into soluble sulphides; from which, if carbonic acid be present, sulphuretted hydrogen gas is set free. Such soluble sulphides, or sulphuretted hydrogen, are the reagents constantly employed in our laboratories to convert the soluble compounds of many of the common metals, such as iron, zinc, lead, copper, and silver, into sulphides, which are insoluble in water and in many acids, and are thus conveniently separated from a great many other bodies. Now, when in a water holding iron-oxide, sulphates are also present, the action of organic matter, deoxidizing the latter, furnishes the reagent necessary to convert the iron into a sulphide; which in some conditions, not well understood, contains two equivalents of sulphur for one of iron, and constitutes iron-pyrites. I may here say that I have found that the unstable protosulphide, which would naturally be first formed, may, under the influence of a persal of iron, lose one half of its combined iron; and that from this reaction a stable bisulphide results. This subject of the origin of iron-pyrites is still under investigation.

"The reducing action of organic matters upon soluble sulphates is well seen in the sulphuretted hydrogen which is evolved from the stagnant sea-water in the hold of a ship, and which coats silver exposed to it with a black film of sulphide of silver, and for the same reason discolors white-lead paint. The presence of sulphur in the exhalations from some other decaying matters is well known, and in all these cases a soluble compound of iron will act as a disinfectant, partly by fixing the sulphur as an insoluble sulphide. Silver coins brought from the ancient wreck of a treasure-ship in the Spanish Main were found to be deeply incrusted with sulphide of silver, formed in the ocean's depths by the process just explained, which is one that must go on wherever organic matters and sea-water are present, and atmospheric oxygen excluded.

"The chemical history of iron is peculiar; since it requires reducing matters to bring it into solution, and since it may be precipitated alike by oxidation, and by further reduction provided sulphates are present. The metals, copper, lead, and silver, on the contrary, form compounds more or less soluble in water, from which they are not precipitated by oxygen, but only by reducing agents, which may separate them in some cases in a metallic state, but more frequently as sulphides. The solubility of the salts and oxides of these metals in water is such that they are found in many mineral springs, in the waters that flow from certain mines, and in the ocean itself, the waters of which have been found to contain copper, silver, and lead. Why, then, do not these metals accumulate in the sea, as the salts of soda have done during long ages? The direct agency of organic life comes again into play, precisely as in the case of phosphorus, iodine, and potash. Marine plants, which absorb these from the sea-water, take up at the same time the metals just named, traces of all of which are found in the ashes of sea-weeds. Copper, moreover, is met with in notable quantities in the blood of many marine molluscous animals, to which it may be as necessary as iron is to our own bodies. Indeed, the blood of man, and of the higher animals, appears never to be without traces of copper as well as of iron.

"In the open ocean the waters are constantly aerated, so that soluble sulphides are never formed, and the only way in which these dissolved metals can be removed and converted into sulphides is by fixing them in organisms, either vegetable or animal. These, by their decay in the mud of the bottom, or the lagoons of the shore, generate the sulphides which fix their contained metals in an insoluble form, and thus remove them from the terrestrial circulation.

"It is not, however, in all cases necessary to invoke the direct action of organisms to separate from water the dissolved metals. It often happens that the waters containing these, instead of finding their way to the ocean, flow into lakes or inclosed basins, as in the case of the drainage-waters of an

English copper-mine, which have impregnated the turf of a neighboring bog to such an extent that its ashes have been found a profitable source of copper. Under certain conditions, not yet well understood, this metal is precipitated by organic matters in the metallic state, but if sulphates are present, a sulphide is formed. Thus, in certain mesozoic slates in Bohemia, sulphide of copper is found incrusting the remains of fishes, and in the sandstones of New Jersey we find it penetrating the stems of ancient trees. I have in my possession a portion of a small trunk taken from the mud of a spring in the province of Ontario, in which the yet undecayed wood of the center is seen to be incrusted by hard and brilliant iron pyrites. In like manner the trees found in the New Jersey sandstone became incrusted with copper-sulphide, which, as decay went on, in great part replaced the woody tissue. Similar deposits of sulphides of copper and of iron often took place in basins where the organic matter was present in such a condition or in such quantity as to be entirely decomposed, and to leave no trace of its form, unlike the examples just mentioned. In this way have been formed fahlbands, and beds of pyrites and other ores.

"The fact that such deposits are associated with silver and with gold leads to the conclusion that these metals have obeyed the same laws as iron and copper. It is known that both persalts of iron and soluble sulphides have the power of rendering gold soluble, and its subsequent deposition in the metallic state is then easily understood.

"I have endeavored by a few illustrations to show you by what processes some of the more common metals are dissolved and again separated from their solution in insoluble forms. It now remains to say somewhat of the geological relations of ore-deposits, which are naturally divided into two classes; the first including those which occur in beds, and have been formed contemporaneously with the inclosing earthy sediments. Such are the beds of iron-ores, which often hold embedded shells and other organic remains, and the copper-bearing strata already mentioned, in which the metal must have been deposited during the decay of the animal or plant which it incrusts or replaces. But there are other ore-deposits evidently of more recent formation than the rocky strata which inclose them, which have resulted from a process of infiltration, filling up fissures with the ore, or diffusing it irregularly through the rock. It is not always easy to distinguish between the two classes of deposits. Thus a fissure may in some cases be formed and filled between two sundered beds, from which may result a vein that may be mistaken for an interposed stratum. Again, a bed may be so porous that infiltrating waters may diffuse through it a metallic ore, or a metal, in such a manner as to leave it doubtful whether the process was contemporaneous with the deposition of the bed, or posterior to it. But I wish to speak of deposits which are evidently posterior, and occupy fissures in previously formed strata, constituting true veins. Whether produced by the great movements of the earth's crust, or by the local contraction of the rocks (and both of these causes have in different cases been in operation), such fissures sometimes extend to great lengths and depths; their arrangement and dimensions depending very much on the texture of the rocks which have been subjected to fracture. When a bone in our bodies is broken, nature goes to work to repair the fractured part, and gradually brings to it bony matter, which fills up the little interval, and at length makes the severed parts one again. So when there are fractures in the earth's crust, the circulating waters deposit in the openings mineral matters, which unite the broken portions, and thus make whole again the shattered rocks. Vein-stones are thus formed, and are the work of nature's conservative surgery.

"Water, as we have seen, is a universal solvent, and the matters which it may bring and deposit in the fissures of the earth are very various. There is scarcely a spar or an ore to be met with in the stratified rocks that is not also found in some of these vein-stones, which are often very heterogeneous in composition. In certain veins we find the elements of limestone or of granite, and these often include the gems, such as tourmaline, garnet, topaz, hyacinth, emerald, and sapphire; while others abound in native metals or in metallic oxides or sulphides. The nature of the materials thus deposited depends very much on conditions of temperature and of pressure, which affect the solvent power of the liquid, and still more upon the nature of the adjacent rocks and of the waters permeating them. The chemistry of mineral veins is very complicated. Many of these fissures penetrate to a depth of thousands of feet of the earth's crust, and along the channels thus opened the ascending heated subterranean waters may receive in their course various contributions from the overlying strata. From these additions, and from the diminished solubility resulting from a decrease of pressure, deposits of different minerals are formed upon the walls, and the slow changes in composition are often represented by successive layers of unlike substances. The power of these waters to dissolve and bring from the lower strata their contained metals and spars in probably due in great part to the alkaline carbonates and sulphides which these waters often hold in solution; but the chemical history of the deposition of the ores of iron, lead, copper, silver, tin, and gold, which are found in these veins, demands a lengthened study, and would furnish not less beautiful examples of nature's chemistry than those I have already laid before you.

"The process of filling veins has been going on from the earliest ages; we know of some which were formed before the Cambrian rocks were deposited, while others are still forming as the observations of Phillips have shown us in Nevada, where hot springs rise to the surface and deposit silica, with metallic ores, which incrusts the walls of the fissures. These thermal waters show that the agencies which in past times gave rise to the rich mineral deposits of our western regions, are still at work there.

"Let us now consider the beneficent results of the process of vein-making. The precious metals, such as silver, are so sparsely distributed, that even the beds rich in the products of decaying sea-weed, which we have supposed to be deposited from the ocean, would contain too little silver to be profitably extracted. But in the course of ages these sediments, deeply buried, are lixiviated by permeating solutions, which dissolve the silver diffused through a vast mass of rock, and subsequently deposit it in some fissure, it may be in strata far above, as a rich silver-ore. This is nature's process of concentration.

"We learn from the history which we have just sketched the important conclusion, that amid all the changes of the face of the globe the economy of nature has remained the same. We are apt, in explaining the appearances of the earth's crust, to refer the formation of ore-beds and veins to some distant and remote period, when conditions very unlike the present prevailed, when great convulsions took place, and mysterious forces were at work. Yet the same chemical and physical laws are now, as then, in operation: in one part dissolving the iron from the sediments and forming ore-beds, in another separating the rarer metals from the ocean's waters; while in still other regions the consolidated and buried sediments are permeated by heated waters, to which they give up their metallic matters, to be subsequently deposited in veins. These forces are always in operation, rearranging the chaotic admixture of elements which results from the constant change and decay around us. The laws which the First Great Cause imposed upon this material universe on the first day are still irresistibly at work fashioning its present order. One great design and purpose is seen to bind in necessary harmony the operations of the mineral with those of the vegetable and animal worlds, and to make all of these contribute to that terrestrial circulation which maintains the life of our mother earth.

"While the phenomena of the material world have been looked upon as chemical and physical, it has been customary to speak of those of the organic world as vital. The tendency of modern investigation is, however, to regard the processes of animal and vegetable growth as themselves purely chemical and physical. That this is to a great extent true must be admitted, though I am not prepared to concede that we have in chemical and physical processes the whole secret of organic life. Still we are, in many respects, approximating the phenomena of the organic world to those of the mineral kingdom; and we at the same time learn that these so far interact and depend upon each other that we begin to see a certain truth underlying the notion of those old philosophers who extended to the mineral world the notion of a vital force, which led them to speak of the earth as a great living organism, and to look upon the various changes in its air, its waters, and its rocky depths, as processes belonging to the life of our planet.

"ON IODINE AND GOLD IN SEA-WATER.

"After the above lecture was delivered, appeared the results of the researches of Sonstadt on the iodine in sea-water, which were published in the Chemical News for April 26, May 17, and May 24, 1872. According to him, this element exists in sea-water, under ordinary conditions, as iodate of calcium, to the amount of about one part of the iodate in 250,000 parts of the water. This compound, by decaying organic matter (and by most other reducing agents), is changed to iodine, from which, apparently by the action of carbonic acid, iodine is set free, and may be separated by agitating the water with bisulphide of carbon. The iodine thus liberated from sea-water by the action of dead organic matters, however, slowly decomposes water in presence of carbonate of calcium, and is reconverted into iodate, the oxygen of the air probably intervening to complete the oxidation, since, according to Sonstadt, iodides are readily converted into iodates under these conditions. He finds that the insolubility of the iodides of silver and of copper is so great that by the use of salts of these metals iodine may be separated from sea-water, without concentration, provided the iodate of calcium has first been reduced to iodide. By this property of iodine and its compounds to oxidize and be oxidized in turn, Sonstadt supposes them to perform the important function of consuming the products of organic decay, and so maintaining the salubrity of the ocean's waters. Their action would thus be very similar to that of the oxides of iron, as explained in the lecture.

"Still more recently the same chemist has announced that the sea-water of the British coasts contains in solution, besides silver, an appreciable amount of gold, estimated by him at about one grain to a ton of water. This is separated by the addition of chloride of barium to the water, apparently as an aurate of baryta adhering to the precipitated sulphate, which yields by assay an alloy of about six parts of gold to four of silver. Other ways have been devised by him for separating these metals from their solution in sea-water. The agent which keeps the gold of the sea in a soluble and oxidized condition is, according to Sonstadt, the iodine liberated by the reaction already described. The views maintained by Lieber, Wurtz, Genth, and Selwyn as to the solution and re-deposition of gold in modern alluvial deposits, seem to be well-grounded, and we are led to the conclusion that the circulation of this metal in nature is as easily effected as that of iron or of copper. The transfer of certain other elements, such as titanium, chrome, and tin, or at least their accumulation in concentrated forms, appears, on the contrary, to require conditions which are no longer operative, at least at the surface of the earth.

"It should here be noticed, that Professor Henry Wurtz of New York, in a paper read before the American Association for the Advancement of Science in 1866, and published in the Journal of Mining in 1868, expressed the opinion that the ocean waters contain gold, and urged experiments for its detection. According to his calculations, the total amount of gold hitherto extracted from the earth, and estimated at two thousand million dollars, would give only one dollar for two hundred and eighty million tons of sea-water; while from the experiments of Sonstadt it would appear that the same quantity of gold is actually contained in twenty-five tons of water."

APPENDIX III.

[From an unpublished Lecture by Professor Raphael Pumpelly.]

ON THE INFLUENCE OF MARINE LIFE AND CURRENTS IN THE FORMATION OF METALLIFEROUS DEPOSITS.

"The researches of Forchhammer and others have proved the existence in the water of the ocean of the following substances:

"1. Oxygen; 2. Hydrogen; 3. Chlorine; 4. Bromine; 5. Iodine; 6. Fluorine; 7. Sulphur; 8. Phosphorus; 9. Carbon; 10. Nitrogen; 11. Silicium; 12. Boron; 13. Silver; 14. Copper; 15. Lead; 16. Zinc; 17. Cobalt; 18. Nickel; 19. Iron; 20. Manganese; 21. Aluminum; 22. Magnesium; 23. Calcium; 24. Strontium; 25. Barium; 26. Sodium; 27. Kalium; 28. Arsenic.

"This list will unquestionably be largely increased when more extended investigations are made; and it seems probable that all of the elements might be found if we could work upon sufficiently large quantities or apply more delicate processes of analysis.

"The dry land of the earth is undergoing an unceasing mechanical and chemical dissolution, and is being carried slowly but surely through rivulets, creeks, and rivers, and, by the action of glaciers and of the waves of the coasts, into the ocean. Slow as this translocation of matter is, nothing is more certain than that, given the necessary time, every portion of the land now above the level of the sea will find its way into the ocean. And this flow toward the great ultimate receptacle of all things has gone on ever since dry land and water existed. What becomes of all this material? Those substances which are carried oceanward in mechanical suspension, as clay and sand and undissolved lime, are deposited along the coast, and are never carried far from the land except under the influence of the currents of great rivers like the Amazon, for instance; but the waters carry seaward an immense amount of carbonate of lime in solution, besides soluble salts of the other earths, of the alkalies, and metals. Why does not this constant influx of carbonate of lime saturate the sea-water and precipitate the excess to form lime deposits? The water of the high ocean contains only a fraction of the amount of this substance which it is capable of taking up. Bischoff supposes that the mollusca and infusoria of the ocean secrete in shell substance and coral banks carbonate of lime directly from the water, which contains an exceedingly small fraction of one per cent., and thus prevents the accumulation.

"This question brings us to the relation between animal and plant life on the one hand and the mineral world on the other. We shall see that many of the most important processes in nature are directly dependent upon life.

"In the mineral kingdom the elementary substances and their combinations have their histories of development according to laws. In their changes of form and association they run through cycles which are less or greater, uneventful or highly complex, according to the limitations fixed upon them by their relative physical characteristics. The cycles of some, at least, of the elements run into, and are intimately dependent upon, some of those in the organic kingdoms. They form the links between matter and life.

"We will look briefly at the cycles of some of the substances with which marine life stands in a causative relation; for some of them are among the agents of the first importance in the production of mineral deposits. These are carbonic acid, lime, phosphoric acid, fluorine, and sulphur.

"We will restrict ourselves to the simpler circuits they follow in the ocean. In a later lecture I shall have occasion to show that these cycles become, on land, much more complex, and merge into those of many of the substances we shall have to deal with.

"CYCLE OF CARBONIC ACID.

"The sea is charged with free carbonic acid. Its water contains about 9 per cent. or 10 per cent. of CO_2. The amount varies with the cloudiness or clearness of the sky and with the roughness or quiet of the water. The excess is aided in its escape into the atmosphere by the action of the waves.

"Under the influence of light the living plants in the sea, as on land, are able to decompose carbonic acid, the oxygen going off free and the carbon going chiefly to form hydro-carbon compounds in the plant. This is the first and essential step: the decomposition of carbonic acid is effected in nature only through the medium of plant life. It can be restored to its original form only through oxidation, which may take place either through direct combustion with the oxygen absorbed as free gas in the sea-water, or by the deoxidation of substances containing combined oxygen. On the dry land it is chiefly oxide of iron which is deoxidized; in the ocean it is the sulphates, especially that of lime. That portion of the hydrocarbon of plants which finds its way into the system of animals is finally oxidized to carbonic acid in the process of respiration during life and of decay after death.

"But another portion is being constantly withdrawn from circulation in the fixed carbon of coal deposits. Unlike any other of the substances which appear to be the most important in the economy of the coördinated realms of nature, coal is, even from a geological point of view, practically incapable of oxidation without the aid of combustion at a high temperature and in presence of oxygen. While the silicates are subject to decomposition by water containing CO_2, and are even slightly soluble as such in pure water, and are sure to return to combination points from which their component parts may be redistributed, the carbon of coal remains fixed. Were there no way outside of the ordinary routine of nature for restoring this element to its combination with oxygen, we should have before us the sure measure of the future duration of plant life, and consequently of animal life also, on our planet.

"But a remedy has sprung into existence almost within the present century—the combustion of coal by man. It is, perhaps, here more than in any other direction that the actions of man show themselves among the physical forces of the first geological importance, and the progress of a material civilization is justified from an entirely new quarter.

"CYCLE OF LIME.

"Nearly all limestones are organic products. Mohr's theory: sulphate of lime decomposed by plants which have the power, under influence of light, of decomposing carbonic acid and sulphuric acid. Carbonic acid gives up its carbon to form hydro-carbon, and oxygen is emitted free. The sulphuric acid yields its sulphur, which unites with the elements of ammonia and with carbon to form albumen, and the oxygen is also here emitted free. The lime enters as an ash ingredient into the fibre of the plant.

"When the plant is eaten by animals the albumen goes to form the living body of the animal, the hydro-carbons are oxidized in respiration to carbonic acid, and this combines with the lime of the plant-fibre, after the oxidation of the organic portion, to form carbonate of lime, which is, secreted together, an organic substance—conchiolin—in the form of shell or skeleton. The animals which live on plants secrete lime directly; those which live on animals obtain it in the last instance from herbivorous animals. The carbonate of lime thus formed goes in the form of shells into the marine strata, or again we find it constituting extensive coral banks and reefs and the immense deposits of glohigerina lime-mud, which seem to form the bottom of the ocean.

"When elevated these deposits are the coralline limestones and chalk; later, the compact or granular limestones, or, after advanced metamorphism, they form rocks which bear no marks of their calcareous origin, and still less of the part organic life has had in their formation.

"Now begins the retrograde movement; the limestone thus elevated must sooner or later return to the ocean. A part goes oceanward in the mechanically suspended silt of streams, but a large part, also in solution, as bi-carbonate. The waters which filter through the soil carry with them carbonic acid, partly from the atmosphere but especially from the vegetable mould, where the hydro-carbons of dead vegetation are constantly oxidizing to carbonic acid. The water, armed with this powerful agent, dissolves slowly but surely the mightiest beds of limestone and carries it seaward. Here it is decomposed by sulphuric acid, under formation of free carbonic acid and sulphate of lime, and the cycle is ended.

"PHOSPHORIC ACID AND FLUORINE.

"The water of the ocean contains phosphoric acid and fluorine. The first can be determined qualitatively in a half pound of the water; besides this, it can be quantitatively determined in plants which live and grow without touching the bottom, and consequently derive their constituents wholly from the sea-water.

"Fluorine was found by Forchhammer directly in the sea-water. It is present in the boiler incrustations of ocean steamers, and Dana found it in the calcareous corals.

"Although these two substances possess little or no chemical affinity, it is a remarkable fact that they are frequently associated in the mineral kingdom, and so generally, indeed, that where one of them is found the other may be almost confidently looked for. This constant coöccurrence is one of the sign-boards in the path of those who would study the genesis of mineral deposits. The coöccurrence is so general that it cannot be accidental, and the fact that the two elements have so slight a chemical affinity is of itself strongly in favor of believing at the start that the association is due to other than inorganic causes. If we turn to the animal kingdom we find these two elements constantly in company.

"In the ocean, as on the land, it is one of the functions of plant life to store up *phosphoric acid*. According to the many analyses of marine fucoids made by Forchhammer, the ashes of these plants contain something over one per cent. of phosphate of lime. It is from the vegetable kingdom or from herbivorous animals that animals obtain their supply of phosphoric acid. The corals contain a larger percentage than the fucoids, and the higher animals, which have skeletons of bone, contain a still larger amount, as in the ox, the bones of which are more than half phosphate of lime.

"We have seen that even the lower marine animals contain fluorine; whether they derive it from some very minute quantity that may be contained in marine plants or directly from the sea-water is not known; in either event the two elements are brought together through the action of vital forces. As these phosphates of lime form essential constituents, especially of the skeletons, teeth, etc., of the vertebrata, and, in a less degree, of the calcareous portions of the rock-building lower animals, they pass into all submarine in which the remains of mollusca and vertebrata are buried, and they form an essential portion, however small the per centage may be, of the extensive coral reefs and the immense deposits of chalk formed by the globigerina. When these submarine formations are raised to form dry land they become, in time, the various limestones and fossiliferous rocks. The phosphate of lime and fluor calcium offer nearly equal resistance to solution by the same solvents, but they sooner or later move in the endless circuit. We find them concentrated in concretionary deposits of phosphates, or, and still near each other, in a generally associated group of minerals, viz: apatile, fluor-spar, tourmaline, topaz, etc. They are here, again, the mineral kingdom, and they are widely spread through the rocks, though in minute quantities. They occur as essential and as incidental ingredients of minerals in nearly all rocks, including granites and basalts. During the decomposition of these rocks the phosphoric acid and fluorine pass into the soil; the process we have followed in the ocean now being again on land, the vegetation extracts phosphoric acid and probably the fluorine from the earth, and the animals concentrate them more rapidly and to a greater extent from the plants and from herbivorous animals, and from the animals they return to the earth partly in their most soluble combinations, which are leached from the soil and carried to the sea to begin afresh their oceanic cycle.

"SULPHUR.

"There is another cycle which is dependent upon the coöperation of organic matters; I refer to that of sulphur. The exhalations of sulphuretted hydrogen and the deposits of sulphur occupy an important place in economic geology; the association of sulphur with metals will demand our attention in treating of ore deposits. The great source of sulphur lies in the ocean, in the dissolved sulphates of lime and magnesia. The reducing agent is organic matter. We have considered one small cycle which sulphur follows in the decomposition of gypsum by plants in which the sulphuric is reduced, the oxygen escaping and the sulphur passing into albumen and finally returning to the sea as sulphuric acid or as sulphuretted hydrogen, which oxidized to the acid in presence of the air, absorbed in the water, and finally returns to gypsum by decomposing the carbonate of lime brought from the land.

"Another and more direct process is in constant operation. The sea is charged with dead organic matter, which requires oxygen for its decomposition, and this it can obtain only from the absorbed air or from the sulphates. Where the amount of dead organic matter is considerable the decomposition of the sulphates is on a very large scale. The carbon of the organic substance takes the oxygen from the sulphuric acid and from its base and the result is carbonic acid and a sulphide. The sulphide is decomposed by water and carbonic acid to sulphuretted hydrogen and a carbonate.

"The sulphuretted hydrogen thus formed is gradually oxidized to sulphuric acid, and the cycle is closed when it again unites with lime to form gypsum.

"This is the circuit of sulphur in the ocean and on the land. The sulphur may branch off into the cycles of other substances, but it must ultimately return to sulphuric acid. As sulphuretted hydrogen it will precipitate any of the heavy metals that are brought in solution in small amounts by the rivers into the ocean; its existence and career is then bound up in that of the deposits in which it is buried.

"On the land it is exposed to a much more complicated career; the sulphuretted hydrogen formed here, as in the sea, through the reduction of sulphates by organic matter, is liable to be seized upon by the metallic salts and fixed as sulphide; when in time this oxidizes, the sulphate or the free acid formed are exposed to a long series of chemical activities, perhaps to many cycles, before the acid combined with lime again enters the ocean as gypsum.

"Besides those substances which exist in amounts which can be quantitatively determined by analyses, the oceanic fluid contains also a very considerable portion of the other elements, some of which have been found directly in the water, while others, especially among the heavy metals, have been found only in the ashes of marine plants or in the calcareous secretions of marine animals, which could have obtained them only from the water in which they live. It is a remarkable fact, that the very careful researches of Bischoff and Forchhammer and Von Bibra failed to find any trace of most of the heavy metals in sea-water directly, while in the ashes of marine plants which germinate, live, and die entirely independent of any root-hold, and pass their whole existence floating in the water, very appreciable quantities of lead, copper, zinc, nickel, cobalt, and silver were found. We have here the most direct proof that the water of the sea contains extremely minute quantities of metals, and that the vital force of plant life has the power of secreting and concentrating them from the enveloping fluid. It is probable that the lower marine animals either secrete them directly from the sea-water or obtain them in the second instance as they do their lime, from the plants which they consume, although here it is perhaps not susceptible of proof that a part of the metals found in coralline structures, may not have been the result of a precipitation of the minute quantities contained in the water, through the agency of sulphuretted hydrogen created by the reaction of the decaying animal matter upon the dissolved sulphates. It may seem to you at first sight that such inappreciable quantities as are represented by the metals contained in ocean-water are too insignificant to have any bearing upon economic geology; but we are too apt to neglect the value of small quantities and unseen forces, and not to concede to nature the ability to accomplish, on a much grander scale, operations which we are every day conducting.

"It may seem also to be an unimportant fact in geology that marine plants have the power of concentrating metals from the ocean. It would, indeed, be a fact of but little moment if the quantity of the plants floating in the ocean were small; but the extent of oceanic vegetation is immense. The amount of marine animal life far exceeds that of the land; and as this presupposes a corresponding amount of vegetation, without which the animal cannot exist, we have an *a priori* reason for placing a high estimate upon the amount of marine plant life; but, fortunately, we have the proof offered by direct observation. The ocean has immense forests containing a great variety of plant forms. The rocky coasts in all parts of the world support a submarine growth of plants, which, though attached to the bottom, obtain their nourishment from the surrounding water. I can give but a faint idea of the magnitude of this vegetation when I state, that on the coasts in many parts of the world the collecting of these plants, for various purposes, forms a very important branch of industry, giving employment to hundreds of thousands of people. In France alone, about three thousand tons of the *ashes* of certain of these plants are worked yearly for iodine, and in Scotland a very much larger amount. On the Orkneys over twenty thousand people are said to have been employed every summer in collecting and burning kelp for potash and iodine. On the coasts of Japan the amount of sea-weed gathered as an article of food, for consumption at home and in China, is immense.

"The size of some of these plants, especially the *Fucus giganteus*, is comparable in point of length, though not in thickness, with our tallest trees. Cook found no bottom in twenty-four fathoms in places where this giant kelp reached the surface, and there is reason to believe that they extend from two to three hundred feet in length. Darwin compares this submarine growth with the tropical land forests, and considers them more important in size and capacity for supplying nourishment to animals than their continental rivals. But besides this fixed vegetation the sea nourishes a vast amount of floating plants, which live in the ocean or move in its currents and accumulate in its eddies. If you will look at a chart of the world you will see, between longitudes 20° and 65° west from Greenwich, and between the parallels of 20° and 45° of north latitude, a long belt stretching from east to west, with a width of from 12° to 4° or 5°, and marked Sargasso. Similar areas exist in the Pacific Ocean.

"These are the accumulation principally of Sargassum of varieties of fucus, brought by the oceanic currents and left behind them in the great eddies. Maury estimated the area of the Atlantic accumulation to be equal to that of the great Valley of the Mississippi. Humboldt rates it about six times the size of the Germany of his day. Roughly stated, it may be considered as occupying an area of from 700,000 to 800,000 square miles. It was in this mass of floating weed that the sailors of Columbus took fright, fearing that their vessels would become hopelessly entangled. 'The sea was covered with such a quantity of sea-weed that we believed that the ships would run aground for want of water.' It was a serious impediment to the early navigators. 'Laerius passed for fifteen continuous days through one unbroken "meadow," so that he could find no way through for oars.' The Sargasso sea often appears 'substantial enough to walk upon.'

"These eddies of the ocean are the ultimate receptacle of everything that floats. The whole ocean surface is subject to greater or less current movements, and everything that has no root-hold or foot-hold and no power of independent motion comes to rest and decay and sink in these quiet waters. When the sea-weed dies the air vessels which buoy it up burst and the plant sinks.

"When we consider that these currents and eddies must be as old as the Atlantic and Pacific Oceans, and that marine vegetation is even older than animal life upon the globe, it becomes evident that deposits of great superficial extent and of great thickness must have accumulated at the bottom of such parts of the sea, and along the track of the currents.

When geological changes occur which bring the coast line or the mouths of great silt-loaded rivers nearer to these deposits, they may become mingled with argillaceous material; or, if the change has carried the eddy to a distance, they may become wholly buried in purely mechanical deposits, and over which the rock-building animals may form calcareous strata. In other words, these accumulations of dead vegetation may come to form members of the series of stratified rocks. With them are buried the minerals secreted by the plant during its life, and also a considerable amount of phosphate and carbonate of lime, contained in the bodies of the vast animal population, which is known to inhabit the floating wilderness of the Sargasso seas; for these are living worlds, teeming with animals which live on the Sargassum, and are in turn preyed upon by the fierce crustacea and carnivorous fish.

"Thus we have a double concentration: first, the plant concentrates substances from the sea-water; secondly, the currents of the ocean concentrate the plants geographically. It seems to me that we have here made one step forward; that we have found at least one of the causes of the unequal geographical distribution of many deposits of metals.

"Besides the metals, the ash ingredients of these plants contain as much as from three per cent. to twenty per cent. of sulphuric acid, besides lime and baryta. The remains of animals deposited with them contain fluoride of calcium.

"In the presence of organic matter and sulphuric acid the metals must in time be reduced to sulphurets. These deposits contain, then, sulphurets of the metals, and the constituents of three of the four principal varieties of vein-stones, viz: carbonate of lime, sulphate of baryta, and fluoride of calcium, the two last being generally closely connected with metallic deposits.

"When these marine accumulations and the accompanying strata are elevated and begin to undergo metamorphism, they contain at least many of the principal metals, as sulphurets, and with these the materials for vein-stones, minutely disseminated through the rock-mass.

"After an advanced metamorphism has either removed the remains of the plants, or after the organic matter has reached that stage of carbonization where it ceases to act vigorously as a reducing agent, it is possible for the next phases of concentration to begin, under which metallic deposits proper are formed, by bringing together within very narrow limits the larger part of the metals diffused in extremely minute quantities through great masses of rock.

"We have seen that the calcareous remains of the lower marine animals also contain appreciable quantities of metals. Bischof was also able to detect the presence of silver in treating only one and one fourth pounds of *Pocillopora alcicornis*, one of the common reef-forming corals. Many of the substances, including metals found in these remains, have not been detected, although looked for in the water of the sea, although it is quite certain that they have been concentrated from it. Here, too, it may seem that we are dealing with very insignificant quantities. Far from it. The rock-masses built up and left by these animals in the form of extensive coral reefs, form now and have formed, through all the geological epochs from the Azoic to the present day, very important portions of the superficial crust of the earth. They, too, contain, besides the carbonate of lime, fluoride of calcium. While the plants required the currents of the ocean to effect a geographical concentration, this process is effected by the corals themselves.

"There is another deposit of far greater extent, the builders of which have not, so far as I am aware, been analyzed to detect the presence of metals. I refer to the present bottom of the ocean. The expeditions sent out to examine the ocean bottom with reference to laying the telegraphic cables, the soundings of the United States Coast Survey, and special expeditions sent out by the British and Swedish Governments, have shown that the floor of the ocean is formed almost wholly of casts of polythalamia, especially of globigerina. According to M. de Portalis, this deposit begins on the American coast in the neighborhood of the hundred fathom contour line, so that practically it is co-extensive with the ocean. Microscopic ex aminations have shown it to be identical in character with the chalk. To these and to the corals we owe, in all probability, the limestone strata of all ages, and many beds of metamorphic rocks, which have resulted from the metamorphism which has replaced the carbonate of lime by silicates.

"With the disintegration and denudation of the dry land the metalliferous deposits inclosed in the rocks are also destroyed, and their contents are carried in mechanical suspension and in solution toward the sea; and were it not for the presence of sulphuretted hydrogen, which is being constantly formed, the ocean would contain in solution metallic salts to an extent which would seem to be incompatible with the existence of life. It is probable that the metals thus brought into the ocean are almost immediately precipitated as sulphurets and intimately diffused in the coast sediments. Here, then, is another great cycle begun in the sea by the action of vital force in plants and animals, running part of its course on land, returning again to the ocean, where the circuit is closed by an agent which can exist there only through the destruction of that vital force."

GEOLOGICAL SURVEY OF KENTUCKY.

N. S. SHALER, DIRECTOR.

REPORT ON THE GEOLOGY

OF THE PROPOSED LINE OF THE

ELIZABETHTOWN, LEXINGTON AND BIG SANDY RAILROAD,

FROM

MT. STERLING TO THE BIG SANDY RIVER,

BY A. R. CRANDALL.

PART X. VOL. II. SECOND SERIES.

REPORT ON THE GEOLOGY OF THE PROPOSED LINE OF THE ELIZABETHTOWN, LEXINGTON AND BIG SANDY RAILROAD, FROM MT. STERLING TO THE BIG SANDY RIVER.

The geological periods represented by the rocks exposed along the line of the proposed extension of the Elizabethtown, Lexington and Big Sandy Railroad are the Cincinnati or Hudson period of the Lower Silurian; the Niagara period of the Upper Silurian, represented by the rocks of the Clinton epoch, and perhaps by some of the rocks of the Niagara; the Hamilton period of the Devonian age; the Lower Carboniferous, made up of two members, the Waverly sandstone and shales, and the Sub-carboniferous limestone; and the Carboniferous period. The aggregate thickness of these rocks is about 1,900 feet. Of this thickness, the Carboniferous rocks comprise about one half. The Sub-carboniferous limestone reaches, at one point, a thickness of nearly 100 feet. The Waverly rocks reach about 500 feet. The Devonian Black shales, and the Upper Silurian Magnesian limestone and shale, show each about 120 feet. Of the Blue limestone of the Lower Silurian, about 150 feet is exposed.

The accompanying profile section is designed to give a general view of the whole line, showing the succession of the rocks of the different periods, and also the occurrence and distribution of valuable mineral deposits. The section is necessarily drawn on such a scale as to make the accurate representation of topographical features impossible; and the want of information in detail, at many points along the line, makes the section, like all profile sections, more or less diagramatic in the representation of the special geological features. It is hoped, however, that, in connection with the text, it will give to the general reader an intelligent view of the country traversed by this line.

The rock formations enumerated above are shown in an ascending order eastward from Mt. Sterling, presenting successive belts of country that display more or less fully the features which are characteristic of the different formations, and which give to them their relative economic values. Only three of them have a thickness equal to the height of the hills where exposed, namely: the Cincinnati beds, the Waverly sandstone and shales, and the Carboniferous rocks or the coal measures. The overlapping of beds reduces the breadth of the belts which are wholly characteristic of these formations, and tends, superficially, to shade the successive formations into each other; yet the rocks of each period have given rise to a topography sufficiently characteristic to make it an index of the general geology. The value of the land for agricultural purposes is also closely related to the geology; more so, perhaps, from the character of the soil for fertility, than from the resulting topography.

The region of the Lower Silurian, as crossed by this line near Mt. Sterling, is almost exclusively agricultural. The beds of the Cincinnati Group are generally too thin for building purposes, and no minerals of commercial value are known to occur in them. The richness of the soil, however, more than compensates for the absence of mineral resources. It is the soil of a large part of the Blue Grass region, which is too well known to need special description.

The belt of the Upper Silurian forms the outer extent of the Blue Grass region. With a soil scarcely as rich as that of the beds below,* and with a more broken surface, it yet presents an area of rich farming land.

That part of the section which takes its character chiefly from the Upper Silurian rocks, extends from near the head of Stepstone Creek to the hills east of Mill Creek. But this belt is not exclusively agricultural. The occurrence of the Clinton iron ore bed adds the possibility of a large and profitable iron-making industry.† The thickness of this bed is twelve feet, as opened near the line of the proposed road.

The change from the Upper Silurian Magnesian limestone to the Devonian Black shale is abrupt in this region. The average thickness of these shales is probably not more than 120 feet; but they give character to a belt of country proportionally broader than this thickness would indicate. In this belt the soil is clayey, and, in the bottom land, heavy, requiring drainage for successful cultivation. It is often heavily timbered, however, and the assemblage of species is, in some sense, peculiar to this formation. The much greater prominence of the Spanish oak (*Q. falcata, L.*) and of the laurel oak (*Q. imbricaria, Mx.*) among the black oaks, and of the post oak (*Q. Obtusiloba, Mx.*) among the white oaks,‡ is at once noticeable and characteristic.

*The following tables of analyses of soils from this region are made up from the report of Dr. Peter, volume IV, first series. Nos. 805–'6–'7–'8 are from the Upper Silurian belt, in Bath county. Nos. 809–'10–'11, and 1149–'50, are from the Cincinnati beds of Bath and Montgomery counties:

	805.	806.	807.	808.	1149.	1150.	809.	810.	811.
	Woods.	Old field	Woods.	Old field	Old field	Sub-soil.	Woods.	Old field	Sub-soil of 810.
Organic and volatile matters	8.165	7.639	5.024	5.118	6.172	4.171	8.376	6.308	4.108
Alumina	4.565	5.390	3.535	5.115	5.440	6.590	5.115	5.265	5.490
Oxide of iron	6.960	7.885	3.535	5.150	4.710	6.235	2.185	4.235	4.235
Carbonate of lime	.570	.420	.095	.170	.420	.220	.586	.445	.370
Magnesia	.710	.615	.385	.523	.583	.634	.660	.617	.613
Brown oxide of manganese	not est.	not est.	.220	.220	.120	.295	.195	.295	.295
Phosphoric acid	.170	.246	.118	.284	.345	.257	.365	.295	.312
Sulphuric acid	not est.	not est.	.041	.058	.067	.041	.084	.067	.055
Potash	.290	.249	.246	.210	.331	.372	.372	.280	.367
Soda	.059	.073	.100	.049	.133	.139	.123	.044	.037
Sand and insoluble silicates	79.145	78.270	86.980	83.320	81.476	81.370	82.595	82.270	84.920

†See report on the ores of the Red River Iron District by Mr. Moore, volume IV, new series.

‡Dr. Engleman has very properly separated the oaks of the United States into two classes, the black oaks, and the white oaks; the latter comprising all the species which grow strong and durable timber. The division is made, however, on characters which are more especially interesting to the botanist.

The shales of this formation yield petroleum, by distillation in closed retorts, in such per cent. as will doubtless bring them into notice, as a source of illuminating and lubricating oils, at no very distant day. They are the source of most of the well known mineral springs of Kentucky. The Olympian Springs, about three miles from the proposed line, is one of these. It has been suggested by Professor Safford, that copperas and alum might be derived in paying quantity from these beds.

The Waverly belt offers a soil of medium fertility. It may be said to extend from the mouth of the North Fork to the head of the East Fork of Triplet Creek. It is characterized by a great number of evenly-rounded hills or knobs, as described by Mr. Leslie, and hence the name knob-stone formation, as used by Owen in the earlier reports.

The rocks of this formation are grayish and olive-colored shales and sandstone, the latter affording the building stone widely known as the "Buena Vista" building stone. The transition from the Black shales is marked in this region by a thick bed of this building stone, as shown in the section. Near the Licking river large blocks from this bed are scattered along the foot of the hills, the wearing away of the shales above and below being a slow process of quarrying this durable rock. The lower part of the Waverly formation southward from this line carries a considerable amount of iron ore, mostly clay-stone or carbonate ore. This ore is not in demand at present.

The timber growth of this belt is similar to that of the coal measures, except that the chestnut oak (*Q. prinus var. monticola, Mx.*), which supplies the tan-bark trade of Eastern Kentucky, is less abundant or entirely wanting.

The limestone member of the lower Carboniferous period has its greatest thickness in the main valley of Tygert's creek, where it reaches a thickness of nearly 100 feet, and where it is overlaid by more than 200 feet of Carboniferous rocks. Along the western outcrop of the coal measures in this region it is rarely five feet. It does not, therefore, predominate in any part of the line. Where it is present in considerable thickness, however, its horizon is marked by characteristic cliffs and benches along the hillsides. It supplies a very pure limestone for the furnace and the kiln, and thin beds of it have proved suitable for use in lithography. At the top of this formation is found the "lower limestone ore" of Eastern Kentucky. It is known as the Red River ore in the Red River iron region. Very little has yet been done to develop this ore along the line in question.

The section upward from the lower limestone ore is that of the coal and iron-bearing rocks of Eastern Kentucky, the successive beds of which are exposed along the line to the eastward to an aggregate thickness of about 950 feet, as previously stated. For convenience of reference this section may be described as being made up of six members*—divisions which are easily recognized in the rocks of this region—as follows: the shale beds above the Sub-carboniferous limestone, and below the Conglomerate sandstone, 10 to 50 feet; the Conglomerate sandstone, from 20 to 100 feet; the shales above the Conglomerate sandstone, 30 to 60 feet; a middle sandstone series, 300 to 350 feet; the greenish shale beds, 90 to 120 feet; and the upper sandstone series, beginning with what is generally regarded as the equivalent of the Mahoning sandstone, and including the rocks above, to a thickness of about 350 feet.

The beds of economic value in the valley of Tygert's Creek are those which occur in the Sub-conglomerate shales. They are the limestone ore† mentioned above, a non-plastic fire-clay, a coal bed, and a block ore. The distribution of these beds is not well shown in the section, as they are somewhat irregular from changes of the character and thickness of the including rocks. The fire-clay will eventually prove a valuable deposit. It is the equivalent of Sciotoville clay, and from four to six feet in thickness where seen in this region. The coal bed is suitable, from its quality, for local use. It is not,

*See report on the Geology of Greenup, Carter, and Boyd counties, &c., volume II, second series, Reports of Kentucky Geological Survey.

†For special notice of the ores of this region, see report of Mr. Moore on the Ores of Greenup, Carter, and Boyd counties, volume I, second series, Reports of Kentucky Geological Survey.

however, thick enough to be mined extensively with profit. The ore is a limonite of good quality, and at one point it shows a thickness of 15 inches. This is probably greater than the average thickness of the bed.

The valley of the Little Sandy river, as crossed by this line, shows all the remaining important beds of this section, or nearly all the important coal, iron, and clay beds in the general section for Greenup, Carter, Boyd, and Lawrence counties.*

The Conglomerate sandstone, after giving rise to the rugged cliffs, and the picturesque scenery of the Sinking creeks, falls below the drainage line east of the Little Sandy river. The shales above the Conglomerate cap the hills in the valley of Tygert's Creek, and fall below the drainage at the Little Fork of Little Sandy. These shales include Coal No. 1 and a block ore. The latter has proved a valuable bed where worked. The former is not known to be thick enough along this line to be profitably worked. It is a pure coal, and has been found in both Greenup and Carter counties, locally from 3 to 4 feet thick.

The sandstone series above caps the hills near the head of Little Sinking Creek, and falls below the drainage towards the head of the Left Fork of Straight Creek. This set of rocks includes in their order the following beds: 1st. Coal No. 2, a bed not opened in this region sufficiently to determine its value, but which does not appear, from the exposures noted, to have more than a local value. 2d. A "rough block" ore, which is generally inferior in quality to the average ores of the region, but which, in places, has proved valuable. 3d. Coal No. 3, a bed that has been scarcely touched along this line, but which is generally known as having a workable thickness of good grate coal. It has not proved, in this region, a good iron-making coal. 4th. The "little block" ore, an ore that is used largely in all the furnaces of the Little Sandy Valley. Its place in the series is about 35 feet above Coal 3,

*See general section (plate 1), report on the Geology of these counties, volume II, second series, Reports of Kentucky Geological Survey.

and 10 feet below Coal 4, the Hunnewell cannel, when that is present. Coal No. 4 has not been seen on this line. It is present, however, a few miles north, on Little Fork and on Stinson Creek. 5th. Coal No. 5, which is irregular in both thickness and quality. It is not regarded as a promising bed, at present, on that account. 6th. The "Ferriferous limestone" and the "limestone ore." The limestone is usually wanting along this line. Where found, it serves as a flux in reducing the ores of the region. The associated ore, which normally rests on this bed, is present in a continuous bed. In thickness and quality it is similar to the "lower limestone ore." It is, therefore, one of the principal ores of this region. The place of the Ferriferous limestone is about 100 feet above the little block ore, and about 20 to 25 feet below Coal No. 6, when that is present. 7th. The fire-clay bed, overlying the limestone ore, a bed usually 2 to 3 feet of No. 1 fire-clay, and an equal thickness of potter's clay at the top. Coal 6 is generally wanting, or thin, on this line. It is the uppermost bed of this series. Near the Big Sandy it would be found of workable thickness by a shaft 40 to 50 feet deep.

The greenish shale beds begin 20 feet above Coal 6. They extend along this line from the valley of the Little Fork to the Big Sandy river, falling below the drainage at the two principal summits. These shales, though comparatively thin, include some of the most important beds of Eastern Kentucky. They are—1st. The so-called "yellow kidney" ore, which is found near the base of these shales, distributed through 5 feet or more of shale rock, or at some points bedded in part between the upper layers of the sand rock overlying Coal 6. 2d. Coal No. 7, 25 feet above the yellow kidney ore. This is the well known Coalton coal. It shows thickness of 6 feet on Straight Creek. Four feet of this bed has proved at other points suitable for use in the furnace without coking. 3d. The red kidney ore, as it is generally known in this region, which follows, 25 feet above. It is similar in character and surroundings to the yellow kidney ore. They are regarded by furnace men as among the best ores of the Hanging

Rock region. 4th. Coal No. 8, 40 to 50 feet above Coal 7. It is best shown on Garner Creek, where it has been opened near the bed of the creek, Coal 7 being below the drainage. As shown here, Coal 8 is 4 feet in thickness, without any considerable parting. 5th. Again, 20 to 25 feet above Coal 8 is a bed of ore, which is known at some of the furnaces as the "bastard limestone" ore. It rests on an impure limestone in some localities, and resembles the other limestone ores; but more commonly the limestone is wanting, and the ore is like the kidney ores of this region. Still another kidney ore is found above, at points where the thickening of the shales extends this series upward for a limited distance.

The upper sandstone series caps the hills east of Little Fork, and occupies the greater part of the section eastward from the head of Garner Creek. It contains no beds of so great economic importance as these already described. Those that have been observed on this line are Coal No. 9, 55 feet above Coal 8, opened at the mouth of Garner Creek, and showing 2 feet of coal between heavy masses of coarse sandstone; and the so-called Rough and Ready ore, which rests upon a band of impure limestone, 70 to 80 feet higher up. This ore is generally regarded as inferior in quality to the other limestone ores.

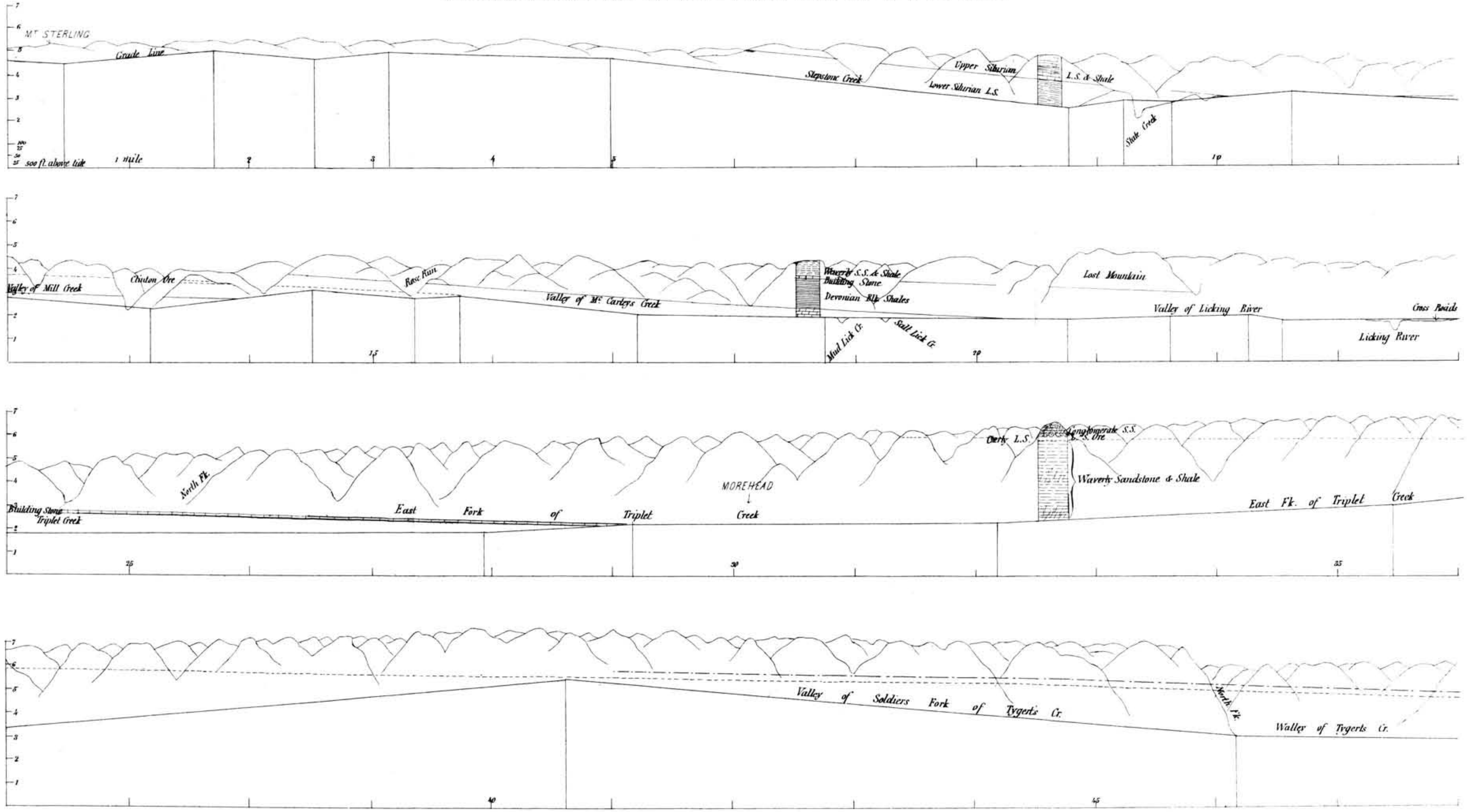
The soil of the coal measures is of medium fertility. The surface of the country is hilly and broken, reducing the per centage of land that is easily cultivated, and increasing the proportion of land that should be held for timber growth* or for pasturage. The climate, surface, and soil all combine to make this region exceptionally well adapted to the raising of fruits.

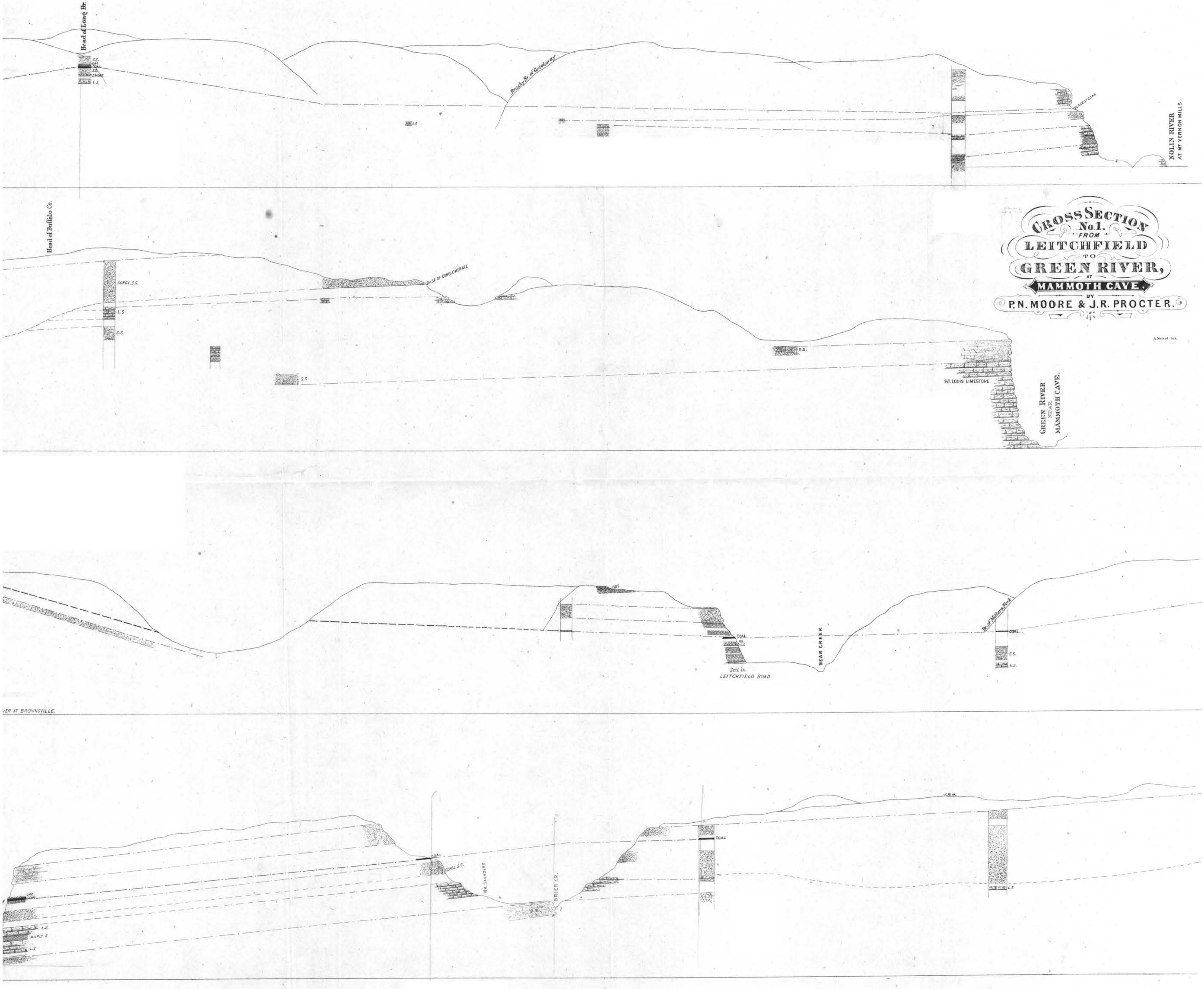
*See report on the Forests of Greenup, Carter, Boyd, and Lawrence counties, volume I, second series. Reports of the Ky. Geol. Sur.

GEOLOGICAL SECTION FROM MT. STERLING TO THE CHATTARAWA OR BIG SANDY RIVER

ON THE PROPOSED LINE OF THE ELISABETHTOWN LEXINGTON AND BIG SANDY RAIL ROAD.

Horizontal Scale 500 Ft. to the Inch. – Vertical Scale 500 Ft. to the Inch.





CROSS SECTION
No. 1.
FROM
LEITCHFIELD
TO
GREEN RIVER,
AT
MAMMOTH CAVE.
BY
P.N. MOORE & J.R. PROCTER.
A. Meisel Lith.
Head of Long Br.
S.S.
ORE
COAL
L.S.
PLACE OF COAL
NOLIN RIVER
AT Mt VERNON MILLS.
Head of Buffalo Cr.
CONGL. S.S.
L.S.
S.S.
BASE OF CONGLOMERATE
S.S.
S.S.
ST. LOUIS LIMESTONE
GREEN RIVER
NEAR
MAMMOTH CAVE.
ORE
COAL
L.S.
Sect. in
LEITCHFIELD ROAD
BEAR CREEK
COAL
S.S.
L.S.
VER AT BROWNSVILLE.
COAL
CONGL. S.S.
WM. SAUNDERS
BRIER CR.
COAL
J.W.M.
L.S.
ORE
COAL
L.S.
L.S.

GEOLOGICAL SURVEY OF KENTUCKY.

N. S. SHALER, DIRECTOR.

A GENERAL ACCOUNT

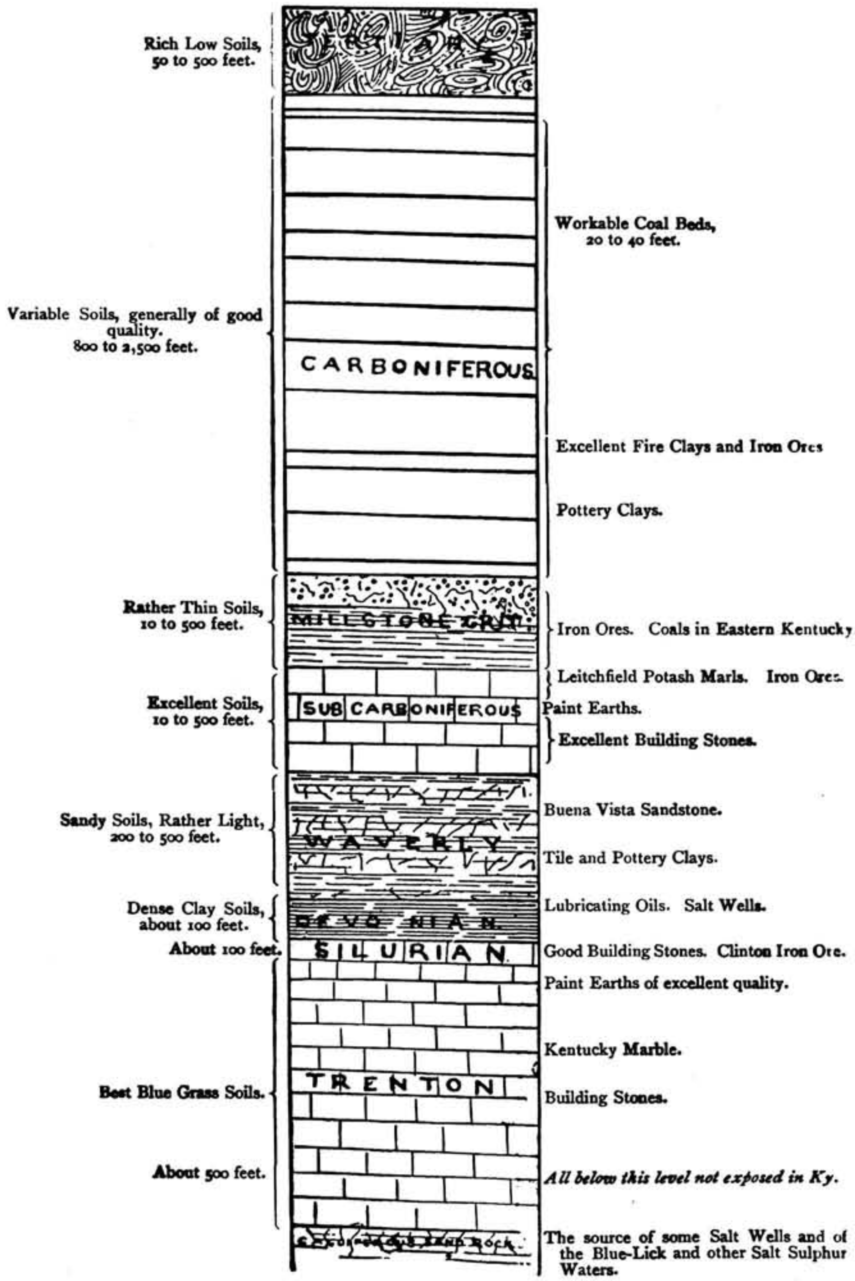
OF THE

COMMONWEALTH OF KENTUCKY,

PREPARED BY THE

GEOLOGICAL SURVEY OF THE COMMONWEALTH.

PART XI. VOL. II. SECOND SERIES.


Rich Low Soils, 50 to 500 feet.
Variable Soils, generally of good quality. 800 to 2,500 feet.
Rather Thin Soils, 10 to 500 feet.
Excellent Soils, 10 to 500 feet.
Sandy Soils, Rather Light, 200 to 500 feet.
Dense Clay Soils, about 100 feet.
About 100 feet.
Best Blue Grass Soils.
About 500 feet.
CARBONIFEROUS
MILLSTONE GRIT
SUB CARBONIFEROUS
WAVERLY
SILURIAN
TRENTON
Workable Coal Beds, 20 to 40 feet.
Excellent Fire Clays and Iron Ores
Pottery Clays.
Iron Ores. Coals in Eastern Kentucky
Leitchfield Potash Marls. Iron Ores.
Paint Earths.
Excellent Building Stones.
Buena Vista Sandstone.
Tile and Pottery Clays.
Lubricating Oils. Salt Wells.
Good Building Stones. Clinton Iron Ore.
Paint Earths of excellent quality.
Kentucky Marble.
Building Stones.
All below this level not exposed in Ky.
The source of some Salt Wells and of the Blue-Lick and other Salt Sulphur Waters.

PREFACE.

THE following brief and imperfect account of the Commonwealth of Kentucky has been prepared under the following circumstances: Owing to the fact that the Legislature of Kentucky did not meet in 1874, or until 31 Dec., 1875, no sufficient action was taken to insure the representation of the Commonwealth in the Centennial Exhibition of 1876. On the sixteenth of February of this year, an appropriation of five thousand dollars was made for the purpose of making some showing of the resources of the State, and the following gentlemen were appointed commissioners to control the expenditure thereof: —

Gov. JAMES B. McCREARY, N. S. SHALER, Esq.

First District	W. B. MACHEN, Esq.
Second "	CLINTON GRIFFITH, Esq.
Third "	JAMES H. BOWDEN, Esq.
Fourth "	Gen. E. H. HOBSON.
Fifth "	Dr. E. D. STANDEFORD.
Sixth "	JOSEPH C. HUGHES, Esq.
Seventh "	WILLIAM WARFIELD, Esq.
Eighth "	Dr. JENNINGS PRICE.
Ninth "	JOHN DISHMAN, Esq.
Tenth "	F. L. CLEVELAND, Esq.

At the first meeting of this Board it became evident that, in the brief time at its disposal, it would be necessary to put the principal part of the burden on the State Geological Survey. The work of making the collections of minerals, soils, &c.,

that accompany this Report, as well as the preparation of the Report itself, was put upon the Survey. Coming in the time of preparation for the field-work of the year, these Centennial preparations have proved a great burden to the Survey, and have been less perfectly executed than was desired. It is believed, however, that the collections, together with this and the several other pamphlets, will give the intelligent observer a good general knowledge of the condition and prospects of Kentucky. Persons desiring additional information are referred to the publications of the Survey, or to the Reports now in preparation, — a list of which is given at the end of this pamphlet. All other information concerning the resources of the State will be cheerfully furnished, on application to the Secretary of the Geological Survey at Lexington, Kentucky.

In the completion of these pages, every possible care has been taken to exclude errors. Owing, however, to the haste of its preparation and printing, some errors have doubtless crept into the text. Corrections are respectfully solicited, and all that may be furnished will be noted in subsequent editions. It is believed that the Tables from the United States Census, the Reports of the Sanitary Commission and the State Treasurer are quite without error.

My acknowledgments are due to my assistants, Dr. Robert Peter, Mr. J. H. Talbutt, Chemists of the Survey; to Messrs. A. R. Crandall, P. N. Moore, C. J. Norwood, Geological Assistants; and more especially to Assistant John R. Procter, for his coöperation in preparing the work for the press.

N. S. SHALER,

Director Kentucky Geological Survey.

May 10, 1876.

A
GENERAL ACCOUNT
OF THE
COMMONWEALTH OF KENTUCKY.

GEOGRAPHY.

Position. — The Commonwealth of Kentucky — situated between latitude 36° 30′ and 39° 06′ north, and longitude 5° 00′ and 12° 38′ west, from Washington — includes about forty thousand square miles of area, extending for six hundred and forty-two and a half miles along the south bank of the Ohio River, from its junction with the Mississippi to the mouth of the Chatterawah or Big Sandy. This river forms the northern, north-western, and north-eastern borders of the State. A part of its north-eastern border, one hundred and twenty miles, is formed by the Chatterawah River; a south-eastern face of about one hundred and thirty miles has a natural boundary in the several ranges which receive the common name of Cumberland Mountains. The southern face alone is an arbitrary line of two hundred and ninety-five miles in length. The western boundary of about fifty miles is formed by the Mississippi River.

A glance at the accompanying map will make it plain that the region occupied by this Commonwealth has a position of peculiar importance with reference to the great feature-lines of the continent. The Mississippi-River system is the key to the continent. Those parts which lie beyond its borders are, by their limited area or their severe conditions of climate, relatively of minor importance. In this system the State of Kentucky, all things being considered, occupies a most important place. Its western border is only one thousand and seventy-five miles* from the mouth of the Mississippi, and its eastern boundary is within five hundred miles of the Atlantic ports.

The special features of position to be considered in measuring the importance of this Commonwealth are its central place with reference to the Valley of the Mississippi, and the advantages it has from its extended contact with the river system of that valley. More than any other State in America it abounds in rivers. Including the Ohio and Mississippi Rivers, where they bound its borders, the State has within its limits rather more than four thousand miles of rivers, which are more or less completely navigable. Improvements of small cost will give this amount of navigation with complete permanency, except for an average of about fifteen days per annum, when they are ice-bound.

GENERAL GEOLOGY.

Just as the State of Kentucky is geographically but a part of the Mississippi Valley, so it is geologically composed of a series of rocks which extend far and wide over the same region. On the eastern line, between Cumberland Gap and Pound Gap, it is generally in sight of the old crystalline rocks of the Blue Ridge, or original axis of the Appalachian Chain, and is closely bordered by rocks of the middle Cambrian or Potsdam age; but the lowest exposed rocks of the State are those found at a point on the Ohio River, about twenty miles above the Licking River, where we come upon Cambrian rocks answering to the base of the Trenton period in New York, and probably to the Bala or Carodoc beds of England. This series is about six hundred feet thick, and consists principally of the remains of organic life laid down in a continually shallowing sea, interrupted by occasional invasions of coarser sediment, derived from the northward. At the close of this Cincinnati section of the Cambrian, there came the invasion of a heavier sand-flow, probably coming from the south-east, that arrested the life and formed some thick beds of rock, known in the reports

* It is 528 miles from Columbus to New Orleans by railroad, and 472 miles to Mobile.

of the Kentucky survey as the Cumberland Sandstone. After this the floor of the sea was sparingly peopled with life, during the whole of the Clinton and Niagara epochs, when it was probably deep water. This deep sunken condition of the ocean floor continued in the Devonian time, when this section seems to have been the seat of a deposition such as is now going on beneath the Sargassa Sea of the Atlantic of to-day. The decaying sea-weed and other organic matter made a bed from three hundred feet thick along Lake Erie to forty feet thick in Southern Kentucky, averaging about one hundred feet in Kentucky. This bed furnishes the rich lubricating oils of the Cumberland Valley. After this came again shallow water, and quick successive sand-invasions moving from the north, which formed several hundred feet of beds. These beds probably represent but a fraction of the time required to form the Black Shale which lies below. This part of our section is called the Waverly, and is commonly regarded as being more nearly related to the Carboniferous than to the Devonian series of rocks. After this period came a repetition of subsidence, and a cessation of the sand-invasions. During this time there was such a development of sea-lilies or stemmed Echinoderms, that this time deserves to be called the period of crinoids. This accumulation ranges in depth from a few feet along the Ohio River to five hundred or more feet under the Western Coal-field. It marks a period of tolerably deep still water, filled with lime-secreting animals. It is probably to the unbroken character of this succession of life, and especially to the crinoids with their upright stems, that we owe the uniformly massive character of many of the beds of this Subcarboniferous Limestone.

Next in the ascending series we come on the coal-bearing rocks. Their deposition was begun by the sudden shallowing of the water over this region, bringing the old sea-floor near the surface of the water, and subjecting it to alternating invasions of sand borne by strong currents, and exposures in low-lying flats covered by a dense swamp vegetation. Each of these swamp-periods answers to a coal-bed; each recurring subsidence, to the deposits of sands and shales that lie between the coals.

After the Carboniferous period, we are warranted in believing that this region was but little below the sea, and with this change it became essentially subjected to land conditions alone. The wear incident to these conditions has swept away a large part of the exposed rocks, and reduced the Carboniferous series to less than half of its original thickness.

Near to the present time there came a sudden subsidence of this whole region, that brought the low-lying western part of the State beneath the level of the sea, and retained it there while the Tertiary deposits were being formed out of the waste of the higher parts of the Mississippi Valley that still remained above the sea.*

The disturbances that have changed the position of the rocks in Kentucky have been few and far between, though they have materially affected the general structure of the State. From the mouth of the Licking south a little westerly, through Monroe County, extends a ridge or axis of elevation, the beds dipping gently, rarely over ten feet in a mile, in either direction away from it. This was in part formed during the deposition of the Lower Cambrian, but probably was completed at a much later date. This has caused the limitation of the Carboniferous beds of this region. To it in fact we owe the abundant diversity of the rock outcrops within the State. In the south-east corner of Kentucky there is a region between Straight Creek and Clear Creek, tributaries of the Cumberland, and the Virginia border, where the Appalachian disturbance has thrown the rocks into mountain folds. Here are some fine exposures of the deeper rocks brought up by the great faults of the region.

No glacial traces of the last period are known within the State, nor are the indications of the more ancient ice-periods at all distinct. This area has probably remained south of all those profound disturbances of temperature that have so greatly affected more northern regions.†

* The appended generalized section on second page of cover will give a general idea of the successions of the Kentucky rocks. Further facts can be found in the Reports of the Survey, for which see list at the end of this pamphlet.

† For further information on this subject, see the Biennial Report of N. S. Shaler for 1874–5, Kentucky Geological Survey, now in press.

Surface. — The whole of Kentucky lies within the Mississippi Basin, and within the special division of the Ohio Valley. Its principal feature-lines have been given it by the river excavations. A small area on the south-east, containing not more than four thousand square miles, lies within the disturbed region of the Alleghanies, and has a true mountain-folded structure. The remainder is essentially a plain or table-land, sloping from the south-east towards the north-west, and little broken, except by the deep-cutting river excavations. In the eastern half this table-land has an average height of about one thousand feet above the sea; the ridges often reaching to fifteen hundred, and the valleys down to seven hundred feet. The greatest difference between the bottom of any one excavation valley and the borders of the divide does not exceed about seven hundred feet, and is usually about half this amount. Eight degrees west of Washington the country begins to sink down rapidly to the west. The cause of this change will be explained in the geological description of the State. Its effect is to carry the upper surface of this table-land gradually downwards, until along the Mississippi its average height is not more than three hundred feet above the sea, and the average difference between the bottoms of the valleys and the tops of the ridges is not over fifty feet. This considerable height of the State above the sea is of great advantage in securing it against fevers, from which it may be said to be practically exempt, except in a narrow belt in the extreme western district, near the borders of the swamp regions.

Although the general surface of the State is that of a table-land sloping towards the Ohio River, and consequently towards the north-west, it has many subordinate features which should be separately described. All that part of its surface indicated as Tertiary on the accompanying map is rather imperfectly drained, the rivers having low banks, and during the winter and early spring being subject to overflow from the floods. The remainder of the State, saving a strip a few hundred feet wide along some of the larger streams, is absolutely free from this danger. The remainder of the State, to the east of this line, has only the variety which comes from the difference in the wear of the streams in the rock. The nature of this difference will be discussed under the head of geology. It is only necessary to say here that the whole of the area described on the map as Cambrian is characterized by broad flat-topped ridges, with steep-banked rivers between; the general character being that of a much cut up table-land. The part marked as Devonian has broad valleys and steep-sided, tower-like hills. That marked Subcarboniferous, especially in the region west of the Cincinnati Southern Railway, is characterized by having all its smaller streams underground, usually only the rivers over fifty feet wide at low water having their paths open to the sky. All this region wants the small valleys which we are accustomed to see in any country, but in their place the surface is covered by broad, shallow, cup-like depressions or sink-holes, in the centre of which is a tube leading down to the caverns below. All this region is completely honey-combed by caverns one level below the other from the surface to the plane of the streams below. In one sense, this set of underground passages may be regarded as a continuous cavern as extensive as the ordinary branches of a stream when it flows upon the surface. The sink-holes answer to the smallest extremities of the branches. Some idea of the magnitude of these underground ways may be formed from the fact that the Mammoth Cave affords over two hundred miles of chambers large enough for the passage of man, while the county in which it occurs has over five hundred openings leading far into the earth, none being counted where it is not possible to penetrate beyond the light of day.

The Carboniferous formation is characterized by being cut into very numerous valleys, mostly rather narrow and with steep-sloped, narrow-topped ridges on either side. The relatively narrow valleys, and the general absence of any large areas of flat land on the top of the ridges, cause this region to have less land well fitted for cultivation than any other part of the State. Every part of the surface of the State not permanently under water may be regarded as fitted by its surface for the uses of men, not one thousandth of it being so precipitous as to be unfit for cultivation in some fashion. The writer knows of no equal area in Europe that has as little waste on account of its contour.

RIVER SYSTEMS.

Reference has been made to the fact that the whole of this Commonwealth lies within the basin of the Mississippi, and over ninety per cent. of its area within the Ohio Valley, the remainder pouring its waters directly into the Mississippi. There are, however, a number of large streams which are the property of the State; and two, the greatest tributaries of the Ohio, gather a part of their waters in the State.

Big Sandy.— Beginning at the eastern end of the State, we have the Big Sandy or Chàtterawah River, which separates for forty miles, by its main stem and then by its eastern fork, the State of Kentucky from West Virginia. This stream is the only river of its size in America all the basin of which is in the coal-bearing rocks. It drains a valley of about four thousand square miles. Its name of Sandy is derived from the very large amount of moving sand in the bed, coming from the rapid wear of the sand rocks which compose the beds of all its tributaries. The valley consists of a narrow belt of level, arable land bordering the streams, and a great extent of hill land of a good quality of soil, but only fit for permanent cultivation on the more gradual slopes. The greatest value of soil-products in this valley is to be found in its timber resources, which will be found specially mentioned under the head of timber. It may be said here that the valley contains, next to the Upper-Kentucky and the Cumberland Valleys, the largest amount of original forest found in any part of the State, and more than any other valley is especially fitted for the continued production of timber of varied quality. The forests throughout this region readily and rapidly reproduce themselves in the same species, after being cut away. The soil of this valley is very well fitted for the growth of fruits of all kinds. The season is rather later than that of the other river basins of the State, and the liability to frosts possibly rather less than in the central region. Owing to difficulties of transportation, fruits have been as yet but little grown for exportation.

The whole of the cereals are produced in the valley. The soil is usually of a light sandy nature, with generally enough clay to give it a fairly lasting quality. The principal disadvantage arises from the steepness of the slope of the hills.

Mineral Resources. — The coal resources of this valley are, in proportion to its total area, greater than any other in the State, scarcely an acre of its area but probably has some workable coal beneath it. These coals are mostly of the ordinary bituminous qualities; some cannel coal occurs therein of workable thickness. A full account of these coals, with illustrative sections, will be found in the general description of the eastern coal-field. Little effort has been made to find iron ores in this valley. The dense forests and the softness of the rocks prevent the occurrence of trustworthy surface indications. In the lower part of the valley very important ores have recently been discovered, of which the precise areas and character are yet to be determined. (See the reports of A. R. Crandall and N. S. Shaler for further details.)

The Little Sandy Valley. — The general character of this small valley is much the same as that of the Big Sandy. The river is altogether within the Carboniferous formation. The early utilization of the iron ores of this valley has led to a knowledge of its mineral resources superior to that yet obtained for any other equal area in the State. About thirty-five feet of workable coals are known in the several beds of the valley. (See p. 42.)

Tygert's Creek. — Here the coal resources are more deeply cut down by the stream, which in good part flows upon the Subcarboniferous Limestone. Though wanting some of the best coals, it has many of the best iron ores of the State. Some beautiful caverns are found along its banks in Carter County. The general surface is much as in the valleys before described. In its upper part, the Limestone rocks give occasional areas of more enduring soils than are furnished by the Sandstones of the country to the eastward. The timber and other soil products are much the same.

The stream is not navigable, but can easily be made so by locks and dams, giving continuous navigation for about forty miles along the meanders of the stream.

The streams from the mouth of Tygert's Creek to the mouth of the Licking or Nepemini are all quite small, and drain a region of limited mineral resources. Kinniconick Creek gives access to a region abounding in admirable Sandstone for building purposes, and to some iron ores of undetermined richness, but of considerable promise. It can be made navigable at small expense. The whole of this valley abounds in excellent oak timber.

The Licking. — This stream, the fourth in size of the rivers of the State, ranking next to the Big Sandy, passes over all the formations found in the State except the Tertiary. From its source to near the mouth of Blackwater Creek it runs on the Carboniferous rocks. As far as Duck Creek, it is still bordered by these beds containing excellent coals, both cannel and bituminous. On the Subcarboniferous Limestone, which crosses the river near Blackwater Creek, is an excellent iron ore. On Slate Creek, near Owingsville, is an admirable mass of ore, the richest of the State, having at places a depth of fifteen feet or more.

Triplett and Salt-Lick Creeks afford excellent building-stones, and the same series of rocks (the Waverly) furnish some stones which give great promise for lithographic purposes.

From the mouth of Fox Creek to the end of the river the stream is entirely in the lower Blue Limestone or Upper Cambrian rocks, which afford excellent building-stones, but no other marketable underground products.

The soil of the valley varies greatly, — light sandy loam in the Carboniferous and Waverly series; rather wet clays on the Black Shale and Silurian; rich, loamy clays giving soils of the first quality over the lower or Cambrian half of the stream.

The Blue Limestone lands of the counties drained by the North Fork are noted for their large yield of a tobacco highly prized by the manufacturers of "fine cut," and well known in the markets under the name of "Mason County tobacco."

The Kentucky.—Sixty miles below the Licking, the Kentucky discharges into the Ohio. This stream is the second of the Kentucky streams in volume, and the first in length.

Its head-waters, from Sturgeon Creek east, lie altogether with the coal-bearing rocks. At least four hundred miles of water-front, open to vessels able to carry three hundred tons of coal, can be made on the three forks of this river. The coal holds along the hill-sides as far as Station-Camp Creek. The upper half of the Red-River branch contains also an abundance of coal. The entire drainage of the Kentucky River, above its forks in Lee County, is in the Carboniferous rocks. No portion of the State exceeds the Upper Kentucky region in number, thickness, or quality of coals. A preliminary section, made by Mr. P. N. Moore, of the Kentucky Geological Survey, from Red River in Wolfe County to the mouth of Troublesome Creek in Breathitt County, establishes the fact that up to the latter point there are at least five workable coal-seams above the Conglomerate Sandstone. The following analyses, from carefully averaged samples, will show the excellent quality of these coals: —

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
Specific Gravity	1.300	1.294	1.297	1.290	1.289
Moisture	2.50	3.50	3.56	2.76	2.10
Volatile Combustible Matter .	41.10	35.20	33.56	36.60	36.20
Fixed Carbon	49.22	56.70	58.38	56.50	58.20
Ash	7.18	4.60	4.50	4.06	3.50
Coke	56.40	61.30	62.88	60.56	61.70
Sulphur	0.818	1.189	1.381	0.865	0.836

No. 1 is a coal from Frozen Creek, Breathitt County.
No. 2 is a coal 5′ 7″ thick, from Devil Creek, Wolfe County.
No. 3 is a coal from Spencer's Bank, Breathitt County.
No. 4 is a coal 6′ thick, from Wolfe Creek, Breathitt County.
No. 5, from near Hazard, Perry County.
Analyses by Dr. Robert Peter and Mr. Jno. H. Talbutt, chemists for the Kentucky Geological Survey.

The cannel coal of the Upper Kentucky is to be found over an extensive area, and is of a remarkably good quality, as will be seen from the following analyses by the chemists of the survey, made from average samples: —

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
Specific Gravity	1.280	1.265	1.280	1.180	. . .
Moisture	0.94	1.30	3.40	1.20	1.20
Volatile Combustible Matter	52.38	47.00	34.40	58.80	40.86
Fixed Carbon	35.54	44.40	46.96	35.30	46.44
Ash	11.14	7.30	6.24	4.70	9.50
Coke	46.68	51.70	53.20	40.00	57.94
Sulphur	1.423	1.574	0.630	not est.	0.634

No. 1. Georges' Branch Cannel Coal, Breathitt County.

No. 2. Haddock's Cannel Coal, mouth of Troublesome Creek, Breathitt County.

No. 3. Robert's Coal, Perry County.

No. 4. Frozen Creek, Breathitt County.

No. 5. Salt Creek, Perry County.

Three of the best gas-coals in Scotland and England are: (No. 1), Lesmahago Cannel; (No. 2), Ramsay's Newcastle Coal; (No. 3), Weym's Cannel Coal. Compare with the above the following analyses, taken from Dr. Peter's Report, Vol. II. First Series Kentucky Geological Survey: —

	No. 1.	No. 2.	No. 3.
Specific Gravity	1.228	1.29	1.1831
Volatile Matter	49.6	36.8	58.52
Fixed Carbon	41.3	56.6	25.28
Ash	9.1	6.6	14.25
	100.0	100.0	98.45

Sulphur not determined.

The indications are that the coal-measures thicken, and the number of workable coals increase south-easterly from the mouth of Troublesome Creek. This, however, can only be determined by detailed survey.

In addition to the numerous workable coals above the Conglomerate Sandstone in this region, there are two workable coals below the Conglomerate. The excellent quality of these coals can be seen from the analysis, No. 1601, p. 81.

Just below the coal the Carboniferous Limestone bears upon its top the ore known as the Red-River iron ore, which has long furnished a very celebrated cold-blast charcoal iron, well known as Red River car-wheel iron. There is probably about one hundred miles of outcrop of this ore within a short distance of the tributaries of the river, and within twenty miles of the main stream. Salt, fire-clay, and hydraulic cement abound in the Black Shale and Upper Silurian rocks. From Burning Creek to the mouth the Kentucky Valley runs entirely within the Upper Cambrian or Blue Limestone.

The soils in this valley have the same character as in the Licking, ranging from the light loamy soils of the Carboniferous, through the clays of the Silurian and Devonian to the exceedingly rich blue-grass soils of the Cambrian and Cincinnati Limestone rocks. The navigation of the Kentucky River has been improved by locks and dams as far up as a point about twenty-five miles above Frankfort. The stream is admirably adapted for the extension of this method of navigation, until over six hundred miles of navigable water is secured. As in the case of the Licking and the Green, it has the peculiar advantage of having a very great variety of soil and natural products within a narrow compass.

The timber resources of the part of this valley that lies within the coal-bearing area are very great; all the important timber trees of Kentucky, except the cypress, are found within the valley. The black walnut is found in abundance on the hill-sides throughout this section, the finer qualities of oak, much yellow pine, some white pine, &c.

Salt River. — This stream is the only considerable river in the State that has little in the way of mineral resources. It will be seen that it follows the line of the outcrop of the Subcarboniferous Limestone throughout its whole extension, being the only river in the State that does not run across the general trend of the stratification. The valley abounds in good Limestone for building purposes, the whole of the Subcarboniferous

Limestone being exposed along its banks. The underlying Sandstones of the Waverly also furnish excellent building materials. Iron ores occur in the Waverly Shales, and perhaps also in the Subcarboniferous. The salt-bearing rocks of the lower Waverly and the Black Shale are doubtless accessible from the line of the surface of the valley. The flow of water is rather more steady than in the other rivers to the eastward, on account of the cavernous nature of the rocks along its banks. It will, therefore, furnish excellent water-powers along its whole course.

The soil of this valley is of pretty even excellence throughout. The head-waters drain a region of Blue or Cambrian Limestone, and the main stream takes the soils of the Waverly which are rather sandy, and the Carboniferous Limestone which affords very good soil.

The river has a more than usually rapid fall, descending about six hundred feet in its course of about one hundred miles from the head-waters, — probably the most rapid fall of any stream of its size in Kentucky. This will make the improvement of the stream more difficult than of other rivers of the State.

The Green. — This, on many accounts the finest of the rivers that have their whole course within the State, differs in many striking regards from the other streams. It is at its lowest stage about one-third larger than the Kentucky. The Kentucky and Licking streams have their mineral belts at their head-waters, while the lower part of their course lies in districts having their greatest value in their agricultural resources. The Green, however, has its lower half within the western coal-field, and its upper waters in the older rocks. This western coal-field is described in another section of this pamphlet, to which the reader is referred for details. In a general way it may be said that it is exceeding rich in coals of varied quality, and abounds in iron ores of high grade. Muddy River, Bear Creek, and Nolin, are peculiarly rich in iron ores, the district between Bear Creek and Nolin being one of the richest in America in the ores of the Carboniferous period.

Soils. — The soils of this valley have throughout a high order of merit when they lie on the Subcarboniferous Limestone. They are clay loams with a perfect underground cavern drainage, excellent for all grains and for fruits. The coal-bearing rocks give soils of a much higher quality than is usual in such formations, nearly the whole of the area occupied by these rocks giving good grain crops and tobacco of a high quality and of a large yield to the acre.

The whole of this valley is peculiarly fitted for furnishing water-power. Rough Creek, Pond River, Muddy River, Bear Creek, Nolin River, Big Barren River and its tributaries, and all the other streams heading in the Subcarboniferous or lower Limestone are singularly steady in their flow, owing to their underground reservoirs of water. To these underground sources they owe as well their comparative immunity from freezing, the Green rarely freezing in the winter season. The whole of this valley is singularly well fitted for fruit culture, on account of its immunity from winter killing and destructive spring frosts, and its neighborhood to Chicago, Cincinnati, Louisville, and other great markets.

Nearly the whole of this valley abounds in excellent timber, principally hard-wood. The upper waters have large quantities of valuable cedar timber; the Carboniferous district abounds with the several species of oak, great quantities of valuable hickories, walnut, tulip-tree (or poplar), some holly of large size, sometimes over fifteen inches in diameter. There is also a good deal of hemlock along the cliff borders of the streams, and some cypress in the lower swamps in the Pond River district.

Tradewater River. — This stream bears about the same relation to the western mineral field that the Little Sandy does to the eastern coal-field. Excepting a few of the less important head-waters, the whole of its basin lies within the coal-bearing rocks. Its soil is very fertile and well fitted for the growth of cereals and tobacco. An abundant growth of hard-wood timber of varied species compose its forests; for its area it is one of the richest fields for the oaks, hickory, poplar, that exists within the State.

The coals accessible in this valley are, in part, only above the drainage level. They represent some of the best coals in the western district. Iron ores exist in abundance, but have never been worked.

The Cumberland. — This river has the upper half and lower sixth of its course within Kentucky. The upper region lies within the coal-field and traverses some of its richest sections. The part above Cumberland Ford is in a great mountain valley between Cumberland Mountain and Pine Mountain. This valley is about twelve miles wide, and is a fertile region abounding in excellent timber, with the land, so far as arable on account of its steepness, of excellent quality. About one-third of the surface is fit for culture with the plow. Below Cumberland Ford the river bottom widens, and the mountains sink down. The land along the river is very rich indeed, and that back on the hills is of good quality. At about two hundred miles from its source, the stream cuts down into the lower rocks, and from near the Kentucky line throughout most of its current in Tennessee runs on the Upper Cambrian or Blue Limestone formation; when it reenters Kentucky it is back to the rocks of the Subcarboniferous age, and the valley is an exceedingly fertile district. The line of this valley brings its southern edge near to the Tertiary formation of the western part of the State. Its proximity to the Tennessee on the west and to the Green on the east narrows the valley to small size; all the tributaries on the lower waters are small, but the upper confluents of this stream contain some of the finest rivers of the State. Martin's Fork, Clear Creek, Straight Creek, Rockcastle River, and Big South Fork are all considerable rivers, and afford excellent water-powers. They are all streams of great steadiness of flow, and all the conditions are favorable to the formation of valuable water-powers. They all traverse regions of very great resources in the way of iron and timber, and have soils of fair quality.

It is probable that no other valley in the West possesses so great a body of valuable timber as the Cumberland and its tributaries. Poplar, the several varieties of oak, beech, maple, sweet and sour gum, walnut, and other deciduous trees abound. Red cedar, yellow and white pine, are found in certain districts in considerable quantities.

The Cumberland is nearly equal to the Kentucky in the area and richness of its mineral districts. The coal section in the valley between Pine Mountain and the Cumberland Mountains has a depth of two thousand feet, and about twenty distinct beds of coal,* of which half-a-dozen are workable. The iron ores have not been examined or sought for. They may be expected to occur at several points in the coal-bearing rocks and on the top of the Subcarboniferous Limestone. The rich Clinton ores of the Cumberland-gap district,† though not in the drainage area of the Cumberland River, are in necessary commercial relations with it, inasmuch as they must be smelted by the charcoal and stone-coal of this valley. It is also most probable that these same ores are accessible along the hundred miles of the Pine-Mountain fault, by means of adits or galleries above the drainage, or by shafts of shallow depth. Detailed reports concerning this region may be expected in the fifth and eighth volumes of the Reports of the Survey. Beneath a large part of the upper Cumberland region the formation, commonly called the "Black" or "Devonian" Shale, is filled with a lubricating oil of great value. Experience has shown that these wells are practically inexhaustible, and that the oil is of a very superior quality, especially fitted for use in high latitudes, where other oils congeal. From one of these wells on Otter Creek, in Wayne County (see map), the oil is exported by wagon to Cumberland City, thence by rail to the river, thence by a precarious navigation to Nashville; even with these hindrances the business is

* Analysis of an average sample taken from a coal-bank forty-four inches thick, on Yellow Creek, Bell County: —

Specific gravity	1.282
Moisture	1.36
Volatile combustible matter	35.80
Fixed Carbon	59.54
Ash	3.30
Coke	62.84
Sulphur	0.975

† See Report of P. N. Moore, in fourth volume, and the Biennial Report of N. S. Shaler, third volume, in second series.

found to be profitable. With effective transportation a very large industry could be founded on this product; for, unlike the light burning oils, those heavy lubricating petroleums are of rare occurrence, and find a market that is scarce supplied by the present production.

This river is navigable for steamboats for a part of the year as far as the crossing of the Cincinnati Southern Railway. The great falls offer an obstacle to improvement of navigation into the upper waters, but not an insuperable barrier. Except this fall and the rapids immediately above it, the stream offers great facilities for improvement; it would be possible to make at least four hundred miles of slack-water navigation within the mineral belt on the upper waters of this stream.

The Tennessee. — This river debouches into the Ohio, within Kentucky, and has the last sixty miles of its magnificent course within the State. This part of the valley is among the lowest lands of the State; on the east side the river is bordered by the Subcarboniferous Limestone, rich in iron ores; on the other, it extends into the low Tertiary lands which reach to the Mississippi River. The land along this stream is very fertile.

The limitations of this brief sketch make it impossible to speak of many lesser streams of great economic importance, some of them capable of being made navigable by simple canalization. Nor has reference been made to the resources of the main Ohio. The mineral resources available in this valley are only in part derived from Kentucky, so they will not be discussed here. The alluvial soils within the valley of the Ohio are of a high order of fertility throughout its course. From the mouth of the Chatterawah, or Big Sandy, downwards to the mouth, the valley is distinctly bounded by cliffs, which gradually diminish from about six hundred feet to less than thirty feet near its mouth; no part of alluvial plains have any distinct swamp character until we come below the mouth of the Tennessee, though they, in part, are liable to winter overflows. This strip of arable land on either side of the stream widens from an average of about one-half of a mile near the Big Sandy to about one and a half miles near the mouth of the Tennessee. Its fertility becomes the greater the further it is removed to the west.

WATER-POWERS.

The very numerous rivers of the State supply a large number of water-powers of great value. Although the soils want the retentive power which belongs to regions where they were formed by the glacial period, and extensive lakes are wanting, owing to the absence of the action of the same agent in this region, yet the freedom from closure by ice, and the excellent character of the foundations for dams and mills, goes far to balance the advantages. It is impossible to consider these mill powers in detail. The following points may be noted: —

The main Ohio at the falls at Louisville offers a very great but unused water-power; the flow at the lowest stage of water exceeds that of any water-power used in this country. A very valuable power exists at Cumberland Falls, in Pulaski County, where a stream as large as the one named falls about sixty feet. This point is near the Cincinnati Southern Railroad. The various slack-water dams now building and to be built in the State all afford admirable water-powers where the power itself and the transportation of the manufactured products are both well assured. As a general rule, the other water-powers are best where the waters drain from the Subcarboniferous Limestone; next in order of merit when their supply is from rocks of the Waverly or Subcarboniferous Sandstones. Next in value are the streams in the Blue Limestones, or Upper Cambrian; and, least of all, the streams from the coal-bearing rocks, which are generally largely composed of dense Sandstones and impervious Shales, having little in the way of water-storage spaces. The deficiency in the storage of water in the soil can be easily remedied by use of storage reservoirs, which, from the depth of the upper valleys and the generally good foundations, can be readily made.

SOILS AND AGRICULTURE.

All the Kentucky soils except the strip of alluvial land along the banks of the rivers have been derived from the decay of the underlying rocks. They may be called soils of immediate derivation, as distinguished from the soils made up of materials that have been borne from a distance by water, or which deserve the name of soils of remote derivation. This feature of immediate derivation gives the Kentucky soils a more local character dependent on position than those of any State north of the Ohio. In that region the intermingling of materials due to the last ice period has reduced the soils to a more nearly equal character. Beginning with the lowest rocks, the soils of the Blue or Cambrian Limestone are those of the first quality, and are surpassed by no soils in any country for fertility and endurance. These soils are derived from a Limestone very rich in organic remains, which decays with great rapidity, and continually furnishes its *débris* to the deeper-going roots. This soil varies considerably in different districts, and at some few points, where the underlying rocks are locally rather sandy, it falls from its usual high quality. The best soil may be known by the growth of blue ash, large black locust, and black walnut. Many other trees are found in its forests, but these are characteristic, and are never found together save on best soils.

The most advantageous crops on this soil are grass, it being a natural grass land, all the grain crops, and on the richer parts hemp. Fruits of all kinds belonging in this climate do quite well on this soil. The steep slopes along the valleys are well suited for grape culture. The peculiar features of the soil are its endurance under culture. This region having been the first settled in the State, the extraordinary capacity of this soil for withstanding bad methods of farming led to the general opinion that soils of less inexhaustible properties were not worthy of notice; hence the comparative neglect of the soils of the lower rocks, which, though generally fertile, can be wasted by careless agriculture far more easily than those of the blue-grass region.

The soils of the Silurian (commonly called Upper Silurian Limestone) are much less fertile than those of the underlying rocks. When not too cherty, they make good grain and grass lands. There is generally such a mixture of the decayed matter of the underlying and overlying rocks that this thin formation, which does not exceed about one hundred feet thick, gives but little soil which can properly be called its own. As this formation ranges from forty to one hundred feet thick in the outcrop, there is only a small area, not exceeding eight hundred square miles, occupied by these soils.

The soils of the Black or Devonian Shale have even less importance than those of the formation last mentioned; not over four hundred miles of the area of the State is covered by them. When found, they are generally a tough clay which only needs drainage to have very valuable qualities.

The Waverly or Subcarboniferous Sandstone has a thickness of several hundred feet, and furnishes an area of about five thousand square miles. Its soils are generally light clay loams, becoming more sandy as we go towards the north-east. They are throughout excellent fruit-soils, and yield fair crops of all the grains.

Next higher in the geological succession we find the Subcarboniferous Limestone, or Cavern Limestone, as it is commonly called. This rock makes a larger area of soil than any other formation except the coal-measures and the Blue Limestone (Cambrian), and may slightly exceed the latter in area. These soils are generally excellent enduring soils, ranking next to the best of the Blue Limestone soils. They are excellent grain and fruit lands, and in the western region are well suited for tobacco. Their drainage is generally excellent, on account of the cavernous character of the Limestone beneath.

The soils of the Carboniferous belt occupy by far the largest single area in the State, covering not far from fourteen thousand miles of surface. The soils in it are exceedingly variable in character, but are generally a sandy loam. On the conglomerate or lowermost part of the coal-measures, the soils are usually the poorest, — about the only really infertile soils of the State being the small strips of the soils formed on this rock.

These strips are usually very narrow, and do not include altogether more than three hundred or four hundred square miles. The remainder of the Carboniferous area is composed of fairly fertile light lands, interspersed with areas of great fertility.

Some of the best lands of the State are upon the summits of the Carboniferous mountains of Eastern Kentucky; it is safe to say that, wherever the shape of the surface admits of cultivation, the Carboniferous rocks of Kentucky furnish fair soils adapted to a varied range of crops. The considerable part of its surface that is not fit for agriculture is admirably suited for the production of hard-wood timber of the most valuable varieties, and will doubtless have in this fitness a source of wealth scarcely less than tillage of the best lands could give.

As a whole, the surface of Kentucky includes a larger area of very fertile land and a less area of barren soil than any other equal area in a State so rich in mineral wealth. The prize of wealth hidden beneath the earth is generally bought by conditions that do not favor agriculture; but, despite the fact that Kentucky has resources of coal and iron that exceed those of Great Britain, she has scarcely a square mile of surface that cannot give a constant return from its soil.

The production of these soils includes the whole of the crops of the Mississippi Valley, except the sugar-cane. Indian corn, wheat, oats, rye, barley, buckwheat, flax, flourish over its whole surface. Sorghum, for making molasses and sugar, is grown over its whole area. The conditions favor the making of sugar from beet-roots. All the ordinary fruits attain their perfection here. Cotton is raised as a crop in the south-western region of the State. Tobacco is more extensively cultivated here than in any other State in the Union. The best natural grass lands of the continent are found in the Cambrian or Blue Limestone district. Hemp is extensively grown in the same area. The blooded horses of the State are perhaps the most famous of its exports. Its remarkable superiority in this regard is doubtless in part due to the care given thereto, but, in the opinion of the best judges, is in the main the result of the peculiarly favorable effects of a combination of conditions in which soil, climate, and water all have their place. Horned cattle and sheep also do well here.

Climate. — That this State is peculiarly well fitted for the European races is shown by the fact that in no region is there a greater degree of physical vigor than in the population within its limits. The statistics of the United States Sanitary Commission distinctly show that this is the largest-bodied native population in this country or Europe, as in the table on the opposite page.

The climatic conditions, as far as they can be described here, are as follows:* The average temperature is about 50° Fahr. As in all America, the range of temperature throughout the year is considerable; it is, however, much less in Kentucky than in the States further to the north. It is rare to have the thermometer below the zero of Fahrenheit, and it never happens that it remains for twenty-four hours below that point. The summers, though warm, are less oppressive than along the lowlands near New York for instance, owing to the considerable elevation above the sea and the relative dryness of the air. The summer heats do not at all interfere with the labor of northern-born people in the open sun. There is much experience to show that in this respect the climate is not more trying than that of New York State. Open-air work is generally possible during the whole winter, the ground rarely being so frozen as to impede construction-work or even ploughing. Cattle are not generally fed more than three to four months, and are often left in the pasture for the whole winter.

The rainfall is about forty-five inches per annum along the Ohio River, increasing towards the south-east to about sixty inches at Cumberland Gap. This is distributed with fair regularity throughout the year, — the summer droughts not being sufficient at any time to destroy crops well planted on well ploughed ground, and rarely sufficient in any way to embarrass

* The following, compiled from the United States Census Reports for 1870, shows the healthfulness of Kentucky: —

In population, Kentucky ranked as the eighth State in the Union.

In percentage of deaths to population, Kentucky ranked as the twenty-eighth State; that is, there were twenty-seven States having a greater death rate than Kentucky.

Population, in 1870, 1,321,011. Deaths, from all causes, 14,345, — or 1.09 per cent. of the population. The health of the State has increased, since 1850, as follows: —

Death to population was, in 1850, 1.53 per cent.
" " " " " 1860, 1.42 " "
" " " " " 1870, 1.09 " "

TABLE OF MEASUREMENTS OF AMERICAN WHITE MEN,

COMPILED FROM REPORT OF THE SANITARY COMMISSION, MADE FROM MEASUREMENTS OF THE UNITED STATES VOLUNTEERS DURING THE CIVIL WAR. By B. A. GOULD.

Mean Height by Nativities.			Mean Weight by Nativities.	Mean Circumference of Chest.		Mean Dimensions of Heads.	Proportional Number of Tall Men in each 100,000 of same Nativity.	Ratio of Weight to Stature.
Nativity.	No. of Men.	Height in inches.	Pounds.	Full Inspiration in inches.	After each Expiration.	Circumference around the Forehead and Occiput in.		Pounds to Inch.
New England	152,370	67.834	139.39.	36.71	34.11	22.02	295	2.075
New York, New Jersey, Pennsylvania	273,026	67.529	140.83	37.06	34.38	22.10	237	2.102
Ohio and Indiana	220,796	68.169	145.37	37.53	34.95	22.11	486	2.153
Michigan, Missouri, and Illinois	71,196	67.822	141.78	37.29	34.04	22.19	466	2.106
Seaboard Slave States			140.99	36.64	34.23	21.93	* 600	2.094
Kentucky and Tennessee	50,334	68.605	149.85	37.83	35.30	22.32	848	2.192
Free States West of Mississippi River	3,811	67.419		37.53	34.84	21.97	184	2.136
British Provinces, exclusive of Canada	6,320	67.510	143.59	37.13	34.81	22.13	237	2.126
Canada	31,698	67.086	141.35	37.14	34.35	22.11	177	2.114
England	30,037	66.741	137.61	36.91	34.30	22.16	103	2.056
Scotland	7,313	67.258	137.85	37.57	34.69	22.23	178	2.086
Ireland	83,128	66.951	139.18	37.54	35.27		84	2.096
Germany	89,021	66.660	140.37	37.20	34.74	22.09	106	2.123
Scandinavia	6,782	67.337	148.14	38.39	35.37	22.37	221	2.158

* Slave States not including Kentucky and Tennessee.

agriculture. The number of days of sunshine is relatively very large, considering the amount of rainfall.

MEAN TEMPERATURE.

	October.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.	Annual Mean.
	°	°	°	°	°	°	°	°	°	°	°	°	°
1870–71. Louisville.	59.08	46.4	33.4	36.7	39.5	50.7	59.1	64.	75.	77.2	79.	6.67	57.3
1871–72. Louisville.	60.5	44.0	38.0	30.8	36.0	38.7	59.1	67.6	74.3	79.0	78.2	69.8	56.3
1872–73. Lexington	....	38.2	27.9	30.4	35.6	40.9	53.1	64.7	73.7	76.5	73.7	66.8	....
Louisville.	56.6	39.5	29.4	31.1	36.8	43.3	54.6	67.	78.	79.	78.	69.5	55.23
1873–74. Lexington	53.8	40.7	39.6	36.5	39.2	44.3	46.9	63.6	77.9	77.8	75.1	70.9	55.5
Louisville.	54.	41.5	38.7	37.5	39.5	45.6	48.8	68.2	80.7	80.7	79.3	72.2	57.2

RAIN-FALL. — Inches.

	October.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.	Annual Mean.
1870–71. Louisville.	3.89	2.40	2.20	3.05	5.74	7.29	20.6	5.97	3.86	2.22	3.06	1.23	42.95
1871–72. Louisville.	1.85	2.51	3.29	(*)	(*)	1.41	8.40	4.49	6.19	3.67	2.45	4.41	38.67 †
1872–73. Lexington	....	1.21	3.53	2.53	4.05	3.73	2.88	6.05	4.54	3.37	2.94	1.60	....
Louisville.	3.92	0.56	2.58	2.93	5.42	3.39	3.05	5.73	3.87	3.43	3.04	2.56	40.42
1873–74. Lexington	5.47	2.09	4.41	5.41	4.89	5.90	6.81	0.79	3.55	6.26	1.57	2.89	50.04
Louisville.	3.26	2.19	6.99	2.39	5.18	6.63	6.01	1.17	2.95	2.71	3.23	0.62	43.33

Average Annual Mean for thirty years, 55.9° Rain-fall, 50.30 inches.

* Rain-Guage not in position.
† Ten Months.

The healthfulness of this region is not exceeded by any State in this country. Epidemic diseases have never been destructive outside of some of the towns. The experience of the city of Lexington has shown that even in the towns such diseases are curable by the use of pure drinking-water. Miasmatic diseases are not known on the table-lands, being limited to the low regions near the large rivers; at least seven-eighths of the State enjoy an absolute immunity from such diseases. Consumption is rare, compared with the northern and eastern States. Yellow fever never occurs. This region is remarkable for the number of persons in extreme old age, who retain their faculties quite unimpaired and a large share of bodily vigor. The writer, who has made this subject of longevity a matter of much inquiry, is satisfied that the region from the Big Sandy to the Cumberland, especially the higher parts of the table-land, and where Limestone soil is found, is peculiarly fitted by its conditions to retain the vigor of the body to an extreme old age, deserving, in this regard, to rank with the Canton de Vaud in Switzerland and the few other favored spots where longevity is a characteristic of the people. He is also satisfied that the proportion of bodily deformities and diseases of imperfect development,—such as curvature of the spine, rickets, &c.,—is smaller within this area than among any equally large native population in this country or in Europe. Of the whole population of whites and blacks, about eleven hundred thousand of the former and three hundred thousand of the latter have been on the soil for three generations (these numbers are approximate). It needs only inspection to show that there has been no degeneration during this time, and that the world-wide reputation for vigor which the State has acquired is not likely to be lessened in the time to come.

Natural Beauties of Scenery.—In all those features of natural beauty which go to lend attractiveness to a fertile region, this State is much favored. Above any other State it is rich in rivers, and these have an incomparable variety of loveliness. Their head-waters lie around the stately mountains of the Cumberland range, their middle distances course through gorges often cut into deep cañons, and their lower waters verge gently into the great valleys of the Ohio and Mississippi. The valley of the Upper Cumberland lies in a broad mountain trough, affording some of the finest scenery of the whole Appalachian chain. Big South Fork of the Cumberland, Rockcastle River, Red River, of the Kentucky the whole of the Upper Kentucky, Tygert's Creek, the upper part of the Big Sandy,—all present that mingling of clear stream, steep cliff, and beautiful vegetation, which is the great charm of a mountain country. The cañon of the Kentucky, between Frankfort and Boonesburg, is perhaps the most charming scenery of its kind in the region east of the Mississippi. The deep gorges of Green River and its tributaries, Nolin and Barren

Rivers, abound in exquisite scenery; cliffs, in the semblance of castles, towering hundreds of feet above the streams, their faces pierced by caverns, and hung with a foliage of almost tropical luxuriance.

The cultivated district of Central Kentucky, commonly known as the Blue-grass District, is perhaps for its area the most beautiful rural district in America. The surface is undulating; large areas of the original forests have been cleared of their undergrowth and produce a fine close sod, and in these wood-pastures are some of the finest flocks and herds in the world. It has happened to the writer to pass on several occasions from this region to the richest lands of Middle England, or *vice versa*, and he has always been struck by the singular likeness of the two countries. There is probably a closer resemblance between the surface of the country, the cattle, horses, the agriculture, and even the people of these two areas than any two equally remote regions in the world.

The western part of the State abounds in natural beauties; the rich forests and the noble rivers, the Mississippi, Ohio, Tennessee, Cumberland, and the Green, give it a most attractive surface. Even the deep swamps of the lowest regions have a sombre charm that deserves the attention of the tourist. No region ever visited by the writer exceeds in weird beauty the environs of Reel Foot Lake, where the great earthquakes of 1811–13 formed a lake some fifty miles in area. All over its surface stand the trunks of the cypresses that grew in the swamp before the convulsion. These are now reduced to tall columns blackened and whitened by decay. The surface of the lake is a mass of water-plants, in summer a perfect carpet of flowers; Nymphæas, a half-foot or over, and the Nelumbium, water-chenquepin, or American lotus, a golden flower often exceeding a foot in diameter, cover its surface with their blossoms and fill the air with their perfume.

Caverns. — The subterranean beauties of the State are already famous. The Mammoth Cave is, however, only a noble specimen of a vast series of caverns, to be numbered by the tens of hundreds, that occupy nearly all of the Subcarboniferous Limestone area of the State. This cavern-belt extends in a great semicircle from Carter County, where there are several beautiful caves and two remarkable natural bridges, to the Ohio below Louisville. These caverns have as yet been but little explored, and their beauties are mostly undiscovered. There are probably many thousand miles of these cavern-ways accessible to man. The Indian tribes knew them better than our own race; for it is rarely that we find any part of their area which does not show some evidence of the presence of ancient peoples.

MARKETS AND TRANSPORTATION.

As regards proximity to markets, this State has peculiar advantages, which only await the completion of transportation routes already begun to render its position unequalled among American States. Reference to a map will show that it is the most centrally placed in the group of States east of the Rocky Mountains. From the geographical centre of Kentucky it is about an equal distance to Central Maine, Southern Florida, Southern Texas, and Northern Minnesota. The State of Colorado, the Great Lakes, and the mouth of the Mississippi fall in the sweep of the same line.

The river system of the Mississippi has its centre within the borders of Kentucky, and her lands are penetrated by more navigable rivers than any other State in the Union. Her territory includes about fifteen hundred miles of streams that are navigable at all stages of water, and about four thousand miles of other streams that can be made navigable by locks and dams. These streams give access to the whole Mississippi system of inland navigation, which includes about twenty-five thousand miles of streams now navigable, or readily rendered so by the usual methods of river improvement. The State has at present connection by water transportation with at least twenty millions of people, occupying an area that will probably contain near two hundred millions within a century from this date. There is a proposition now under discussion to use the convict labor of the State on the improvement of the rivers, which if carried to success is likely to make their complete canalization an accomplished fact within twenty-five years.

The existing railways of the State form a system which wants but a few connecting links to give it an admirable relation to the rest of this country. The north and south lines consist of the following roads, beginning on the east: The Eastern Kentucky, from Riverton in Greenup County to Willard in Carter County; thirty-five miles of road built to develop the coal and iron district of this section, with the expectation of eventual continuation to Pound Gap, and connecting with the south-eastern system. The Maysville and Lexington Railway, running south as far as Lexington, and connecting there with the system of roads about to be described. Third in the series on the west we have the Kentucky Central Railway, now extending to Lexington along the banks of the Main Licking Valley and its South Fork. The continuation of this road, by either Pound Gap or Cumberland Gap, to the railway system of Eastern Tennessee and the valley of Virginia, is likely to be accomplished at an early day. The Cincinnati Southern Railway, from the mouth of the Licking directly south to Chattanooga, will be completed during the present year, and afford an admirably built road traversing the State on its longest south and north line, and crossing the Blue-grass lands on their longest and best section. This road is likely to be of incalculable value to the State, forming as it does a main line to the South and South-east.

The Lexington and Big Sandy Railway is completed, as far as Mount Sterling in Montgomery County. This road when finished will give Kentucky cheaper and more direct communication, by way of the Chesapeake and Ohio Railroad, with the Atlantic ports. The Mount Sterling coal-road, now almost completed, extends from the latter place to the border of the eastern coal-field, in Menifee County. The extension of this road will greatly facilitate the development of the coal and iron region through which it is proposed to continue it.

The Kentucky and Great Eastern Railway is a proposed road on which considerable work has been done; extending up the south bank of the Ohio River from Newport, Kentucky, to the Big Sandy River. The completion of this road will add greatly to the wealth of river line of counties, and will give the State a shorter road to the Atlantic ports than she now has.

The Louisville, Frankfort, and Lexington Railroad extends through the Counties of Jefferson, Oldham, Shelby, Franklin, and Fayette. From Lagrange in Oldham County a branch extends from this road to Cincinnati, known as the Louisville and Cincinnati short line, — that line, passing through the counties of Oldham, Henry, Grant, Carroll, Gallatin, Boone, and Kenton.

The Cumberland and Ohio Railroad, narrow-guage, now building, when completed, will pass through the counties of Henry, Shelby, Spencer, Nelson, Washington, Marion, Taylor, Green, Metcalf, Barren, and Allen. Its length in Kentucky will be 165 miles.

The Louisville and Nashville Railroad extends, with its branches, a distance of 356.4 miles through Kentucky in different directions. The Main Stem, from Louisville to Nashville, has a length within the limits of the State of 139.6 miles, running through the counties of Jefferson, Bullitt, Nelson, Hardin, Larue, Hart, Edmonson, Barren, Warren, and Simpson. The Memphis Branch runs through the counties of Warren, Logan, and Todd, having a length in the State of 46 miles. The Lebanon Branch extends into Southeastern Kentucky, running through the counties of Nelson, Marion, Boyle, Lincoln, and Rockcastle; it has a completed length within the State of 109.9 miles, and its extension to the State line is projected, and its completion only a matter of time; it will then connect with a road leading to Knoxville in the State of Tennessee. The Richmond Branch runs through the counties of Lincoln, Garrard, and Madison for 33.4 miles, to within a short distance of the rich iron region of Kentucky. The Bardstown Branch runs through the county of Nelson, a distance of 17.3 miles. The Glasgow Branch, 10.2 miles long, runs to Glasgow, the county-seat of Barren County. The Louisville and Nashville Railroad is undeniably one of the most important thoroughfares of this continent; it is second only to the Mississippi River as a way for the commerce between the Northern and Southern States. By means of the magnificent railway bridge over the Ohio River at Louisville it connects with all the great northern roads, and at Nashville and Memphis, its southern termini, it connects with all the important roads of the South.

The Louisville, Paducah, and South-western Railroad extends from Louisville to Paducah, a flourishing city situated on the banks of the Ohio River, fifty miles from its junction with the Mississippi, and is the principal market-town of Western Kentucky. This railroad penetrates Western Kentucky in such a manner, therefore, as to afford easy access to a large portion of that section. It runs through the counties of Hardin, Grayson, Ohio, Muhlenberg, Hopkins, Caldwell, Lyons, Livingstone, Marshall, and McCracken. It passes directly through that section of the valuable coal-fields of Western Kentucky which lies within the area of the counties of Ohio, Muhlenberg, Hopkins, and Grayson. The entire length of the Louisville, Paducah, and South-western Railroad is 225 miles, all of which is within the territory of Kentucky.

The Paducah and Memphis Railroad runs through the counties of McCracken and Graves, connecting at Memphis all of the south-western railroads.

The Owensboro, Russelville, and Nashville Railroad is completed from Owensboro, on the Ohio River, to Owensboro Junction on the Louisville, Paducah, and South-western Railroad, passing through the counties of Daviess, McLean, and Muhlenburg.

The Evansville, Henderson, and Nashville Railroad, from Henderson on the Ohio River to Nashville, Tenn., passes through the counties of Henderson, Webster, Hopkins, Christian, and Todd. At Henderson a ferry takes cars to the northern system of roads. It forms the most important link in a great trunk line known as the St. Louis and South-eastern Railway. The New Orleans, St. Louis, and Cairo Railroad passes through the counties of Ballard and Hickman. The Mobile and Ohio Railroad, connecting the city of Mobile on the Gulf of Mexico with the Ohio River, penetrates Kentucky through the counties of Hickman and Fulton.

At Columbus, in Hickman County, a ferry fitted for the carriage of trains gives passage to cars from St. Louis directly through to the south-eastern cities. Of the ten before described north and south railways, four have northern connections; two (the Cumberland and Ohio and the Cincinnati Southern), now under construction, will have southern connections. The others all look to the same end, but have not yet succeeded in accomplishing it.

It is in roads with eastern connections that the State lacks most. There is not yet a single railway crossing the eastern line of the State. It is to this difficulty of access from the seaward that the State owes the small share it has had in the immigration of capital and labor that has filled the lands of less attractive regions. Three routes have been begun, which, when complete, will fully remedy this grave defect; namely, a road from Louisville to the south-east *via* Cumberland Gap, completed to Livingston, and requiring a continuation of about one hundred miles to connect with roads leading from Morristown, Tenn., to Charleston, S. C.; a road from Mount Sterling to Abingdon, Va., *via* Pound Gap, requiring about one hundred and sixty miles of road to complete the connection; a road from Lexington to connect with the Chesapeake and Ohio, requiring about eighty miles to bring it to completion. The northernmost and southernmost of these roads are likely to be carried forward to completion within a few years. There is a project for building up, east and west, a road along the northern range of counties of the State, giving a continuous route from Henderson, and the roads connecting at that point, to the connections with Charleston and Savannah from Morristown, Tenn.; also a project for a road from Chicago to Charleston, crossing Kentucky from Gallatin County to Cumberland Gap.

It will be seen from this brief sketch that the railway system of Kentucky is on the whole good, and wants but little to make it, as a system of trunk lines, exceedingly well adapted to the development of her resources. Taken in connection with the river system, it is clear that, within a generation, we may expect here a transportation system excelled by no State on the continent.

With reference to markets, it will be seen, by consulting the census tables, that the State has at present access to a larger number of markets than any other Western State: although there is but one large city within her limits, the cities of Cincinnati, St. Louis, Nashville, and Indianapolis lie upon her borders. Her principal export products have a special value that makes them sought on her own soil by purchasers enough to take any product that can be furnished; on the borders of the State, a host of manufacturing towns are rising that will certainly make a market for all the food, fuel, and raw products from her soil, quarries, and mines.

PRICE OF LANDS.

In no other State having any thing like the same advantages can lands be bought at so low a price. The best agricultural lands, or those commanding the highest price, are found in the Limestone regions and along the principal rivers; these, when cleared and not worn, bring from thirty to one hundred dollars per acre. The same, uncleared, will be about half these rates. The second-rate lands in the same regions bring from ten to forty dollars per acre. The lands on the coal-bearing beds, though often exceedingly fertile, are generally very cheap. When contiguous to transportation they may generally be estimated at about ten dollars per acre, but the tracts of good tobacco lands, with excellent timbering and great mineral resources, can often be purchased for two to four dollars per acre in tracts suitable for ordinary farming, within ready access of permanent transportation. Vast tracts of timber land, suitable for grazing, with much excellent land in the *coves*, or other level places, can be bought for from fifty cents to one dollar and a half per acre.

As a general thing, it may be said that the lands in this State are much cheaper than in any State north of the Ohio River. This is owing to the fact that, destitute of eastern communication, the State has hitherto had but a small share of the tide of immigration of capital and labor that has poured past her borders to fill the favored fields of the far West.

Nearly all the products of Kentucky have their prices determined by the cost of transportation to the great centres of population along the Atlantic seaboard or beyond the sea. Its tobacco, pork, grain, and some of the costlier native woods, and some other products find their principal markets in Europe; cattle, and to a certain extent the other agricultural products of the State, have their values determined by the cost of transportation to the American Atlantic markets. Hitherto, this access to the domestic and foreign markets of the Atlantic shores has been had by way of the railway systems which traverse the region north of Kentucky, and from which the State has been divided by opposing interests and the physical barrier of the Ohio River. All the development of the State has taken place under these disadvantages. A comparison of the tables of cost given below will show that the complete opening of the mouth of the Mississippi to ocean ships will result in the enfranchisement of the productions of Kentucky in an extraordinary way.* At the present time, the freight-rates from the lower Ohio to Liverpool would permit the profitable shipment of the cannel coal

* "The following are taken from published freight-rates, and give time and cost of transit from St. Paul's, two thousand miles above New Orleans, to Liverpool by the two routes: —

	Cost per bushel. Cents.	Time. Days.
From St. Paul's to Chicago	18	4
Lake from Chicago to Buffalo	8	6
Canal from Buffalo to New York	14	24
New York to Liverpool	16	12
Elevator or trans-shipment charges, Chicago	2	2
" " " Buffalo	2	2
" " " New York	4	2
Total	64	52

	Cost per bushel. Cents.	Time. Days.
From St. Paul's to New Orleans (*via* river)	18	10
New Orleans to Liverpool	20	20
Elevator charges, New Orleans	2	1
Total	40	31

Here is a saving by direct trade of twenty-four cents per bushel, or eight shillings per quarter, and a saving of twenty-one days in time. To be fair, I have taken the extreme point: *but the nearer the grain is to the Gulf, the cheaper the transportation.*"

and native woods of many different species to Europe with one trans-shipment at New Orleans. It is impossible, on account of limited space, to give a detailed statement on this point; but evidence can be furnished to those desiring it. It is to be noticed that it is possible for several months each year to bring ships of large draught of water to the loading points on the Ohio River, and load them for direct trade with Europe. The tonnage of such vessels both ways from New Orleans would be at the lowest rates for such work current in any region. It will be seen that the State of Kentucky has the most extensive shore on the navigable waters of the Mississippi Valley, and that even in the present incomplete development of her navigation system she will have over fifteen hundred miles of frontage on continuously navigable waters. There can be no doubt that the market expenses of the products of the State will be reduced nearly one-half when the far-reaching consequences of the development of water-transportation are attained. It will not be amiss to notice that the costs of transportation by water, far lower than by rail in most countries, is peculiarly cheap on the Mississippi and its principal tributaries; coal is lower than in any other country, as is also timber for boat-building; there are no tolls on the streams, and the currents are generally slow near the shores, admitting of tolerably easy ascent.

FITNESS FOR INVESTMENTS OF CAPITAL AND LABOR.

For all the important branches of agriculture and manufacture, so far as they depend on cheap and fertile soils, good climate, and a great abundance and low price of coal, iron, and hard-wood timber, and last, but not least, low taxation, — Kentucky offers unsurpassed advantages for the creation of industries. It will be impossible to name these opportunities in detail, but some of the most important may be suggested. The growing industries of the Ohio-River Valley and the neighboring regions offer continued opportunities for the increase in the export of the raw products of the State. Coal, iron, salt, timber, cements, building-stones, can all be produced at great profits, even in the present depressed state of the industries of the world. The Ohio Valley probably gains in population at an average rate of not less than five per cent. per annum. This great elasticity of demand insures a successful result in any discreet industrial venture. Besides the coal and iron mines, the attention of capitalists is requested to the production of other articles of equally steady demand. Salt can be produced over a large area at the cheapest possible rate,— the water hardly requiring pumping from the shallow wells, and the gas furnishing fuel. The great amount of fire-clays should be considered. The tile-clays are admirable in quantity and quality. An area of several thousand square miles in the State is rich in marls, containing large quantities of potash and soda, fitted for the production of fertilizers. The western section of the State is admirably fitted for ship-building; excellent ship-timber can be had cheaper than in any other country, and there is ample water to take ships drawing twenty feet to the sea for half the year. Besides the enormous possibilities of business derived from the working of raw products, finding their market in the great and growing States of the Mississippi Valley, there are most important opportunities derived from its relation to the regions beyond the sea. The natural outlet to the Atlantic ports for these products is by way of the Mississippi to the sea. The freights from Western Kentucky to New Orleans are less than one-half of the rate from the same region directly to New York. Until the success of the Eades-Jetty project, this method of carriage to the sea was practically impossible. At present it is practicable to load timber-ships and colliers at the ports from the western coal-field, and send them directly to the Atlantic ports, or to any markets beyond the sea. Already a large trade in wine-cask staves exists between this region and Europe. These staves pass through six hands before coming to the consumer. These exchanges could be readily reduced to three by direct shipment. The demand seems to be practically inexhaustible, and the timber exists in very great quantities. To this industry there could be readily added a business in the manufacture and shipment of spokes, felloes, and other carriage-parts, the parts of railway-carriages, agricultural implements, &c. Building-stones of admirable quality exist all along the tributaries of the Ohio, and their export to the Atlantic ports is already a considerable commerce.

As will be seen from the accompanying map, the State of Kentucky lies, as a region of peculiar mineral resources, in the centre of the region now holding, and destined always to hold, the mass of American population. The present centre of population is adjacent to the northern border of Kentucky, and it is practically certain that in centuries to come it must remain within or on the borders of Kentucky. This makes it sure that manufactures will from this region always command the widest markets with the least carriage.

The advantages of this district to the agriculturist are known by the cheap land, good climate, and abundant variety of crops. These crops are near to a great and growing set of markets. Among the new ventures in agriculture must be placed fruit-culture for the northern markets, — a business that is now taking a very important place in the industries of the State. The poorer lands of the southern part of the State have a peculiar fitness for this purpose.

The following table, compiled from the United States census report, proves that Kentucky is susceptible of a greater variety of production than any other State. It will be observed that it is in each census the first State in the production of some one or more staple articles: —

	1840.	1850.	1860.	1870.
Wheat	First.	Ninth.	Ninth.	Eighth.
Swine	Second.	Second.	Fourth.	Fifth.
Mules		Second.	Second.	Third.
Indian Corn	Second.	First.		Sixth.
Tobacco	Second.	Second.	Second.	First.*
Flax	Third.	First.	Third.	Eighth.
Rye	Fourth.		Fifth.	Fifth.
Hemp		First.	First.	First.
Cotton	Eleventh.			Twelfth.
Value of Home Manufactures	Third.		Second.	Third.

* In 1870 Kentucky produced near one-half of all the tobacco produced in the United States, and more than half of all the Hemp. The production of Tobacco increased from 105,305,869 pounds in 1870, to 158,184,929 pounds in 1873.

The high rank of Kentucky as an agricultural State can best be appreciated when it is remembered that more than one-half of the State is in forest, and that the State is only exceeded in area of woodland by three States. Yet, with less than half the land in cultivation, the State ranks eighth in the value of agricultural products.

Building and other Economic Stones.— The building-stones of this State are limited to Limestones and Sandstones. Within these limits, however, there is a most abundant variety of color, hardness, and other qualities. The Limestones of the Upper Cambrian, or so-called Lower Silurian, are excellent stones of exceedingly varied qualities. Usually they afford a gray marble of admirable resisting powers against wear, especially fitted for buildings when their courses of rocks are suitable. Along the Kentucky River this series of rocks affords a beautiful buff and cream-colored marble, admirably fitted for detailed sculpture work, the Clay Monument at Lexington being made of this stone. This stone can be quarried on the banks of the river in any quantity and at small expense, and transported by boat to the Ohio River. Next above this level we have the equivalent of a part of the cliff-limestone of Ohio, which has received the local name of Cumberland Sandstone in the Kentucky reports. This Sandstone is thin, and passes into a cherty Limestone in the northern part of the State; but in the basin of the Cumberland it is of a peculiar greenish color, affording a very handsome and durable building-stone, resembling in many regards the Buena Vista Sandstone of Ohio. This stone will doubtless have considerable value in the time to come, as it is peculiar in its color among all the building-stones of the Ohio Valley. No other good building-stones occur until, after passing above the Black Shale, we come to the beds of Sandstone of the Waverly period. The beds of this section afford the only Sandstones of the State that have been extensively worked for building purposes. These beds, commonly known as Buena Vista stone, are the only source of the Sandstones used in Cincinnati and Louisville, and in most of the other western cities. At present they are worked along the Ohio and south-east of Mount Sterling in Montgomery County; but they can be had where the Licking, Kentucky, Salt, and Green Rivers cross the Waverly, and at the points where the railroads of the State pass over the same formation.

It is, however, in the Subcarboniferous or Mountain Limestone that the greatest variety and area of economic stones occur. Here we have Limestones (carbonates) which are the finest known in this country; Oölites which, for beauty of grain and endurance of time and other forms of wear, are unsurpassed; Dolomites that have all the fine qualities belonging to those Magnesian Limestones; and, finally, a series of more or less Argillaceous Limestones, some of which are already in use as lithographic stones, and promise good results. These Oölites have been in use for forty years in the town of Bowling Green, and retain all their tool-marks as when dressed, having hardened very much since their working. Stones for furnace-hearths abound throughout the whole mineral district. Some millstones have been worked for local purposes, but have had no extensive test. Grindstones are made from the Waverly Sandstone, which is admirably fitted for this use. Some good grindstones have been made from the Carboniferous Sandstones of Western Kentucky.

GOVERNMENT, POPULATION, TAXES, EDUCATION, FUTURE.

The government of Kentucky is at present modelled in part on that of New York, and in part on that of Virginia, — the legal framework being essentially that of the former State. The legislative machinery differs somewhat from that of the other States, in that the senate is re-elected one-half each two years, while the lower house is simply renewed each two years by election. There is no actual State debt, — the school-fund debt being such only in appearance, in fact only an obligation to pay a certain sum for the support of schools. No State debt can constitutionally be contracted, and during the last ten years, while other States have been steadily increasing their obligations, Kentucky has paid off the debt which was left by the war, and now is debtless, and with considerable assets. The last legislature (1876) reduced the taxes by one-eighth, after a careful inquiry going to show that it could be done with safety. The following statement summarizes the condition of the State in 1875: —

"It will thus be seen, that in the last two years we have redeemed and paid off $347,000 of the public debt, and there now only remains of bonds outstanding and unredeemed $184,394. The residue of these bonds are not due and redeemable until 1894–5–6."

To meet this indebtedness we had, on the 10th of October, 1875, the end of the fiscal year,* —

To the credit of the Sinking Fund	$153,559.07
230 United States 5–20 gold-bearing interest bonds, worth not less than 20 per cent. premium . . .	246,000.00
Making	$399,559.07

The whole traditions of the State are strongly in favor of economy and honesty in every branch of public affairs. No loss by defalcation has ever occurred to the State. Debts cannot be incurred by counties, cities, or towns without special authority from the legislature. This permission is now given only in rather rare cases, and is subject to great limitations from the organic law. The result of these conditions is an immunity from the danger of destructive taxation, such as does not exist in any other State in this country.

Education. — The State now gives from the general treasury the sum of one million dollars to the purpose of common school education; this is, *per capita*, as large a contribution from the general fund as is given in any State; as yet, this has been inadequately supplemented by local aid, but much progress is now making towards the creation of graded schools in every village where the population admits of it. The laws allow the imposition of a considerable local tax for schools. There is no State with an equally scattered population where so much has been done for the elementary education.

Universities and colleges do not now receive the aid of the State. There are, however, a number of excellent institutions of this grade in the State. The first collegiate institution west of the Alleghanies was Transylvania University, at Lexington. Kentucky University, Georgetown College, Centre College, and a number of other similar schools of newer date, many of

* In a report made by the State Treasurer, January, 1876, the State debt was shown to have been much less than the above, and the surplus in the Treasury had increased to near one million of dollars. This report will appear in next edition of this pamphlet.

them excellent in their methods, and provided with considerable endowments, furnish the higher education of the State.

The charitable institutions, nominally so called, are sufficiently furnished by the State. A very high place is held by the asylums for the deaf and dumb and for the feeble-minded, in both of which recognized advances have been made in the methods of dealing with these forms of human infirmity.

It remains to speak of the most important element in the State, its population.* Probably no other State in this Union contains a people as purely English in descent as this. At this date (1876) the population numbers 1,600,000; of these only 200,000 are of African descent, or about one-eighth of the total. There is a steady decrease in the black population, and an equally steady increase of the white, so that the negro now makes but an inconsiderable fraction of the State; by far the greater part of the blacks are gathered about the towns in light labor of the domestic class. The relations between the two races are those of entire harmony. Separate schools are founded for the two races.

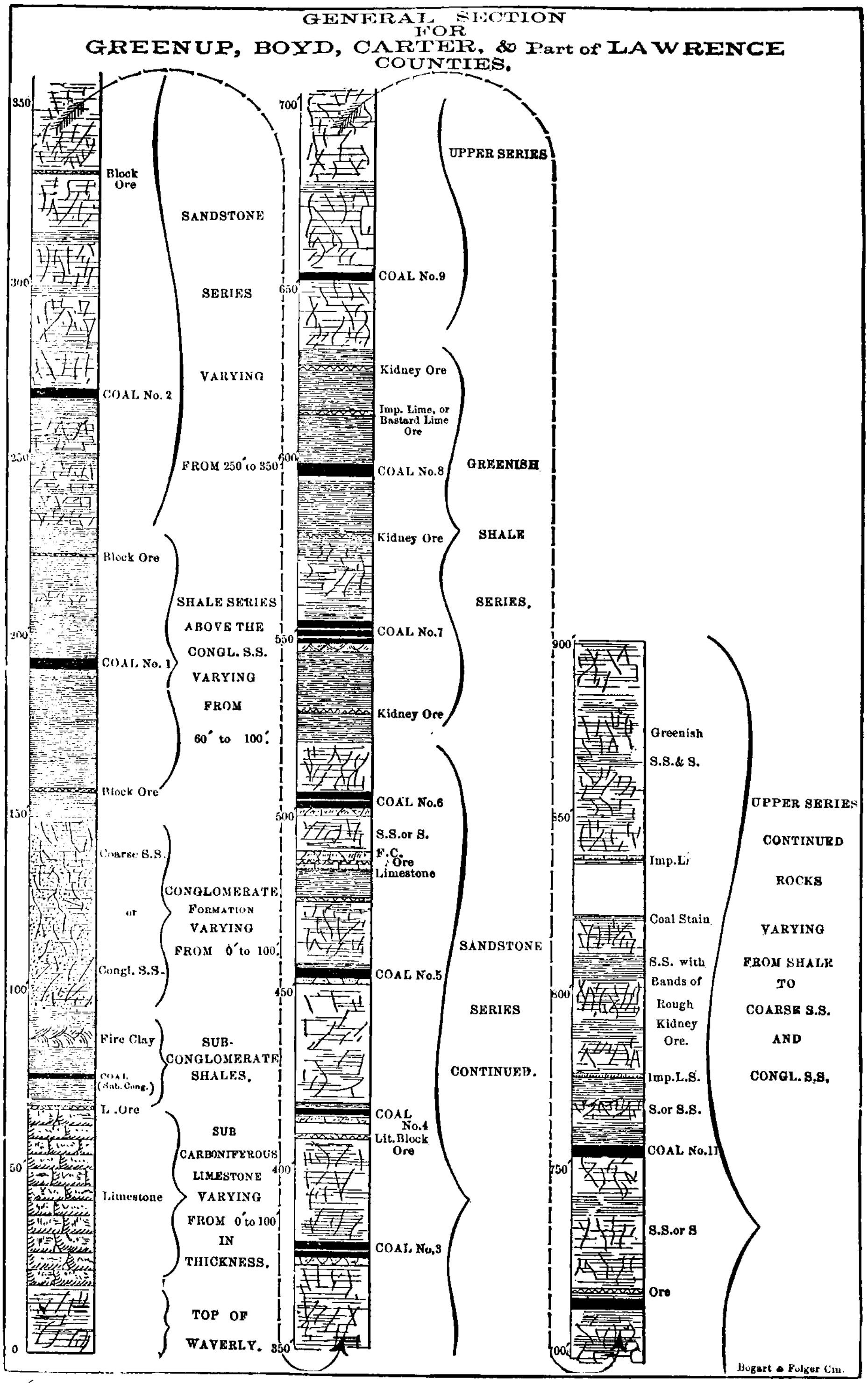
In 1870, the foreign-born population in Kentucky amounted to 63,398 (is probably at the present time less than 100,000); of these 31,767 were Germans, and the remainder from various other European countries. The greater part of this foreign population is settled along the Ohio River, but it exists in almost every county. The honest and self-supporting citizen of every country has always received a warm welcome in Kentucky; no jealousy has ever shown itself towards the foreigner. The government of the State has for years always had a number of conspicuous members from beyond the sea; one of the United States senators and several of the members of the legislature are also from other countries.

Without indulgence in excessive claims, which would be quite foreign to the sober tone of this Commonwealth, we may reasonably expect for Kentucky, in the time to come, a substantial growth proportioned to her natural advantages. As at the present moment, when the country generally is under

* In 1790, Kentucky was the fourteenth State in population, having a population of 73,677. In 1870, Kentucky was the eighth State in population, having 1,321,011

a heavy burden, the result of its commercial extravagances, the State of Kentucky is actually prosperous in a fair degree, so we may expect in the future a consistent and conservative progress that will not be attended by those periods of commercial depression that so generally accompany a growth of an excessive kind. The unequalled blessings of the Ohio Valley, its wealth of mineral stores, fertility of soil, goodness of climate, and facilities for transportation, are all shared in large measure by Kentucky. Another century will doubtless see this Valley the greatest seat of those productions that require cheap power and cheap food for their making, bringing a population equal to that of the equal areas in the great European States; when this comes, this Commonwealth will contain within her borders probably not less than eight millions of people, and sources of wealth and power unsurpassed on this continent.

Plate No. 1.



GENERAL SECTION FOR GREENUP, BOYD, CARTER, & Part of LAWRENCE COUNTIES.
Block Ore
SANDSTONE
SERIES
VARYING
FROM 250' to 350'
COAL No. 2
Block Ore
SHALE SERIES
ABOVE THE
CONGL. S.S.
VARYING
FROM
60' to 100'.
COAL No. 1
Block Ore
Coarse S.S.
or
Congl. S.S.
CONGLOMERATE
FORMATION
VARYING
FROM 0' to 100'.
Fire Clay
COAL (Sub. Cong.)
SUB-
CONGLOMERATE
SHALES.
L. Ore
Limestone
SUB
CARBONIFEROUS
LIMESTONE
VARYING
FROM 0' to 100'
IN
THICKNESS.
TOP OF
WAVERLY.
UPPER SERIES
COAL No.9
Kidney Ore
Imp. Lime, or Bastard Lime Ore
COAL No.8
GREENISH
SHALE
SERIES.
Kidney Ore
COAL No.7
Kidney Ore
COAL No.6
S.S. or S.
F.C. Ore
Limestone
SANDSTONE
SERIES
CONTINUED.
COAL No.5
COAL No.4
Lit. Block Ore
COAL No.3
Greenish
S.S. & S.
Imp.L.
Coal Stain
S.S. with
Bands of
Rough
Kidney
Ore.
Imp.L.S.
S.or S.S.
COAL No.11
S.S. or S
Ore
UPPER SERIES
CONTINUED
ROCKS
VARYING
FROM SHALE
TO
COARSE S.S.
AND
CONGL. S.S.
Bogart & Folger Cin.

BRIEF STATEMENT OF THE ECONOMIC GEOLOGY OF THE BIG-SANDY VALLEY.

THE valley of the Chatterawah or Big-Sandy River is entirely within the limit of the coal-measures, and, with perhaps one or two exceptions, where the Subcarboniferous Limestone is brought to the surface, the rocks exposed on the waters of the Big Sandy are those of the coal-measures proper.

The number of distinct beds of coal known to be present in this valley is twelve. Iron ores are found at about an equal number of levels. The accompanying general section, from report of A. R. Crandall on the geology of Greenup, Carter, Boyd, and Lawrence Counties, shows the order of the beds, both of coal and of iron ore, near the Ohio River. Further southward changes occur in the general character of the rocks above coal No. 3, so changing the general section as to render any identification of beds from the little that is now known of them quite untrustworthy. Fuller investigation will doubtless discover most of the coals as found near the Ohio, and the thickening of beds as found southward gives promise of richer fields than those already developed.

The following table shows the thickness of the beds that have been fully identified as seen in the localities where mined: —

	Minimum.	Maximum.
Coal, No. 1.	3 ft. 0 in.	5 ft. 0 in.
" " 2.	2 " 0 "	3 " 8 "
" " 3.	2 " 6 "	6 " 6 "
" " 4.	2 " 0 "	4 " 6 "
" " 5.	3 " 6 "	9 " 0 "*
" " 6.	3 " 0 "	4 " 0 "
" " 7.	3 " 0 "	6 " 0 "
" " 8.	2 " 6 "	8 " 0 "
" " 9.	2 " 0 "	2 " 6 "
" " 10.		3 " 6 "
" " 11.	2 " 0 "	2 " 6 "
" " 12.		†

* Coal 5 is generally slaty in part where found in great thickness.
† Not opened.

The following table of analyses of samples, taken from the whole thickness of beds as mined, will serve to indicate the character of the beds included, and of the coals of this field generally: —

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.	No. 8.
	Graham Bank.	Kibby's Bank.	Peach Orchard.	Cannel Hunnewell.	Buena Vista.	Keye's Creek.	Coalton.	Head of Nat's Cr'k.
Specific Gravity . .	1.267	1.289	1.317	1.306	1.360	1.279	1.320	1.367
Moisture	2.50	4.10	3.26	1.50	3.20	2.94	5.00	3.50
Volatile Com. Mat.	36.00	34.60	34.22	52.20	32.30	32.50	34.50	31.90
Fixed Carbon . .	57.30	55.25	55.36	40.60	53.00	56.76	55.40	52.06
Ash.	2.90	4.77	7.16	5.70	11.50	7.74	5.10	12.50
Sulphur	1.148	1.414	0.901	0.782	1.999	1.972	1.285	0.873

Coal No. 8, as represented in this table, is from the head of Nat's Creek, in the north-eastern corner of Johnson County, where it is fully eight feet in thickness, with slight partings. The only average sample from this locality was necessarily taken from near the outcrop, giving too large a percentage of ash, and probably too small a percentage of sulphur.

The thickness of the measures, which include the coals of this table, is about four hundred feet in the regions best known. Coal No. 1 is exposed along the Big Sandy, southward from Peach Orchard and Warfield, at a level which is in general slightly above high-water mark. The hills along the river and the main creeks rise to the height of six and seven hundred feet, including the equivalents of the accompanying general section from coal No. 1 upward. What beds are present in these hills is yet to be ascertained.

GENERAL RESOURCES

OF THE

WESTERN COAL-FIELD AND BORDERING TERRITORY.

I.

SUBCARBONIFEROUS BEDS.

THE coal-field is bordered by Subcarboniferous beds, which are, in succession, those forming the Chester group, and those included in the St. Louis group.

The Chester series are rich in stores of potash-marls, while the St. Louis group yields a number of beds of very admirable building-material.

It is also in the region underlaid by the Subcarboniferous beds that the excellent Limonite iron-ore, so highly esteemed by iron-manufacturers, is found.

As the group is of especial interest, the following typical section of the Chester group, as it occurs on the eastern outskirts of the coal-field, is given: * —

No. 1.	Shale, with thin beds of Limestone	15 feet.
2.	Heavy-bedded, cherty Limestone	13 "
3.	Red and green Shale	5 "
4.	Rhomboidally-jointed Sandstone, frequently charged with Brachiopoda	0 to 10 "
5.	Limestone	2 "
6.	Shale	10 "
7.	Limestone and Shale	20 "
8.	Green, red, purple, and Blue, marly Shales; the Leitchfield marls	25 to 60 "
9.	Shale and thin-bedded Limestone	5 "
10.	Shaley Sandstone	0 to 20 "
11.	Heavy-bedded, dark-gray, and blue Limestone	15 to 45 "
12.	Massive Sandstone; the "big-clifty" Sandstone	60 to 130 "

* Described in detail in Part VI., Vol. I., Second Series Kentucky Geological Reports. N. S. Shaler, Director.

This section is frequently modified. The economic values of the different beds are dependent, in a measure, on their persistency. Space forbids any detailed discussion of the question here. It may be remarked, however, that none of the beds are found to be trustworthy over large areas, unless it be the marls. The persistency of the marls, however. as *individual* beds, is not a settled question. The strata are exceedingly variable in their lithological features, and lateral changes are very frequent, both in their composition and thickness. It is not uncommon for Limestone or Sandstone-beds to be, either in whole or in part, replaced by Shales. Hence beds occurring at some certain locality that would, from their color and composition, be referred to the horizon of the Leitchfield marls, may really belong at a lower or higher level, having replaced some more solid bed. This, however, does not militate against the fact that the Leitchfield marls proper extend over a great area.

The St. Louis group is distinctly separated by the physical characters of its strata into two divisions. The upper or gray Limestone division is formed of a series of gray and drab beds, among which are included two well-marked varieties. One variety, a white Oölite, is quite characteristic of the division. Usually associated with the Oölite are beds of dense drab to cream-colored stone, which breaks with a smooth, conchoidal fracture, and resembles lithographic stone.

The upper division furnishes some of the best building-stones and materials for lime that are to be found in the State. The lower division includes beds of dark-blue to bluish-gray Limestone. The rock is frequently fetid from carbonaceous matter, such as bitumen, held in it, and nests of massive calcite and fluor spar are not infrequent in it. The study of this group is especially interesting on account of its being the repository of the lead deposits of Western Kentucky.

* A section of the beds forming the group, and other matters concerning it, will be found in Part VI., Vol. I., Second Series Kentucky Geological Reports. N. S. Shaler, Director.

II.

THE COAL-FIELD

In studying the resources of the area occupied by the Carboniferous beds in Western Kentucky, the greatest interest naturally belongs to that section underlaid by the coal-measures.

In form the coal-field is somewhat basin-like; that is, the beds incline from the margins towards the centre. The border of the field has never been completely traced with accuracy; but its course may be approximately delineated as follows: * —

Commencing at the Ohio River, in Crittenden County, it follows up the valley of the Tradewater River into Caldwell County; thence crossing into Christian County at a point about five or six miles above Tradewater station (on the Louisville, Pacudah, and South-western Railroad), it keeps in a south of easterly course towards the head-waters of the Pond River. From a point about two and a half or three miles south of Petersburg, Christian County, the southern boundary makes a south-eastwardly curve, passing by the head-waters of the Pond River to the Muddy River, which stream it crosses somewhere near its forks. Thence it passes through the southern part of Butler County, crossing Barren River below the mouth of Gasper River, thence eastwardly along the divide between those rivers, crossing Green River above the mouth of Nolin River, and extending north-eastward to the head-waters of Casey Creek in Hart County. Thence it curves to the north-west, crossing Nolin River near the mouth of Dog Creek; passing a point between Millwood and Leitchfield in Grayson County, — an outlier or tongue extending north-eastwardly, on the north side of Nolin River to the

* These outlines have been mainly obtained from Vol. I. Kentucky Geological Reports, First Series; D. D. Owen, Director. They are quite imperfect, so far as regards details, but are sufficiently accurate for present general purposes. The faithful delineation of the outline of the coal-field has been made part of the work of the present survey.

head-waters of Hunting Fork, of Rock Creek, — and thence on to the Ohio River, to a point not far below Cloverport in Breckenridge County.

In the space thus included lie the whole of nine counties, and parts of five more, making an approximate total of nearly four thousand square miles for the area of the coal-field.

The Number of Coal-beds, &c. — Twelve coal-beds have been identified in the space between the Conglomerate (the base of the coal-measures) and the summit of the series.

It is believed as not improbable, however, for reasons unnecessary to discuss here, that, when sufficient data have been gathered to warrant a generalization concerning the number of beds, it will be found expedient to designate a less number of coals in the general section for the coal-field. For the present, therefore, a letter is used to designate each bed.

The results of the work of the Survey, so far, point to eight as the number of beds that may prove sufficiently trustworthy to receive final numbers. The total thickness of the coal-measures is as yet only approximately known. The thickness is variable, as is the number of coal-beds, and is greater at some localities than at others. It does not seem probable, however, that it will anywhere exceed one thousand (1,000) feet, and there are districts in which it is less than eight hundred (800) feet.

On the map of Kentucky will be found a section showing the position and number of these coals as determined by Dr. Owen's Survey, as well as some modifications made by the present Survey.

The thickness indicated for each bed, and the included space, are strictly in accordance with Dr. Owen's statement.

1. Anvil Rock Sandstone	20	feet.
2. Coal, No. 12 (Coal A)	3	"
3. Space	21	"
4. Coal, No. 11 (Coal B)	5	"
5. Space	46	"
6. Coal No. 10 (Coal C)	3	"
7. Space	68	"
8. Coal No. 9 (Coal D)	5	"
9. Space	50	"

10. Coal No. 8 (Coal E)	2½	feet.
11. Space	43	"
12. Coal No. 7 (Coal F ?)	2	"
13. Space	84	"
14. Coal No. 6 (Coal G ?)	3	"
15. Space	65	"
16. Coal No. 5 (Coal H ?)	4	"
17. Space	95	"
18. Coal No. 4 (Coal I)	4	"
19. Space	154	"
20. Coal No. 3 (Coal J)	2½	"
21. Space	71	"
22. Coal No. 2 (Coal K ?) No thickness given.		
23. Space	82	"
24. Coal No. 1 B (Coal L)	5	"

The preliminary arrangement adopted in the present survey differs in some particulars from the foregoing. In some instances the distances between the coals are increased, and in others diminished; and several of the beds are represented at a greater or smaller thickness than they are in Dr. Owen's Section.

The irregular distribution of the coal necessitated the separation of that part of the coal-field thus far examined into three divisions. The first extends from the eastern border of the field to the Green River; the second is approximately bounded by the Green and Pond Rivers; and the third extends from the Pond River to the western margin of the field.*

In the first division are found coals A, B, C, D, E, H, K, and L; proving eight of the twelve beds to be present.

In the second division are found coals A, B, C, D, E, F, G, and H; the number here also being eight. This, however, does not represent all of the coals that may be found, as the base of the coal-measures was not reached; it represents only those coals that come to the surface, or that have been reached in pits; no doubt, most of the lower beds are present.

* The region in question is that which is traversed by the Louisville, Paducah, and South-western railroad: none of the country bordering the Ohio River is included; nor yet that lying near the southern margin of the field. None of that region has yet been sufficiently studied to report on the number of beds. See Part VI. Vol. I., Second Series Kentucky Geological Reports, page 374.

In the third division most of the coals are found, the absent ones probably being C, F, G, and K (?).

Generalizing from the results obtained in each of these divisions, it is found that the average distances between the coals from A to H inclusive, in the region examined, are about as follows: —

1. Coal A	5	feet.
2. Space	5	"
3. Coal B	6	"
4. Space	15	"
5. Coal C	Nothing to 2	"
6. Space	75	"
7. Coal D	5	"
8. Space	75	"
9. Coal E	1½	"
10. Space	20	"
11. Coal F	1½	"
12. Space	50	"
13. Coal G	½	"
14. Space	100	"
15. Coal H	4½	"

From coal H to coal L the spaces between the beds are very variable, and sufficient data have not been obtained to warrant the making of an average. As an instance of the changes, it may be mentioned that the distance from coal I to coal J varies from fifty to eighty-three feet.

Were all of the coals united in one bed, the deposit would be about thirty-five feet thick. As far as our examinations now show, coals K, G, F, E, and C may prove to be only local beds.

Quality of the Coals. — As a consequence of the very imperfect knowledge hitherto had concerning the coals of this field, the percentage of sulphur in the coals of Western Kentucky has been rated by many not only as inordinately high, but greater than in the coals of neighboring regions. This has been an error. It is true that in some of the beds the percentage of sulphur is large; but as a class the coals will compare favorably with those in any section of the Western coal-field. The matter of sampling coals for a representative analysis has not always received the attention that should be given it; what may be termed "hand" or picked specimens have in the largest number of cases been used for analysis, and analyses made under such conditions cannot be fairly compared with ours, that were in every case made from samples *mechanically* taken and faithfully averaged.

It has been known for some years that the coals of the Western coal-field carry, as a class, more sulphur than do those in the Appalachian field; and less than do those in the Missouri and Iowa coal-field. It is not, therefore, with the coals of the States in the Appalachian coal-field that the Western Kentucky beds are to be compared as a class, but with those in the West; and when such comparison is impartially made, the Kentucky coals, as a class, are not excelled by those in other sections of the Western coal-field.

In Indiana and Illinois there are certain beds that have won a high reputation, a better one indeed than has hitherto been accorded the Kentucky coals; but later investigations have developed the fact that here, too, are exceptionally good beds, unexcelled, perhaps, by the most famous of those States. They have hitherto escaped general notice, from the fact that they do not lie in what has been the district of active mining operations, although within convenient reach of transportation facilities. Following are averaged analyses of those beds which so far have been deemed the most important: — *

	Number of Coal.						
	A.	B.	D.	J.	L.*	L?†	?‡
Moisture	3.43	3.27	3.37	3.70	4.85	3.30	1.30
Volatile Comb. Mat.	39.26	38.80	36.66	32.56	32.22	36.00	59.60
Fixed Carbon . .	50.23	51.23	51.97	50.04	55.03	57.88	27.00
Ash	7.08	6.70	8.00	13.70	7.90	2.82	12.10
	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Sulphur	2.753	2.548	2.806	3.716	1.373	1.024	1.896
Specific Gravity .	1.383	1.309	1.354	1.398	1.319	1.241	1.213

* From the Coaltown Banks, Christian County.
† From near Wrightsburg, McLean County.
‡ The "Breckenridge" Cannel Coal, from near Cloverport, Breckenridge County.

* Some of the beds as yet insufficiently studied for judgment to be passed on them may prove fully as important, so far as regards quality, as those now wrought.

For comparison with the analyses of coal L, the following analyses of the Indiana "block" coal, and the "Big Muddy" coal of Illinois are given. These coals are considered to be among the best in the Western coal-field: —

	Number of Analysis.			
	No. 1.	No. 2.	No. 3.	No. 4.
Moisture	2.70	2.68	2.62	3.44
Volatile Combustible Matter .	36.38	36.32	32.04	31.86
Fixed Carbon	55.64	53.58	58.58	59.54
Ash	5.28	7.42	6.76	5.16
Sulphur	1.664	1.802	2.472	1.376
Specific Gravity	1.313	not est.	1.310	1.310

Numbers 1 and 2 are analyses of the Indiana "block" coal; numbers 3 and 4, of the "Big Muddy" coal of Illinois.

The analyses were made in the laboratory of the Kentucky Geological Survey of carefully averaged samples collected in the same manner that the Kentucky coals are sampled.* Special attention is directed to the analyses of the Coaltown and Wrightsburg coals. These are what are known as "blocking" coals, and withstand weathering remarkably well.

The Wrightsburg coal is remarkably good, containing less than three per cent. of ash, a small proportion of water, and but little more than one per cent. of sulphur. There is reason to hope that the Wrightsburg and Coaltown coal may prove serviceable as an iron-making fuel.

The Breckenridge Cannel is already well known for its remarkable properties.

Coal D seems to be the most trustworthy of all of the beds, and is the one most generally wrought throughout the coal-field. It is most useful as a household fuel.

Coal B is usually divided about the middle by a clay parting. The upper sixteen inches serves admirably for gas-making; several analyses show it to contain very little sulphur, and a large proportion of volatile combustible matters. At some points the coal yields an admirable coke.

* See page 177 of the Chemical Report of the Kentucky Geological Survey; Vol. I. Second Series. N. S. Shaler, Director.

III.

WATER-WAYS AND RAILWAYS.

The coal-field is crossed by three railroads, and is so drained by several streams that, were they all prepared for navigation (a work of no very serious difficulty), no part of it would suffer for means of transportation.

All of the streams drain towards the Ohio River, which offers cheap transportation to the sea.

The streams that have already been made navigable for part of their extent are the Green, the Tennessee, and the Cumberland Rivers; those streams whose partial improvement is both feasible and desirable are the Tradewater and Pond Rivers, Rough Creek, Nolin River, Muddy River, and Bear Creek.

The Green River and its tributaries is navigable by locks and dams for two hundred and sixty-eight miles. The Tennessee is navigable from its mouth to Florence, Alabama, a distance of about two hundred and fifty miles; and the Cumberland River is navigable from its mouth to a point about one hundred miles above Nashville.

Regular lines of steamers ply on these rivers. Large shipments of coal are sent south by the Tennessee River.

The Pond River flows into the Green River, and during high stages of water is navigable for about fifteen miles; it may be rendered navigable by a system of locks and dams, as far up as Bakersport, a distance of about thirty miles.

The Tradewater River is ascended by light-draught boats during the spring freshets as far up as Belleville; it is quite practicable for it to be rendered navigable for forty miles, or more.

Prior to the building of the Louisville, Paducah, and Southwestern Railroad, Rough Creek (which empties into Green River), was regularly plied by light-draught steamers as far up as Hartford, Ohio County, having been rendered navigable by locks and dams. It will be seen that it is a mere question of enterprise whether or not the streams may be used as roads for carrying out produce, &c.

The railways are the St. Louis and South-eastern Railway (connecting St. Louis, Mo., and Nashville, Tenn.), which passes north and south through Henderson, Webster, Hopkins, and Christian Counties; the Evansville, Owensboro', and Nashville railroad (not yet completed), which (so far as built) passes north and south through Daviess and McLean Counties into Muhlenburg County; and the Louisville, Paducah, and South-western railroad which passes westwardly through Grayson, Ohio, Muhlenburg, Hopkins, and Caldwell Counties intersecting the north and south running railroads; one at Owensboro' Junction, and the other at Nortonville.

The total number of miles of railroads in the coal-field is about one hundred and eighty-five.

Thus it will be seen that transportation is, or can easily be, furnished to nearly all of the workable coal-beds. The Green, Pond, and Tradewater Rivers and their tributaries (some of them of considerable size), and Rough Creek drain a large portion of the coal-field; while other portions are reached by the several railroads. Some of the best coals are found on the Green and Tradewater Rivers; but as yet comparatively little mining has been done in them.

So far nearly all of the important mines have been opened along the paths of the railroads, a plan which has resulted in giving them a more rapid, although more costly, transportation than was offered by the rivers.

IV.

NUMBER OF COAL MINES, &c.

In all there are about thirty collieries of importance in the coal-field.

The mines are worked on a general plan modelled on the post and stall-system. About fifteen of them are located along the Louisville, Paducah, and South-western Railroad; six along the St. Louis and South-eastern Railway; and two on the Evansville, Owensboro', and Nashville Railroad. Others are located in the neighborhood of Owensboro', bordering the Ohio River; at Airdrie on the Green River; and several in Crittenden and Union Counties, in the vicinity of Caseyville.

The Coal Trade. — It is difficult to determine the precise amount of coal raised in this field, as the records are very imperfect. The product of the Kentucky collieries, however, has operated greatly in regulating the amount of foreign coal brought into the State and into the Southern markets.

Louisville, of the home markets, has especially been benefitted by these mines, as the following will show: —

In the winter of 1871–72, on account of low water, the Pittsburgh coal reached the price of $7.00 per load of twenty-five bushels, while the Kentucky coal sold at $5.00 and $5.50 per load.* In the succeeding winter (1872–73), the Ohio River was again at a low stage; but the highest price paid for Pittsburgh coal was $5.00, the average being $4.50; the Kentucky article selling at $4.50 and $4.00 per load. In the winter of 1873–74, there was a good stage of water in the Ohio River, and at the same time plenty of Kentucky coal, and the Pittsburgh coal sold at $3.50 and $4.00 per load. In 1874–75, there was a still greater reduction in prices, the Pennsylvania coal selling at $3.00, and that from Kentucky at $2.75 per load.

This season, the Kentucky collieries have suffered in common with those of other regions, and also from internal complications; hence their product may fall behind that of former seasons, or at most not go beyond it.

According to the census reports of 1870, when few collieries were in operation in this field, the production of the mines amounted to about 115,094 tons of coal; of which 67,466 tons were raised in Union County, and 23,600 tons in Crittenden County.

The product of the mines on the Louisville, Paducah, and South-western Railroad alone, from October 1872 to October 1874, amounted to 270,000 tons,† and at least half as much

* A ton of coal contains about twenty-five bushels.

† A number of the largest collieries were not in operation until 1873, hence for some of them the statement does not represent a business of two years. Scarcely any of the mines had been opened longer than two years when the statistics were obtained.

more may be estimated for the product of the other mines for that time, placing the probable product at 405,000 tons.

V.

BUILDING MATERIALS.

Wood.—The larger portion of the region west of Salt River, especially that lying within the limits of the coal-field, is supplied with forests of valuable timber.

In different sections of the region bordering the Green River fine white oak, chestnut, oak, yellow poplar, and black-walnut trees are found. In Daviess, and some other Counties, large-sized chestnut trees are not infrequent. The forests of Hopkins County and neighboring regions are noted for their growth of large-sized oaks and poplars.

Stone.—The St. Louis group furnishes admirable building-stone and material for lime. Some important quarries have been opened in its beds. At Bowling Green the Oölite is quarried very extensively, and the exportation of the stone in dressed blocks has grown into an important industry. At Glasgow Junction, in Barren County, the "lithographic" beds have also been largely quarried and dressing-works erected.

The Oolite and "lithographic" stone are both very valuable as building material, being unexcelled, perhaps, for nice work by any of the Subcarboniferous beds. The Oölite is especially esteemed by builders for its durability and beautiful appearance after dressing. Large quantities of it are sent to St. Louis and other western cities and to the south, and even to the Atlantic States. The dark blue beds of the St. Louis group, and a few of the Chester group, serve very well for heavy work.

Few of the Sandstones in the coal-measures are of much value as building material. They are, as a class, too soft and incoherent; hence liable to disintegrate when set in a wall. They are occasionally found suitable for ordinary purposes. The great sand-rock at the base of the Chester group is in a number of places a fairly good building stone.

Gravel Beds.— Between the Cumberland and Tennessee Rivers are large deposits of gravel, the shipment of which to cities in which gravelled streets are used may prove a source of profit. The gravel covers a considerable area, and in many places seems to have formed into ridges. The beds seem to be practically almost inexhaustible, and may be accounted among the valuable deposits stored in Western Kentucky.

The material is largely used on the streets of Paducah, and has also been tried in Louisville.

Paint Materials.— It is possible that some of the red earths found associated with the St. Louis beds may prove useful as materials for paint; their merit, however, is as yet only conjectural.

The Chester group, however, furnishes deposits of undoubted value for paint material. Southwardly from Leitchfield, Grayson County, beds are found of two colors, — red and light blue. The material has been locally used, and with very favorable results. The Shales overlying Coal A frequently furnish an abundance of ochre.

VI.

OTHER MATERIALS.

Marl Beds.— One of the most interesting results of the geological survey was the discovery of potash and soda in some of the marls of the Chester group, in such quantities as to prove them valuable as fertilizers.

Attention was first directed to the deposits near Leitchfield, Grayson County, and now they are searched for with interest wherever the Chester group is known to occur. They have been found in Grayson, Edmonson, Breckenridge, Caldwell (?), Christian (?), and Livingston Counties. Their entire extent is unknown, but it is not improbable that further explorations may prove their existence wherever the Chester group is fully developed.

Scarcely too high an estimate can be placed on these marls in Kentucky, as we have therein a ready and cheap fertilizer for tobacco lands, — the properties of the marl being to renew the vigor of the soil as it is impoverished by the tobacco. The infertility of much of the land is largely due, not to original poorness, but to the exhaustion produced by tobacco; these potash marls are expected to serve in placing the lands once more in a fertile condition.

Following, is the analysis of a sample of the marl collected from Haycraft's Lick, Grayson County: —

Composition, dried at 212° Fahrenheit: —

Alumina, iron, &c., oxides	27.811
Lime carbonate	.880
Magnesia	.824
Phosphoric acid	.109
Potash	5.554
Soda	.657
Water and loss	4.245
Silica and insoluble silicates	59.920
	100.000

Lead. — In nearly all of the regions where the St. Louis group is fully developed more or less lead has been found. The only mining that has been done for the metal, however, has been in Livingston, Crittenden, and Caldwell Counties. In Livingston and Crittenden Counties a number of pits and excavations of various sorts have been dug for the purpose of working the deposits; with possibly one exception, however, the work has so far proven unprofitable. In Crittenden County considerable lead has been found at a point known as the Columbia mines, leading to the supposition that, economically managed, they may be wrought at a small profit. So far these lead-mines have had to contend with the production from the mines in the Rocky Mountains, where a large quantity of this metal has been produced, almost without cost, in the reduction of ores for their silver. Should this competition be in time removed, they would become more important sources of profit.

Zinc. — Zinc is frequently found in the form of the sulphide (Black-Jack) accompanying the lead; it has never been found in sufficient quantities for working.

Iron Ore. — As hitherto mentioned, some of the regions underlaid by the Subcarboniferous beds furnish admirable Limonite ore.

Towards the base of the coal-measures the Shales frequently carry good beds of the Carbonate ore; in general, however, the beds of the coal-measures are unproductive, save near their base, where some of the best ores of the Ohio Valley are found.

Fluor Spar. — Fluor spar is found in more or less quantities throughout the lead region. In Crittenden County, northwardly from the Columbia mines, fluor spar is found in great abundance. Considerable deposits of the massive variety, very white and apparently free from impurities, are found at the Memphis mines and vicinity. It is not unlikely that other important deposits may be found.

Mineral Springs. — Springs of sulphur and chalybeate water are not uncommon in regions where the Subcarboniferous series come to the surface.

The ones most frequented are the Grayson and Rough Creek Springs in Grayson County, the Ohio Springs in Ohio County, and the Sebree Springs in Webster County.

The Grayson and Rough Creek Springs are watering-places of considerable popularity in Kentucky and the South; the Grayson Springs being, perhaps, the most generally known. There are a number of other springs resorted to, and whose waters are esteemed by many; they have, however, more of a local reputation. The Sebree Springs have many visitors from the western part of the State and contiguous regions during the summer.*

The coal-measures also furnish mineral waters in some regions. The most interesting are in Daviess County, and are known as Hickman's Springs. Several of the waters are remarkable for the amount of alum they contain.

* Analyses of the waters from the various springs will be found in the Chemical Report, Vol. I., Second Series, Kentucky Geological Reports.

VII.

GENERAL REMARKS ON AGRICULTURE.

Soil.—There are three general varieties of soil found in the region of the Carboniferous rocks.

The soil of the coal-measures, originating as it does from Sandstones and Shales, is a light, sandy mixture, usually yellowish in color; or a rather dense, dark-colored material becoming waxy and unmanageable after rains,—according to localities. The soil resulting from the beds of the coal-measures seems especially adapted for the growth of tobacco. This may be due to the fact that nearly all of the Sandstones are micaceous, and that upon disintegration the mica furnishes the mixture with the potash required by the plant.

In the Chester group we get a mingling of sandy, calcareous, and aluminous materials, producing in some regions a fairly good soil. In general, however, Shale predominates largely, and produces, when unmingled with other materials, a poor and stubborn soil.

The finest soil for general purposes is furnished, perhaps, by the St. Louis group. It is a deep-red earth, rich in iron and other desirable matters. This soil is very characteristic of the St. Louis group, and is almost invariably found where the limestones are the first beds below the surface.

Crops.— Tobacco is the staple agricultural product of Western Kentucky; the other crops, such as wheat, oats, corn, and hay, are raised more for home consumption than as an article for exportation.

The following are the yields per acre of the several products, so far as past observation would indicate:—

	Lowest Yield.	Highest Yield.	Average Yield.
Corn *	10	60	30
Wheat *	8	35	10
Hay, (Timothy) †	1½	2	1½
„ (Red Top) †	1	2	1½
Tobacco ‡	300	1500	800

* Yield in Bushels. † Yield in Tons. ‡ Yield in Pounds.

In her tobacco yield, Kentucky now stands first among the States, and the western part of the State furnishes by far the larger portion.

The principal tobacco-growing counties east of the Tennessee River are Caldwell, Christian, Daviess, Henderson, Hardin, Hopkins, Muhlenburg, and Ohio; Daviess County is said to be the largest producer, Christian County standing second.

The principal shipping points are Henderson, Owensboro', and Hopkinsville; Princeton and Eddyville are also depots for the handling of tobacco, — the former place doing a considerable business.

Owensboro', it is said, is the largest "strip" market in the world; Henderson falls but little behind it, and was until within the last year or two the largest market.

The time has been too limited wherein to obtain complete statistics of the trade at the different shipping points; the following statements, however, of the market at Owensboro' and Hopkinsville for a period of years will serve to show the magnitude of the tobacco interest.

The statistics concerning the Owensboro' market were kindly furnished by Captain R. L. Triplett.

Statement of the Amount of Tobacco exported from Daviess County for six years previous to 1876.

	From Owensboro'.	From other Points.	Hhds.	Pounds.
Product of 1868	5,000	500	5,500	8,250,000
" " 1869	5,500	500	6,000	9,000,000
" " 1870	6,500	500	7,000	10,500,000
" " 1871	6,000	500	6,500	9,750,000
" " 1872	7,500	500	8,000	12,000,000
" " 1873	9,000	500	9,500	14,250,000
" " 1874 *	3,000	500 †	3,500	5,250,000
" " 1875 ‡	8,000	500	8,500	12,750,000

* A short crop year.
† Not quite that much, but a fair enough estimate.
‡ Product not yet gone forward, but will reach as much.

Statistics concerning the Hopkinsville market are taken from the Annual Circular of Messrs. J. K. Gaut & Son: —

In 1870, there were sold 2,468 hogsheads.
" 1871, " " " 5,970 "
" 1872, " " " 6,711 "
" 1873, " " " 9,155 "
" 1874, " " " 13,047 "

These sales are up to Nov. 1 of each year, and include all the sorts of tobacco that are sent from the place.

Statistics of the Henderson market have failed to come to hand.

It must be borne in mind that Louisville and Paducah also receive large amounts of tobacco from this region; * hence the foregoing show but a small proportion of the yield.

The following Table, extracted from a late circular from Liverpool, may be of interest, as it shows the number of hogsheads of Virginia and Kentucky tobacco on hand, March 1, for a series of years: —

VIRGINIA.	Leaf.	Strips.	KENTUCKY.	Leaf.	Strips.
1872	2,402	1,820	1872	8,436	9,754
1873	2,372	1,363	1873	6,449	4,228
1874	3,206	3,517	1874	8,024	10,817
1875	2,706	4,353	1875	9,039	14,032
1876	3,313	3,824	1876	9,204	7,740

This table serves as an approximate means of measuring the exports from the two States.

* Much of the Puducah exports, however, are of the tobacco grown west of the Tennessee River.

THE IRON ORES OF KENTUCKY.

THE iron resources of Kentucky are extensive and varied. At a few localities a considerable development of them has been attained; but, taking the State as a whole, it has hardly reached a fraction of the possibilities of production. The greater portion of the ore territory of the State is as yet untouched by the pick of the miner; but enough has been done in most of the ore districts to learn the quality and something of the extent of the ores.

Geographically the ore districts of the State may be divided into the eastern and western.

Geologically the ores of most importance may be divided into three classes, as follows: —

1. The Clinton ore of the Silurian period. This is the equivalent of the Dyestone ore of Tennessee and Virginia.

2. The unstratified Limonites of the Subcarboniferous Limestone.

3. The stratified Carbonates and Limonites of the coal-measures.

There are also ores associated with the Waverly and Devonian Shales in many parts of the State, which have been worked to some extent; but they are of minor importance in comparison with the other varieties of ore. Of the three classes of ore above named the first and the third are found in Eastern and the second and third in Western Kentucky. It may be said also that the ores of the coal-measures are the best developed and of the most importance in Eastern, while the unstratified Limonites of the Subcarboniferous Limestone are of the greatest value in Western Kentucky.

It is also proper to state here that the State has been imperfectly prospected, and that it is altogether possible, and indeed probable, that the ores of one or another of these varieties will be found to be much more extensive and valuable than at present supposed.

The Iron Ores of Eastern Kentucky. — The ore districts of Eastern Kentucky, where the ores have been manufactured, are two, known as the Red River and the Hanging Rock iron regions. The Red River iron region embraces portions of Estill, Lee, Powell, Menifee, and Bath Counties.

The ores found in this region are the Clinton ore, and an ore, stratified, resting upon the Subcarboniferous Limestone at the base of the coal-bearing Shales. It is found both as Carbonate, or clay Ironstone, and as Limonite, or Brown Hematite. It is this ore which has been most largely worked, and upon which the excellent reputation of the iron from this region has been made.

The Clinton ore has not been so extensively worked; but the principal deposit of it is situated geographically near this region, and may be said to belong to it.

The best known deposit of this ore in Kentucky is in Bath County, on the waters of Slate Creek, and is known as the Slate Furnace Ore-bank. It is a stratified deposit of Oölitic Fossiliferous Limonite, capping several hills in the vicinity. It reaches a thickness of fifteen feet at places. The area covered by the ore at this point is somewhat over forty acres, and the total amount of ore about one and a half million tons. The ore bears evidence of having been formerly a Hematite, similar to the Dyestone ore of the same geological horizon along the great valley from New York to Alabama, but it has lain so long, unprotected by any thing except a slight covering of earth, that it has absorbed water, and been converted into a Limonite.

This deposit seems to be somewhat local, — at least of this thickness, — as it grows thin, and finally disappears in this neighborhood. The Limestone which bears the ore is, however, present in a narrow rim all round the central part of the State, and it is probable that, when thorough examination is made, other deposits of the ore will be found.

The following analysis by Dr. Peter and Mr. Talbutt, of the Kentucky Geological Survey, of a sample of ore from this deposit, shows the composition of the ore:—

Iron Peroxide	70.060
Alumina	4.540
Lime Carbonate	.040
Magnesia	.021
Phosphoric Acid	1.620
Sulphuric Acid	.031
Silica and Insoluble Silicates	11.530
Combined Water	12.300
	100.142
Metallic Iron	49.042
Phosphorus	.707
Sulphur	.012

The Dyestone ore, a Fossiliferous Hematite, extends along the flank and foot-hills of the Cumberland Mountain in Virginia, just across the State line from Kentucky, the crest of the mountain forming the line for about forty miles. It lies in two or three beds, ranging from six inches to three feet or more in thickness, and forms in the aggregate an enormous mass of cheaply-obtainable ore. This ore, although situated in Virginia, is of the greatest importance to Kentucky, as it is destined to be smelted with Kentucky coals, which lie on the opposite side of the mountain, and are the only coals accessible to the ore, as there is no coal to the south of the mountain.

This ore, although somewhat phosphatic, is easily worked, and yields from forty to fifty per cent. of iron. From this ore, smelted with stone-coal, iron will probably be made as cheaply as in any region of the country.

The great Pine-Mountain fault, which extends from some distance south of the Kentucky line in Tennessee, in a course about north thirty degrees east through Kentucky to the Chatterawah or Big-Sandy River, at many places is of sufficient uplift to have brought the rocks of the Clinton or Dyestone group above the drainage; and it is probable that on exploration the ore will be found in Kentucky. It has been found at the foot of the Pine Mountain in Tennessee. In Kentucky the place of the ore is usually covered deeply by the talus from the overlying rocks, which probably accounts for its not having been discovered. Should it be found along the foot of Pine Mountain in Kentucky, it will be most favorably situated for cheap iron-making, as on the opposite side of the stream, which flows at the base of the mountain, there is found excellent coal in great abundance.

The Limestone ore of the Red River iron region, from which the iron is manufactured which gives to the region its reputation, rests upon the Subcarboniferous Limestone, and from this association takes its name. It lies in a bed of irregular thickness, ranging from a few inches to three feet or more in thickness, but probably averaging, where found in any quantity, about one foot thick, or a little less. It is occasionally irregular and uncertain in its distribution; but, in general, it may be said that it is found in its proper position almost wherever the Subcarboniferous Limestone is above the drainage, along the edge of the coal-measures from the Kentucky to the Ohio River. South of the Kentucky River the ore is known to extend a short distance, as far as it has been explored; but its limit in this direction is as yet unknown.

The Red River region embraces, however, only that portion between the Licking and the Kentucky Rivers. This region has been little developed, except in a portion of Estill County, where four charcoal-furnaces have been in operation. There are many eligible sites for charcoal-furnaces in this region, where timber and ore are both in abundance and as yet untouched. The development of this region has been retarded by the lack of transportation facilities, as the iron had to be hauled a long distance in wagons to railroad or river. This difficulty is likely to be remedied in the near future by the construction of one or two projected railroads into or along the edge of this region, and we can then look for a largely-increased production of the excellent iron from this region. The iron is of great strength, and ranks very high in the markets of the West. It is used principally for car-wheel purposes, as it is of very great strength and chills well.

The following analyses show the character of the ore of this region: —

	No. 1.	No. 2.	No. 3.	No. 4.
Iron Peroxide	66.329	63.535	74.127	65.591
Alumina	12.532	2.798	3.542	5.762
Lime Carbonate	trace.	.450	.390	trace.
Magnesia	.173	1.073	.461	.248
Phosphoric Acid	.709	.537	.601	.447
Silica and Insoluble Silicates	9.720	20.480	9.580	16.230
Combined Water	9.580	9.800	11.270	11.060
Total	99.043	100.673	99.971	99.914
Metallic Iron	46.440	45.874	51.889	45.914
Phosphorus	.309	.234	.262	.195

No. 1. From the Richardson Bank, Clear Creek, Bath County.
No. 2. From Logan Ridge, Estill Furnace, Estill County.
No. 3. From Thacker Ridge, near Fitchburg, Estill County.
No. 4. From Horse Ridge, Cottage Furnace, Estill County.

The above analyses were made by Dr. Peter and Mr. J. H. Talbutt, chemists of the Kentucky Geological Survey, from samples selected by the writer.

THE HANGING ROCK IRON REGION.

The Kentucky division of the Hanging Rock Iron Region at present embraces the whole, or parts, of Greenup, Boyd, Carter, and Lawrence Counties. The ores are stratified Carbonates and Limonites, occurring in the lower coal-measures, beginning with the ore just described, resting upon the Subcarboniferous Limestone, and extending through six hundred to seven hundred feet of the coal-measure strata. The ores are mineralogically similar, but differ somewhat in their physical character and circumstances of deposition. They are popularly known as Limestone, Block, and Kidney ores. They usually occur at well defined geological levels, but do not always form connected beds. They also differ in thickness, ranging from four to eight inches in some of the thinner beds to fourteen feet in one local deposit. This latter is the Lambert ore of Carter County. The most common thickness is from six inches to one foot. There are from ten to twelve ore beds which are of more than local extent in this region. In addition there are numerous local beds, one or more of which is found at nearly every furnace. This region supports eleven charcoal and two stone-coal furnaces. The Hanging Rock iron bears a reputation for excellence for general foundry purposes, which is unsurpassed by any iron in the United States. The iron produced is mostly hot-blast charcoal iron; but some of the furnaces are worked with cold-blast for the production of car-wheel iron. The reputation of the iron of this region is, however, chiefly founded upon its excellence for castings of all sorts. The iron combines in a remarkable degree great strength with fluidity in casting, and non-shrinkage on cooling.

The stone-coal iron of this region is used almost entirely for the manufacture of bar iron and nails.

The stone-coal iron is made from the ores of this region mixed with a considerable proportion of ore from other States. The fuel used is the celebrated Ashland, or Coalton coal. It is a dry-burning, non-coking coal, which is used raw in the furnace, and is of such excellent quality that no admixture of coke with it in the furnaces is necessary, as is the case with most of the other non-coking furnace coals of the West.

The charcoal iron is manufactured exclusively from the native ores, which yield, as shown by the books at a number of the furnaces, for periods ranging from one to four years, an average of between thirty-one and thirty-two per cent. of iron. The ores of the region are known as Limestone, Block, and Kidney ores. These names are due to peculiarities of structure or position, rather than to any essential difference in chemical composition. As a rule, however, the Limestone ores are the richest and most uniform in quality. The Kidney ores are next in value; while the Block ores present greater variations in quality than any other, some of them being equal to the best of this region, and some so silicious and lean that they cannot be profitably worked.

The following analyses by Dr. Peter and Mr. Talbutt, of the Kentucky Geological Survey, show the composition of some of the ores of each class in this region:—

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
Iron Peroxide. . .	67.859	71.680	54.530	68.928	61.344	66.200
Alumina	1.160	4.155	2.120	2.768	4.236	3.907
Mang. Brown Oxide	.980	.090	1.380	.290	. . .	.030
Lime Carbonate . .	.120	.380	.040	.680	.750	.430
Magnesia	1.275	.050	1.823	.641	.208	.345
Phosphoric Acid .	.143	.084	.908	.249	.795	.130
Sulphuric Acid . .	. . .	.270	.336	.748	.041	.182
Silica and Insoluble Silicates. . . .	15.560	12.650	28.360	15.240	21.480	16.530
Combined Water .	*12.903	10.800	10.900	11.100	11.200	11.730
Total . . .	100.000	100.159	100.397	100.643	100.054	99.484
Metallic Iron . . .	47.501	50.176	38.171	48.249	42.941	46.340
Sulphur	. . .	.108	.134	.298	.016	.072
Phosphorus . . .	.062	.036	.428	.098	.347	.057

* And loss.

No. 1. Lower Limestone Ore, Kenton Furnace, Greenup County.
No. 2. Upper Limestone Ore, Graham Bank, near Willard, Carter County.
No. 3. Lower Block Ore, Kenton Furnace, Greenup County.
No. 4. Upper or Main Block Ore, Laurel Furnace, Greenup County.
No. 5. Yellow Kidney Ore, Buena Vista Furnace, Boyd County.
No. 6. Yellow Kidney Ore, Mount Savage Furnace, Carter County.

THE IRON ORES OF WESTERN KENTUCKY.

The most extensive and best developed ore region of Western Kentucky is called the Cumberland River iron region. It embraces the whole, or parts of, Trigg, Lyon, Livingstone, Crittenden, and Caldwell Counties. The ores of this region are Limonites found resting in the clay and chert above the St. Louis or Subcarboniferous Limestone. They occur in deposits of irregular shape and uncertain extent, but in the aggregate the amount of ore is immense. The ores are distributed with great irregularity throughout this region, but they seem to be found in greatest abundance and quantity where the Limestone has been most extensively worn away, and where, as a consequence, the clay and chert which are the result of its decomposition are of greatest thickness.

The ores are, perhaps, found in greater abundance in the country between the Cumberland and Tennessee Rivers than in any other portion of this region, although there are extensive deposits on the east side of the Cumberland River which have been largely worked. As a rule, however, the deposits decrease in size and frequency in going from the Cumberland River toward the east, and, after a few miles' distance from the river is reached, they are scattering and small. The ores are of excellent quality, being almost entirely free from sulphur, and containing but a small amount of phosphorus; but they are sometimes mixed with chert and sand. The quality in this respect is as variable as the size of the deposits; the ore in the same deposit frequently showing all degrees of admixture with chert, from a chert breccia, to a rich, pure ore with only an occasional lump of chert enclosed.

The average yield of iron from the ore at the furnaces of this region, where it is not very carefully selected previous to roasting, is between thirty and thirty-five per cent. With careful sorting the yield can be brought much higher, from forty to fifty per cent.

The iron produced from these ores is of a very high grade. There are three active furnaces in this region which use charcoal fuel exclusively for the production of pig-iron. From this iron is manufactured the celebrated Hillman's boiler-plate, of which it is said, by the manufacturers, that no boiler constructed of this iron has ever exploded. This iron ranks equal, or superior, to any other boiler-plate manufactured in the United States. It is used largely for steamboat and locomotive boilers, for which latter purpose it finds an extensive market, even as far as the Pacific slope.

Considerable ore from this region has been shipped to furnaces at a distance; but within the past two years the depressed condition of the iron market has rendered this unprofitable. This region is well situated as regards transportation facilities, — it being drained by the two navigable rivers, the Cumberland and Tennessee, and on the lower border by the Ohio, so that the iron manufactured here can be very cheaply placed in market.

The following analyses of two samples of ore from the Suwannee furnace-lands, Lyon County, will show the character of the ore from this region. The analyses are by Dr. Peter and Mr. Talbutt of the Kentucky Geological Survey: —

	No. 1.	No. 2.
Iron Peroxide	59.370	70.518
Alumina	1.622	.045
Manganese	.090	.190
Lime Carbonate	.170	.090
Magnesia	.100	trace.
Phosphoric Acid	.179	.275
Sulphur	.212	.045
Silica and Insoluble Silicates	30.000	18.910
Combined Water	8.400	9.850
Total	100.053	99.923
Metallic Iron	41.559	49.363
Phosphorus	.077	.120

This same variety of ore is found, in greater or less quantity, in many other counties where the St. Louis Limestone is the prevailing rock formation, but in none of them, save those mentioned, has any extensive iron industry been established. In the Cumberland-River iron region there are many furnace-sites unoccupied where iron can be cheaply and profitably manufactured.

This region is capable of, and destined to, a much greater development than it has yet attained. The charcoal-iron manufacture will always be an important and extensive industry, for over a large part of the region the most profitable use that can be made of the land is the production of timber for charcoal. There is destined at no far-distant day to be a large stone-coal or coke iron industry established here, using the ores of this region with the coals of the Western Kentucky coal-field, either raw or coked. The best known of the Western coals at present are too sulphurous for use in iron-making, without previous separation from sulphur by washing and coking. It is through the introduction of modern machinery and ovens, by which these operations can be cheaply and thoroughly effected, and a coke fit for iron-smelting produced, that the coal and iron ore of Western Kentucky will be most profitably and extensively developed. The Louisville, Paducah, and

South-western Railroad affords direct communication between the coal and ore fields. Already measures are in progress for the erection of extensive coke-works on the line of this railroad, which will doubtless prove but the first step in the successful development of a different form and more extensive iron industry than any yet established in Western Kentucky.

THE NOLIN-RIVER DISTRICT.

In Edmonson and Grayson Counties, north of Green River, between Nolin River and Bear Creek, is an area of considerable size called the Nolin-River District. The ores of this region are stratified Carbonates and Limonites, found near the base of the coal-measures. The ore of most value occurs above the Conglomerate. It is about four feet thick, and, so far as present developments indicate, underlies an area of large extent. It is almost wholly undeveloped. A number of years since a small charcoal furnace was established on Nolin River, but it was so far from market, and transportation of the iron was so uncertain and expensive, that the enterprise soon failed. It ran long enough, however, to establish the fact that an excellent iron could be made from these ores.

The following analyses, by Dr. Peter and Mr. Talbutt, show the quality of a sample of this ore from near the head of Beaver-Dam Creek in Edmonson County:—

Iron Peroxide	52.926
Alumina	4.792
Manganese	.210
Lime Carbonate	.180
Magnesia	.425
Phosphoric Acid	.355
Sulphuric Acid	143
Silica and Insoluble Silicates	30.580
Combined water	10.400
Total	100.011
Metallic Iron	37.048
Phosphorus	.154
Sulphur	.057

In addition to the great amount of timber available for charcoal, stone-coal in abundance occurs in the same region. This coal is the lowest of the series, and is of most excellent quality,—analyses showing it to be far superior to the higher coals of Western Kentucky, which are the ones more generally mined. This region is now more accessible than formerly as it lies within fifteen miles of the Louisville, Paducah, and South-western Railroad; but the lack of transportation facilities directly to it has prevented its development. The aggregate amount of ore, coal, and timber suitable for charcoal in this region, is immense, and it offers great opportunities for development. It is one of the most richly endowed undeveloped iron regions of the State.

In many other localities in the Western coal-field iron ores have been found, but they have not been thoroughly prospected, and little is known of their extent. One of the best-known localities of this sort is in Muhlenburg County. In this county are found, at Airdrie Furnace, on Green River, and at Buckner Furnace, near Greenville, deposits of so-called black-band iron ore,—a ferruginous bituminous Shale, yielding about thirty per cent. of iron. At Airdrie Furnace this ore rests immediately above an excellent coking coal, and the two can be mined together very cheaply. At this place iron can be produced very cheaply by bringing ore from the Cumberland-River region, and using it in admixture with the native ore. For a more detailed description of this locality, see Report in the second volume, new series, "Kentucky Geological Reports, on the Airdrie Furnace."

The above described localities embrace all the most important iron-ore districts of the State. There are numerous ore deposits at other places, some of which have been worked, but, in comparison with the others, to a small extent only.

For more detailed information in regard to some of these districts, the reader is referred to the volumes, first series, "Kentucky Geological Reports;" to the "Report on the Iron Ores of Greenup, Boyd, and Carter Counties," in the first volume, second series; to the "Report on the Geology of the

Nolin-River District," in the second volume, second series; to the forthcoming reports on the iron ores in the vicinity of Cumberland Gap, and on the iron ores of the Red-River iron region, in the fourth volume, second series, "Kentucky Geological Reports."

CHEMICAL GEOLOGY OF KENTUCKY.

The Geological Survey of Kentucky has given very especial attention to the study of the chemical conditions of its products, — the soils, ores, coals, &c., on which industries could be founded. In the following tables will be found selections from the work of its laboratories, done by Dr. Peter, the chief chemist of the present Survey, as well as of that under Dr. Owen, with the assistance for the last three years of Mr. John H. Talbutt. Attention is called to the fact that these tables represent analyses made with a high degree of care to securing trustworthy results. In the first place, a great deal of care has been exercised in procuring average samples representing the actual character of the several substances considered as workable deposits. Usually such analyses are made from selected specimens, or at best from a rough selection of several fragments believed to represent the average of the beds. A series of experiments has shown that, taken in this way, the samples lead uniformly to too favorable results. The Survey has been to the trouble to have carefully-averaged samples obtained from a number of important deposits of coal in neighboring States. The analyses based thereon have shown the general untrustworthiness of the usual method of collecting the specimens from which the analyses were made. The errors of this imperfect method of sampling are particularly striking in the case of coal analyses, where it is easy to halve the amount of sulphur, and greatly diminish the ash by a careless selection of the specimens. The reader is, therefore, requested to be on his guard in comparing these analyses with those from other regions, and to remember that the quantities of the several substances given in each analysis recorded in these tables are as near to the average amounts found in the deposits whence they were taken as it was possible to make them by a very great care.

In the several reports from the Chemical Laboratory will be found various practical recommendations concerning the use of the materials represented in these tables. Any further information can be had by addressing the Secretary of the Geological Survey, Lexington, Ky.

TABLE I. OF COMPOSITION OF SOILS.

(Dried at 212° Fahrenheit.)

No. in Report.	County.	Organic and Volatile Matters.	Alumina.	Iron Oxide.	Manganese Oxide.	Lime Carbonate.	Magnesia.	Phosphoric Acid.	Sulphuric Acid.	Potash.	Soda.	Sand & Silicates.	Water lost at 380° F.	Hygroscopic Moisture.	Potash in the Silicates.	Soda in the Silicates.	Extracted from 1000 parts by carbonated water.	Geological Formation, General Remarks, Etc.
					Soils on the *Cambrian or Blue Limestone* formation.													
574	Bourbon	7.702	4.620	6.585	0.720	0.622	0.508	0.321	0.145	0.224	0.077	78.680	5.865		not estimated.		6.760	Virgin Soil, Cane Ridge, Wood-pasture.
826	Bracken	7.981	6.645	6.825	0.296	1.582	1.354	0.342	0.110	0.758	0.047	72.920	6.975				9.861	Virgin Tobacco Soil, Hill-side, near Augusta.
27	Fayette	8.000	4.181	6.170		1.037	0.200	0.256	n. e.	0.205	0.062	79.910	4.440		"		9.861	Virgin Soil, Wood-pasture, Meredith Farm.
619	Gallatin	7.005	5.965	6.035	0.320	0.920	0.768	0.360	0.114	0.484	0.013	77.770	5.575		"		2.908	Field, 30 years in cultivation, near Big Lick Cr'k.
621	Garrard	8.548	6.190	3.920	0.520	1.910	0.763	0.559	0.128	0.393	0.081	77.380	5.825		"		7.634	Virgin Soil, Wood-pasture, J. S. Hoskins.
622	"	5.238	7.805	5.165	0.649	3.270	1.358	0.484	0.059	0.386	0.025	75.570	4.550		"		4.586	Field, 60 or 70 years in cultivation, J. S. Hoskins.
1134	Mason	8.462	4.745	6.240	0.146	0.836	0.798	0.231	0.084	0.558	0.160	78.100	4.175		"		4.570	Virgin Tobacco Soil, Hill-side, near Dover.
681	Mercer	10.365	5.395	7.110	0.620	1.995	1.234	0.333	0.093	0.762	0.106	72.035	4.500		"		11.095	Virgin Soil, Woods, West part of County, near Cornishville.
682	"	6.980	7.495	7.270	0.645	2.080	1.184	0.298	0.090	0.705	0.106	72.810	4.375		"		3.754	Old Field, 50 years in cultivation, same locality.
550	Woodford . . .	7.771		12.961		2.464	0.173	0.319	0.150	0.394	0.130	75.266	4.700		"		6.014	Virgin Soil, near Versailles, Judge R. C. Graves.
551	" . . .	5.513		13.344		2.734	0.333	0.306	0.037	0.205	n. e.	77.594	4.600		"		3.720	Field, 47 years in cultivation, same locality.
				Soils on the *Silicious Mudstone* of the Lower Silurian formation.														
504	Fayette	4.881		10.306		0.276	0.133	0.254	0.109	0.139	0.047	83.834	4.120		"		3.520	Virgin Soil, 2½ m. from Lexington, Richmond R'd.
1204	Owen	4.865	2.965	2.810	0.005	trace.	0.514	0.086	0.050	0.094	0.035	88.020	2.375		"		1.770	Virgin Soil, Woods, Southern edge of Owen C'y.
						Soils on the *Upper Silurian* formation.												
805	Bath	8.165	4.565	6.965	n. e.	0.570	0.710	0.174	n. e.	0.290	0.059	79.145	3.650		"		3.050	Clinton Group Soil, 2½ m. West of Owingsville.
522	Jefferson	7.996		7.480		0.394	0.240	0.205	0.082	0.200	0.043	83.134	4.420		"		n. e.	Virgin Soil, O'Bannon's St'n, on Mag. Limestone.
1070	"	5.173	2.900	3.085	0.395	0.370	0.719	0.203	0.076	0.208	0.154	86.370	2.100		"		2.783	Virgin Soil, Middle F. of Bear-grass Creek.

						Soils on the *Black Devonian* Shale.												
583	Bullitt	5.665	2.476	4.790	0.176	0.196	0.526	0.253	0.054	0.258	0.058	85.056	4.680		"		2.022	Soil, Flats, near Shepherdsville.
1125	Madison	6.125	2.215	11.015	n. e.	0.095	0.385	0.271	n. e.	0.121	0.039	79.270	2.450		"		1.733	Soil, mid-way between Elliston and Richmond.
1215	Powell	8.033	3.215	4.885	0.130	0.095	0.581	0.278	0.278	0.579	0.031	81.795	2.900		"		2.135	Soil, M. S. Conners, F. near Red River.
						Soils on the *Waverly Sandstone*.												
1222	Rowan	5.461	3.490	3.085	0.195	0.220	0.311	0.078	0.110	0.400	0.022	86.520	1.850		"		2.161	Virgin Soil, near Morehead.
1405	Carter	2.860		4.540		0.145	0.035	0.125	n. e.	0.111	0.157	91.240	0.690	1.215	"		1.180	Old Field Soil, West Branch Tygert's Creek.
*						Soils on the *Subcarboniferous Limestone*.												
229	Wayne	5.370	4.326	2.526	0.236	0.256	0.246	0.036	n. e.	0.115	0.136	86.066	3.160		"		2.551	Average of the "Barren" Soil of Wayne County.
817	Bath	10.527	4.240	2.210	0.295	0.645	0.405	0.223	0.050	0.212	0.046	81.295	3.350		"		5.733	East Hill-side of McCormick's Valley.
839	Breckenridge . .	8.411	5.240	4.838	0.345	1.880	0.830	0.130	0.076	0.434	0.099	77.495	4.000		"		6.823	Virgin Soil, 1 m. W. of Sinking Cr'k, Mr. Dant's.
960	Estill	8.483	6.750	3.210	0.460	0.030	0.460	0.318	0.055	0.408	0.068	79.695	3.510		"		4.066	Virgin Soil, on Billy's Creek.
1473	Grayson	4.950		6.195		0.340	0.176	0.125	n. e.	0.327	0.023	86.780	1.075	1.950	"		n. e.	Soil 3 years in cultivation.
1549	Hardin	4.150		6.865		0.495	0.501	0.108	trace.	0.209	0.079	86.590	1.250	1.650	"		n. e.	Soil 5 years in cultivation.
						Soils on the *Subcarboniferous Sandstone*.												
812	Bath	4.215	1.515	2.210	0.130	0.195	0.329	0.095	0.033	0.130	0 050	91.095	1.425		"		3.077	Virgin Soil, Valley of McCormick's Run.
1469	Grayson	3.850	7.215			0.345	0.240	0.076	n. e.	0.243	0.125	86.850	0.925	2.025	1.039	0.479	n. e.	Old Field Soil, uncultivated for last 15 years.
1061	Jackson	4.737	9.210		n. e.	0.080	0.306	0.176	0.050	0.373	0.085	84.620	1.850		not estimated.		3.833	Virgin Soil, Indian F. of Rockcastle River.
						Soils on the *Tertiary* formation.												
1	Ballard	3.040	3.814		0.411	0.034	0.461	0.116	n. e.	0.108	0.037	92.010	1.840		"		1.530	Soil, heavily timbered land, South part of County.
2	"	4.120	4.695		0.081	0.134	0.280	0.155	n. e.	0.139	0.063	89.650	2.440		"		1.943	Soil from North-western part of the County.

* See Table Carboniferous Soils, page

TABLE II. MARLS AND MARLY SHALES.

No. in Report.	County.	Silica and Silicates.	Silica.	Alumina.	Iron Oxide.	Lime Carbonate.	Lime.	Magnesia Carbonate.	Magnesia.	Phosphoric Acid.	Sulphuric Acid.	Potash.*	Soda.*	Total Potash.†	Total Soda.†	Water expelled at red heat.	Remarks.
587	Bullitt	48.840	. . .	5.480		41.740	. . .	1.088	. . .	0.157	0.066	0.573	0.152	. . .	. . .	1.904	In *Favosites Maximus* Beds, Lower Silurian.
1431	Franklin	77.380	. . .	10.415		1.440	. . .	. . .	0.800	0.435	0.738	3.488	0.042	0.847	0.696	5.350	Green Marly Shale, Upper Cambrian Group.
1432	„	70.060	. . .	15.395		. . .	0.875	. . .	2.298	0.460	0.570	3.565	0.318	7.130	0.748	6.400	Olive Marly Shale, „ „ „
1434	„	. . .	52.060	18.831	9.200 ‡	. . .	3.666	. . .	1.210	0.319	0.920	. . .	. . .	5.402	0.720	7.672	Marly Shale (mineral paint), Cincinnati Group.
1433	„	. . .	50.360	16.816	6.997 ‡	. . .	8.736	. . .	0.936	0.217	2.280	. . .	. . .	3.623	1.730	8.304	„ „ „ „ „ „
971	Fayette	. . .	56.880	24.656		2.480	. . .	3.276	. . .	0.182	n. e.	. . .	. . .	6.655	0.195	5.676	Marly Clay, Brink's Quarry, Lower Silurian.
1446	Grayson	70.580	. . .	19.133		. . .	0.269	. . .	0.353	0.267	0.027	2.910	0.052	4.115	0.605	6.230	Marly Shale, Sunset Lick, 1½ miles West of Litchfield.
1446 (a)	„	. . .	60.060	14.130	13480‡	. . .	0.538	. . .	1.158	0.280	0.204	. . .	. . .	4.625	0.783	6.000	Marly Shale, Sunset Lick, 1½ miles West of Litchfield.
Page 496 L. B.	„	59.920	. . .	27.811		0.880	. . .	. . .	0.824	0.109	n. e.	. . .	. . .	5.554	0.657	n. e.	Marly Shale, Haycraft's Lick.
Page 492 L. B.	„	62.160	44.760	21.592	4.629	9.160	. . .	6.629	. . .	1.089	n. e.	. . .	. . .	4.944	1.061	6.136	Marly Shale, Hat Branch of Bear Creek.

* Extracted by digestion in Chlorohydric Acid. † Whole amount of the Alkalies obtained by fusion, etc. ‡ And Manganese Oxide.

The large proportion of Sulphuric Acid, which appears in the statements of the analyses of some of these Marls, is doubtless mostly derived from the oxidation of Iron Sulphide, which was not separately determined.

TABLE III. IRON ORES (*a. Limonite Ores*).

(Dried at 212° Fahrenheit.)

No. in Report.	County.	Iron Peroxide.	Iron Carbonate.	Alumina.	Manganese br. Oxide.	Lime Carbonate.	Magnesia.	Phosphoric Acid.	Sulphuric Acid.	Combined Water.	Silica and Silicates.	Moisture and Loss.	Per cent. of Iron.	Per cent. of Phosphorus.	Per cent. of Sulphur.	Per cent. of Silica.	Remarks.
1269	Bath	76.077	. . .	2.592	0.430	0.130	0.281	0.731	0.030	12.300	8.180	. . .	53.254	0.319	0.011	6.160	Old Slate Furnace Ore.
782	"	82.120	. . .	0.820	1.340	trace.	. . .	0.220	0.386	5.420	8.980	. . .	57.510	. . .	. . .	. . .	Limestone Ore, Clear Creek.
1274	Boyd	58.960	. . .	7.284	0.380	0.430	0.227	0.376	0.206	10.800	21.210	0.127	41.272	0.164	0.082	19.980	Yellow Kidney Ore, Star Furnace.
1275	"	51.802	10.596	4.523	trace.	7.480	0.440	0.570	0.089	8.772	15.730	. . .	41.357	0.231	0.035	13.161	Limestone Ore, Bellfont Furnace.
1277	"	56.022	8.821	7.194	"	2.540	1.271	0.526	0.091	10.126	13.430	. . .	43.473	0.229	0.036	11.660	Yellow Kidney Ore, Buena Vista.
1371	Carter.	81.640	. . .	3.160	"	0.180	0.919	0.060	n. e.	11.280	2.600	0.221	57.148	0.026	n. e.	n. e.	Horsley Bank, Boone Furnace.
1373	"	65.657	. . .	4.921	"	trace.	0.040	0.893	0.604	10.740	17.780	. . .	45.959	0.391	0.241	15.960	Potato Knob Ore.
1375	"	38.285	. . .	5.455	0.120	0.460	0.065	1.000	0.071	9.500	44.760	0.284	26.799	0.436	0.030	40.960	Royster Hill, Lambert Ore.
1376	"	57.557	. . .	2.727	trace.	trace.	0.065	1.746	0.185	11.700	26.180	. . .	40.290	0.760	0.074	n. e.	Smith Hill, German Ore.
1381	"	71.502	. . .	8.557	"	"	0.054	0.466	0.800	9.500	9.030	0.091	50.051	0.203	0.320	7.640	Old Mt. Tom, Main Block Ore.
1384	"	71.680	. . .	4.155	0.090	0.380	0.050	n. e.	0.270	10.800	12.650	. . .	50.176	n. e.	0.108	11.560	Graham Bank Ore.
1385	"	66.200	. . .	3.907	0.030	0.430	0.345	0.130	0.182	11.730	16.530	0.633	46.340	0.057	0.072	13.860	Yellow Kidney Ore, Mt. Savage Furnace.
1411	Edmonson . . .	76.284	. . .	2.361	0.030	0.180	0.068	1.055	0.151	12.000	7.951	. . .	53.399	0.460	0.059	7.660	Proctor Ore Bank.
1509	Greenup	80.040	. . .	2.680	. . .	trace.	0.425	0.115	0.264	10.000	6.560	. . .	56.280	0.050	0.107	. . .	Limestone Ore, Tygert's Creek.
1516	"	72.957	. . .	1.660	0.640	0.380	0.083	0.500	0.178	9.344	15.160	. . .	51.070	0.218	0.070	. . .	Limestone Ore, Shover Drift.
1521	"	68.928	. . .	2.768	0.290	0.680	0.641	0.249	0.748	11.100	15.240	. . .	48.249	0.098	0.299	13.600	Main Block, L. Morton Bank.
1598	Lyon	70.518	. . .	0.045	0.090	0.090	trace.	0.275	0.113	9.850	18.910	0.009	49.363	0.120	0.045	18.160	Suwannee Furnace Bank.
1600	"	69.392	. . .	trace.	0.170	0.140	"	0.303	trace.	9.550	20.500	. . .	48.574	0.144	. . .	19.660	Suwannee Iron Mt. Bank.
1605	Muhlenburg . .	63.048	. . .	5.290	0.090	0.680	0.930	0.147	0.112	12.430	17.250	. . .	44.133	0.064	0.044	16.500	Airdrie Furnace Ore, near No. 4 entry.
1606	" . . .	60.492	. . .	7.075	0.360	1.980	1.550	0.083	0.185	12.530	15.560	0.185	42.344	0.035	0.074	13.660	Jerry Hope's Land, Muddy River.
1608	" . . .	69.546	. . .	3.914	0.230	0.480	0.921	0.115	0.216	11.250	12.730	0.598	48.822	0.050	0.086	11.300	Martin Ore.

TABLE IV. IRON ORES (*b. Clay Iron Stones, and Black Band*).

(Dried at 212° Fahrenheit.)

No. in Report.	County.	Specific Gravity.	Iron Carbonate.	Iron Peroxide.	Alumina.	Lime Carbonate.	Magnesia Carbonate.	Manganese Carbonate.	Phosphoric Acid.	Sulphuric Acid.	Silica and Silicates.	Water and Loss.	Per cent. of Iron.	Per cent. of Phosphorus.	Per cent. of Sulphur.	Per cent. of Silica.	Remarks.
1271	Boyd	3.362	66.854	0.276	4.260	2.460	4.086	0.572	0.709	0.885	18.360	1.538	32.466	0.308	0.354	15.500	Blue-Block Ore, Wilson's Creek.
866	Carter	n. d.	87.527	0.778	0.984	trace.	1.924	1.324	0.207?	0.613	6.680	. . . . .	42.807	. . .	. . .	. . .	Blue Kidney, Star Furnace.
1363	"	. . .	62.662	10.024	1.600	0.240	2.838	3.251	0.127?	0.521	13.720	3.017	37.285	0.055	0.208	n. e.	Old-Orchard Diggings.
1365	"	. . .	44.242	27.296	1.560	6.580	1.046	0.842	0.732	4.587	11.160	1.955	40.465	0.321	1.855	n. e.	Horsley Bank.
1369	"	. . .	30.708	31.544	1.779	2.730	0.144	0.060	0.421	0.491	25.430	6.523	36.627	0.184	0.196	10.560	Mt. Savage Furnace Ore.
937	Estill	. . .	78.086	1.050	2.460	1.290	4.508	3.492	0.438	0.176	8.670	. . . . .	38.461	. . .	. . .	n. e.	Gray Ore, Cottage Furnace.
1644	Grayson	. . .	16.598	42.761	4.994	2.840	n. e.	n. e.	1.017	trace.	20.830	8.054	37.945	0.444	trace.	n. e.	Glady Ore, West of Bear Creek.
1503	Greenup	3.297	78.722	0.204	2.746	2.250	0.380	0.421	0.505	1.160	11.340	2.272	38:146	0.221	0.524	9.700	Blue-Kidney Ore, near Laurel Furnace.
1507	"	n. d.	55.258	13.468	0.670	4.880	4.528	0.060	0.368	1.043	15.600	4.065	36.103	0.200	0.416	13.360	Main-Block or Gray Ore, Laurel Furnace.
1611	Muhlenburg . . .	"	42.950	29.618	2.454	2.490	4.828	1.083	0.083?	1.596	9.030	5.868	36.916	0.035?	0.638	6.220	Slate Ore, Old Buckner Furnace.
149	"	"	62.420	3.380	0.950	3.650	7.410	2.490	0.100	n. e.	15.270	(*a*) 1.570	32.520	. . .	. . .	. . .	Black Band, William's Landing.
150	"	. . .	64.900	7.410	0.600	3.250	6.570	1.180	0.350	n. e.	7.070	(*b*) 0.110	36.540	. . .	. . .	. . .	Black Band, Battist Creek.

(*a*) Bituminous matters = 2.41 per cent. (*b*) Bituminous matters = 7.81 per cent.

TABLE V. IRON ORES (*c. Red Hematite Ores of the Clinton Group*).

No. in Report.	County.	Specific Gravity.	Iron Peroxide.	Alumina.	Manganese Brown Oxide.	Lime Carbonate.	Magnesia.	Phosphoric Acid.	Sulphuric Acid.	Combined Water.	Silica and Silicates.	Moisture and Loss.	Per cent. of Iron.	Per cent. of Phosphorus.	Per cent. of Sulphur.	Per cent. of Silica.	Remarks.
Page in L. B. 533	Nr. Cumb. Gap, Ten.	n. e.	80.820			. . .	. . .	. . not	deter	mined	. . .	. . .	56.574	. . .	. . .	11.260	Dyestone Ore, Clinton Furnace.
540	" "	3.942	77.380	3.941		0.420	trace.	0.319	trace.	2.500	15.960	. . .	54.166	0.140	trace.	. . .	Poor-Valley Ridge, Upper Bed.
541	" "	3.914	73.935	5.776		4.510	0.260	0.319	trace.	3.850	11.730	. . .	51.754	0.140	trace.	11.760	Foot of Poor-Valley Ridge, Upper Bed.
542	" "	3.190	47.965	2.130		1.230	0.194	0.575	trace.	4.000	43.690	. . .	33.575	0.251	trace.	42.76	Foot of Poor-Valley Ridge, Middle Bed, 26 in. thick.
1594	Lawrence, Ky. . .	4.184	80.004	3.474	0.250	0.360	0.396	0.172	0.055	1.089	14.200	. . .	56.028	0.075	0.020	13.500	Near Louisa, Top of Hill.

TABLE VI. COALS (*Air-dried*).

Number in the Report.	County.	Specific Gravity.	Hygroscopic Moisture.	Volatile Combustible Matters.	Coke.	Total Volatile Matters.	Carbon in the Coke.	Ashes.	Character of the Coke.	Color of the Ash.	Per cent. of Sulphur.	Remarks.
1280 (*a*)	Boyd	1.358	3.40	32.30	64.30	37.70	55.40	8.90	Dense	Light purple-gray	1.230	Turkey-pen Hollow, Raccoon furnace (Coal No. 6).
1280 (*b*)	"	n. e.	4.70	34.30	61.00	39.00	59.04	1.96	"	" " " . .	0.982	Turkey-pen Hollow (a selected sample, Coal No. 6).
1285	"	1.315	2.70	36.70	60.60	39.40	52.60	8.00	Spongy	Dark lilac-gray . .	1.711	Horse-Run Coal (Coal No. 6).
1286	"	1.308	3.30	33.30	63.40	36.60	57.60	5.80	Moderately Dense	Light lilac-gray .	2.480	Coalton Coal, Ashland Co. Mine (4 entry, Coal 7).
1289	"	1.320	5.00	34.50	60.50	39.50	55.40	5.10	Spongy	Light brown-gray .	1.285	Coalton Coal, Ashland Co. (250 yds. from West end, **Coal 7**).
835	Breathitt . . .	1.219	0.30	56.70	38.10	57.00	43.00	4.90	Dense	Light purple-gray .	0.452	Cannel Coal (South's), near Jackson.
871	Carter	1.200	.60	66.30	33.10	66.90	28.30	4.80	"	Tawny yellow . .	1.320	Cannel Coal, Stinson Bank.
1348 (*a*)	"	1.435	5.40	32.70	61.90	38.10	52.52	9.38	Moderately Dense	Lilac-gray . . .	2.356	W. Pritchard's Bank (Coal 7).
1348 (*b*)	"	n. e.	4.50	37.10	58.40	41.60	56.40	2.00	" "	Yellowish . . .	0.571	W. Pritchard's Bank (Selected sample, Coal 7).
1350	"	1.340	6.40	31.40	62.20	37.80	57.66	4.54	Porous	Purplish-gray . .	1.670	Drift on Gum Branch of Straight Creek (Coal 7).
1353	"	1.274	3.80	34.50	61.70	38.30	58.50	3.20	Dense porous . .	Brownish-gray . .	2.164	Graham Bank, near Willard (Coal 1).
1356	"	1.289	4.10	34.60	61.30	38.70	56.525	7.775	" " . .	Lilac-gray . . .	1.414	Kibby drift, Everman's Creek (Coal 2).
1357	"	1.298	4.60	33.50	61.90	38.10	51.60	10.30	" " . .	Yellowish-gray . .	1.200	Stone-Coal branch of Tygert's Creek (Coal 1).
1413	Edmonson . .	1.282	2.30	32.10	65.60	35.40	56.30	9.30	Cellular	Light lilac-gray .	1.059	Tar-Lick Coal, 5½ feet thick.
1418	" . .	1.336	3.66	35.14	61.20	38.80	54.26	6.94	Light Cellular . .	Lilac-gray . . .	2.706	Shoal Branch, Main, Nolin Coal.
1448	Grayson . . .	1.305	4.70	31.40	63.90	36.10	52.20	11.70	Spongy	Lt. Brownish-gray	1.945	Tar-Lick Coal, Dismal Creek.
1484	Greenup . . .	1.316	4.82	32.90	62.28	37.72	55.18	7.10	Friable	Chocolate . . .	1.409	Coal used at Kenton furnace (Coal 1).
1486	" . . .	1.250	4.80	34.64	60.56	39.44	52.58	7.98	Dense	Lilac-gray . . .	1.331	Main Coal at Raccoon furnace (Coal 3).
1493	" . . .	1.289	4.10	34.96	60.94	39.06	55.54	5.40	Spongy	Dark brick . . .	1.590	Below the Kidney Ore, Laurel furnace (Coal 3).
1496	" . . .	1.300	3.20	36.60	62.20	39.80	53.14	7.06	Dense Spongy . .	Lilac-gray . . .	2.264	From a drift near Pennsylvania furnace (Coal 3).
1649	" . . .	1.306	1.50	52.20	46.30	53.70	40.60	5.70	Very Friable . .	Lt. Yellowish Gray	0.782	Cannel Coal, Hunnewell Mines.
1579	Hopkins . . .	1.322	3.20	35.90	60.90	39.10	54.00	6.90	Light Spongy . .	Light lilac-gray .	2.759	St. Charles's Mines.
1588	Lawrence . . .	1.316	4.60	35.70	59.70	40.30	52.28	6.42	Spongy	" " " .	1.080	McHenry Bank, near Louisa (Coal 3).
1589	" . . .	1.281	5.10	35.30	59.60	40.40	57.80	1.80	Light Spongy . .	Light gray-buff .	0.736	F. Swetman's Bank, Brushy Creek (Coal 1).
1591	" . . .	1.349	2.10	33.90	64.00	36.00	56.00	8.00	Friable	Yellowish-white .	0.736	Holbrook's coal, Brushy Creek (Coal 3).
1601	Menifee . . .	1.319	2.94	33.06	64.00	36.00	56.60	7.40	Dense	Lt. Brownish gray	0.997	Subconglomerate Coal, Hawkins's Creek.
1618	Muhlenburg . .	1.278	3.60	31.40	65.00	35.00	58.50	6.50	Dense Spongy . .	Lilac-gray . . .	1.438	Airdrie furnace Coal (Coal 12).
1623	" . .	1.221	3.80	32.70	63.50	36.50	58.60	4.90	Dense Spongy . .	Br'sh. Salmon-gray	1.923	Muddy River Coal mine.
185	Union	1.308	3.50	36.00	60.50	39.50	57.50	3.00	. . . .	. . . .	1.746	**Mulford's Main, or five-foot coal.**

TABLE VII. MINERAL WATERS (*a. Sulphur Waters*).

Composition; in 1000 parts of the Waters.

	Number in Report.											
	No. 798.	No. 1456.	No. 1457.	No. 1458.	No. 1459.	No. 952.	No. 953.	No. 956.	No. 1436.	Page 525 of L. B.	No. 733.	Page 583 of L. B.
Specific Gravity	n. e.*	1.0022	1.0011	1.0015	1.0016	n. e.	n. e.	n. e.	. . .	1.005	1.007	n. e.
Free Carbonic Acid	n. e	0.195	0.1234	0.150	0.165	0.3256	0.360	0.263	0.2772	n. e.	0.355	n. e.
Free Sul. Hydrogen	n. e.	.020	.0248	.0203	.410	n. e.	n. e.	n. e.	.0343	n. e.	.0395	n. e.
Lime Carbonate	0.239	0.1736	0.1952	0.1806	0.2002	0.2020	0.303	0.113	0.1397	0.1223	0.385	0.2178
Magnesia Carbonate	.124	trace.	.0512	.0002	trace.	.0832	.011	.027	.1029	.0253	.003	.0499
Iron Carbonate	trace.											
Manganese Carbonate	n. e.	.0027	.0048	.0078	.0066	trace.	trace.	.069	trace. n. e.	.0013	.006	.0009
and Phosphates	n. e.											
Silica	n. e.	.0022	.0094	.0028	.008	n. e.	n. e.	n. e.	n. e.	.0112	n. e.	n. e.
Organic Matters and Loss	n. e.	n. e.	n. e.	.0022	.0268	n. e.	n. e.	n. e.	n. e.	. . .	n. e.	n. e.
Total sediment on boiling	. . .	0.1785	0.2606	0.1914	0.0340	. . .	. . .	. . .	. . .	0.1601		
Lime Sulphate	trace.	1.1649	0.4541	0.4528	0.6291	. . .	. . .	. . .	. . .	0.1156	0.553	0.0617
Iron Manganese and Alumina Sulphates	trace.	.0034	.0007	.0192	n. e.	. . .	.016	.023	. . .	. . .	trace.	
Magnesia Sulphate	. . .	.5774	.3768	.4616	.6093	.0105	.105	.018	. . .	.4329	. . .	.0570
Potash Sulphate	. . .	n. e.	n. e.	.0024	.0023	.0926	.072	.017	.2535	. . .	.152	.0042
Soda Sulphate	. . .	n. e.	n. e.	.0126	.0374	.1723	.043	.035	. . .	.5347	. . .	.1433
Sodium Sulphide	n. e.	.0521	.0409	n. e.	n. e.	n. e.	n. e.	n. e.	.1057	n. e.	. . .	n. e.
Soda, combined with Organic Acids	n. e.	.0044	.0066									
Potash, combined with Organic Acids	n. e.	.0009	.0038									
Potassium Chloride	0.183	. . .	. . .	. . .	. . .	. . .	. . .	. . .	.0798	trace.	.223	
Sodium Chloride	2.847	. . .	. . .	.0200	.0053	.0842	.009	.036	1.0152	3.3647	8.347	.2760
Magnesium Chloride	.950	.1898	.0145	. . .	. . .	. . .	. . .	. . .	.0228			
Calcium Chloride	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	.0713			
Silica	.018	.0034	.0145	n. e.	n. e.	.0068	.004	.013	.0343	. . .	.018	.0176
Lithium	n. e.	trace.	trace.	trace.	trace.	. . .	. . .	. . .	trace.	. . .	n. e.	trace.
Iodine and Bromine	trace.	trace.	trace.	trace.	trace.	. . .	. . .	. . .	trace.	.0018 †	.0007 †	trace.
Soda Carbonate	. . .	. . .	. . .	. . .	. . .	.0237	.083	. . .	. . .	.2366	.004 ‡	
Total Saline Matters	5.709	2.0748	1.609	1.3252	1.5740	0.7153	0.696	0.410	1.8250	. . .	4.8464	0.8358
Temperature of Spring	n. e.	61°	66°-67°	60	64°	n. e.	n. e.	n. e.	n. e.			
Organic Matters	n. e.	n. e.	n. e.	n. e.	.020	.040	.050	0.059	trace.			

* n. e. = not estimated. † Magnesium Iodide. ‡ Magnesium Bromide.

TABLE VII.—*Continued.* (*b. & c. Chalybeate and Saline Waters.*)

Composition; in 1000 parts of the Waters.

	Number in Report.										
	No. 954.	Page 581 (No. 1).	Page 581 (No. 6).	Page 524 of L. B.	No. 531.	No. 532.	Page 527 of L. B.	Page 584 of L. B.	Page 581 (No. 4).	No. 535.	No. 536.
Specific Gravity	n. e.	1.0031	1.0016	n. e.	n. e.	n. e.	n. e.	n. e.	1.0012	1.0041	1.0068
Free Carbonic Acid . . .	0.269	. . .	. . .	n. e.	. . .	n. e.	0.093	. . .	n. e.	n. e.	n. e.
Lime Carbonate	0.159	. . .	. . .	0.1155	0.195	0.117	0.0438	0.0247	0.1196	0.673	0.912
Magnesia Carbonate . . .	0.046	. . .	. . .	.0046	.041	.020	.0148	.0179	.0331	.116	.131
Iron and Manganese Carbonates, with Phosphates, &c.	0.032	. . .	. . .	.0260	.026	.033	.0145	.0297	trace.	trace.	trace.
Silica	n. e.	. . .	. . .	.0107	n. e.	. . .	n. e.	n. e.	n. e.	n. e.	n. e.
Total held in solution by Carbonic Acid	. . .	. . .	. . .	0.1568	. . .	. . .	0.0731				
Lime Sulphate	0.286	0.5996	0.3271	0.0204	. . .	0.015	0.0029	0.0218	0.0838	0.203	0.185
Magnesia Sulphate . . .	.168	.3330	.2513	.0768	.056	.112	.0036	. . .	.1057	3.454	3.520
Potash Sulphate	.011	.0005	.0074	.0403	.013	.028	. . .	.0042	.0129	.067	.170
Iron Sulphate (per basii) .	. . .	.8756	.1460								
Copper Sulphate	. . .	.0009	. . .								
Alumina Sulphate	trace.	1.2468	.3500								
Manganese Sulphate . . .	. . .	.0032	.0721								
Sodium Chloride	.009	.0031	.0651	.0146	.013	.018	.0026	.0026	.0213	.081	.304
Potassium Chloride . . .											
Calcium Chloride											
Magnesium Chloride . . .											
Iodine and Bromine . . .	n. e.	n. e.	n. e.								
Lithium	n. e.	trace.	trace.	.0013 *	. . .	. . .	. . .	. . .	trace.	n. e.	n. e.
Silica	.032	.0012	.0022	.0142	.040	.046	.0128	.0010	.0254	. . .	.056
Soda Carbonate											
Soda Sulphate	.012	. . .	. . .	.0476	. . .	. . .	.0531	.0205	.5019	.774	1.013
Total Saline Contents .	0.896	3.1364	1.4090	0.3720	0.384	0.442	0.1481	0.1290	0.9041	5.428	6.884

* Chloride.

TABLE VIII. CLAYS.

(Dried at 212° F.)

No. in Report.	Page of Laboratory Book.	County.	Silica.	Alumina.	Iron Oxide.	Lime.	Magnesia.	Phosphoric Acid.	Sulphuric Acid.	Potash.	Soda.	Water expelled at red heat.	Remarks.
1337	48	Carter	48.560	37.471	trace.	0.112	trace.	0.255	n. e.	0.289	0.283	13.030	Fire Clay, 4 feet thick, Boone Furnace Property.
1338	49	"	45.960	38.531	trace.	0.145	trace.	0.563	n. e.	0.250	0.341	14.210	Fire Clay, Lower Bed, Boone Furnace Property.
1339	50	"	54.620	32.466	trace.	trace.	trace.	0.243	n. e.	0.212	0.679	11.780	Fire Clay, Rougher part of Upper Layer, Boone Furnace Property.
1340	51	"	62.460	27.203	trace.	trace.	trace.	0.147	n. e.	1.850	0.584	7.756	Fire Clay, Under Coal, Old Orchard Diggings, Boone Furnace Property.
1341	52	"	45.560	44.150	trace.	0.145	trace.	0.307	n. e.	0.963	0.728	8.522	Fire Clay, Dark Colored, from lower portion of deposit, Boone Furnace Property.
1342	226	"	64.260	24.604	n. e.	0.538	0.209	0.946	0.157	0.751	0.515	8.300	Clay, under the 12-inch Coal, G. Ossenton's land, near Grayson.
	500	Edmonson . . .	77.660	18.800		0.268	n. e.	n. e.	n. e.	1.002	0.484	4.340	Clay, 7-8 feet thick, in Chester Group, Sowder's Farm, first layer.
	501	" . . .	74.460	20.440		0.348	n. e.	n. e.	n. e.	n. e.	n. e.	4.100	Clay, 7-8 feet thick, second layer (nearly white).
	502	" . . .	71.560	22.860		0.381	n. e.	n. e.	n. e.	n. e.	n. e.	3.500	Clay, 7-8 feet thick, third layer (Gray).
1477	64	Greenup . . .	49.680	35.281	trace.	0.213	0.136	0.626	n. e.	0.193	0.211	13.660	Fire Clay, Louder's Bank, near Kenton Furnace.
1479	68	" . . .	66.560	22.679	trace.	0.157	0.605	0.563	n. e.	1.946	0.690	6.800	Clay, 2-2½ feet thick, Pea Ridge, fourth above the Limestone.
1481	70	" . . .	67.700	22.092	trace.	0.101	0.285	0.498	n. e.	1.156	0.268	7.900	Clay, 2-2½ feet thick, Pea Ridge, second above the Limestone.
1483	225	" . . .	47.560	40.661	trace.	0.157	0.497	0.249	trace.	0.308	0.409	10.036	Fire Clay, Thomas's Bank, Upper Layer, Schultz Creek.
	668	Lincoln	61.580	23.946	5.814*	0.201	0.850	n. e.	n. e.	1.542	0.362	5.705	Clay (Tile Clay), Head-waters Green River, Hon. J. W. Varnon's.
	651	Madison . . .	57.976	27.640		0.156	0.606	n. e.	n. e.	3.931	0.547	7.120	Potter's Clay (best), Upper Silurian, from Waco.
	651 (a)	" . . .	56.960	28.740		0.112	0.752	n. e.	n. e.	2.502	0.315	10.531	Potter's Clay (blue, second quality), Upper Silurian, from Waco.

* Protoxide.

TABLE IX. BUILDING STONES (*Limestones*).

No. in Report.	Page in L. B.	County.	Specific Gravity.	Lime Carbonate.	Magnesia Carbonate.	Alumina.	Iron Oxide.	Manganese Oxide.	Phosphoric Acid.	Sulphuric Acid.	Potash.	Soda.	Sand and Silicates.	Per cent. of Lime.	Per cent. of Magnesia.	Remarks.
494	. . .	Bullitt	2.799	63.450	29.640		3.150		n. e.	0.270	0.200	0.210	2.180	35.532	14.114	Magnesian Limestone (Upper Silurian).
1638	442	Bourbon	2.600	79.140	11.826	0.380	5.510	n. e.	.511	.240	.231	.252	1.270	44.318	5.371	Magnesian Limestone (Lower Silurian).
1314	315	Butler	n. e.	93.020	2.088		0.917		.243	.604	n. e.	n. e.	2.760	52.091	n. e.	From Barren River (Subcarboniferous).
1388	46	Carter	2.624	97.720	n. e.		.300		.083	n. e.	.115	.167	1.780	54.723	n. e.	Boone Furnace Limestone (Subcarboniferous).
1421	343	Barren	2.678	98.050	.363		.511		.051	.260	.115	.327	1.060	50.428		Oölitic Limestone (Upper Subcarboniferous Limestone).
1422	344	"	2.721	77.550	13.314		2.680		.051	.192	.154	.188	6.060	43.428	6.339	Compact Limestone (Upper Subcarboniferous Limestone).
512	. . .	Fayette	2.703	55.540	40.800		.960		n. e.	.020	.360	.220	2.790	31.160	19.680	Magnesian Limestone (Clay's Mon. Stone), Grimes's Qr.
616	. . .	"	2.767	64.400	33.900		.950		n. e.	n. e.	n. e.	n. e.	2.000	36.064	16.143	Magnesian Limestone, Harris's Quarry.
109	. . .	Greenup	2.708	97.850	1.300		.550		n. e.	n. e.	.150	.500	1.270	54.796	n.e.	Subcarboniferous Limestone, New Hampshire Furnace.
1500	124	"	2.700	92.050	.220		1.490		.128	.199	n. e.	n. e.	4.460	51.548		Subcarboniferous Limestone, Kenton Furnace.
530	. . .	Jefferson . . .	n. e.	56.360	37.070		1.280		n. e.	trace	.330	.350	5.630	31.620	17.639	Upper Silurian Magnesian Limestone.
1065	. . .	"	. . .	52.080	31.473		4.473		.208	.303	.606	.307	10.480	29.165	14.987	Upper Silurian Variegated Limestone.
1123	. . .	Madison	2.691	49.320	30.729		2.960		.271	.509	.374	.058	14.180	27.169	14.631	Magnesian Limestone (Devonian).
164	. . .	Trimble	2.704	97.019	.740	.160	1.324	n. e.	.636	n. e.	n. e.	n. e.	.660	54.330	n. e.	Marble, from Dr. Hopson's Quarry.
776	. . .	Woodford . . .	2.655	59.860	36.640		0.980			.160	.400	.080	2.480	33.590	17.440	Magnesian Limestone, Shryock's Ferry (Lower Silurian).

TABLE X. BUILDING STONES (*Sandstones*).

(Dried at 212° Fahrenheit.)

Number in the Report.	County.	Specific Gravity.	Sand and Silicates.	Alumina and Iron and Manganese Oxides.	Lime Carbonate.	Magnesia Carbonate.	Phosphoric Acid.	Sulphuric Acid.	Potash.	Soda.	Remarks.
496	Bullitt	2.427	93.68	3.95	trace.	0.84	n. e.	trace.	0.21	0.59	Building-stone at Bullitt's Knob.
497	"	2.415	94.78	2.85	0.18	2.29	. . .	trace.	.27	.14	Building-stone at Button-mould Knob.
498	"	2.453	94.75	3.48	.16	.70	. . .	trace.	.96	.10	Building-stone at Bellemonte Furnace.
1221	Rowan	2.539	90.240	3.965	1.480	1.857	0.117	0.269	.336	.089	Building-stone, mouth of Triplett's Creek.

TABLE XI. Hydraulic Cement Limestones.

(Dried at 212° Fahrenheit.)

No. in Report.	Page in Laboratory Book.	County.	Specific Gravity.	Lime Carbonate.	Magnesia Carbonate.	Alumina.	Iron Oxide.	Manganese Oxide.	Phosphoric Acid.	Sulphuric Acid.	Potash.	Soda.	Sand and Silicates.	Per cent. of Lime.	Per cent. of Magnesia.	Total Silica.	Remarks.
456	...	Grayson	2.651	46.830	26.840	0.380	2.380	trace.	0.120	0.330	0.500	0.370	20.780	26.280	12.960	n. e.	From near Grayson Springs.
521	...	Jefferson	n. e.	50.430	18.670		2.930		0.060	0.158	0.320	0.130	25.780	28.290	8.890	22.580	„ Falls of the Ohio, Louisville.
1066	...	„	n. e.	42.819	21.819		6.560		1.284	0.233	0.233	0.372	23.980	24.118	10.395	n. e.	„ Chenowick Creek.
1137	...	Meade	n. e.	47.560	26.515			2.160		1.332	0.126	0.265	19.680	26.688	12.631	n. e.	„ Mitchell's Spring.
1165	...	Nelson	n. e.	40.480	24.267		4.493		0.207	0.819	0.455	0.042	29.380	22.667	11.554	....	„ Bardstown.
1201	...	Oldham	...	41.580	24.030		5.860		0.374	0.303	0.455	0.204	23.580	23.284	11.443	....	„ near La Grange.
1202	...	„	...	41.980	21.400		6.860		0.310	0.386	0.370	0.379	24.680	23.508	10.190	....	„ Curry's Fork of Floyd's Creek.

TABLE XII. Soils and Sub-Soils (*Coal Measures Formation*).

No. in Report.	County.	Extracted from 1,000 grains by water charged with carb. acid.	Moisture expelled at 400° F.	Organic and Volatile Matters.	Alumina.	Oxide of Iron.	Lime Carbonate.	Magnesia.	Manganese Brown Oxide.	Phosphoric Acid.	Sulphuric Acid.	Potash.	Soda.	Sand and Silicates.	Remarks.
1029	Hancock	4.751	2.200	4.422	3.215	3.285	0.171	0.446	0.241	0.161	0.059	0.205	0.040	88.130	Virgin Soil (Woods).
1051	Hopkins	7.133	2.600	6.263	3.390	2.700	0.445	0.491	0.295	0.148	0.076	0.158	0.034	85.970	Soil.
1052	„	2.983	1.900	4.295	4.845	2.910	0.160	0.507	0.370	0.078	0.059	0.330	0.113	86.070	Sub-soil.
1058	Jackson	2.450	1.915	4.998	5.560	2.970	0.011	0.444	0.120	0.126	0.042	0.243	0.074	85.860	Virgin Soil.
1156	Morgan	3.333	2.325	7.243	3.590	3.260	0.320	0.489	0.195	0.204	0.067	0.372	trace.	84.360	Virgin Soil.

DESCRIPTION OF TABLES.

SOILS.

(See Table I.)

Soils on Blue Limestone. — Lower Silurian Formation.

No. 574. (Vol. III. p. 218, Rep. Geol. Surv. Ky., O. S.) Virgin soil, from wood-pasture on Wm. Buckner's farm. Cane-ridge land. Primitive forest-growth, — large Buckeye, Oak, Honey-locust, Sugar-tree, &c. Lower Silurian or Blue Limestone formation. Bourbon County.

No. 826. (Vol. IV. p. 85, Rep. Geol. Surv. Ky., O. S.) Virgin Tobacco soil; hill-side, north exposure; Blue Limestone formation. Near Augusta, on Mr. L. J. Bradford's land, Bracken County.

No. 27. (Vol. I. p. 276, Ky. Geol. Rep., O. S.) Virgin soil; wood-pasture. About seven miles south of Lexington (Meredith farm); farm of late Mr. Dallam, head-waters of North Elkhorn Creek. Blue Limestone formation. Fayette County.

No. 619. (Vol. III. p. 263, Ky. Geol. Rep., O. S.) Blue Limestone soil, from a field thirty to forty years in cultivation, near Big-Lick Creek, Gallatin County.

No. 621. (Vol. III. Ky. Geol. Rep., p. 265, O. S.) Virgin soil; wood-pasture. J. S. Hoskins' farm, forks of road. Some of the best soil in the county. Lower Silurian formation. Garrard County.

No. 622. (Ibid., p. 266.) Same soil as next preceding, from the oldest field in Garrard County, sixty to seventy years in cultivation. Over the cherty beds of Blue Limestone, Lower Silurian formation. Garrard County.

(The second samples from the same locality exemplify a loss of available essential mineral fertilizing ingredients, resulting from cultivation.)

No. 1134. (Vol. IV. Ky. Geol. Rep., p. 217, O. S.) Virgin Tobacco soil. From hill-side near Dover, Mason County, about a hundred and fifty feet above the Ohio River, in the midst of the Blue Limestone. Growth — Sugar-tree, Walnut, Black and White Ash, Buckeye, &c.

No. 681. (Vol. III. p. 322, Rep. Ky. Geol. Surv., O. S.) Virgin soil, from woods near Cornishville, on Chætetes beds of Blue Limestone, western part of Mercer County. Characteristic forest-growth, White Oak.

No. 682. (Ibid.) Same soil, from an adjoining field, fifty years in cultivation; now in corn, &c.

No. 550. (Vol. II. p. 281, Rep. Ky. Geol. Surv., O. S.) Virgin soil, from Judge R. C. Graves' farm. Water-shed between Greers' and Clear Creek, near Versailles, Woodford County. Natural growth — Hackberry, Ash, Walnut, Mulberry, Box-elder, &c. One of the best soils of Kentucky.

No. 551. (Ibid., p. 282.) Same soil as the preceding, from a field in constant cultivation since 1808. It has been fourteen years in Hemp. Average of the last year's (1855) crop of corn, eighteen to twenty barrels of five bushels each to the acre. It has produced thirty-five bushels of wheat to the acre.

Soils of the Silicious Mudstone. — Lower Silurian Formation.

No. 504. (Vol. II. p. 162, Rep. Geol. Surv. Ky., O. S.) Virgin soil, from a Beech ridge on Robert Wickliffe's farm, two and one-half miles from Lexington, on the Richmond Turnpike. Much less productive than the neighboring Blue Limestone soil, Fayette County.

No. 1204. (Vol. IV. p. 245, Rep. Geol. Surv. Ky., O. S.) Virgin soil, from woods on the first farm after ascending the hill from Harmony to Stamping-Ground, southern edge of Owen County. Forest growth, White Oak on the top of the ridge; some Beech on the sides of the hill.

Soils on the Upper Silurian Formation.

No. 805. (Vol. IV. p. 73, Rep. Ky. Geol. Surv., O. S.) Genuine Clinton group red soil, from over the encrinital, flesh-colored, Magnesian Limestone (see No. 797), two miles west of Owingsville, Bath County. Primitive growth — Blue Ash, Sugar-tree, Hickory, &c.

No. 1070. (Vol. IV. p. 192, Rep. Ky. Geol. Surv., O. S.) Virgin soil; eight inches of the surface, taken immediately under the sod of native Blue Grass, in wood-pasture. Farm of Theodore Brown, six miles east of Louisville on the Lexington Turnpike, middle fork of Bear-Grass Creek, Jefferson County. Primitive growth — Walnut, Black Locust, Wild Cherry, Elm, Ash, Hackberry, Box-Elder, Buckeye, Pignut and Shell-bark Hickories, Coffee-nut, Red and Over-cup Oak, large Sugar Maples, and Root-covered Beech. Upper Silurian formation. Some of the best Bear-grass land.

Soils on the Black Devonian Shale.

No. 583. (Vol. III. p. 227, Rep. Ky. Geol. Surv., O. S.) Soil from the flats near Shepherdsville, derived chiefly from the Black Devonian Shale, at the base of the knobs and overlying the ash-colored Shales; considered almost unfit for cultivation, except for grass, because too wet; but little cultivated. Primitive growth — Oak, Beech, Black Hickory, &c. Bullitt County.

No. 1125. (Vol. IV. p. 213, Rep. Ky. Geol. Surv., O. S.) Virgin soil, derived from the Black Devonian Slate, taken from the level tract of land about half way between Elliston and Richmond, Madison County.

No. 1215. (Vol. IV. p. 249, Rep. Ky. Geol. Surv., O. S.) Virgin soil, from Moses S. Conner's farm, near Red River, Powell County. Principal forest growth — small White Oak and small Hickories. Soil chiefly derived from the Black Devonian Shale.

Soils on the Waverly Sandstone.

No. 1222. (Vol. IV. p. 253, Rep. Ky. Geol. Surv., O. S.) Virgin soil, near Morehead, Rowan County. Forest growth — White Oak, Chestnut, Hickory, Beech, and some Sugar-tree and Black Walnut.

No. 1405. (Vol. I. Second Series, Ky. Geol. Rep., p. 60.) Old field-soil. Farm of Wm. Abbott, west branch of Tygert's Creek. Field fifty-five feet above the bed of the creek on a bench of Waverly Sandstone. Tops of the hills capped with Limestone; surface soil; has been cultivated sixty years; was once an orchard. Carter County.

Soils on the Subcarboniferous Limestone.

No. 229. (Vol. II. p. 272, Ky. Geol. Rep., O. S.) Average quality of the Wayne County "Barrens" soil, based on a reddish ferruginous sub-soil. Head-waters of Meadow Creek, Wayne County. Hickory and Black Oak land.

No. 819. (Vol. IV. p. 78, Ky. Geol. Rep., O. S.) Soil from east hill-side of McCormick's Valley, from field nine years in cultivation, &c. Geological position on the Subcarboniferous Limestone, &c. Bath County.

No. 839. (Ibid., p. 99.) Virgin soil, from Mr. Dent's land, two miles north of the base line, one mile west of Sinking Creek, Breckenridge County. The waste of the Limestone, two hundred feet below the base of the Millstone grit, &c.

No. 960. (Ibid., p. 145.) Virgin soil, taken from the north side of the house of Mr. Jas. Townsend on Billy's Creek, a branch of Miller's Creek, Estill County. Geological position on a terrace of Subcarboniferous Limestone.

No. 1473. (Vol I. N. S., Rep. Geol. Surv. Ky., p. 234.) Soil three years in cultivation to the depth of seven inches, on Louisville and Paducah Railroad, about one thousand feet west of the twenty-sixth mile-post, &c., in Grayson County. Timber — Red, Black, and White Oak, with Sugar-tree and Poplar.

No. 1549. (Vol. I. N. S., Rep. Geol. Surv. Ky., p. 256.) New soil, five years in cultivation in Corn, Wheat, and Oats, taken to the depth of eight inches. Farm of Daniel Klingelsnutte's heirs, 11,350 feet west of Elizabethtown, on the Elizabethtown and Paducah Railroad, and 250 feet to the north. Yield of Corn, thirty, of Wheat, twenty, and of Oats, twenty-five bushels per acre. Hardin County.

No. 1029. (Vol. IV. Ky. Geol. Rep., p. 175, O. S.) Labelled "Soil, top of hill, woods; farm of George Smith, Esq., waters of Blackford Creek; two and a half miles in the rear of Lewisport, Hancock County."

No. 1051. (Ibid., p. 184.) Labelled "Soil from east side of Whiteside's Creek, Hopkins County."

No. 1052. (Ibid.) Labelled "Sub-soil from east side of Whiteside's Creek, Hopkins County."

No. 1058. (Vol. IV. Ky. Geol. Rep., p. 186, O. S.) Labelled "Virgin Soil, on dividing ridge between Jackson and Estill Counties."

No. 1156. (Ibid., p. 226.) Labelled "Virgin Soil from the coal-measures of Caney Creek of Licking River, Morgan County. Forest growth — White Oak, Beech, Sugar-tree, and Black Walnut."

Soils on the Subcarboniferous Sandstone.

No. 812. (Vol. IV. p. 77, Ky. Geol. Rep., O. S.) Virgin soil, from the valley of McCormick's Run, Bath County. The soils of this locality show *débris* from the Conglomerate, Limestone, Olive Sandstone, and of the Iron and Coal horizon.

No. 1469. (Vol. I. N. S., Rep. Geol. Surv. Ky., p. 233.) Soil of an old field, fifty years in cultivation, lying fallow for the last fifteen years, 2500 feet west of the twenty-first mile-post on the Louisville and Paducah Railroad. Timber, mostly Black Oak, some White and Red Oaks, and a few Poplars.

No. 1061. (Vol. IV. p. 187, Ky. Geol. Rep., O. S.) Virgin soil; land of Mr. Sloan, Indian Fork of Rockcastle River, Jackson County, four miles from McKee on the Big Hill and Richmond Road.

Soils on the Tertiary Formation.

No. 1. (Vol. I. p. 259, Ky. Geol. Rep., O. S.) Soil from heavily timbered land, southern part of Ballard County, between the waters of Bowles and west branch of Mayfield Creeks.

No. 2. (Ibid., p. 261.) Soil from the north-western part of Ballard County, near Colonel Gohlson's.

MARLS. — MARLY SHALES.

(See Table II.)

No. 587. (Vol. III. p. 232, Ky. Geol. Rep., O. S.) Marl from the line between Bullitt and Spencer Counties; in the *Favosites maximus* beds. Lower Silurian formation.

No. 1431. (Vol. I. Geol. Surv. Ky., N. S., p. 211.) Green Marly Shale from below the Arsenal at Frankfort. Bed eight inches thick (Lower Silurian). Franklin County.

No. 1432. (Ibid., p. 212.) Marly Shale. Same locality as the preceding, but lying above that.

No. 1433. (Ibid.) Marly Shale. Used as mineral paint at Frankfort. Franklin County.

No. 1434. (Ibid.) Marly Shale. From Armstrong farm, Bridgeport, Franklin County. In Cincinnati group, just below the silicious mudstone. In same position as the marl near Newport, Ky. Used for paint.

No. 971. (Vol. IV. p. 150, Ky. Geol. Rep., O. S.) Marly clay from Daniel

Brink's place. One hundred and two feet above Phillip Brink's branch. Fayette County. Lower Silurian formation.

No. 1446. (Vol. I. N. S., Geol. Surv. Ky., p. 220.) Marly Shale, from Sunset Lick, a mile and a half west of Litchfield, Grayson County. Geological position, the Chester group.

No. 1446 *a*. Same marl analyzed by fusion.

Page 496 of Laboratory book (unpublished). Marly Shale, found just below the Upper Limestone. Haycraft's Lick, Grayson County.

Page 492 of Laboratory book (unpublished). Marly Shale, four feet thick; found below the Upper Limestone. Hat branch of Bear Creek, Grayson County.

IRON ORES.

(See Table III.)

a. *Limonite Ores.*

No. 1269. (Vol I. N. S., Ky. Geo. Rep., p. 152.) Limonite iron ore from the Block-House Ore Bank, one and a half miles from the Old-Slate furnace, Bath County. Bed ten to twelve feet thick, on the Clinton group.

No. 782. (Vol. IV. p. 63, Ky. Geol. Rep., O. S.) Limestone ore, from the east side of Clear Creek. Clear-Creek furnace, Bath County.

No. 1373. (Ibid.) Potato-Knob ore. Average sample. Iron-Hills furnace, &c., Carter County.

No. 1274. (Vol. I. N. S., p. 155, Ky. Geol. Rep.) Yellow-Kidney ore, sampled from a number of places. Star furnace property, Boyd County.

No. 1275. (Ibid.) Limestone ore; average sample. Bellefonte furnace, Boyd County.

No. 1277. (Ibid.) Yellow-Kidney ore, or Kidney ore below the No. 7 Coal. Straight Creek. Buena-Vista furnace. Average sample. Boyd County.

No. 1371. (Ibid., p. 188.) Limestone ore, from Horsley Bank. Boone furnace property, Carter County. A cabinet specimen.

No. 1375. (Ibid.) From Royster-Hill Lambert ore bed. The ochre from the lower part of the bed. Iron-Hills furnace.

No. 1376. (Ibid.) German ore. Smith Hill. Iron Hills, Carter County.

No. 1381. (Ibid., p. 189.) Main-Block ore. Old Mount-Tom ore. Carter County.

No. 1384. (Ibid., p. 190.) Red-Limestone ore from the Graham Bank. Average sample.

No. 1385. (Ibid.) Yellow-Kidney ore. Mount-Savage furnace, Carter County. Average sample.

No. 1411. (Ibid., p. 200.) Procter Ore Bank. Sycamore Creek, Edmonson County.

No. 1509. (Ibid., p. 244.) Limestone ore. Samuel Wamock's land, Tygert Creek. Bed one foot thick. Not an average sample. Greenup County.

No. 1516. (Ibid., p. 245.) Shover-drift Limestone ore. Average sample. Kenton furnace, Greenup County.

No. 1521. (Ibid., p. 246.) Main-Block ore. Little-Morton Bank. Laurel furnace, Greenup County.

No. 1598. (Ibid., p. 274.) Limonite. Old Suwannee furnace. Bank close to the furnace. Subcarboniferous. Lyon County.

No. 1600. (Ibid.) Old Suwannee furnace property. Iron-Mountain Bank. Subcarboniferous. Average sample.

No. 1605. (Ibid., p. 277.) Iron ore from near No. 4 entry. Airdrie furnace, Muhlenburg County.

No. 1606. (Ibid.) Limonite iron ore from Jerry Hope's land, near Muddy River. Average sample of the surface Limonite from the upper part of the bed.

No. 1608. (Ibid., p. 278.) Martin ore from near Greenville, Muhlenburg County. Average sample.

b. *Clay Ironstone and Black-band Ores.*

(See Table IV.)

No. 1271. (Ibid., p. 154.) Blue-Block ore from Wilson's Creek. Average sample from the Star-furnace stock pile, Boyd County.

No. 866. (Vol. IV. p. 108, Ky. Geol. Rep., O. S.) Blue-Kidney ore from Star furnace, Carter County.

No. 1363. (Vol. I. N. S., p. 186, Ky. Geol. Rep.) Kidneys in the Shale below coal; layer four inches thick; Old-Orchard diggings. Boone furnace property, Carter County.

No. 1365. (Ibid.) Average sample of Limestone ore at Horsley Bank. Boone furnace property, Carter County. (Clay iron-stone and Limonite mixed.)

No. 1369. (Ibid., p. 187.) Gray Limestone ore. Mount-Savage furnace, Carter County. Average sample.

No. 937. (Vol. IV. p. 136, Ky. Geol. Rep., O. S.) Gray iron ore, associated with the rough ore. Cottage furnace, Estill County.

No. 1644. (Vol. I. p. 300, Ky. Geol. Rep., N. S.) The Glady ore on the old Brownsville and Litchfield road, west of Bear Creek, Grayson County.

No. 1503. (Ibid., p. 242.) Blue-Kidney ore, locally replacing the Main-Block ore; from a drift one mile south-east from Laurel furnace, Greenup County.

No. 1507. (Ibid., p. 243.) Gray ore, or Main-Block ore. Baker drift. Laurel furnace, Greenup County. Average sample from the stock pile.

No. 1611. (Ibid., p. 299.) Bitumimous clay iron-stone, or so-called Black-band ore. Labeled Slate-iron ore, from Buckner furnace. Weathered thirty years. Average sample. Muhlenburg County.

No. 149. (Vol. I. p. 347, Ky. Geol. Rep., O. S.) Black-band ore from Williams's Landing, Muhlenburg County.

No. 150. (Ibid., p. 348.) Shaley Black-band iron ore from the waters of Battist Creek, Muhlenburg County.

An extensive layer of Black-band ore, from two to three feet thick, has recently been discovered in Lawrence County, some samples of which on preliminary examination are found to contain from thirty-three to thirty-four per cent. of iron, and from a half to a third of one per cent. of sulphur, much of which could be removed by roasting.

c. *Red Hematite Ore of the Clinton Group.*

(See Table V.)

Page 533, of Laboratory book (unpublished). Dyestone iron ore from near Cumberland Gap, Tenn.; from Old Clinton furnace.

Page 540. (Ibid.) Clinton ore (Dyestone or Fossil ore) upper bed. Poor Valley Ridge, Cumberland Gap, Tenn. Average sample from a number of exposures.

Page 541. (Ibid.) Clinton ore; upper bed. Foot of Poor Valley Ridge, on a branch down from the Virginia road. Cumberland Gap, Tenn.

Page 542. (Ibid.) Clinton ore; middle bed, twenty-six inches thick. Cumberland Gap, Tenn.

No. 1594. (Vol. I. p. 273, Ky. Geol. Rep., N. S.) Red Hematite iron ore; found on top of hill near Louisa, Lawrence County, Ky. In this locality it is in nodular lumps of various sizes; but it is doubtless to be found in regular layers in other localities in this State.

COALS.

(See Table VI.)

No. 1280 *a*. (Vol. I. N. S., Ky. Geol. Rep., p. 157.) Coal No. 6 from Turkey-pen Hollow, Old Clinton track. Bellefonte furnace, Boyd County.

No. 1280 *b*. (Ibid., p. 149.) Selected sample of same coal.

No. 1285. (Ibid., p. 157.) Coal No. 6 from Horse Branch (or Run), near Catlettsburg, Boyd County. Average sample.

No. 1286. (Ibid.) Coal No. 7 from the Ashland Company's mine No. 4, Coalton, Boyd County. Average sample.

No. 1289. (Ibid., p. 158.) Coalton coal No. 7. Two hundred and fifty yards from the west end of No. 4 entry. Average sample. Boyd County.

No. 835. (Vol. IV. p. 96, Ky. Geol. Rep., O. S.) Cannel coal from Mr. South's coal bank (three feet thick) near Jackson, Breathitt County. furnace, Carter County.

No. 871. (Ibid., p. 111.) Cannel Coal, twenty-one inches thick, Stinson Bank, Carter County.

No. 1348 *a*. (Vol I. N. S., p. 182, Ky. Geol. Rep.) Coal No. 7, Coalton. Average sample from Wiley Pritchard's bank, near Mount Savage.

No. 1348 *b*. (Ibid., p. 149.)

No. 1350. (Ibid., p. 182.) Coalton coal (No. 7), from a drift on Gum branch of Straight Creek. Mount Savage Company's drift, lower part of the bed. Carter County.

No. 1353. (Ibid., p. 183.) Coal No. 1 from Graham bank. Little Fork of Little Sandy River, near Willard, Carter County. Average sample.

No. 1356. (Ibid.) Coal No. 2 from Kibby drift, Everman's Creek, a mile from Grayson, Carter County. Average sample.

No. 1357. (Ibid.) Coal No. 1 from Stone branch of Tygert's Creek, Carter County.

No. 1413. (Ibid., p. 201.) Coal from Tar Lick, Davis's Creek, Edmonson County. Five and a half feet thick.

No. 1418. (Ibid., p. 202.) Coal from Shoal Branch. Nolin coal.

No. 1448. (Ibid., p. 222.) Tar-Lick coal. Dismal Creek, Grayson County. Average sample.

No. 1484. (Ibid., p. 238.) Coal No. 1, used at Kenton furnace, Greenup County. Average sample.

No. 1486. (Ibid.) Coal No. 3. Average sample of the main coal of Raccoon furnace below the Shale parting, Greenup County.

No. 1493. (Ibid., p. 239.) Coal, probably No. 3; thirty feet below the Kidney ore. Laurel furnace, Greenup County. Average sample from the coal-shed.

No. 1496. (Ibid.) Coal No. 3 from a drift near Pennsylvania furnace, Greenup County.

No. 1649. (Ibid., p. 302.) Hunnewell Cannel coal. Hunnewell mines. Greenup County.

No. 1579. (Ibid., p. 266.) Coal from St. Charles mines, Hopkins County. Average sample. Coal D.

No. 1588. (Ibid., p. 271.) Coal No. 3 from McHenry's coal-bank, six miles south of Louisa, Lawrence County. Average sample.

No. 1589. (Ibid.) Coal No. 1 from near Henderson. Bogg's Mill, Cane's Creek, Lawrence County.

No. 1591. (Ibid.) Coal No. 3. Holbrook's coal, Brushy Creek, Lawrence County.

No. 1601. (Ibid., p. 275.) Subconglomerate coal, forty feet above the Subcarboniferous Limestone. Hawkins's Creek, near the line of Powell County, Menifee County. Average sample.

No. 1618. (Ibid., p. 283.) Coal No. 12 of Owen. Airdrie furnace, near No. 4 entry, Muhlenburg County. Average sample.

No. 1620. No. 11 of Owen. Muhlenburg County.

No. 1623. (Ibid.) Coal from Muddy River coal-mine, Muhlenburg County.

No. 185. (Vol. I. p. 49, and Vol. II. p. 286, Ky. Geol. Rep., O. S.) Mulford's main coal, or five-feet coal. Union County.

MINERAL WATERS.

(See Table VII.)

No. 798. (Vol. IV. p. 69, Ky. Geol. Rep., O. S.) Salt Sulphur-water from a well ten feet deep, about sixty steps from the main house, Olympian Springs, Bath County.

No. 1456. (Vol. I. N. S., Ky. Geol. Rep., p. 225.) Sulphur-water from the Centre Spring, a natural spring, the most popular of the Grayson Springs. Grayson County.

No. 1457. (Ibid.) Sulphur-water from the Moreman Spring, Grayson Springs.

No. 1458. (Ibid., p. 226.) Sulphur-water from the McAtee Spring. Grayson Springs.

No. 1459. (Ibid.) Sulphur-water of the Stump Spring. Grayson Springs.

No. 952. (Vol. IV. p. 142, Ky. Geol. Rep., O. S.) Red Sulphur-water near the saloon, Estill Springs, near Irvine, Estill County.

No. 953. White Sulphur at the saloon. Ibid.

No. 956. Black Sulphur-water. Ibid.

No. 1436. (Vol. I. p. 215, Ky. Geol. Rep., N. S.) Sulphur-water from a bored well, ninety-six feet deep, at the Fleetwood farm of Colonel J. W. Hunt Reynolds, near Frankfort, Franklin County.

Page 525, of Laboratory book (unpublished). Salt Sulphur-water, from a bored well, 134 feet deep, on the premises of Mr. John B. Trice, Hopkinville, Christian County.

No. 733. (Vol. III. p. 361, Ky. Geol. Rep., O. S.) Salt Sulphur-water, of the Lower Blue-Lick Spring, Nicholas County.

Page 583, of Laboratory book (unpublished). Sulphur-water, from Sebree Springs.

(b.) *Chalybeate Waters.*

No. 954. (Vol. IV. p. 142, Ky. Geol. Rep., O. S.) Chalybeate water, north-west side of Sweet-Lick Knob, near Irvine, Estill County.

Page 581, of Laboratory book (unpublished). Alum Spring (No. 1), Crow's Station (on the E. O. and N. Railroad). Coal-measures formation. Daviess County.

Page 581. (Ibid.) Sweet Spring (No. 6). Ibid.

Page 524. (Ibid.) Chalybeate water, from Murray's Spring, near Lewis (E. O. and N. Railroad), Daviess County.

No. 531. (Vol. II. p. 233, Ky. Geol. Rep., O. S.) Chalybeate Mineral-water, from the Grove Spring, in the yard of the proprietor of Crab-Orchard Springs, Mr. Caldwell, Lincoln County.

No. 532. (Ibid., p. 234.) Chalybeate water, from the Brown Spring, half a mile from Crab-Orchard Springs, on the Lancaster Turnpike, Lincoln County.

Page 527, of Laboratory book (unpublished). Chalybeate water, from Rockcastle Springs, Pulaski County. From a natural spring on the west side of Rockcastle River, near its margin. L. Renfros', near Cumberland Falls.

Page 584, of Laboratory book (unpublished). Chalybeate spring, Sebree Springs, of Webster County.

(c.) *Saline Waters.*

Page 581, No. 4, of Laboratory book (unpublished). Water from the Brick Spring, at Mr. Hickman's Springs, Crow's Station (E. O. and N. Railroad), Daviess County.

No. 535. (Vol. II. p. 236, Ky. Geol. Rep., O. S.) Mineral-water, from the Epsom Spring, one mile from Crab Orchard, on the Lancaster Turnpike, Lincoln County.

No. 536. (Ibid., p. 237). Mineral-water, from the Epsom Spring at Foley's, half a mile from the centre of Crab Orchard, on the Fall-Dick Road.

CLAYS.

(See Table VIII.)

No. 1337. (Vol. I. p. 179, Ky. Geol. Rep., N. S.) Fire-clay. Average sample from the upper four-foot bed; the whole bed eight to ten feet thick; on both sides of the hills; ridge between Grassy and Three-Prong Creeks; Boone furnace property, Carter County.

No. 1338. (Ibid.) Fire-clay, from same locality. From the lower bed.

No. 1339. (Ibid.) Fire-clay, from same locality; the rougher part of the upper layer.

No. 1340. (Ibid., p. 180.) Fire-clay, under coal, Old-Orchard diggings, Boone furnace property, Carter County.

No. 1341. (Ibid.) Fire-clay, from same locality as Nos. 1337, 1338, and 1339, — the dark-colored clay from the lower portion of the deposit. Carter County.

No. 1342. (Ibid.) Fire-clay, under the twelve-inch coal, on Geo. Ossenton's land, near Grayson, Carter County.

Page 500, of Laboratory book (unpublished). Clay, from a bed seven to eight feet thick, in the Chester group of the Subcarboniferous Limestone, on Sowder's farm, one mile north of Green River, on Caney Branch, Edmonson County, — the upper or light dove-colored portion of the bed.

Page 501. (Ibid.) Clay, from the same locality, — the second layer; light-gray or nearly white.

Page 502. (Ibid.) Clay, from the same locality; the third or gray layer. The lowest layer is of an olive-gray color, and contains about 2.5 per cent. of Potash, and nearly one per cent. of Lime.

No. 1477. (Vol. I. p. 236, Ky. Geol. Rep., N. S.) Fire-clay. Louder's Bank, near Kenton furnace, Greenup County.

No. 1479. (Ibid., p. 236.) Clay. Fourth bed above the Limestone and

Limestone ore, on Pea Ridge, Greenup County. Thickness of this bed, two to two and one-half feet; weathers, white; two hundred and fifty feet above the railroad at the depot. Hunnewell furnace.

No. 1481. (Ibid., p. 236.) Clay. Second bed above the Limestone ore, on Pea Ridge, &c., Greenup County.

No. 1483. (Ibid., p. 237.) Fire-clay. Thomas's Bank; upper layer; an average sample; five feet above the cherty Limestone. Head-waters of Wing's Branch of Schultz Creek, Greenup County.

Page 668, of Laboratory book (unpublished). Clay, from the head-waters of Green River, in Lincoln County, from a bed represented to be of great thickness, resting on Black Shale.

Page 651, of Laboratory book (unpublished). Potter's Clay; No. 1 quality; Upper Silurian formation. Waco, nine miles east of Richmond, Madison County, Ky.

Page 651 (a), of Laboratory book (unpublished). Potter's Clay; same locality; of quality No. 2.

BUILDING-STONES.

(See Table IX.)

Limestones.

No. 1638. (Vol. I. p. 291, Ky. Geol. Rep., N. S.) Magnesian Limestone, used for the foundation of the Court-house, Paris, Bourbon County. Lower Silurian. From Cane Ridge, five miles east of Paris.

No. 494. (Vol. II. p. 143, Ky. Geol. Rep., O. S.) Magnesian Limestone, on the road from Shepherdsville to Mount Washington, Bullitt County. Upper Silurian formation.

No. 1314. (Vol. I. p. 169, Ky. Geol. Rep., N. S.) Limestone, from Barren River, near the mouth of Gasper Creek. Subcarboniferous formation. Butler County.

No. 1388. (Ibid., p. 192.) Limestone, used as a flux at Boone Furnace, Carter County.

No. 1421. (Vol. I. p. 152, Ky. Geol. Rep., N. S.) Oölitic Limestone. Glasgow Junction, Barren County. Upper layers of Upper Subcarboniferous Limestone.

No. 1422. (Ibid., p. 152.) Compact Limestone. Upper Subcarboniferous Limestone. Glasgow Junction, Barren County.

No. 512. (Vol. II. p. 169, Ky. Geol. Rep., O. S.) Limestone, Building-stone, from Grimes' Quarry, on the Kentucky River, near Clay's Ferry on the Richmond Road, Fayette County. Lower Silurian, Magnesian Limestone, used in the construction of the Henry Clay Monument in the Lexington Cemetery, &c.

No. 616. (Vol. III. p. 259, Ky. Geol. Rep., O. S.) Magnesian Limestone, from Harris' Quarry on Elk Lick, about one mile below Clay's Ferry, and about one and one-half miles in a straight course from Grimes' Quarry on the Kentucky River, Fayette County.

No. 109. (Vol. I. p. 323, O. S., Ky. Geol. Rep.) Limestone from Brushy Fork of Tygert's Creek, under the Limestone ore. Used as a flux at New Hampshire furnace, Greenup County.

No. 1500. (Vol. I. p. 241, N. S., Ky. Geol. Rep.) Limestone, Subcarboniferous; average sample; used as a flux at Kenton furnace, Greenup County.

No. 530. (Vol. II. p. 227, O. S., Ky. Geol. Rep.) Magnesian Limestone, building stone; Upper Silurian formation. White-Oak Ridge at Pleasant Grove meeting-house, Wm. Galey's farm, Jefferson County.

No. 1065. (Vol. IV. p. 189, O. S., Ky. Geol. Rep.) Variegated Limestone, near the base of the Upper Silurian of Jefferson County. Three miles from Middletown, on the Shelbyville road.

No. 1123. (Ibid., p. 212.) Magnesian Limestone, a good building stone, from Mr. Covington's farm at Elliston, Madison County; where the Red-bed soil was collected. (Devonian?)

No. 164. Marble. (Vol. I. Ky. Geol. Rep., p. 358, O. S.) Coon Creek on the Ohio River, opposite to Marble-Hill quarry of Jefferson County, Indiana. Quarry of Dr. Hopson, Trimble County.

No. 776. (Vol. III. p. 409, O. S., Ky. Geol. Rep.) Limestone. The lowest rock in the bluff at Shryock's Ferry, Kentucky River, Versailles road, Woodford County. Lower Silurian formation. There are also some good building stones in the Clinton group not yet analyzed.

Sandstones.

(See Table X.)

No. 496. (Vol. II. p. 144, O. S., Ky. Geol. Rep.) Sandstone. Building stone from the Knob at Bullitt's Lick, Bullitt County. Waverly formation.

No. 467. (Ibid.) Sandstone. Building stone from a quarry on the top of Button-mould Knob, Bullitt County.

No. 468. (Ibid., p. 145.) Sandstone from seventy feet above the Shale at Bellemont furnace, Bullitt County.

No. 1221. (Vol. IV. p. 252, O. S., Ky. Geol. Rep.) Sandstone. Knob building-stone; mouth of Triplett's Creek, edge of Rowan County.

HYDRAULIC CEMENT.

Limestones.

(See Table XI.)

No. 456. (Vol. II. p. 208, O. S., Ky. Geol. Rep.) Magnesian Limestone. Hydraulic Limestone. Two miles west of Grayson Springs, Grayson County.

No. 522. (Ibid., p. 220.) Hydraulic Limestone (unburnt) from the falls of the Ohio River at Louisville, Jefferson County.

No. 1066. (Vol. IV. p. 189, O. S., Ky. Geol. Rep.) Hydraulic Limestone. Chenowick Creek, Jefferson County.

No. 1137. (Ibid., p. 219.) Hydraulic Limestone from Mitchell's Spring, Meade County. Cliff three hundred feet above the Ohio River.

No. 1165. (Ibid., p. 231.) Hydraulic Limestone from Bardstown, Nelson County.

No. 1201. (Ibid., p. 244.) Limestone from one mile north-east of La Grange, Oldham County. Upper Silurian.

No. 1202. (Ibid.) Hydraulic Limestone, Curry's Fork of Floyd's Creek, Oldham County.

COLLECTIONS AND PUBLICATIONS

OF THE

KENTUCKY GEOLOGICAL SURVEY.

THIS survey, begun as a preliminary reconnoissance, in 1854, was interrupted by the war, and its records destroyed by fire. In 1873 the work was resumed. The collections and publications herein referred to have been prepared since the close of the year 1873. The specimens shown at the Centennial Exposition comprise only a part of the total collections made during the progress of the work. The large map exhibited with the collection shows the distribution of the rocks of the State, as far as yet determined. The specimens of coal, ore, &c., represent only the beds and other deposits that have been opened, in the present state of the industries of the State. It is probable that, when complete explorations have been made, the aggregate mineral wealth will be many times greater than is shown here.

Attention is called to the following publications of the Kentucky Survey, already issued or in preparation. These reports, memoirs, maps, &c., will be furnished at the cost of printing. Applications should be made to the Secretary of the Geological Survey, Lexington, Kentucky.

List of the Publications of the Survey already printed or in preparation.

Reports of the Geological Survey of Kentucky, all in royal 8vo.

VOLUME I. NEW SERIES.

I. Report on the Timber Growth of Greenup, Carter, Boyd, and Lawrence Counties, in Eastern Kentucky. By N. S. Shaler, and A. R. Crandall, Assistant.

II. Report of the Botany of Barren and Edmonson Counties. By John Hussey, Botanical Assistant. With an Introduction by N. S. Shaler.

III. Report on the Iron Ores of Greenup, Boyd, and Carter Counties, the Kentucky Division of the Hanging Rock Iron Region. 8 Plates. By P. N. Moore, Assistant.

IV. Chemical Report of the Soils, Marls, Clays, Ores, Coals, Iron Furnace Products, Mineral Waters, &c., of Kentucky. By Robert Peter, M.D., &c., Chemist to the

Kentucky Geological Survey. Assisted by John H. Talbutt, S.B., Chemical Assistant. The First Chemical Report in the New Series, and the Fifth since the beginning of the Survey.

V. The Iron Manufacture of the Kentucky Division of the Hanging Rock Iron Region. 1 Plate. By P. N. Moore, Assistant.

VI. Report on the Geology of the Region adjacent to the Louisville, Paducah, and South-western Railroad, with a Section and 4 Plates. By Charles J. Norwood, Assistant.

VII. Report of a Reconnoissance in the Lead Region of Livingston, Crittenden, and Caldwell Counties, including a sketch of their General Wealth. Map and 4 Plates. By Charles J. Norwood, Assistant.

VOLUME II. NEW SERIES.

I. Report on the Geology of Greenup, Carter, and Boyd Counties, and a part of Lawrence. With Map and Sections. By A. R. Crandall, Assistant.

II. On the Geology of the Edmonson Coal and Iron District. With Map and Sections. By P. N. Moore, Assistant, and J. R. Proctor; with Map by W. B. Page, Assistant, and C. W. Beckham and John B. Marcou, Aids.

III. On the Chemistry of the Hemp Plant. By Dr. R. Peter, Principal Chemist of the Survey.

IV. On the Airdrie Furnace. By P. N. Moore, Assistant.

V. Topographical Report of W. B. Page, Assistant, for the year 1874.

VI. On the Geology of the Line of the proposed Railway from Livingston Station to Cumberland Gap. With Sections. By A. R. Crandall and C. J. Norwood, Assistants.

VII. Geology of the Henry County Lead District. With Sections. By N. S. Shaler, and C. J. Norwood, Assistant.

VIII. On the Geology of the Route of the proposed Lexington and Big Sandy Railway. With Sections. By A. R. Crandall, Assistant.

IX. A General Account of Kentucky. By N. S. Shaler and Assistants. Maps and Sections.

VOLUME III. NEW SERIES.

I. Report of N. S. Shaler, Director, on the Conduct of the Survey for 1873.

II. Biennial Report of N. S. Shaler, Director, for the years 1874 and 1875, giving a summary account of the principal economic results of the Survey during those years.

III Notes on the various Scientific Problems encountered in the prosecution of the Kentucky Geological Survey. By N. S. Shaler, Director.

IV. Plan for the organization of a State Cabinet. By N. S. Shaler.

V. Description of the Preliminary Geological Map of Kentucky. By N. S. Shaler, Director.

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II. Report on the Geology of the Counties of Bath, Menifee, Powell, and Lee. With Map and Sections. By A. R. Crandall, Assistant.

III. Report on the Iron Ores in the Region near Cumberland Gap. With Sections. By P. N. Moore, Assistant.

IV. Report of the Results of a Reconnoissance of the State Line from Cumberland to Pound Gap, and on a Line from Abingdon, Virginia, to Mount Sterling, Kentucky. By P. N. Moore, Assistant.

V. Report on the Breckinridge Coal Mines. By C. J. Norwood, Assistant.
VI. Report on the Geology of the Kentucky Red River Iron District. With Sections. By P. N. Moore, Assistant.
VII. Preliminary Report on the Geology of Martin County. With Sections. By A. R. Crandall, Assistant.
VIII. Report on the Geology of the North and South-running Railways of Western Kentucky. With Sections. By C. J. Norwood, Assistant.
IX. Topographical Report of W. B. Page, Assistant, for 1875.

VOLUME V. NEW SERIES.

I. Report on the Building Materials of Kentucky. By N. S. Shaler, and J. R. Proctor, Assistant. With Map and Sections.
II. Report on the Geology of the Section from Grayson County to the Ohio River. By P. N. Moore, Assistant. Map and Sections.
III. Report on the Improvement of Kentucky Rivers, with special reference to Navigation, Water Power, and the Prevention of Floods. By N. S. Shaler, and W. B. Page and J. R. Proctor, Assistants.
IV. Report on the Geology of the Region adjacent to the Louisville and Nashville Railway and its branches. By C. J. Norwood, Assistant. With Map and Sections.
V. Report on the Geology of the Region adjacent to the Cincinnati Southern Railway. By N. S. Shaler and Assistants. With Map and Sections.
VI. Report on the Mineral Waters of Kentucky. By Robert Peter and J. H. Talbutt, Assistants.
VII. Report on the Coal Measures Section between Slate Creek and the Virginia Border. By A. R. Crandall, Assistant. Map and Sections.

VOLUME VI. NEW SERIES.

This volume will be devoted to a special class of Reports, prepared with reference to the International Exhibition at Philadelphia, and designed to bring the results of that Exhibition to bear on the questions of mining, commerce, and other interests in Kentucky. It is not possible to announce the precise limitations of these Reports; but, as far as possible, they will be made to include the following classes of facts: —

I. The Management of Surveys, Topographical, Geological, &c. II. The Arrangement of Collections to illustrate resources. III. The Working of Coal, Iron, and other Economic Mineral Deposits. IV. The Use of Building Materials. V. Agricultural Geology. History of Soils, Marls, &c., Commercial Manures. VI. Metallurgy of Iron, Lead, &c. VII. The Improvement of Navigation in Rivers.

MEMOIRS OF THE GEOLOGICAL SURVEY OF KENTUCKY. VOL. I.

All in 4to.

I. On the Antiquity and History of the Caverns of the Ohio Valley. 1 Plate. By N. S. Shaler, Director.
II. On the History of the Buffalo, with special reference to the Fossils found at Big Bone Lick. Map and 12 Plates. By J. A. Allen.
III. On the Fossil Brachiopods of the Ohio Valley. Part I. 8 Plates. By N. S. Shaler, Director.
IV. On the Prehistoric Remains of Kentucky. Part I. 7 Plates. By Lucian Carr, Assistant, and N. S. Shaler, Director.

MEMOIRS. VOLUME II.

I. On the Prehistoric Remains of Kentucky. Part II. By L. Carr, Assistant, and N. S. Shaler, Director. Map and Plates.
II. On the Fossil Corals of the Family Calceolidæ. By N. S. Shaler, Director. Map and 4 Plates.
III. On the Cavern Animals of Kentucky. By A. S. Packard and F. A. Sanborn, Assistants, and others. 4 Plates.
IV. On the Fossil Brachiopods of the Ohio Valley. Part II. By N. S. Shaler. Maps. 8 Plates.
V. On the Cavern-dwelling Races of Kentucky. By F. W. Putnam, Assistant. 6 Plates.
VI. History of the Investigations into the Affinities of Cavern Animals. By H. A. Hagen.
VII. On the Dynamic Geology of Kentucky. By N. S. Shaler, Director. Maps and Plates.

A few copies of the volumes of the first series of Reports made between 1854 and 1860, now out of print and extremely scarce, can be furnished to those who desire to complete such sets of Reports.

Persons desiring information concerning these Reports, or any other information concerning the natural resources of Kentucky, with a view to immigration or to the investment of money in the State, should address Kentucky Geological Survey, Frankfort, Kentucky.

The order of arrangement of the Reports in the fourth and fifth volumes, as well as their titles, may vary somewhat from the list as above given; but the changes will be only matters of detail. It is expected that all of the above described matter will be printed by December, 1877.

These Reports will be furnished, each part separately, in paper bindings, or as volumes bound in cloth or paper, as may be desired. The first volume of the Reports, and the first of the Memoirs, will be ready July 10, 1876. The second and third volumes of the Reports will be ready October 1st, 1876.

DESCRIPTION OF THE MAPS ACCOMPANYING THIS PAMPHLET.

Two maps are given herewith, one a general map designed to show the position of the Commonwealth of Kentucky, with reference to the other parts of the Continent of North America. It will be seen from this map that the most important points are as follows: —

1. Its central position, with reference to the whole country; it being very nearly in the middle of the great fertile section of the continent. The present centre of population is probably at or very near the northernmost point of the State.

2. The relation of this Commonwealth to the natural transportation routes of the country, — its great rivers. There can be little doubt that, as this country becomes more and more peopled, the commerce will become more limited to the north and south channels. This will necessarily give a continually-increasing importance to the commercial relations of Kentucky.

It should be noticed that the shores of the Caribbean Sea and the Gulf of Mexico are in peculiarly favorable relations for commerce with the Mississippi Valley. A geological map would show that the most favorably-situated deposits of coal and iron for the supply of this great region lie within the central district of the Mississippi Valley, of which Kentucky has so large a share.

The large map of the State of Kentucky, bound with this pamphlet, is designed to show the special geography and geology of the State. It is a compilation from various sources, but is largely based on the work of the present Survey. Geologically and topographically it is much in advance of any other map of the State that has been made. Where the geological indications are given by coloring or shading, they may be trusted as approximately correct. All such work is from the results of the Kentucky Survey. Some parts of the outcrop lines are left undetermined. These, it is expected, will be surveyed within two or three years.

The topography of the State is still the most doubtful part of the work. This region has never been surveyed in its entirety in any fashion. There was no Government Survey in the beginning. During the war some lines of roads were run. The Geological Survey has mapped in some detail about five thousand square miles; but it is not possible to construct an accurate map at present. The errors at present may be reckoned as putting the position of nearly every point in doubt. The average error of position will not fall far short of two miles. The general relations of streams, towns, and roads is, however, given with sufficient accuracy for the purpose in view.

For the better understanding of this map, the reader is referred to the first pages of this pamphlet.

MAP OF

THE SOUTHERN PART OF NORTH AMERICA

designed to show the position of

THE COMMONWEALTH OF KENTUCKY.

KENTUCKY GEOLOGICAL SURVEY
N. S. SHALER, Director.

KENTUCKY GEOLOGICAL SURVEY
1875.
PRELIMINARY MAP
COMPILED FROM VARIOUS SURVEYS.
N. S. SHALER, Director.
L. TROUVELOT
Scale of Miles.
Tertiary &c.
Coal Measures
Sub Carb. L.S.
Waverly or Silicious Gr.
Devonian Shale
Silurian (Upper Silurian)
Cambrian (Lower Silurian)
GENERAL SECTION as given by Dr. D. D. OWEN.
GREEN RIVER to SPRINGLICK.
GREEN RIVER to POND RIVER.
SECTION OF THE LOWER COALS SOUTH OF HAMBY'S STATION HOPKINS CO.
GROUP OF GENERAL SECTIONS IN THE WESTERN COALFIELD.
GENERAL SECTION for GREENUP, BOYD, CARTER & Part of LAWRENCE COUNTIES.
ILLINOIS
MISSOURI
INDIANA
OHIO
WEST VIRGINIA
TENNESSEE