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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.

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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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PART III.

PART IV.

PART VII.

PART VIII.

PART IX.

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PART XI.

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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.

1&2


LOUISA
Cat Fk.
Willard
Big Sinking Cr.
Olive Hill
GRAYSON
ASHLAND
Riverton
GREENUP
Liberty
S
E
W
FURNACE
Per Mile

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

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*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 uniform-

ly 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 coincide.

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 fur-

nishes 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	"

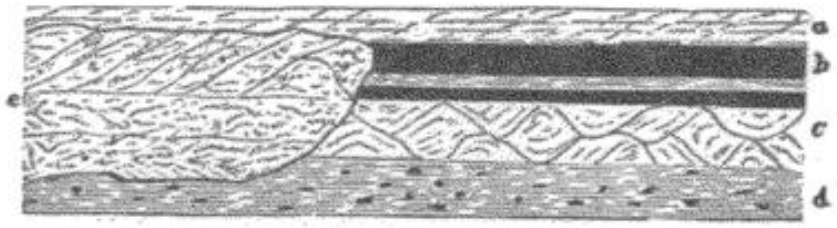
The thickening of the limestone, as shown southward from Brushy Creek, continues across the heads of Little White Oak, Big Lost, and Leatherwood Creeks. Few openings have been made on these creeks. The sections given on the Kenton Furnace lands would doubtless be found a sufficient guide for developing 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 Sel-

lard'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	"

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 subcarboniferous 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).	

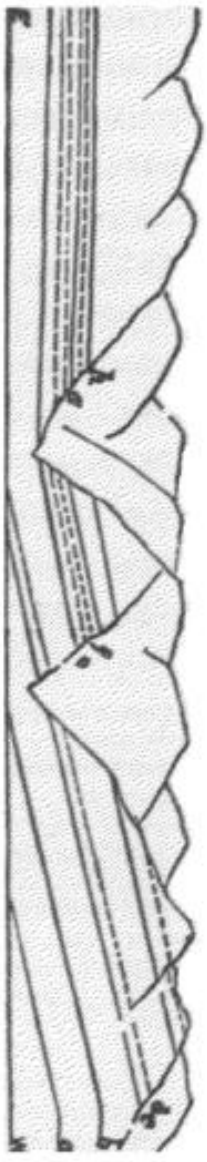
Section 33, plate 9, at Mr. Ball's, on Wolf Creek, shows Coal No. 3 and the main block ore, and a high point in the divide between these creeks and Little Fork includes the limestone ore, as in the following section:

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.



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 inter-

section 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 Gar-

ner 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 á 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 sam-

ple 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	.900	.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	.859	.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	.790	.600	.480	1.000	.685	1.235	1.315	.656	525	.915	.500

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Plate No. 1.

GENERAL SECTION FOR GREENUP, BOYD, CARTER, & Part of LAWRENCE COUNTIES.

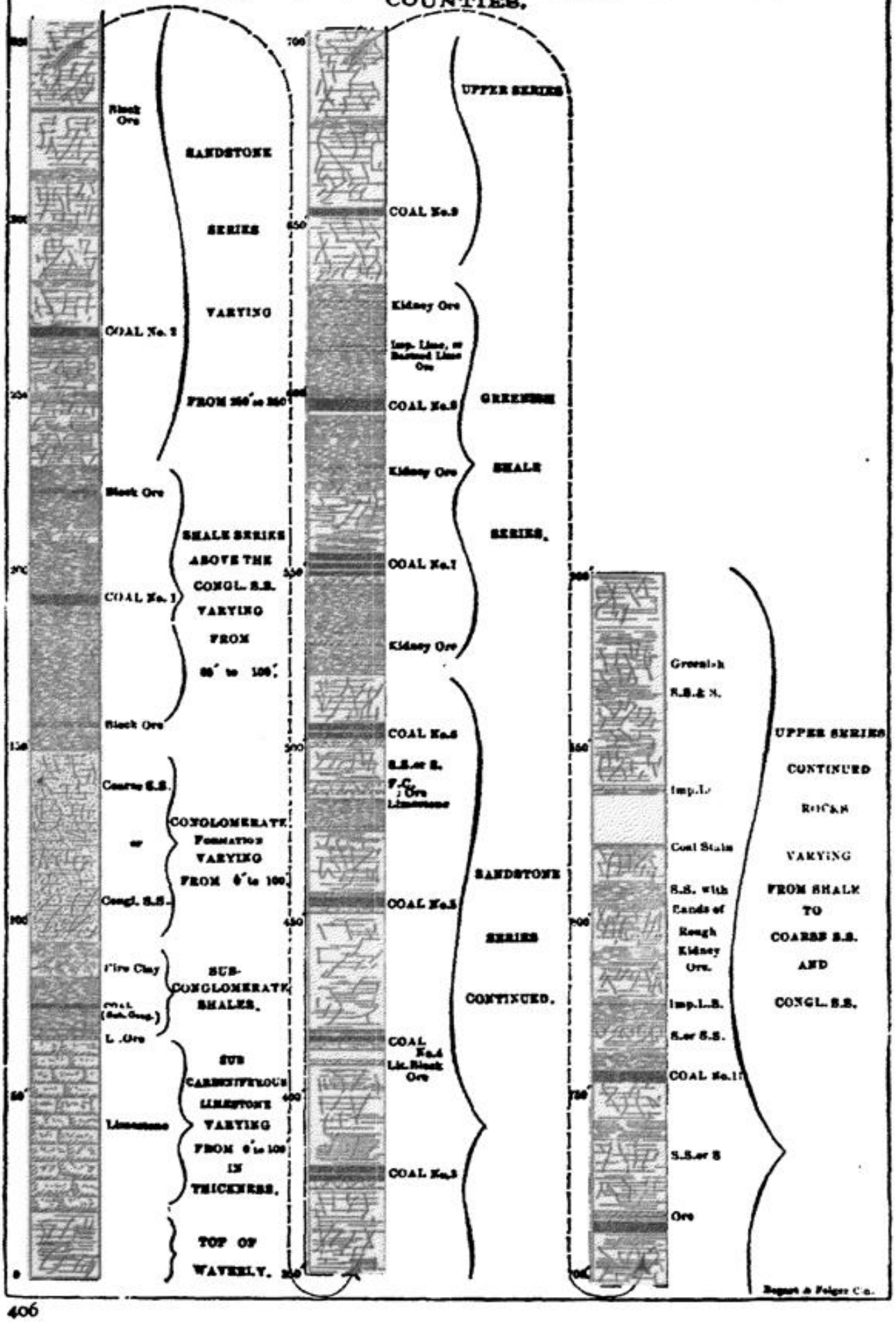

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Plate No. 2

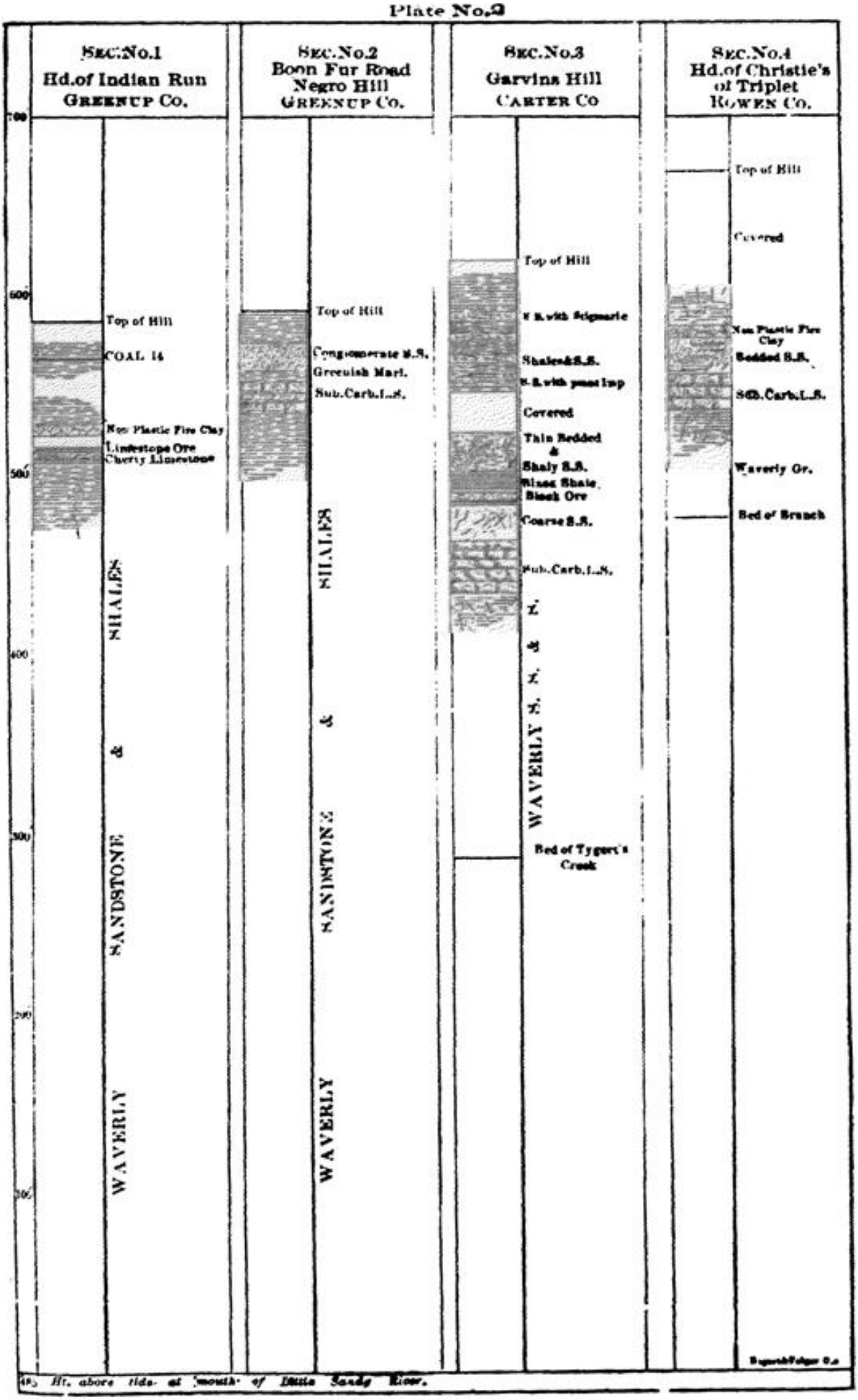
Sec. No. 1
Hd. of Indian Run
Greenup Co.
Top of Hill
COAL 14
Non Plastic Fire Clay
Limestone Ore
Cherty Limestone
SHALES & SANDSTONE
WAVERLY
Sec. No. 2
Boon Fur Road
Negro Hill
Greenup Co.
Top of Hill
Conglomerate S.S.
Greenish Marl.
Sub. Carb. L.S.
SHALES & SANDSTONE
WAVERLY
Sec. No. 3
Garvins Hill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

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Plate No. 3

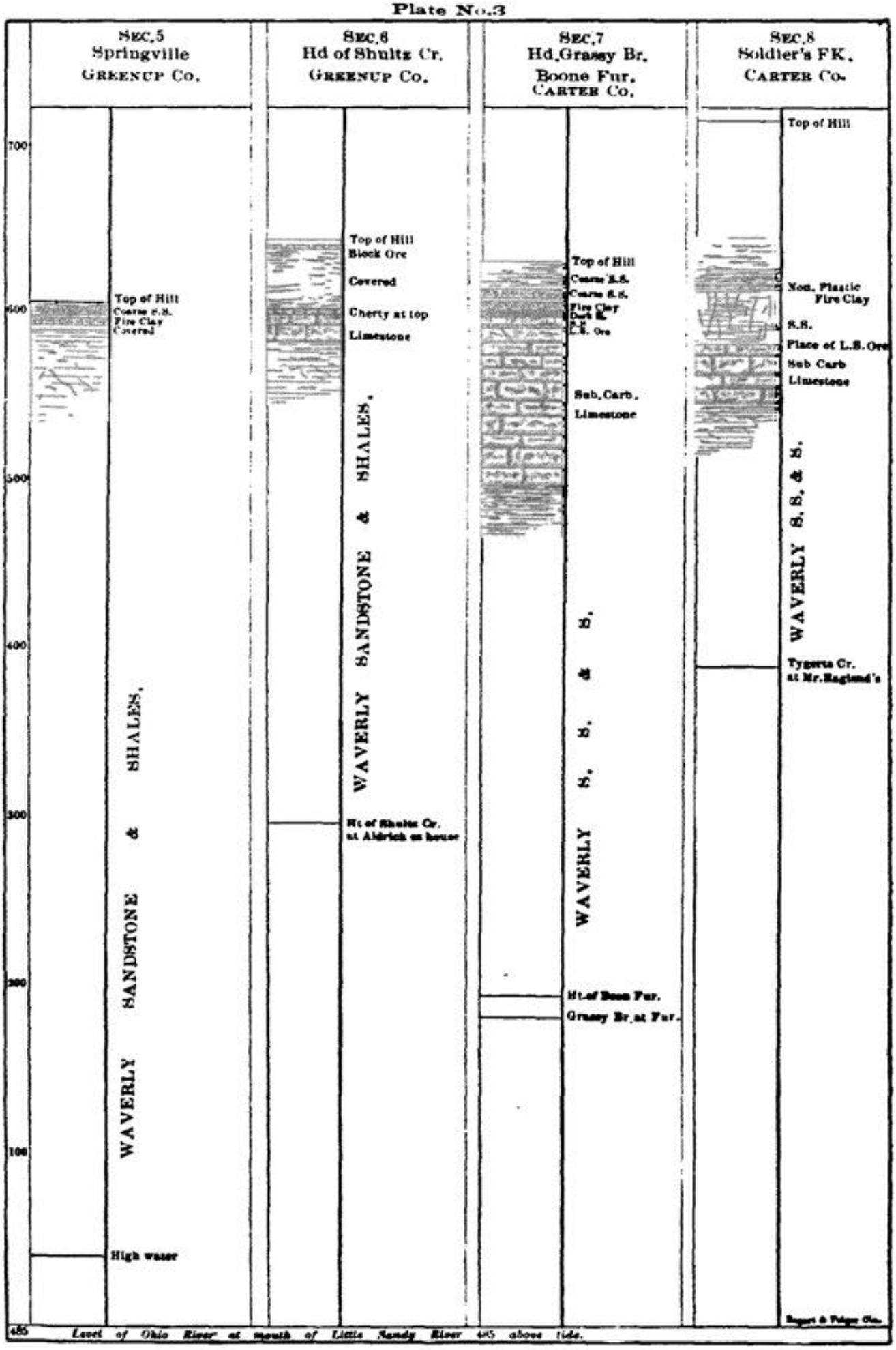
SEC. 5
Springville
GREENUP Co.
SEC. 6
Hd of Shultz Cr.
GREENUP Co.
SEC. 7
Hd. Grassy Br.
Boone Fur.
CARTER Co.
SEC. 8
Soldier's FK.
CARTER Co.
700
600
500
400
300
200
100
Top of Hill
Coarse S.S.
Fire Clay
Covered
WAVERLY SANDSTONE & SHALES.
High water
Top of Hill
Black Ore
Covered
Cherty at top
Limestone
WAVERLY SANDSTONE & SHALES.
Ht of Shultz Cr. at Aldrich on house
Top of Hill
Coarse S.S.
Coarse S.S.
Fire Clay
Dark &
L.S. Ore
Sub. Carb.
Limestone
WAVERLY S. S. & S.
Ht. of Boone Fur.
Grassy Br. at Fur.
Top of Hill
Nom. Plastic
Fire Clay
S.S.
Place of L.S. Ore
Sub Carb
Limestone
WAVERLY S. S. & S.
Tygarts Cr.
at Mr. Ragland's
685
Level of Ohio River at mouth of Little Sandy River 485 above tide.

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Plate 4

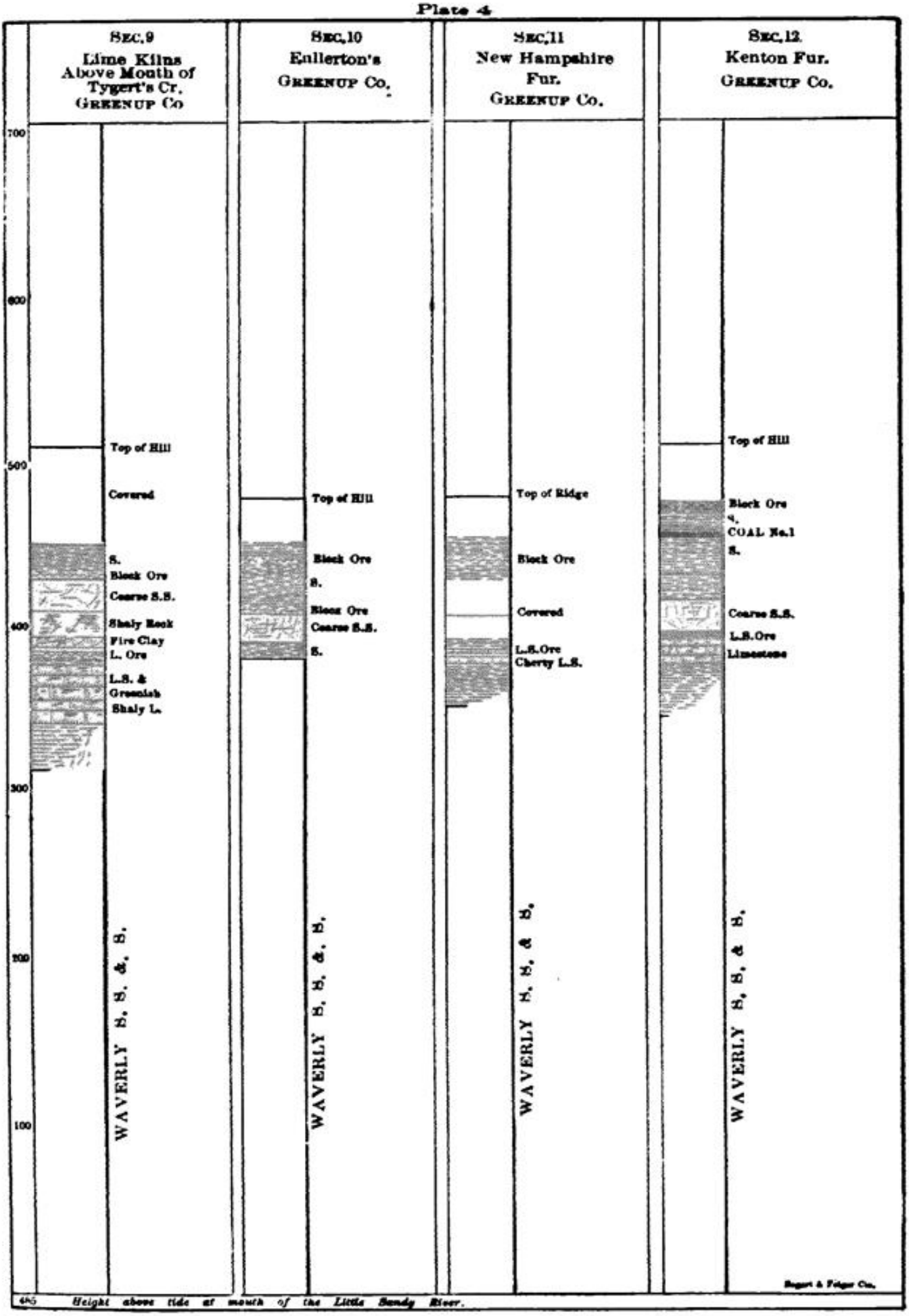
Sec. 9
Lime Kilns
Above Mouth of
Tygert's Cr.
Greenup Co
Top of Hill
Covered
S.
Block Ore
Coarse S.S.
Shaly Rock
Fire Clay
L. Ore
L.S. &
Greenish
Shaly L.
WAVERLY S. S. & S.
Sec. 10
Fullerton's
Greenup Co.
Top of Hill
Block Ore
S.
Block Ore
Coarse S.S.
S.
WAVERLY S. S. & S.
Sec. 11
New Hampshire
Fur.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

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Plate 5

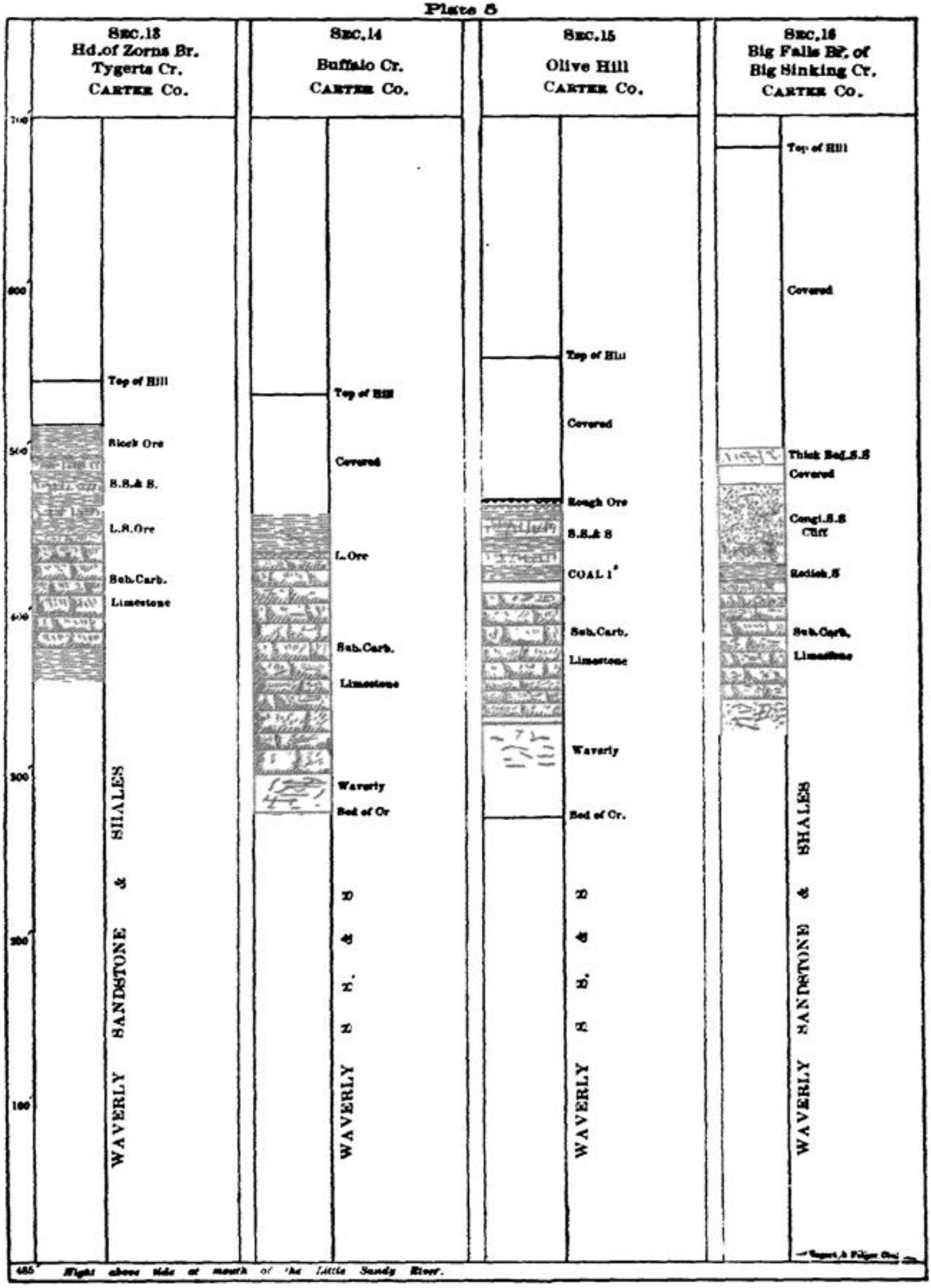
Sec. 13
Hd. of Zorns Br.
Tygerts Cr.
Carter Co.
Top of Hill
Rock Ore
S.S.& S.
L.S.Ore
Sub.Carb.
Limestone
WAVERLY SANDSTONE & SHALES
Sec. 14
Buffalo Cr.
Carter Co.
Top of Hill
Covered
L. Ore
Sub.Carb.
Limestone
Waverly
Bed of Cr
WAVERLY SANDSTONE & SHALES
Sec. 15
Olive Hill
Carter Co.
Top of Hill
Covered
Rough Ore
S.S.& S
COAL 1'
Sub.Carb.
Limestone
Waverly
Bed of Cr.
WAVERLY SANDSTONE & SHALES
Sec. 16
Big Falls Br. of
Big Sinking Cr.
Carter Co.
Top of Hill
Covered
Thick Bed S.S
Covered
Congl. S.S
Cliff
Reddish S
Sub.Carb.
Limestone
WAVERLY SANDSTONE & SHALES
800'
600'
400'
200'
100'
485' Flight above tide at mouth of the Little Sandy River.

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Plate No 6.

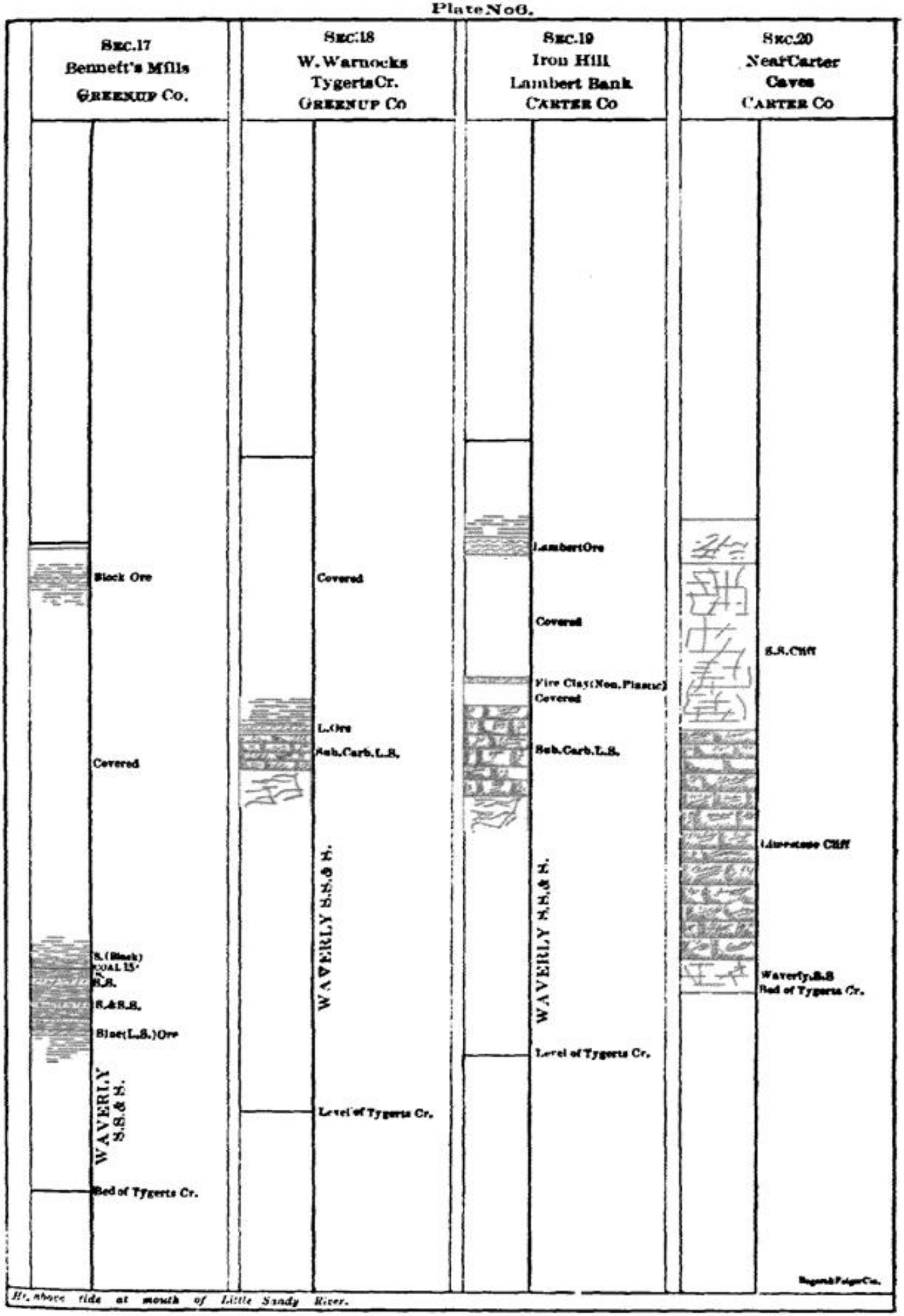
Sec.17
Bennett's Mills
Greenup Co.
Sec.18
W. Warnocks
Tygerts Cr.
Greenup Co
Sec.19
Iron Hill
Lambert Bank
Carter Co
Sec.20
Near Carter
Caves
Carter Co
Block Ore
Covered
S. (Block) COAL 15'
S.S.
S.&S.S.
Blue (L.S.) Ore
WAVERLY S.S. & S.
Bed of Tygerts Cr.
Covered
L. Ore
Sub. Carb. L.S.
WAVERLY S.S. & 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.
Ft. above tide at mouth of Little Sandy River.

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Plate No. 7

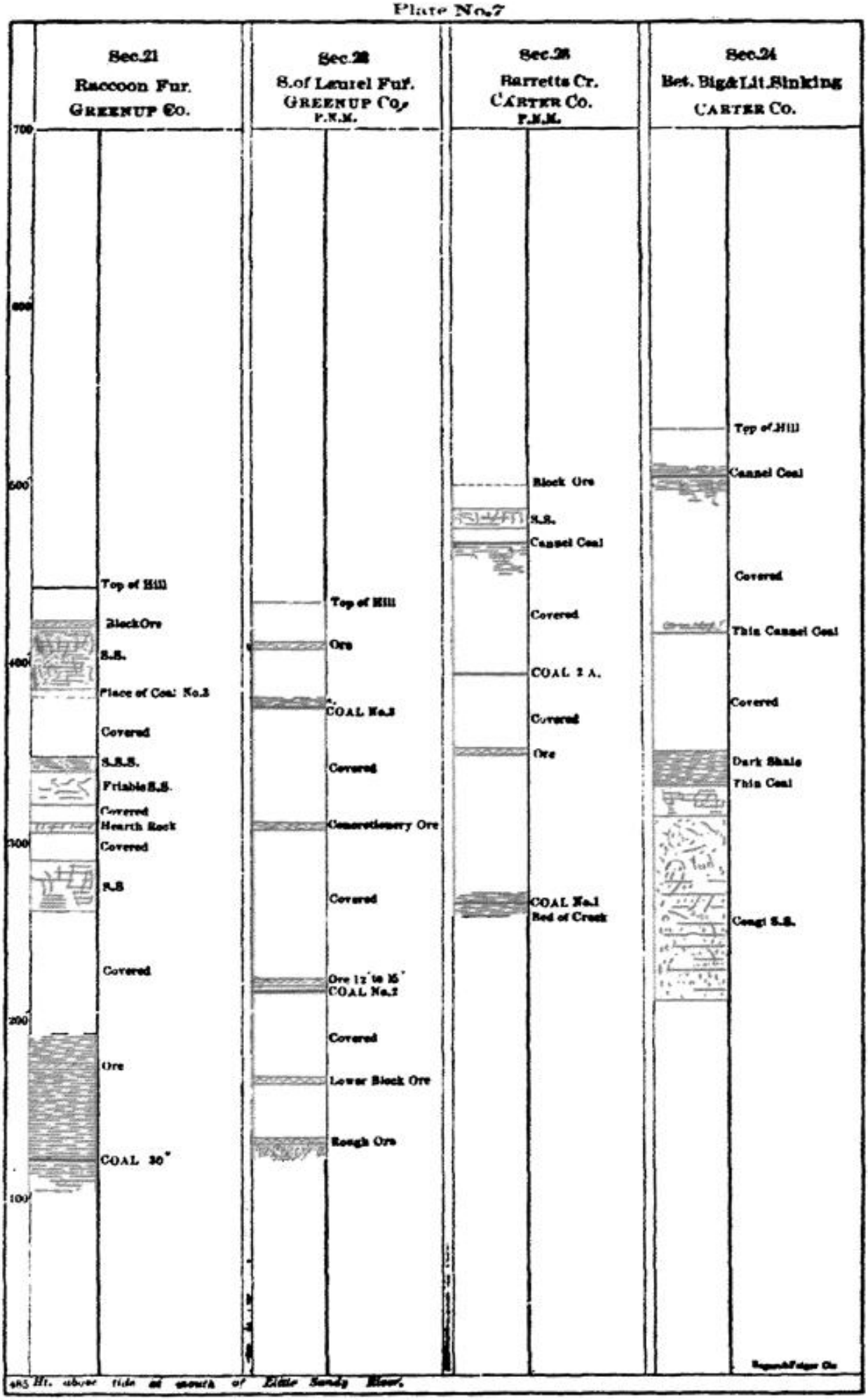
Sec. 21
Raccoon Fur.
GREENUP Co.
Sec. 22
S. of Laurel Fur.
GREENUP Co.
P.N.M.
Sec. 23
Barretts Cr.
CARTER Co.
P.N.M.
Sec. 24
Bet. Big & Lit. Sinking
CARTER Co.
700
600
500
400
300
200
100
Top of Hill
Block Ore
S.S.
Place of Coal No. 3
Covered
S.S.S.
Friable S.S.
Covered
Hearth Rock
Covered
S.S
Covered
Ore
COAL 30"
Top of Hill
Ore
COAL No. 3
Covered
Concretionary 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
Conglt S.S.
485 Ft. above tide at mouth of Little Sandy River.

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Plate No. 8

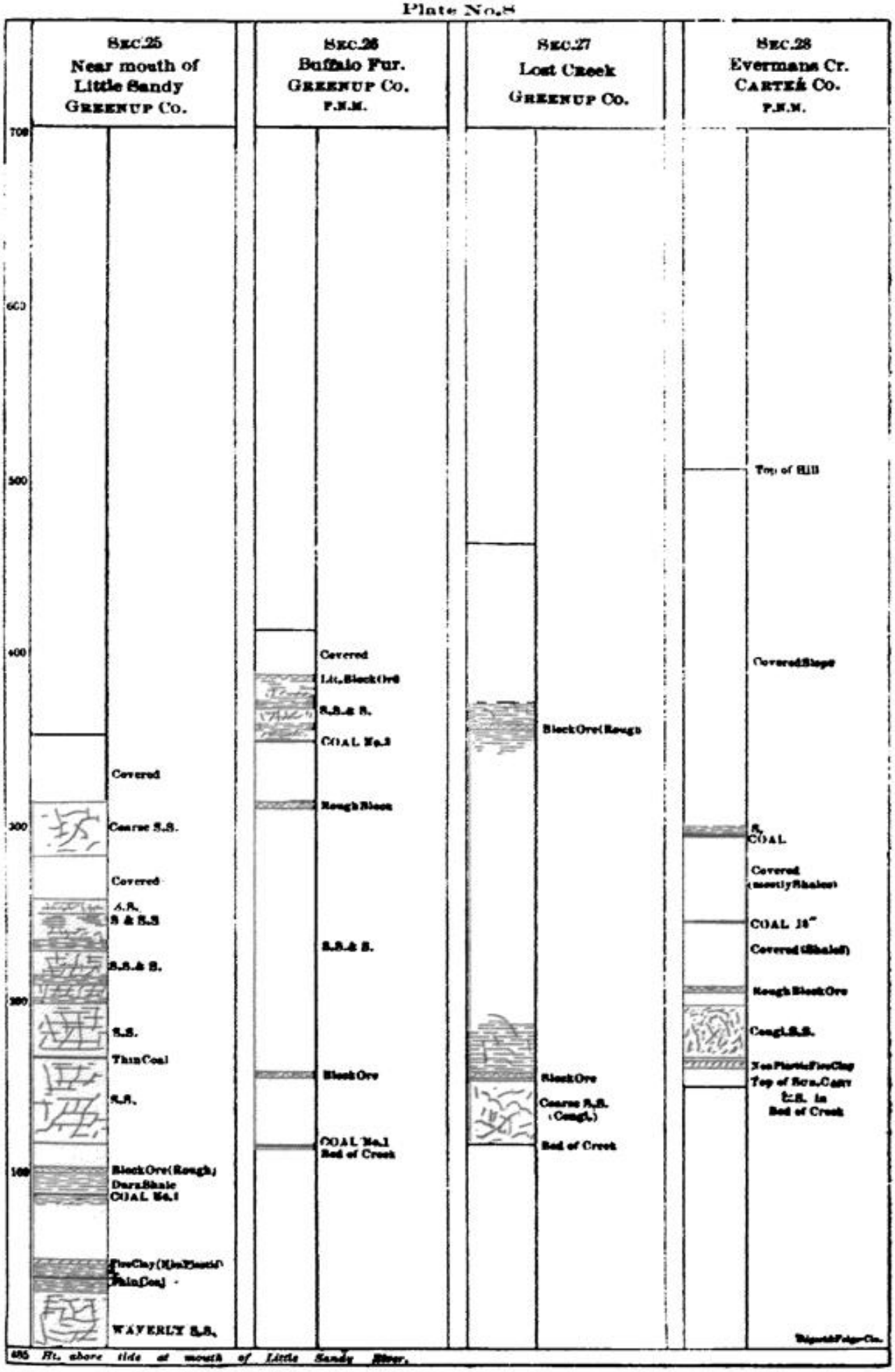
SEC. 25
Near mouth of
Little Sandy
GREENUP Co.
SEC. 26
Buffalo Fur.
GREENUP Co.
P.M.M.
SEC. 27
Lost Creek
GREENUP Co.
SEC. 28
Evermans Cr.
CARTER Co.
P.M.M.
700
600
500
400
300
200
100
Covered
Coarse S.S.
Covered
A.R.
S & S.S
S.S.& S.
S.S.
Thin Coal
S.S.
Block Ore (Rough)
Dark Shale
COAL No. 1
Fire Clay (Non Plastic)
Thin Coal
WAVERLY S.S.
Covered
Lt. Block Ore
S.S.& S.
COAL No. 3
Rough Block
S.S.& S.
Block Ore
COAL No. 1
Bed of Creek
Block Ore (Rough)
Block Ore
Coarse S.S.
(Congl.)
Bed of Creek
Top of Hill
Covered Slope
S.
COAL
Covered
(mostly Shales)
COAL 18"
Covered (Shales)
Rough Block Ore
Congl. S.S.
Non Plastic Fire Clay
Top of Sons. Carry
S.S. in
Bed of Creek
485 Ft. above tide at mouth of Little Sandy River.

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Plate 9.

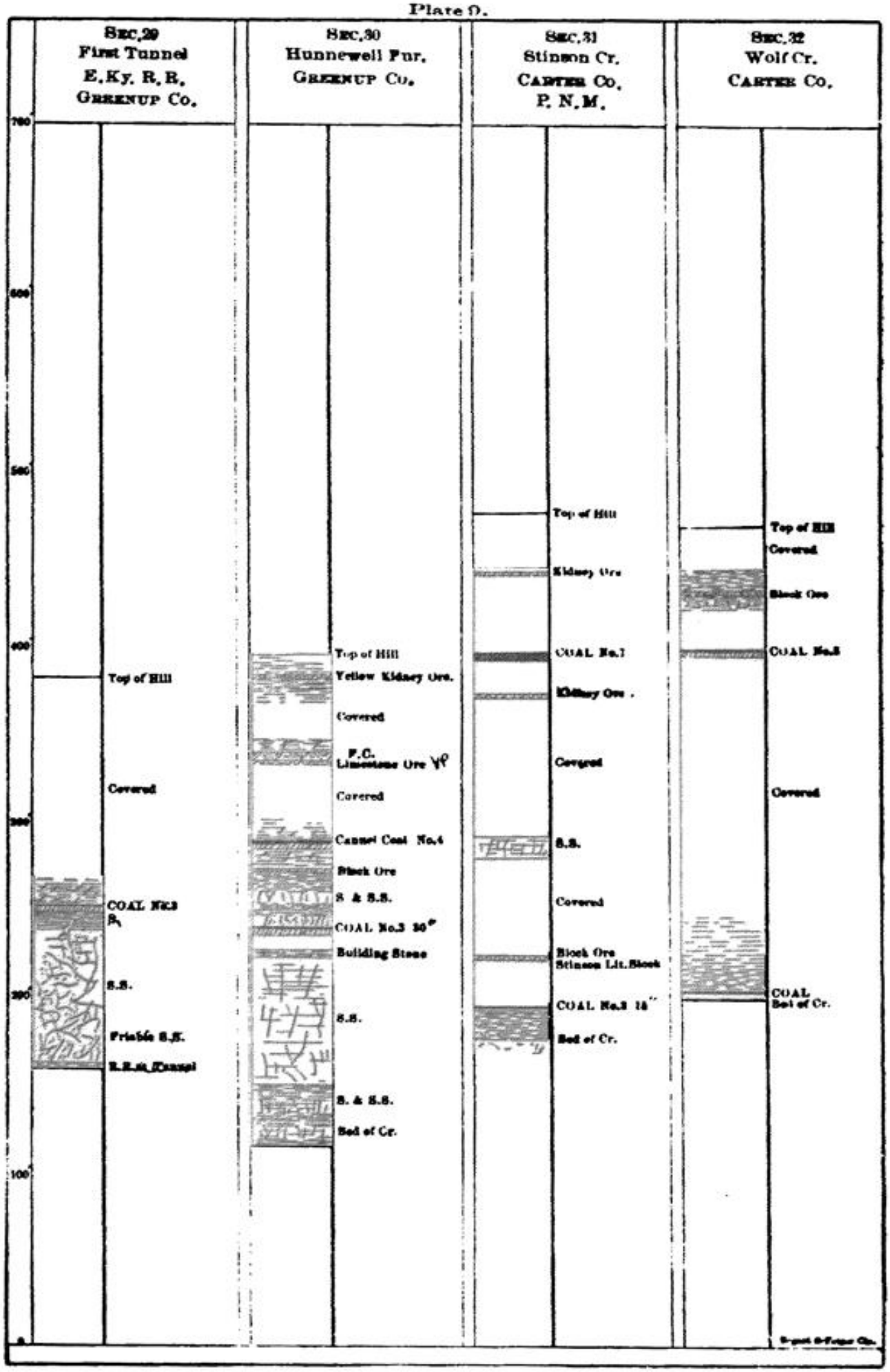
Sec.29
First Tunnel
E.Ky. R.R.
Greenup Co.
Top of Hill
Covered
COAL No.3
S.S.
Friable S.S.
Sec.30
Hunnewell Fur.
Greenup Co.
Top of Hill
Yellow Kidney Ore.
Covered
F.C. Limestone Ore
Covered
Cannel Coal No.4
Block Ore
S & S.S.
COAL No.3 30"
Building Stone
S.S.
S. & S.S.
Bed of Cr.
Sec.31
Stinson Cr.
Carter Co.
P. N. M.
Top of Hill
Kidney Ore
COAL No.3
Kidney Ore
Covered
S.S.
Covered
Block Ore
Stinson Lit. Block
COAL No.3 18"
Bed of Cr.
Sec.32
Wolf Cr.
Carter Co.
Top of Hill
Covered
Block Ore
COAL No.3
Covered
COAL
Bed of Cr.

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Plate No. 10.

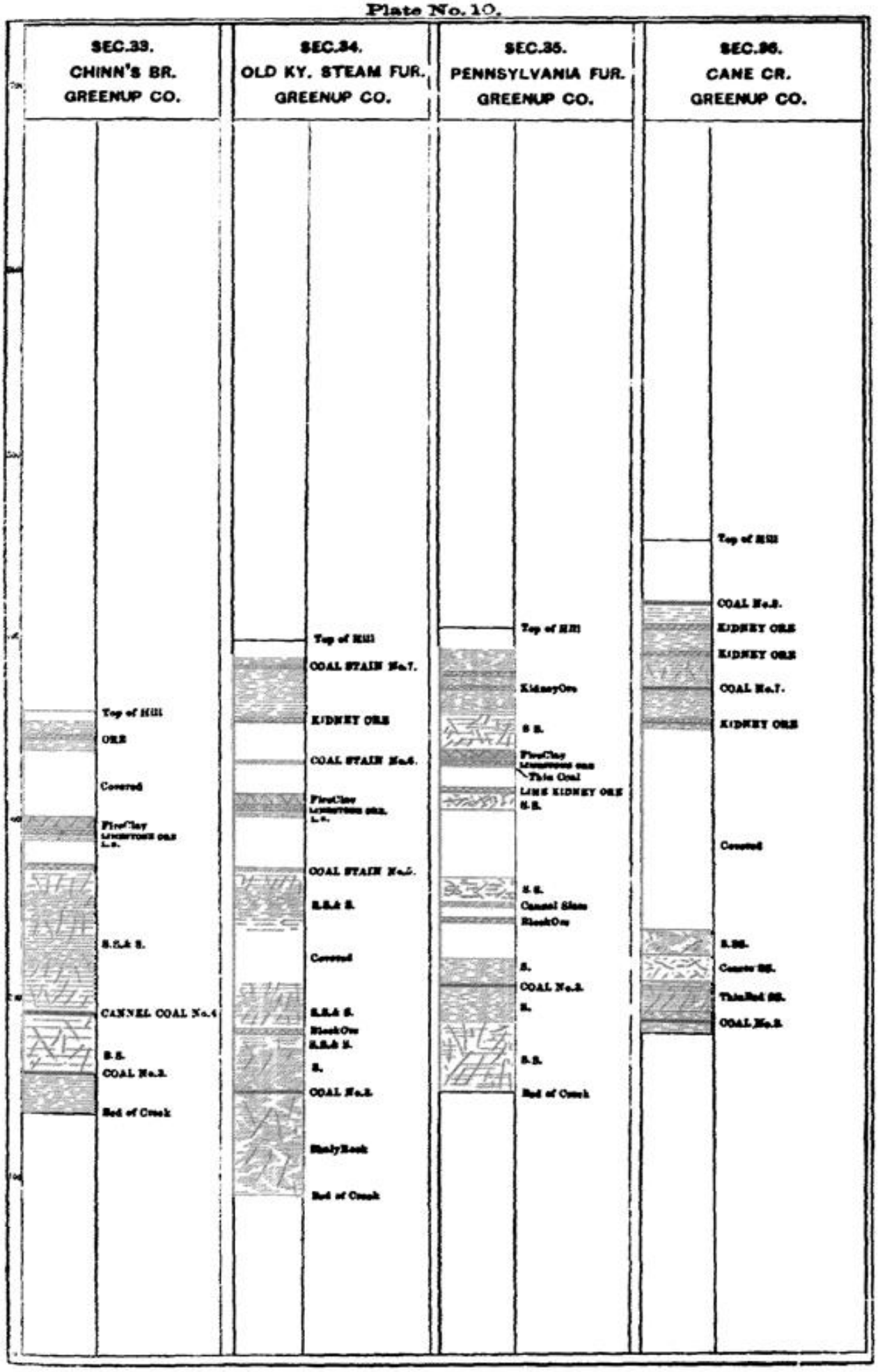
SEC.33.
CHINN'S BR.
GREENUP CO.
Top of Hill
ORE
Covered
Fire Clay
S.S.& S.
CANNEL COAL No.4
S.S.
COAL No.3.
Bed of Creek
SEC.34.
OLD KY. STEAM FUR.
GREENUP CO.
Top of Hill
COAL STAIN No.7.
KIDNEY ORE
COAL STAIN No.6.
Fire Clay
COAL STAIN No.5.
S.S.& S.
Covered
S.S.& S.
Block Ore
S.S.& S.
S.
COAL No.3.
Shaly Rock
Bed of Creek
SEC.35.
PENNSYLVANIA FUR.
GREENUP CO.
Top of Hill
Kidney Ore
S.S.
Fire Clay
Thin Coal
LIME KIDNEY ORE
S.S.
S.S.
Cannel Slate
Block Ore
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.S.
Coarse SS.
Thin Red SS.
COAL No.3.

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Plate No. 11

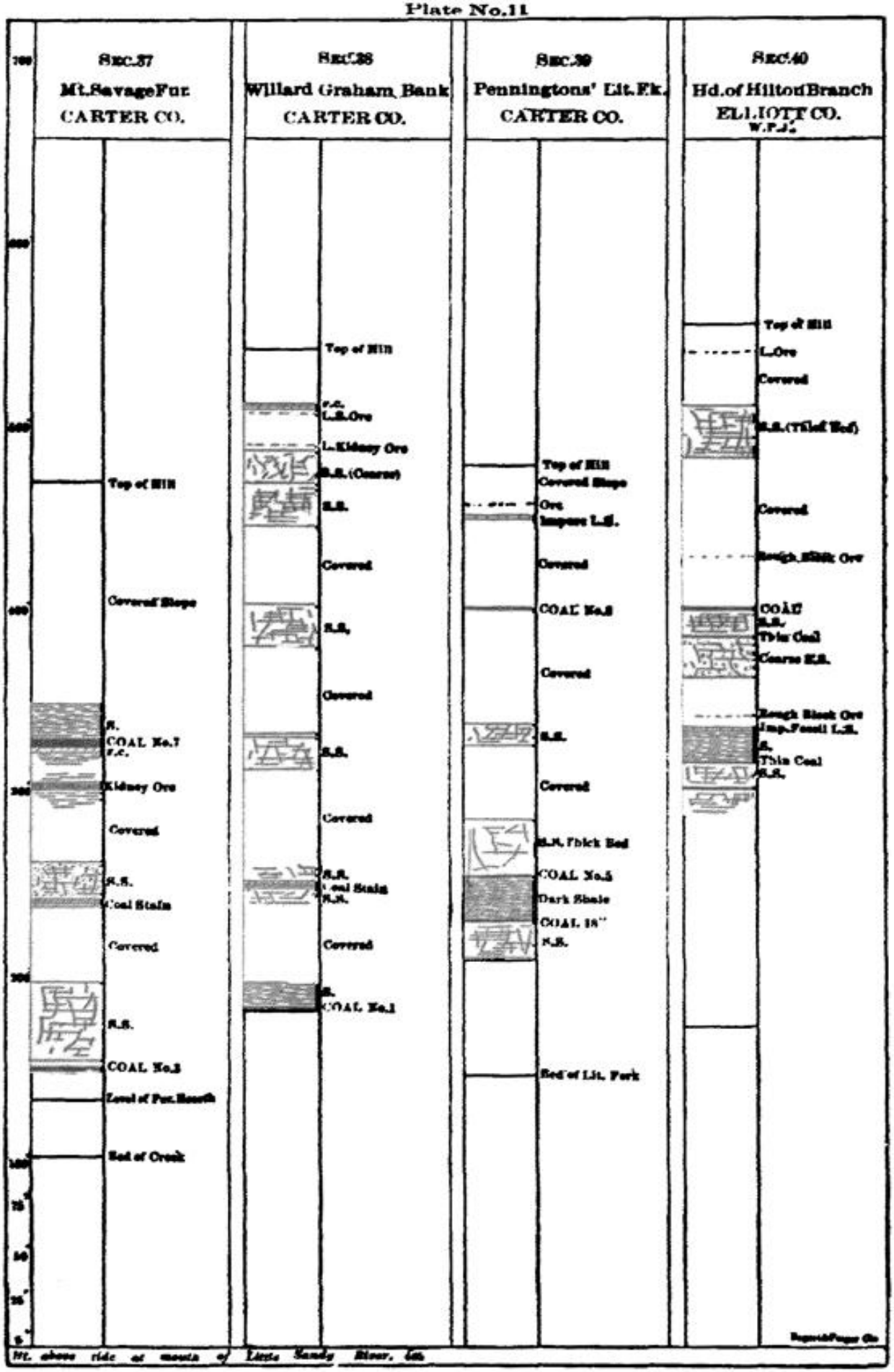
Sec. 37
Mt. Savage Fur
CARTER CO.
Top of Hill
Covered Slope
S.
COAL No. 7
F.C.
Kidney Ore
Covered
S.S.
Coal Stain
Covered
S.S.
COAL No. 8
Level of Fur. Mouth
Bed of Creek
Sec. 38
Willard Graham Bank
CARTER CO.
Top of Hill
F.C.
L.S. Ore
L. Kidney Ore
S.S. (Coarse)
S.S.
Covered
S.S.
Covered
S.S.
Covered
S.S.
Coal Stain
S.S.
Covered
S.
COAL No. 1
Sec. 39
Pennington's 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.
Ft. above ride at mouth of Little Sandy River, &c.

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Plate 12

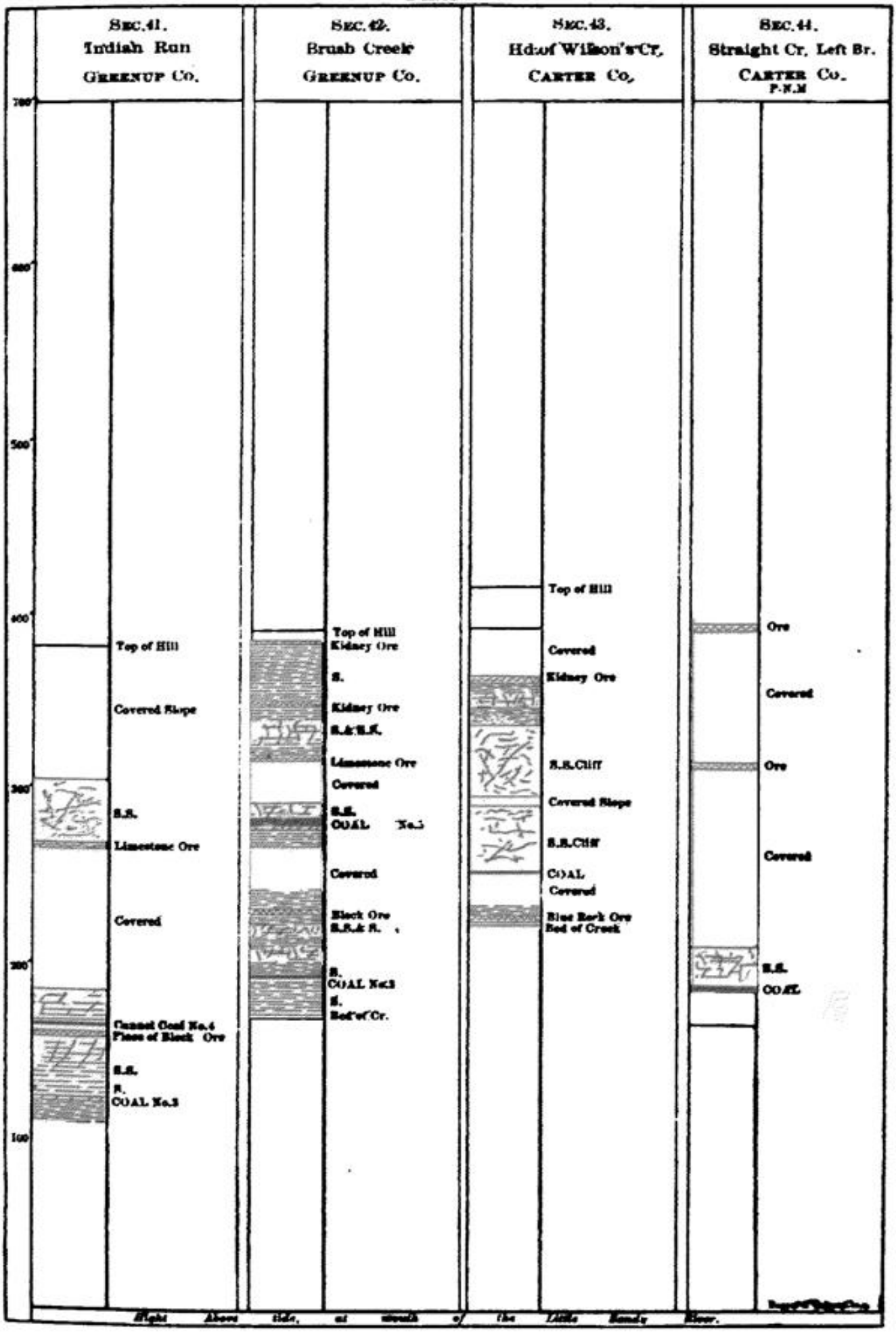
Sec. 41.
Indian Run
Greenup Co.
Top of Hill
Covered Slope
S.S.
Limestone Ore
Covered
Gannet Coal No. 4
Piece of Black Ore
S.S.
S.
COAL No. 3
Sec. 42.
Brush Creek
Greenup Co.
Top of Hill
Kidney Ore
S.
Kidney Ore
S.S.&S.S.
Limestone Ore
Covered
S.S.
COAL No. 3
Covered
Black Ore
S.S.& S.
S.
COAL No. 3
S.
Bed of Cr.
Sec. 43.
Hd. of Wilson's Cr.
Carter Co.
Top of Hill
Covered
Kidney Ore
S.S.Cliff
Covered Slope
S.S.Cliff
COAL
Covered
Blue Rock Ore
Bed of Creek
Sec. 44.
Straight Cr. Left Br.
Carter Co.
P.M.M
Ore
Covered
Ore
Covered
S.S.
COAL
Height Above Side, at mouth of the Little Sandy River.

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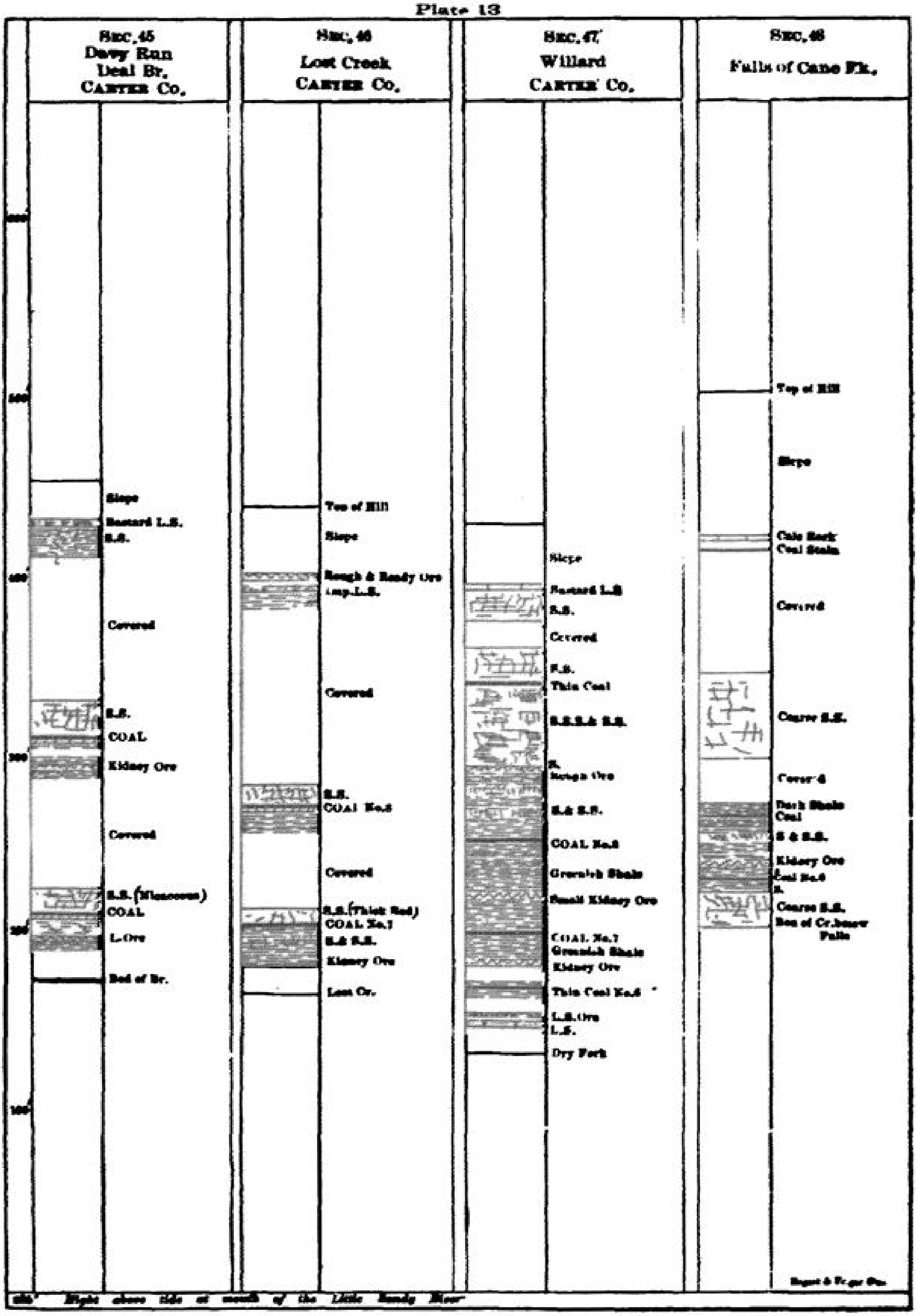
Plate 13



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.
500
400
300
200
100
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 & Sandy Ore
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
Cale 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
Height above tide at mouth of the Little Sandy River

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Plate 14

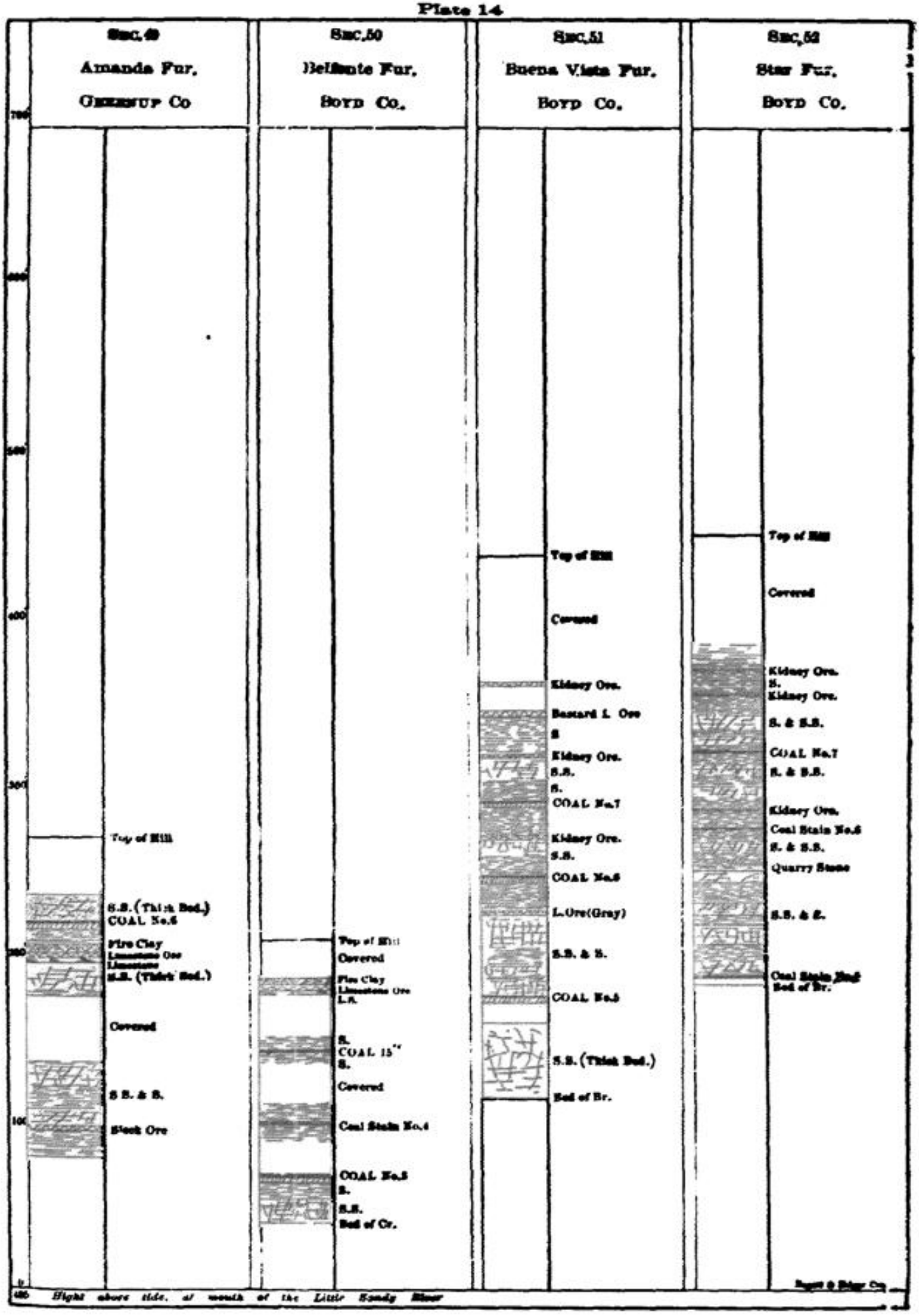
Sec. 49
Amanda Fur.
Greenup Co
Sec. 50
Bellaire Fur.
Boyd Co.
Sec. 51
Buena Vista Fur.
Boyd Co.
Sec. 52
Star Fur.
Boyd Co.
700
600
500
400
300
200
100
Top of Hill
S.S. (Thick Bed.)
COAL No.6
Fire Clay
Limestone Ore
Limestone
S.S. (Thick Bed.)
Covered
S.S. & S.
Block Ore
Top of Hill
Covered
Fire Clay
Limestone Ore
L.S.
S.
COAL 15"
S.
Covered
Coal Stain No.4
COAL No.5
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.
Height above tide, at mouth of the Little Sandy River

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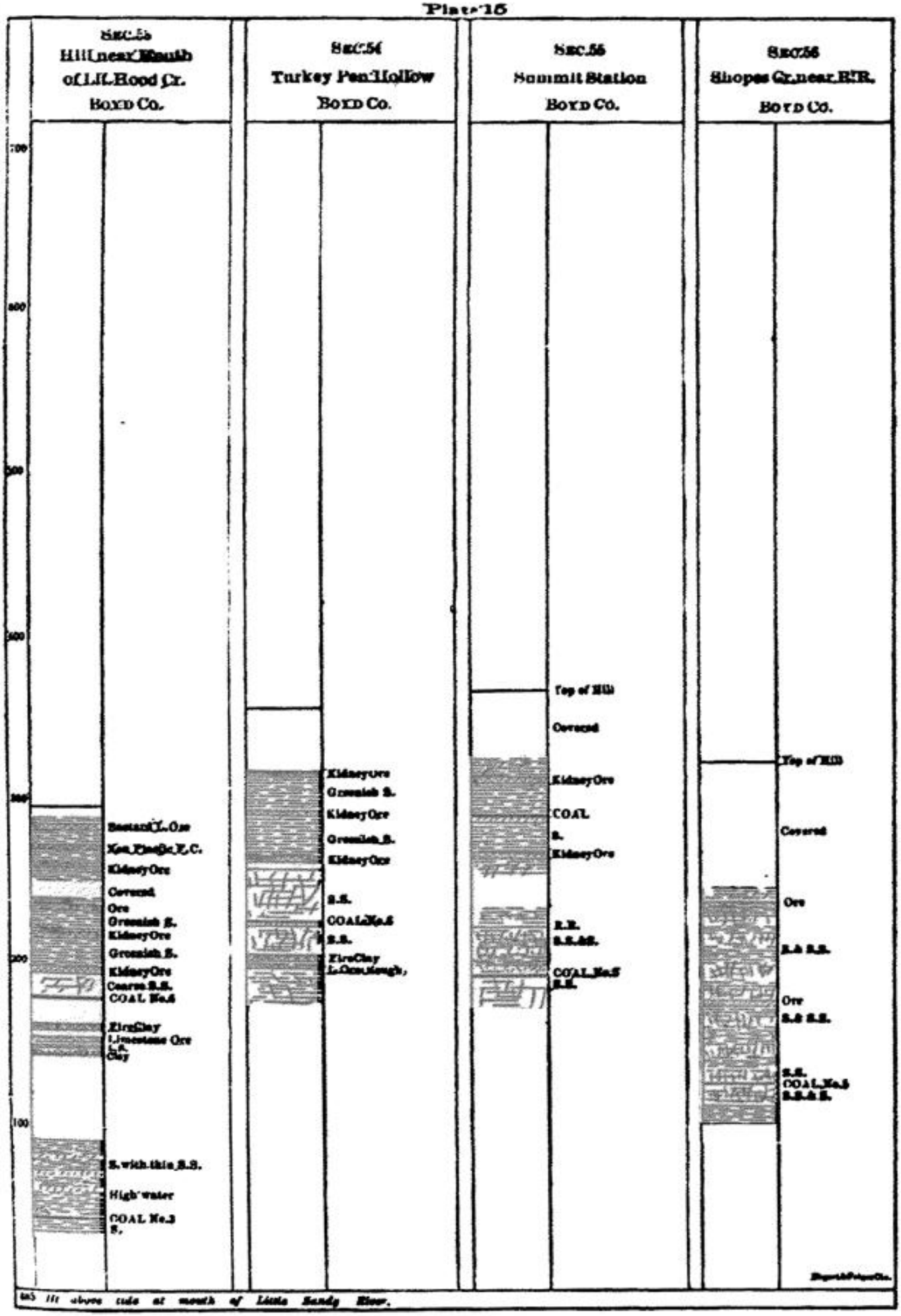
Plate 16



ft. above tide at mouth of Little Sandy River.

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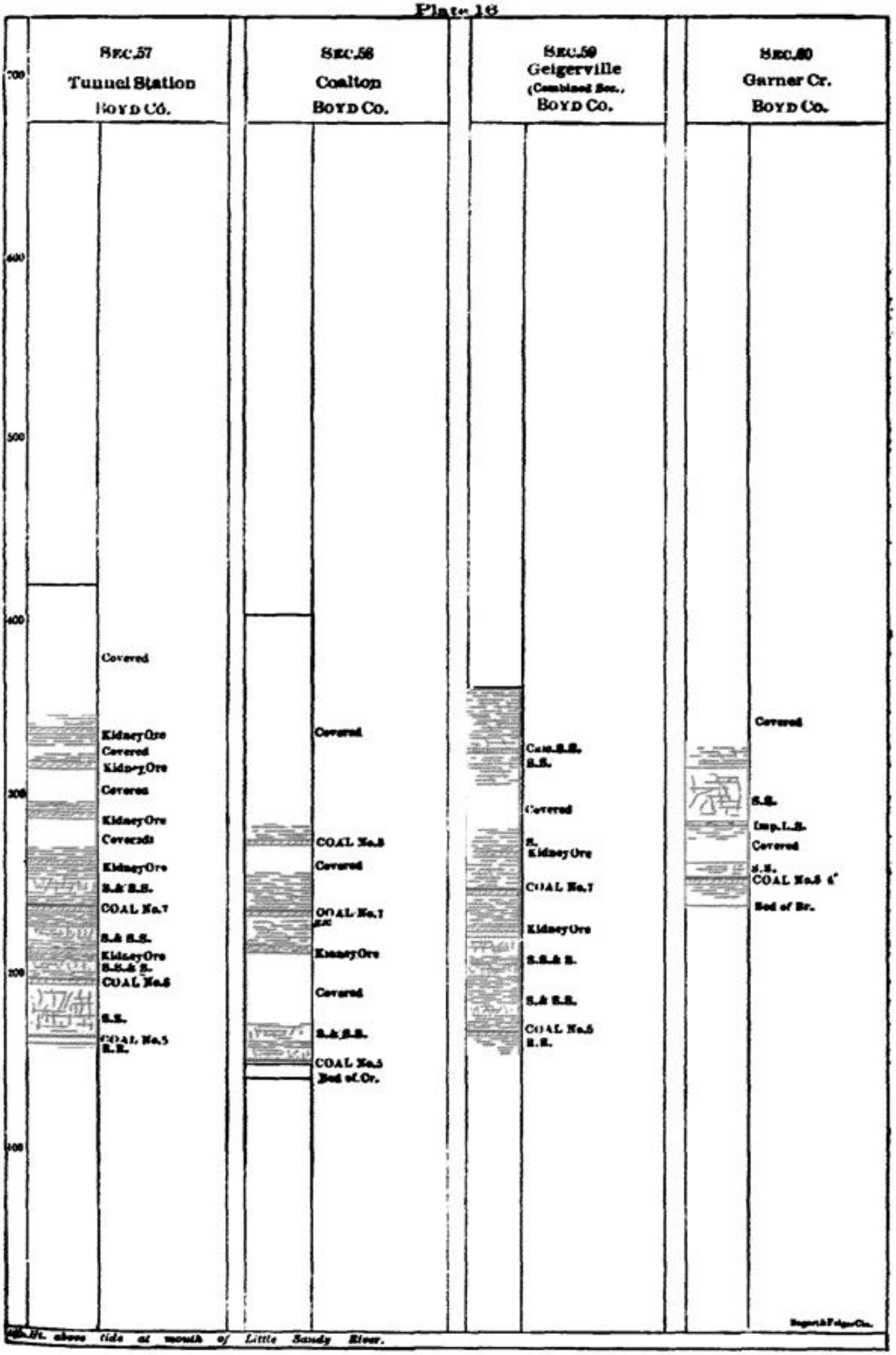
Plate 16



Ft. above tide at mouth of Little Sandy River.

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Plate 17

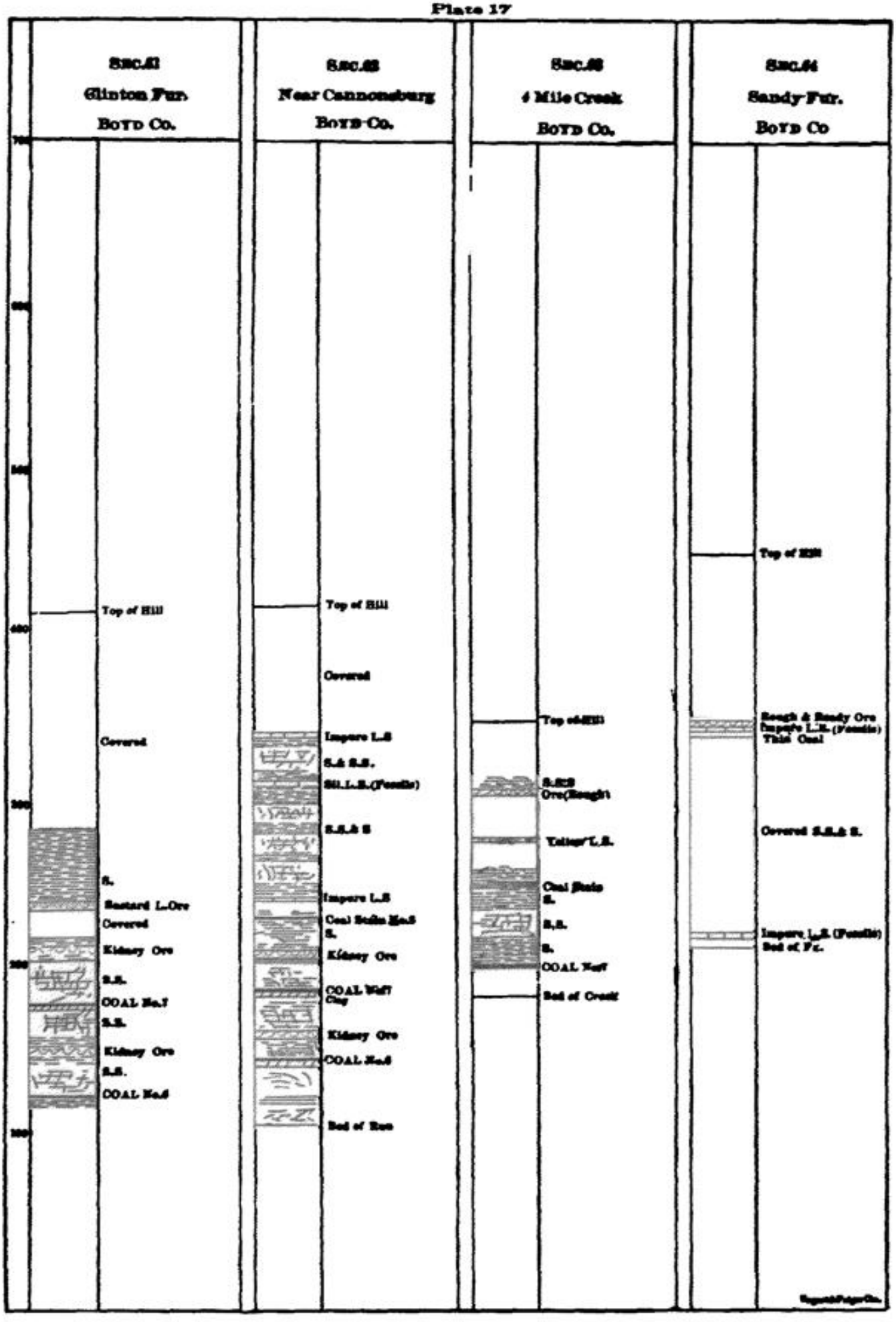
Sec.61
Clinton Fur.
Boyd Co.
Top of Hill
Covered
S.
Bastard L.Ore
Covered
Kidney Ore
S.S.
COAL No.7
S.S.
Kidney Ore
S.S.
COAL No.6
Sec.62
Near Cannonsburg
Boyd Co.
Top of Hill
Covered
Impure L.S
S.& S.S.
Sil.L.S.(Fossils)
S.S.& S
Impure L.S
Coal Strike No.8
S.
Kidney Ore
COAL No7
Clay
Kidney Ore
COAL No.6
Bed of Run
Sec.63
4 Mile Creek
Boyd Co.
Top of Hill
S.S2S
Ore(Rough)
Yellow L.S.
Coal Strata
S.
S.S.
S.
COAL No7
Bed of Creek
Sec.64
Sandy Fur.
Boyd Co
Top of Hill
Rough & Sandy Ore
Impure L.S. (Fossils)
Thin Coal
Covered S.S.& S.
Impure L.S. (Fossils)
Bed of Fr.

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Plate No.18

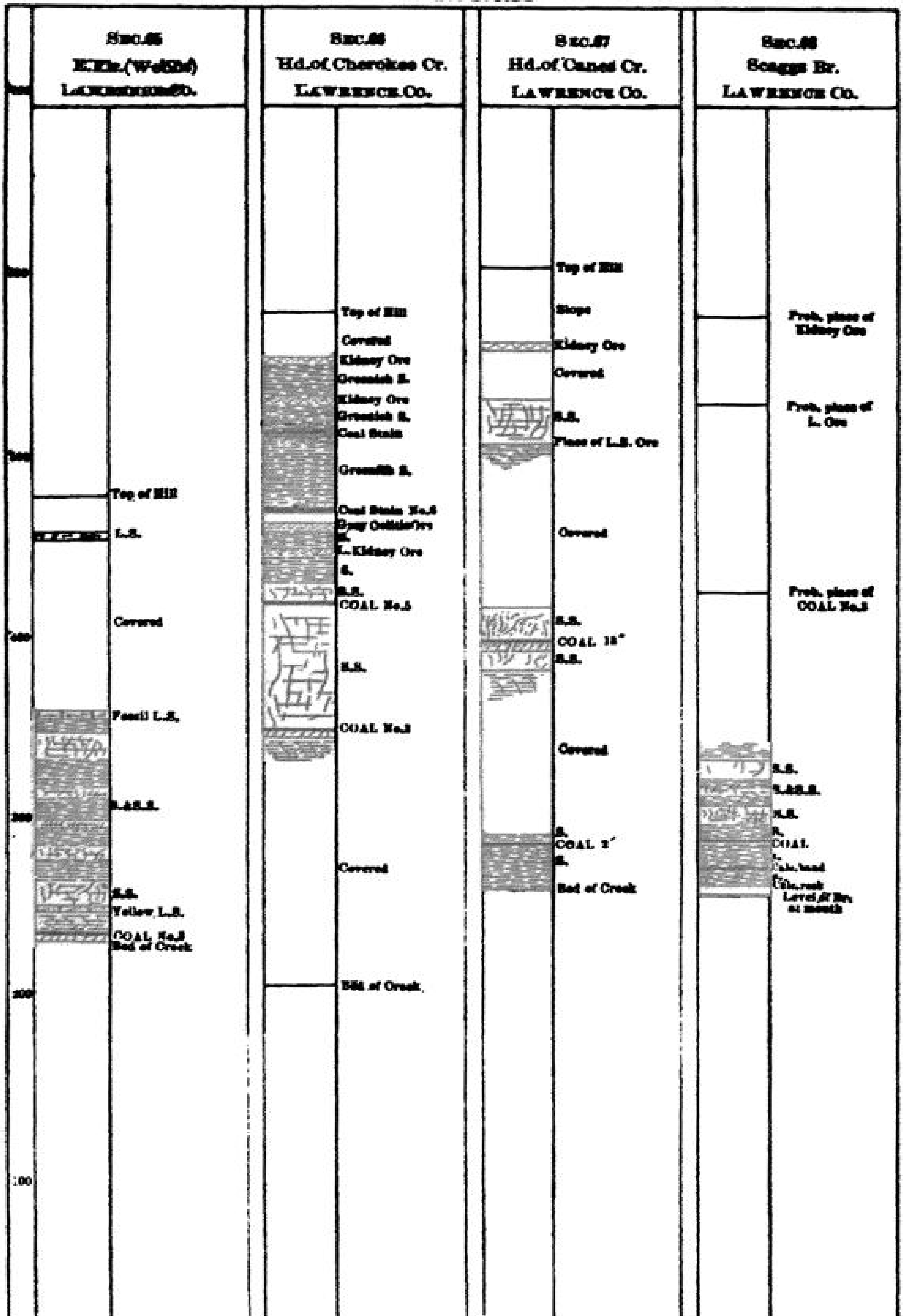
Hd.of Cherokee Cr.
LAWRENCE Co.
Hd.of Canes Cr.
LAWRENCE Co.
LAWRENCE Co.
Top of Hill
L.S.
Covered
Fossil L.S.
S.S.
Yellow L.S.
Bed of Creek
Top of Hill
Covered
Kidney Ore
Greenish S.
Kidney Ore
Greenish S.
Coal Stain
Greenish S.
L.Kidney Ore
S.
S.S.
S.S.
Covered
Top of Hill
Slope
Kidney Ore
Covered
S.S.
Place of L.S. Ore
Covered
S.S.
S.S.
Covered
S.
COAL 2'
S.
Bed of Creek
Prob. place of Kidney Ore
Prob. place of L. Ore
S.S.
S.S.
COAL
Level of Br. at mouth

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Plate 19

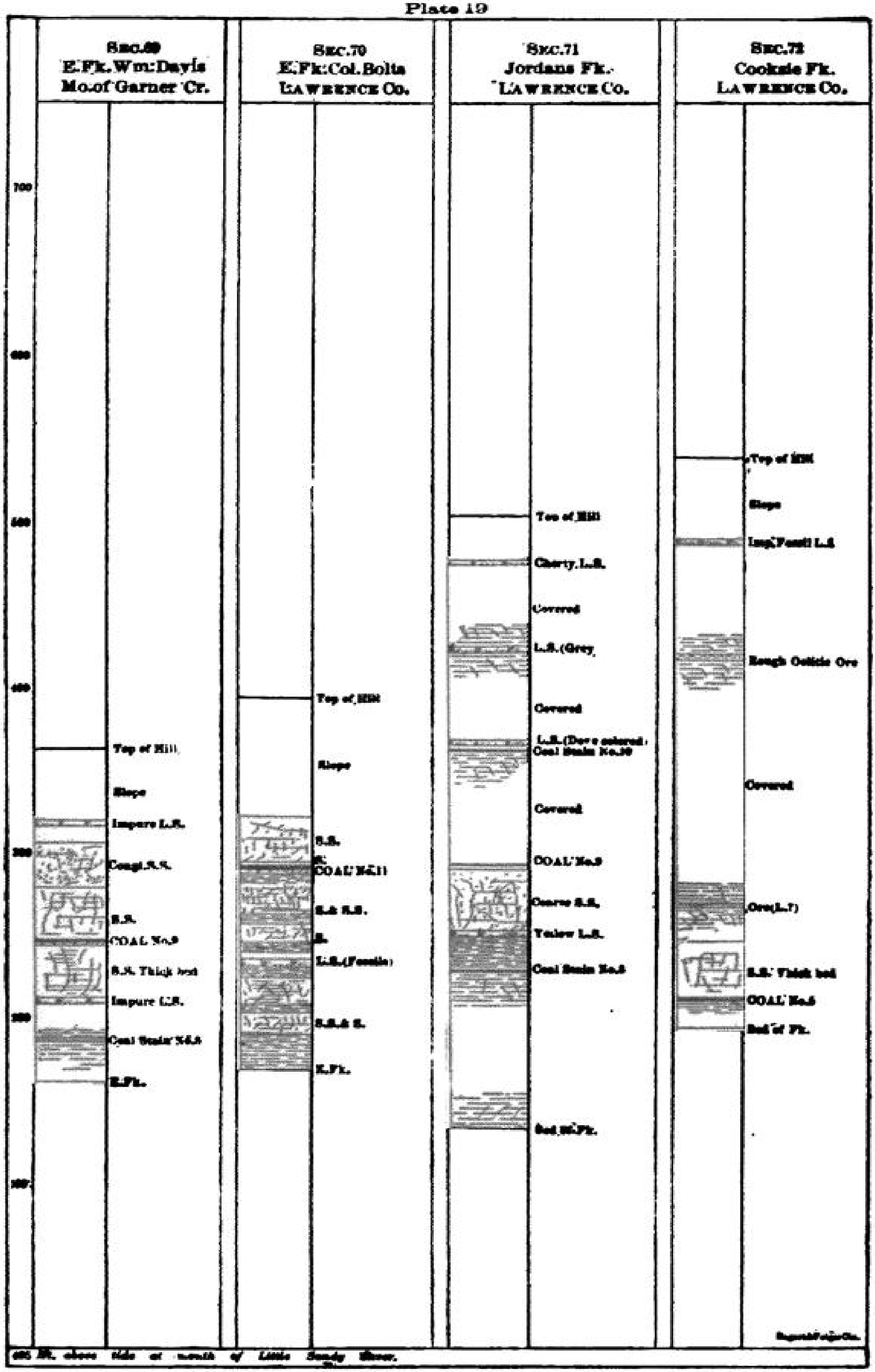
Sec.69
E. Fk. Wm. Davis
Mo. of Garner Cr.
Sec.70
E. Fk. Col. Bolts
Lawrence Co.
Sec.71
Jordans Fk.
Lawrence Co.
Sec.72
Cooksie Fk.
Lawrence Co.
700
600
500
400
300
200
100
Top of Hill
Slope
Impure L.S.
Congl. S.S.
S.S.
COAL No.9
S.S. Thick bed
Impure L.S.
Coal Stain No.8
E. Fk.
Top of Hill
Slope
S.S.
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.7)
S.S. Thick bed
COAL No.8
Bed of Fk.
405 ft. above tide at mouth of Little Sandy River.

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Plate 20

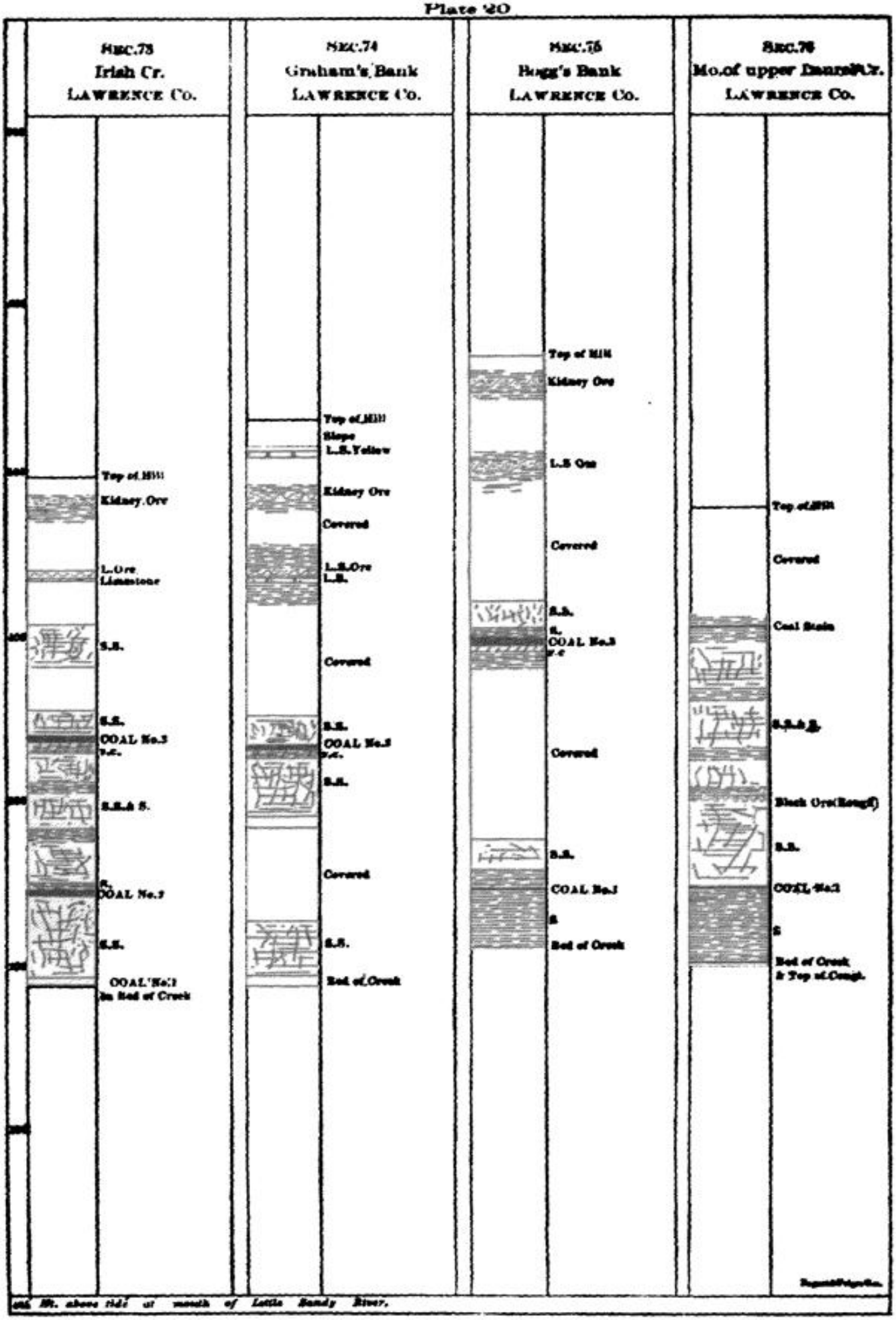
SEC.73
Irish Cr.
LAWRENCE Co.
SEC.74
Graham's Bank
LAWRENCE Co.
SEC.75
Bogg's Bank
LAWRENCE Co.
SEC.76
Mo.of upper Danville
LAWRENCE Co.
Top of Hill
Kidney Ore
L.Ore Limestone
S.S.
COAL No.3
S.S.& S.
COAL No.2
S.S.
COAL No.1 in Bed of Creek
Top of Hill
Slope
L.S.Yellow
Kidney Ore
Covered
L.S.Ore
L.S.
Covered
S.S.
COAL No.3
Covered
S.S.
COAL No.2
S.S.
Bed of Creek
Top of Hill
Kidney Ore
L.S Ore
Covered
S.S.
COAL No.3
Covered
S.S.
COAL No.2
S
Bed of Creek
Top of Hill
Covered
Coal Stain
S.S.& S.
Black Ore(Rough)
S.S.
COAL No.2
S
Bed of Creek & Top of Cough.
Ft. above tide at mouth of Little Sandy River.

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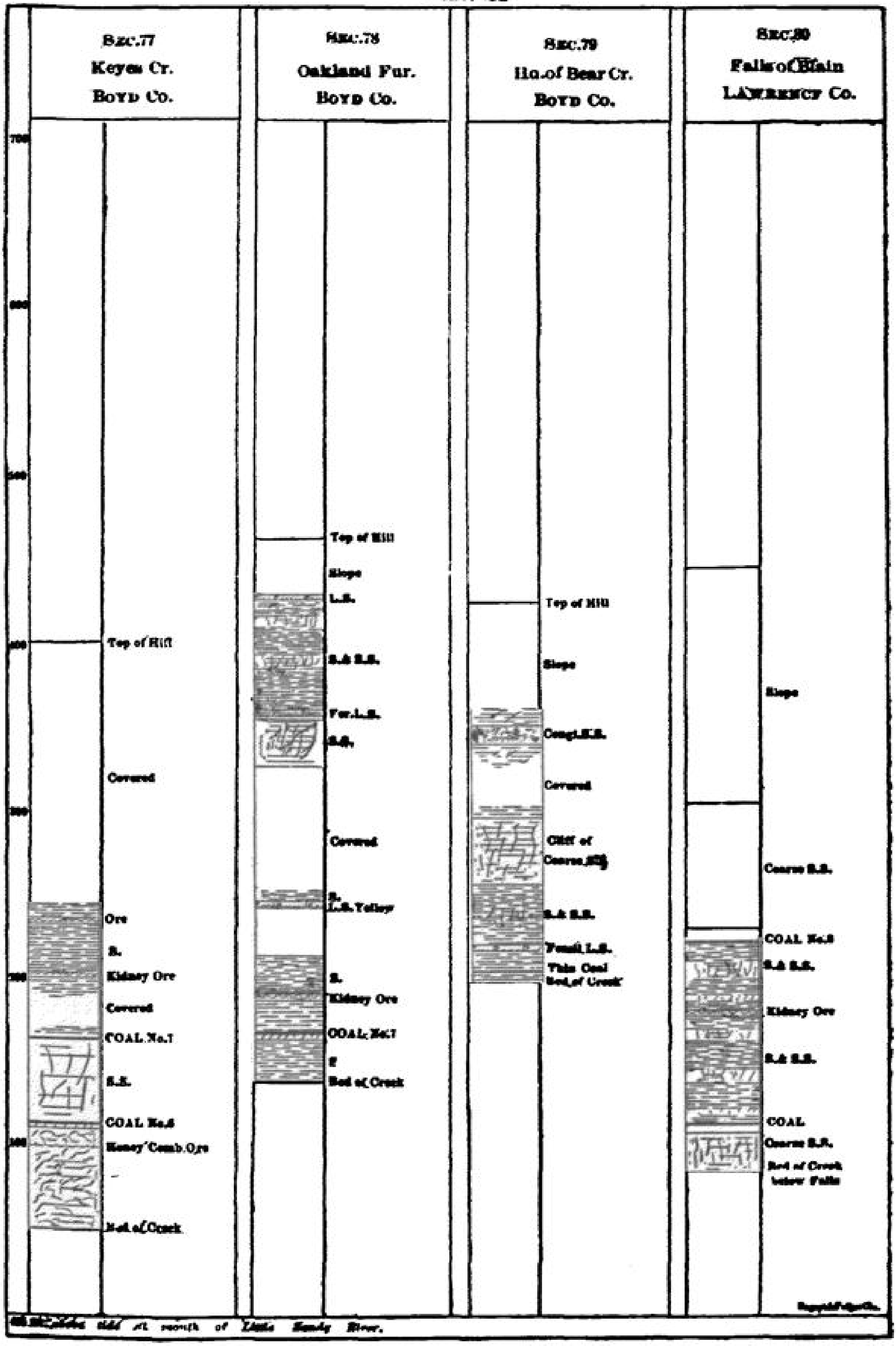
Plate 21



Sec. 77
Keyes Cr.
Boyd Co.
Top of Hill
Covered
Ore
S.
Kidney Ore
Covered
COAL No. 7
S.S.
COAL No. 6
Honey Comb Ore
Bed of Creek
Sec. 78
Oakland Fur.
Boyd Co.
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
Bed of Creek
Sec. 79
Hd. of Bear Cr.
Boyd Co.
Top of Hill
Slope
Congl. S.S.
Covered
Cliff of
Coarse S.S.
S. & S.S.
Fossil L.S.
Thin Coal
Bed of Creek
Sec. 80
Falls of Blain
Lawrence Co.
Slope
Coarse S.S.
COAL No. 8
S. & S.S.
Kidney Ore
S. & S.S.
COAL
Coarse S.S.
Bed of Creek
below Falls
above tide at mouth of Little Sandy River.

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Plate No. 22

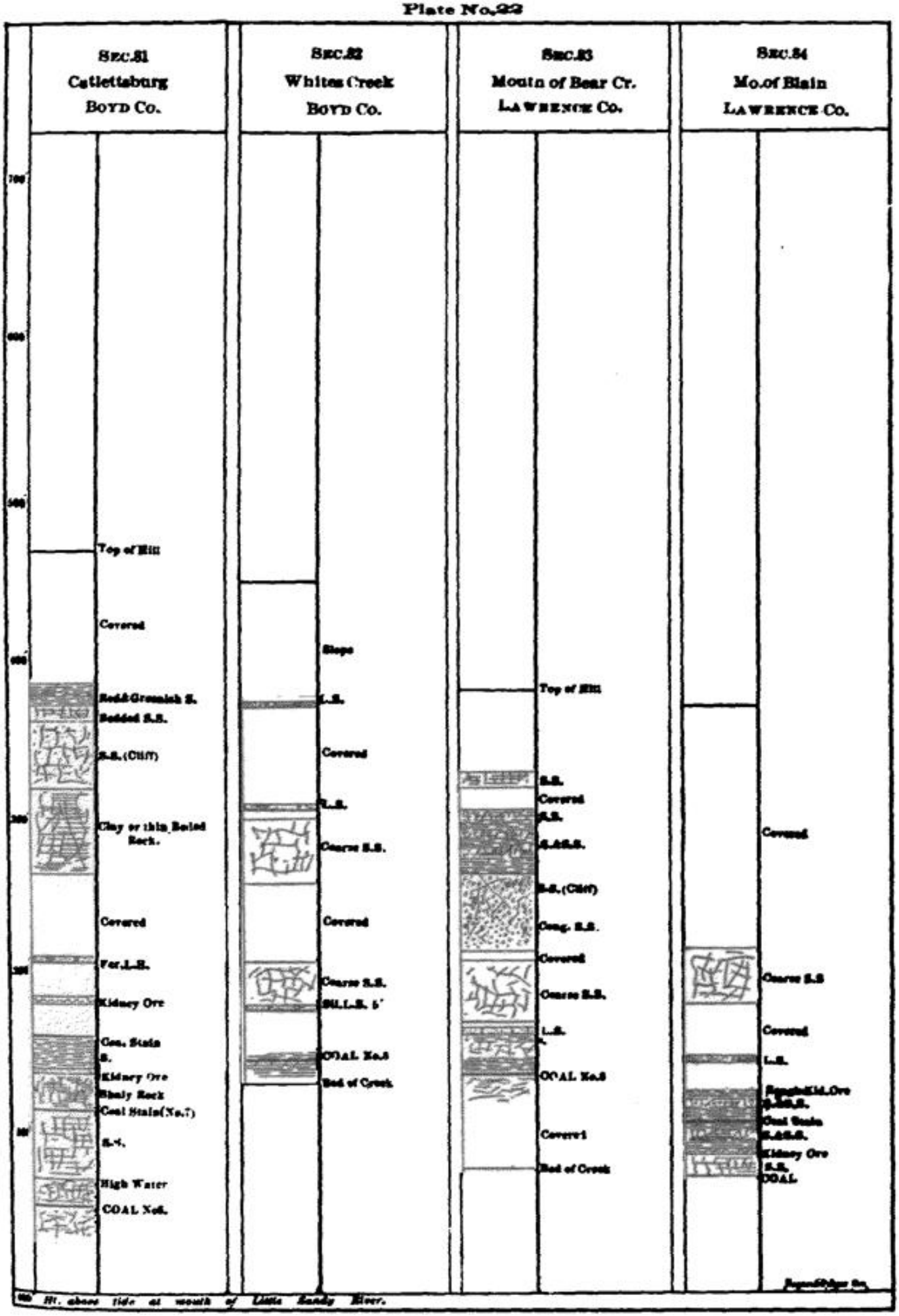
Sec. 81
Catlettsburg
Boyd Co.
Top of Hill
Covered
Red & Greenish S.
Bedded S.S.
S.S. (Cliff)
Clay or thin Bedded Rock.
Covered
Fer. L.S.
Kidney Ore
Gen. Stain S.
Kidney Ore
Shaly Rock
Coal Stain (No. 7)
S.S.
High Water
COAL No. 6.
Sec. 82
Whites Creek
Boyd Co.
Slope
L.S.
Covered
L.S.
Coarse S.S.
Covered
Coarse S.S.
Sh. L.S. 5'
COAL No. 6
Bed of Creek
Sec. 83
Mouth of Bear Cr.
Lawrence Co.
Top of Hill
S.S.
Covered
S.S.
S.S.
S.S. (Cliff)
Cong. S.S.
Covered
Coarse S.S.
L.S.
COAL No. 6
Covered
Bed of Creek
Sec. 84
Mo. of Slain
Lawrence Co.
Covered
Coarse S.S
Covered
L.S.
Kidney Ore
S.S.
Coal Stain
S.S.
Kidney Ore
S.S.
COAL
Ft. above tide at mouth of Little Sandy River.

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Plate 23.

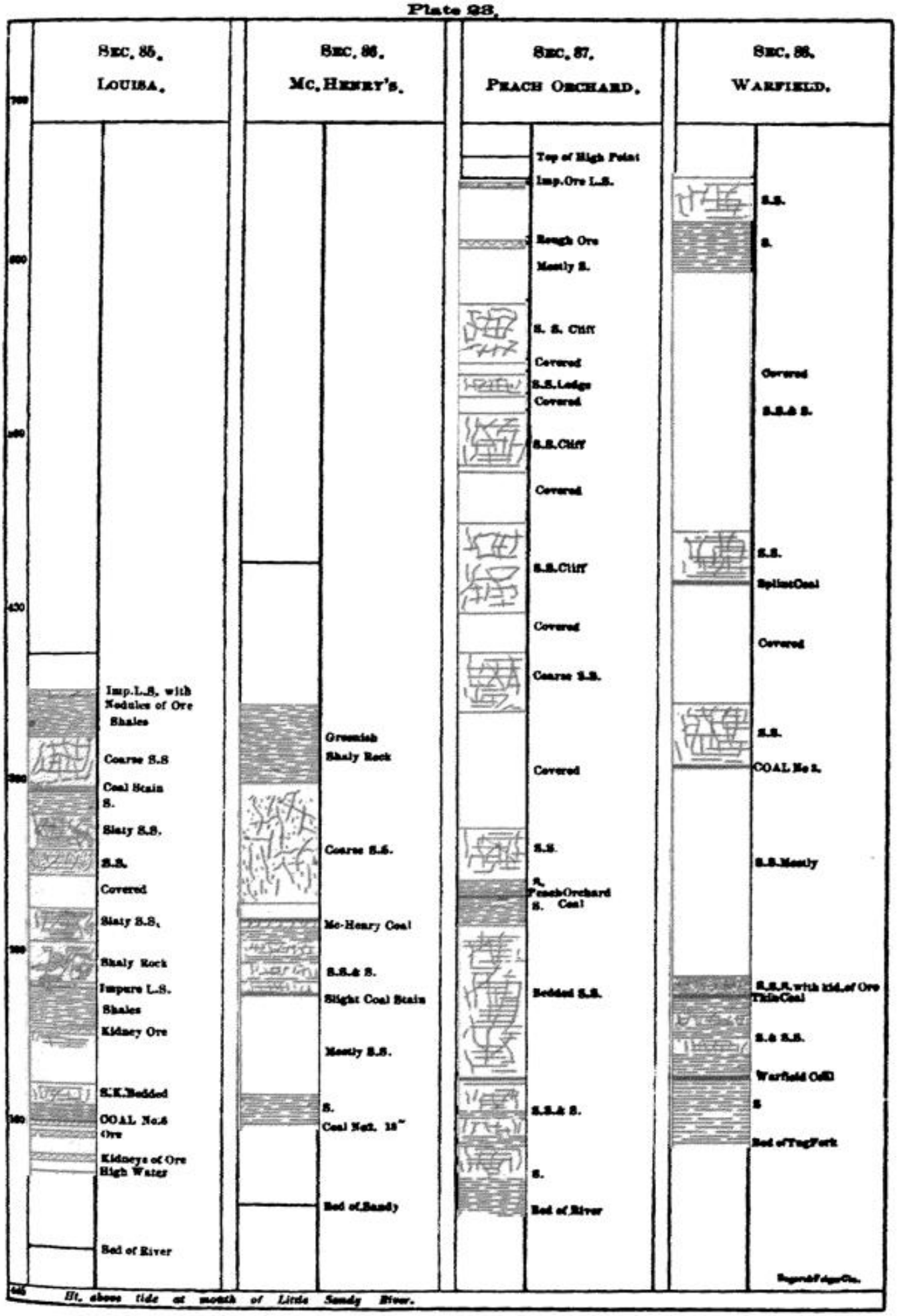
Sec. 85.
Louisa.
Sec. 86.
Mc. Henry's.
Sec. 87.
Peach Orchard.
Sec. 88.
Warfield.
700
600
500
400
300
200
Imp. L.S. with Nodules of Ore
Shales
Coarse S.S
Coal Stain
S.
Slaty S.S.
S.S.
Covered
Slaty S.S.
Shaly Rock
Impure L.S.
Shales
Kidney Ore
S.K. Bedded
COAL No. 6
Ore
Kidneys of Ore
High Water
Bed of River
Greenish
Shaly Rock
Coarse S.S.
Mc-Henry Coal
S.S. & S.
Slight Coal Stain
Mostly S.S.
S.
Coal Nod. 18"
Bed of Sandy
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.
Peach Orchard Coal
Bedded S.S.
S.S. & S.
S.
Bed of River
S.S.
S.
Covered
S.S. & S.
Splint Coal
Covered
S.S.
COAL No 8.
S.S. Mostly
S.S.S. with kid. of Ore
Thin Coal
S. & S.S.
Warfield Coal
S
Bed of Tug Fork
Ht. above tide at mouth of Little Sandy River.

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Plate 24.

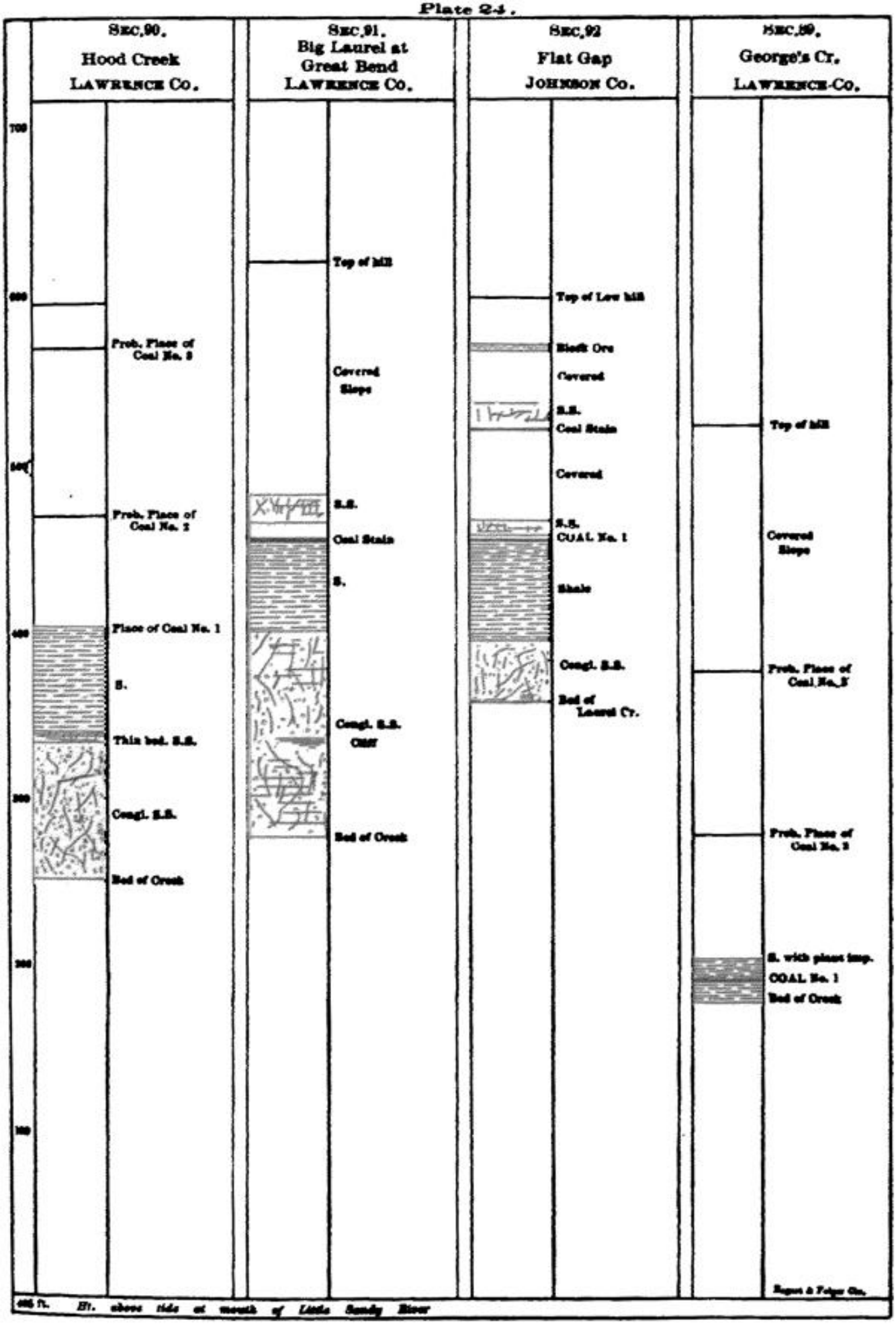
SEC. 90.
Hood Creek
LAWRENCE CO.
Prob. Place of Coal No. 3
Prob. Place of Coal No. 2
Place of Coal No. 1
S.
Thin bed. S.S.
Congl. S.S.
Bed of Creek
SEC. 91.
Big Laurel at Great Bend
LAWRENCE CO.
Top of hill
Covered Slope
S.S.
Coal Stain
S.
Congl. S.S.
Bed of Creek
SEC. 92
Flat Gap
JOHNSON CO.
Top of Low hill
Bloeft Ore
Covered
S.S.
Coal Stain
Covered
S.S.
COAL No. 1
Shale
Congl. S.S.
Bed of Laurel Cr.
SEC. 89.
George's Cr.
LAWRENCE CO.
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
ft. Ht. above tide at mouth of Little Sandy River

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Plate 25.

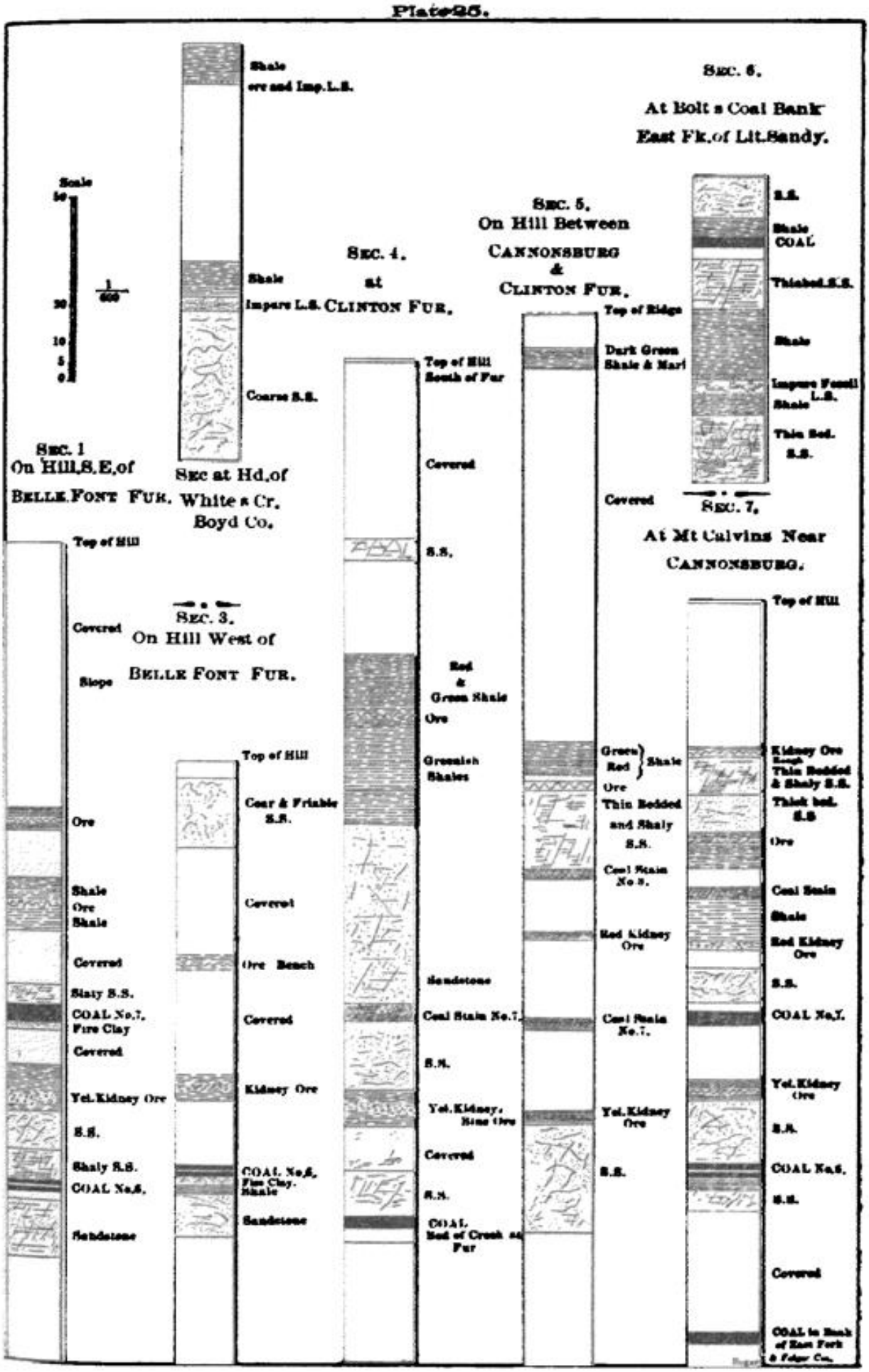
Scale
50
30
10
5
0
1/600
Sec. 1
On Hill, S.E. of
Belle Font Fur.
Top of Hill
Covered
Slope
Ore
Shale
Ore
Shale
Covered
Slaty S.S.
COAL No. 7.
Fire Clay
Covered
Yel. Kidney Ore
S.S.
Shaly S.S.
COAL No. 6.
Sandstone
Sec at Hd. of
White's Cr.
Boyd Co.
Shale
ore and Imp. L.S.
Shale
Impure L.S.
Coarse S.S.
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.
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
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
Thicbed S.S.
Shale
Impure Fossil
L.S.
Shale
Thin Bed.
S.S.
Covered
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
& Edgar Co.

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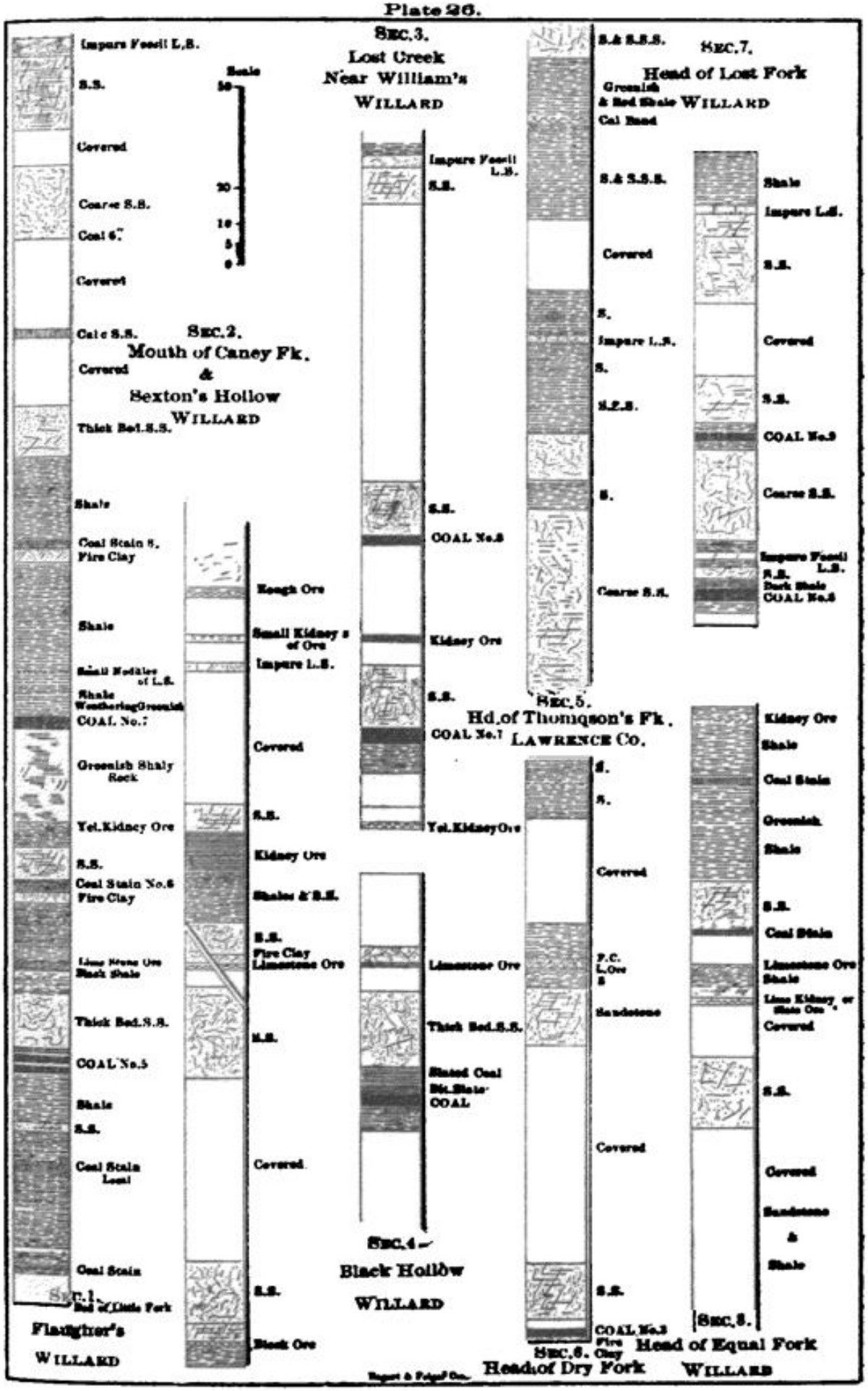
Plate 26.


Impure Fossil L.S.
S.S.
Covered
Coarse S.S.
Coal 6"
Covered
Coal S.S.
Covered
Thick Bed S.S.
Shale
Coal Stain & 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
Coal
Coal Stain
Bed of Little Fork
Flaugher's
WILLARD
Scale
50
20
10
5
0
SEC.2.
Mouth of Caney Fk.
&
Sexton's Hollow
WILLARD
Rough Ore
Small Kidney s of Ore
Impure L.S.
Covered
S.S.
Kidney Ore
Shales & S.S.
S.S.
Fire Clay
Limestone Ore
S.S.
Covered
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. Shale
COAL
SEC.4
Black Hollow
WILLARD
S.& S.S.S.
Greenish & Red Shale
Coal Band
S.& S.S.S.
Covered
S.
Impure L.S.
S.
S.S.S.
S.
Coarse S.S.
SEC.5.
Hd. of Thomqson'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 Shale Ore
Covered
S.S.
Covered
Sandstone & Shale
SEC.8.
Head of Equal Fork
WILLARD

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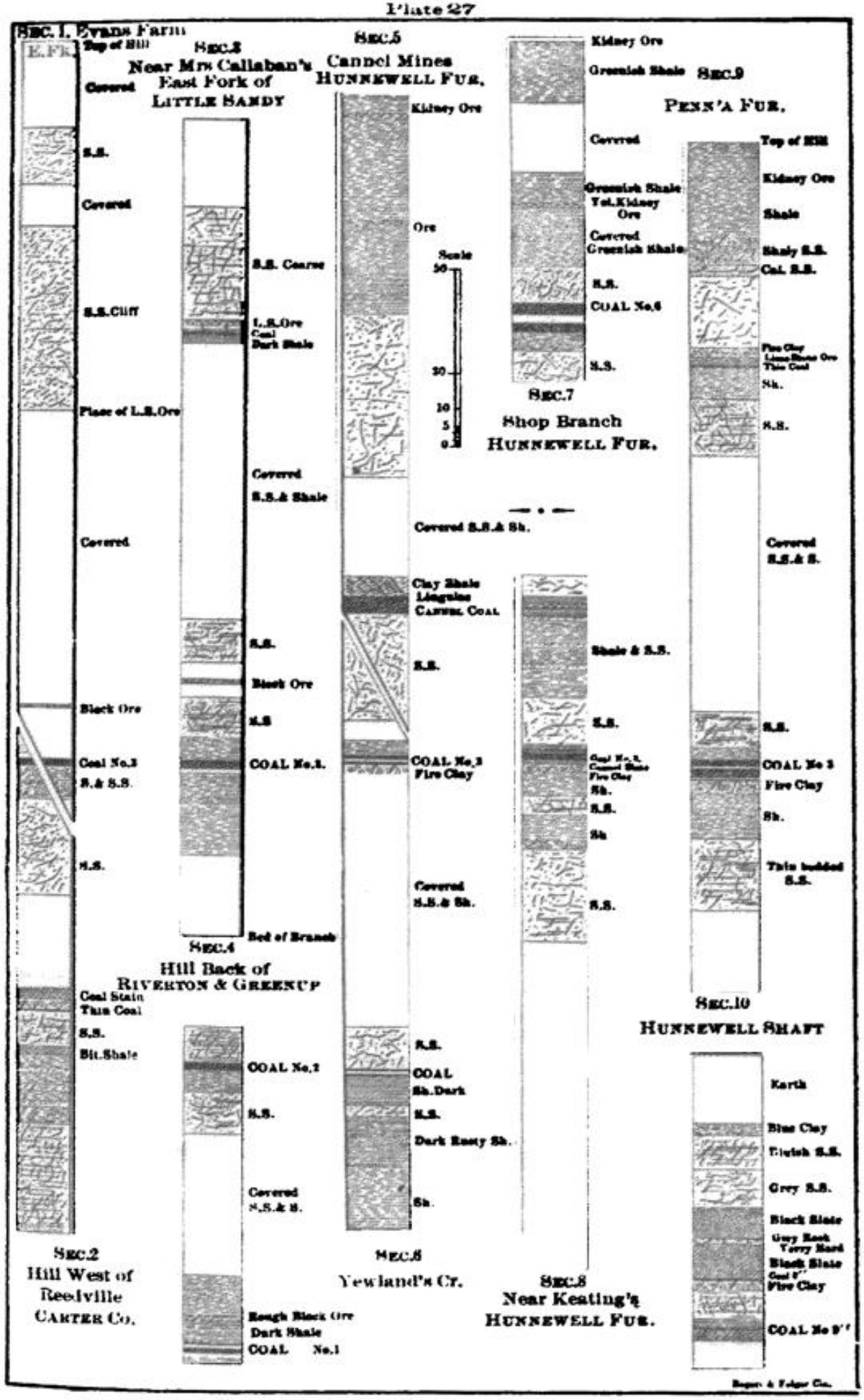
SEC. 1. Evans Farm
E. Fk.
Top of Hill
Covered
S.S.
Covered
S.S. Cliff
Place of L.S. Ore
Covered
Black Ore
Coal No. 3
S. & S.S.
S.S.
Coal Stain
Thin Coal
S.S.
Bit. Shale
SEC. 2
Hill West of
Reedville
CARTER CO.
SEC. 3
Near Mrs Callahan's
East Fork of
LITTLE SANDY
S.S. Coarse
L.S. Ore
Coal
Dark Shale
Covered
S.S. & Shale
S.S.
Black 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
30
10
5
0
Covered S.S. & Sh.
Clay Shale
Limpsine
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
SEC. 9
PENN'A FUR.
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. 5
Cannel Shale
Fire Clay
Sh.
S.S.
Sh
S.S.
SEC. 8
Near Keating's
HUNNEWELL 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
Variab S.S.
Grey S.S.
Black Slate
Grey Rock
Very Hard
Black Slate
Coal 9"
Fire Clay
COAL No 9"

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Plate 28.

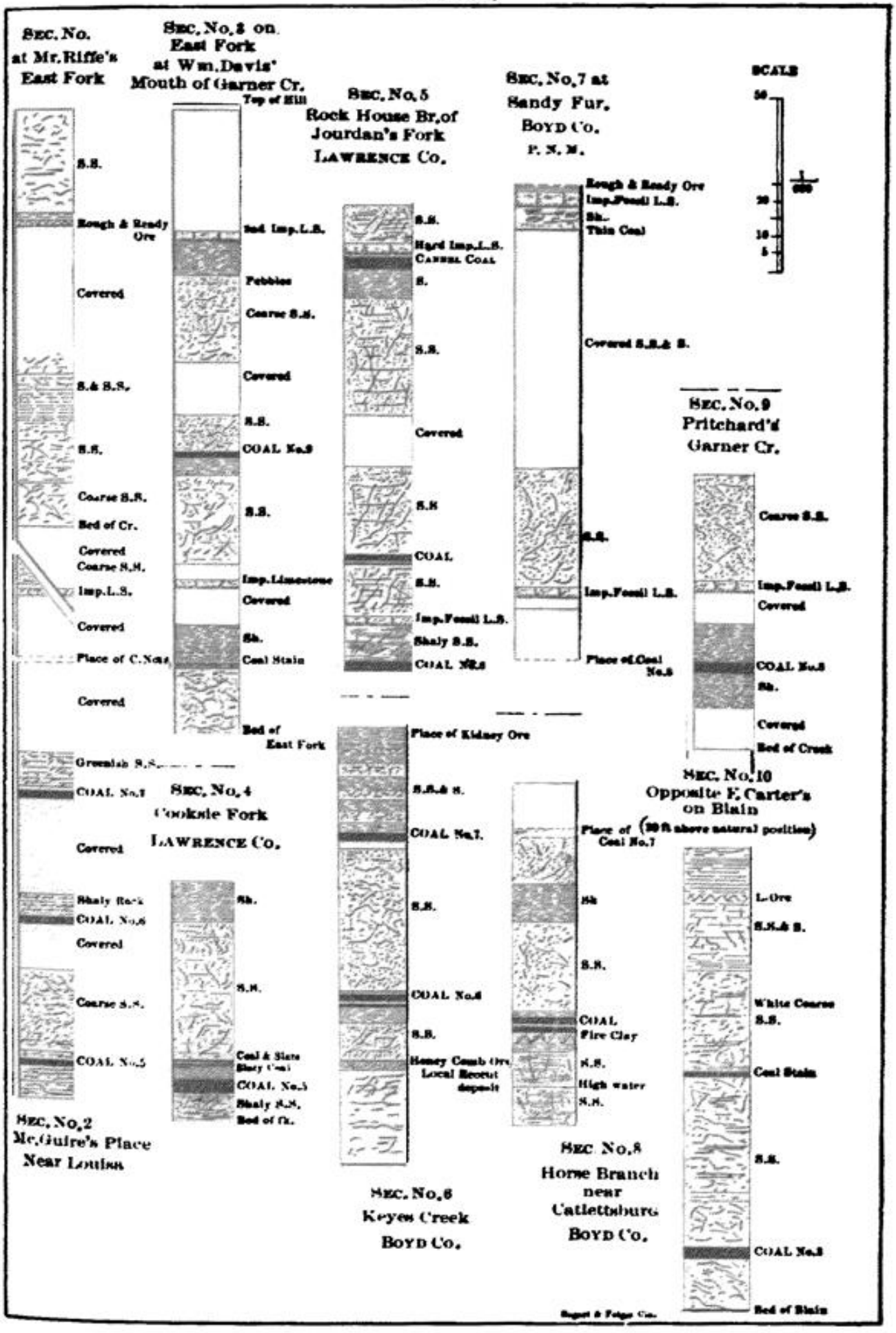
Sec. No. at Mr. Riffe's East Fork
S.S.
Rough & Ready Ore
Covered
S.& S.S.
S.S.
Coarse S.S.
Bed of Cr.
Covered
Coarse S.S.
Imp.L.S.
Covered
Place of C.Nos
Covered
Greenish S.S.
COAL No.1
Covered
Shaly Rock
COAL No.6
Covered
Coarse S.S.
COAL No.5
Sec. No.2
Mc.Guire's Place
Near Louisa
Sec. No.3 on East Fork at Wm. Davis' Mouth of Garner Cr.
Top of Hill
Sod 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 Cr.
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
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
(20 ft above natural position)
Place of Coal No.7
L.Ore
S.S.& S.
White Coarse S.S.
Coal Stain
S.S.
COAL No.8
Bed of Blain
Sugart & Folger Co.

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Plate 29.

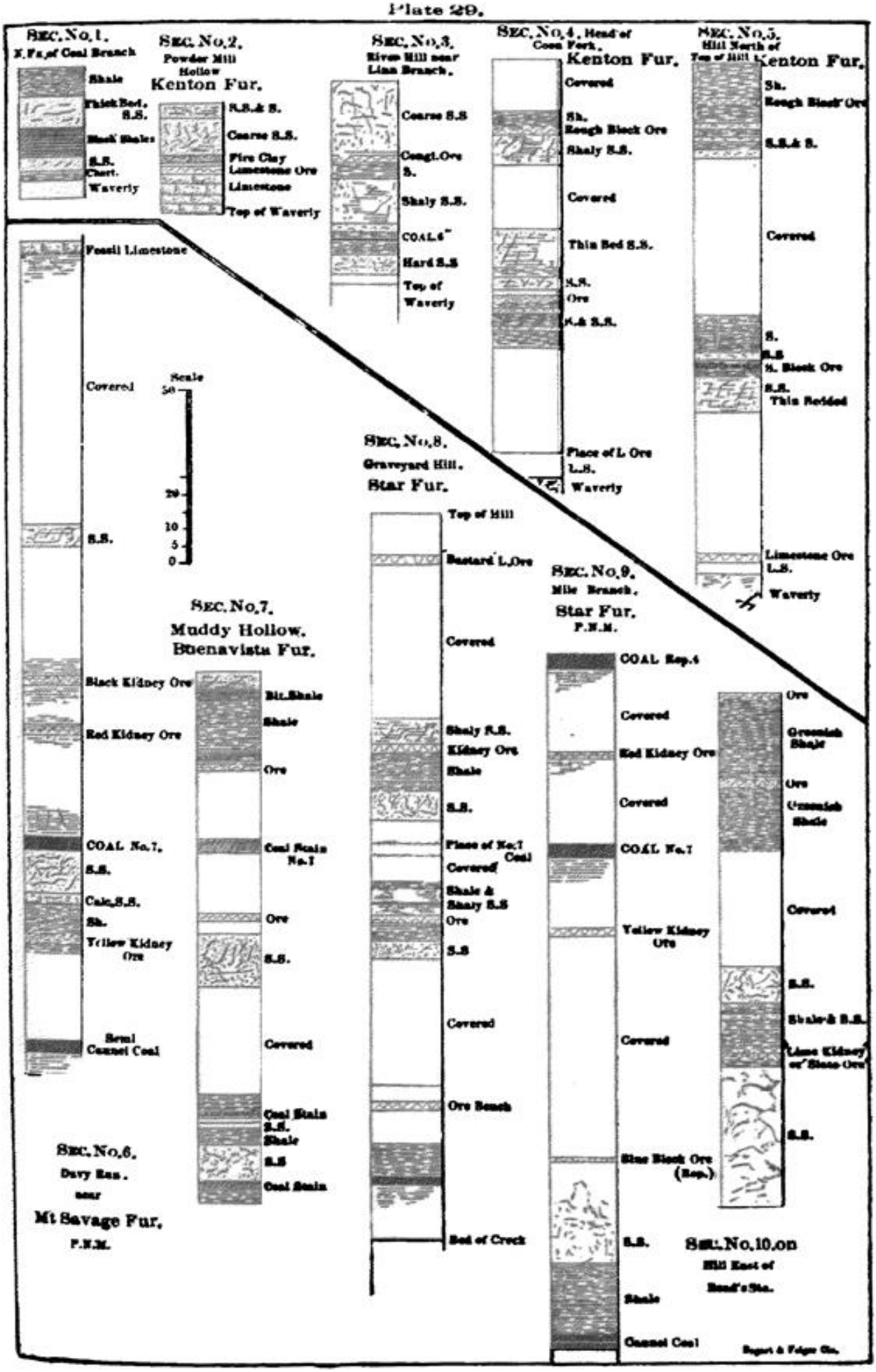
Sec. No. 1.
Sec. No. 2.
Powder Mill Hollow
Kenton Fur.
Sec. No. 3.
River Hill near Linn Branch.
Sec. No. 4. Head of Coon Fork.
Kenton Fur.
Sec. No. 5.
Kenton Fur.
Shale
Thick Bed. S.S.
Black Shales
S.S.
Chert.
Waverly
S.S.& S.
Coarse S.S.
Fire Clay
Limestone Ore
Limestone
Top of Waverly
Coarse S.S
Congl. Ore
S.
Shaly S.S.
COAL 6"
Hard S.S
Top of Waverly
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
Sh.
Rough Block Ore
S.S.& S.
Covered
S.
S.S
Block Ore
S.S.
Thin Bedded
Limestone Ore
L.S.
Waverly
Fossil Limestone
Covered
S.S.
Scale
50
20
10
5
0
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.
F.N.M.
COAL Rep. 6
Covered
Red Kidney Ore
Covered
COAL No. 7
Yellow Kidney Ore
Covered
Blue Block Ore (Rep.)
S.S.
Shale
Cannel Coal
Sec. No. 7.
Muddy Hollow.
Buenavista Fur.
Black Kidney Ore
Red Kidney Ore
COAL No. 7.
S.S.
Calc. S.S.
Sh.
Yellow Kidney Ore
Semi Cannel Coal
Bit. Shale
Shale
Ore
Coal Stain No. 7
Ore
S.S.
Covered
Coal Stain
S.S.
Shale
S.S
Coal Stain
Sec. No. 6.
Davy Run.
near
Mt Savage Fur.
F.N.M.
Ore
Greenish Shale
Ore
Greenish Shale
Covered
S.S.
Shale & S.S.
Lime Kidney or Stone Ore
S.S.
Sec. No. 10. on
Hill East of Bond's Sta.
Report & Edgar Sc.

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Plate 30.

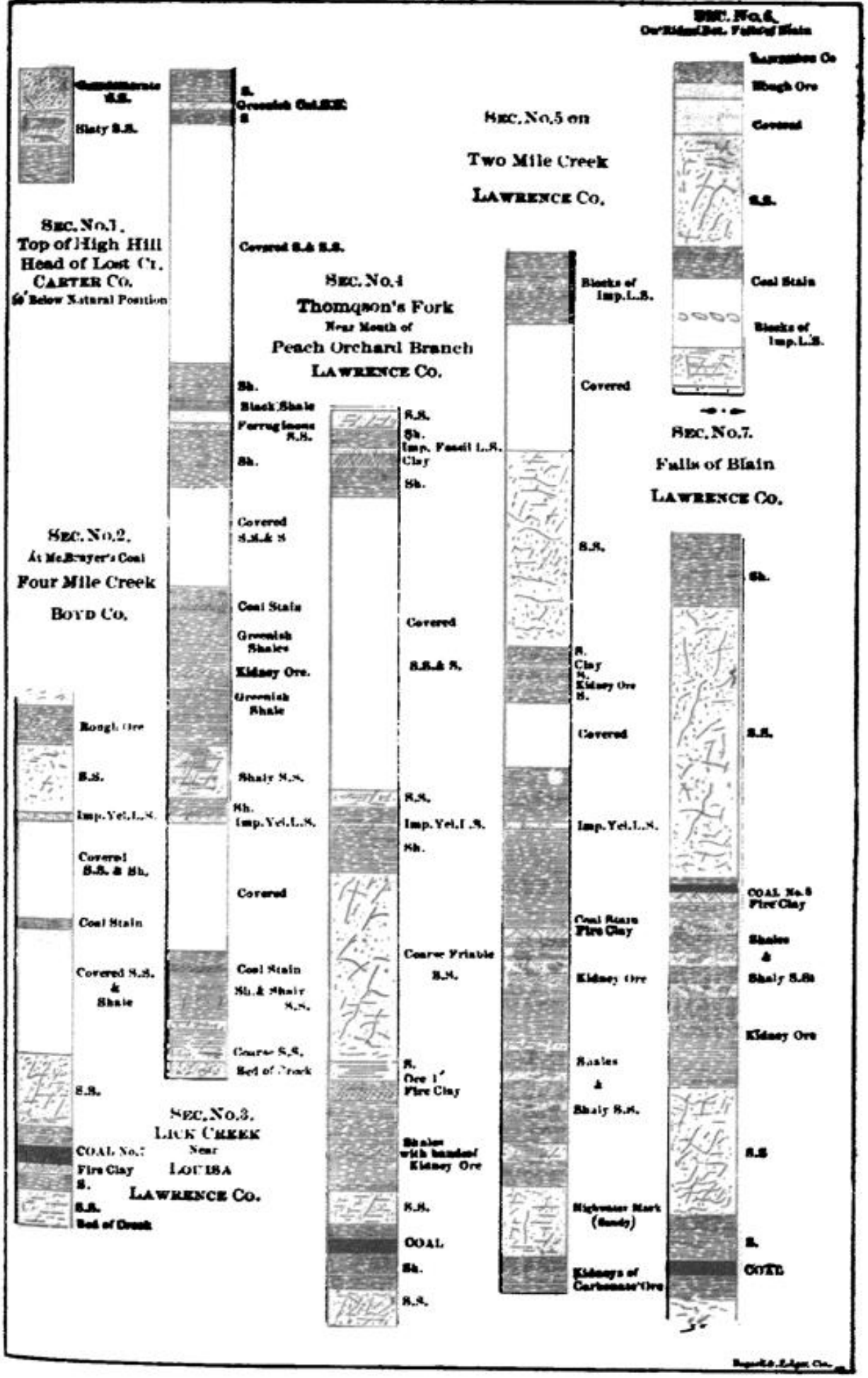
Sec. No.1.
Top of High Hill
Head of Lost Cr.
Carter Co.
60' Below Natural Position
Slaty S.S.
Covered S.S. & S.S.
Sec. No.2.
At McBrayer's Coal
Four Mile Creek
Boyd Co.
Rough Ore
S.S.
Imp. Yel. L.S.
Covered S.S. & Sh.
Coal Stain
Covered S.S. & Shale
S.S.
COAL No.7
Fire Clay
S.S.
Bed of Creek
Sec. No.3.
Lick Creek
Near
Louisa
Lawrence Co.
Sec. No.4
Thompson's Fork
Near Mouth of
Peach Orchard Branch
Lawrence Co.
Sh.
Black Shale
Ferruginous S.S.
Sh.
Covered S.S. & S
Coal Stain
Greenish Shales
Kidney Ore.
Greenish Shale
Shaly S.S.
Sh.
Imp. Yel. L.S.
Covered
Coal Stain
Sh. & Shaly S.S.
Coarse S.S.
Bed of Creek
S.S.
Sh.
Imp. Fossil L.S.
Clay
Sh.
Covered
S.S. & S.
Imp. Yel. L.S.
Sh.
Coarse Friable S.S.
S.
Ore 1'
Fire Clay
Shales with bands of Kidney Ore
S.S.
COAL
Sh.
S.S.
Sec. No.5 on
Two Mile Creek
Lawrence Co.
Blocks of Imp. L.S.
Covered
S.S.
S.
Clay
S.
Kidney Ore
S.
Covered
Imp. Yel. L.S.
Coal Stain
Fire Clay
Kidney Ore
Shales & Shaly S.S.
Highwater Mark (Sandy)
Kidneys of Carbonaceous Ore
Sec. No.6.
Lawrence Co
Rough Ore
Covered
S.S.
Coal Stain
Blocks of Imp. L.S.
Sec. No.7.
Falls of Blain
Lawrence Co.
Sh.
S.S.
COAL No.8
Fire Clay
Shales & Shaly S.S.
Kidney Ore
S.S.
S.
COAL

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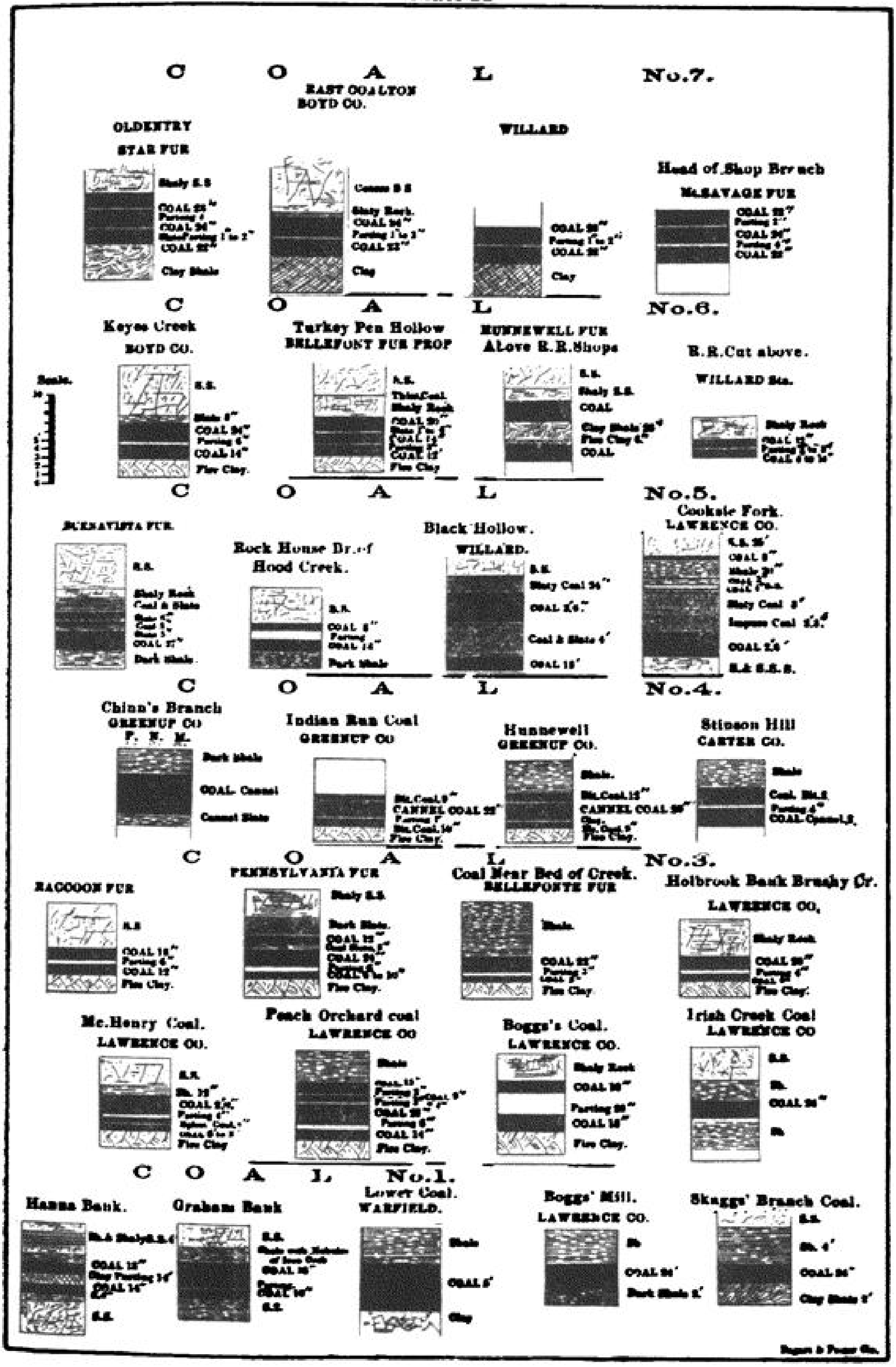
Plate 31


COAL No.7.
EAST COALTON
BOYD CO.
OLDENTRY
STAR FUR
WILLARD
McSAVAGE FUR
COAL No.6.
Keyes Creek
BOYD CO.
Turkey Pen Hollow
BELLEFONT FUR PROP
HUNNEWELL FUR
Above R.R.Shops
R.R.Cut above.
WILLARD Sta.
Scale.
COAL No.5.
Black Hollow.
WILLARD.
Cooksie Fork.
LAWRENCE CO.
Rock House Br. of
Hood Creek.
COAL No.4.
Chinn's Branch
GREENUP CO
Indian Run Coal
GREENUP CO
Hunnewell
GREENUP CO.
Stinson Hill
CARTER CO.
COAL No.3.
RACOOON FUR
PENNSYLVANIA FUR
Coal Near Bed of Creek.
BELLEFONTE FUR
Holbrook Bank Brushy Cr.
LAWRENCE CO,
Mc.Henry Coal.
LAWRENCE CO.
Peach Orchard coal
LAWRENCE CO
Boggs's Coal.
LAWRENCE CO.
Irish Creek Coal
LAWRENCE CO
COAL No.1.
Hanna Bank.
Graham Bank
Lower Coal.
WARFIELD.
Boggs' Mill.
LAWRENCE CO.
Skaggs' Branch Coal.

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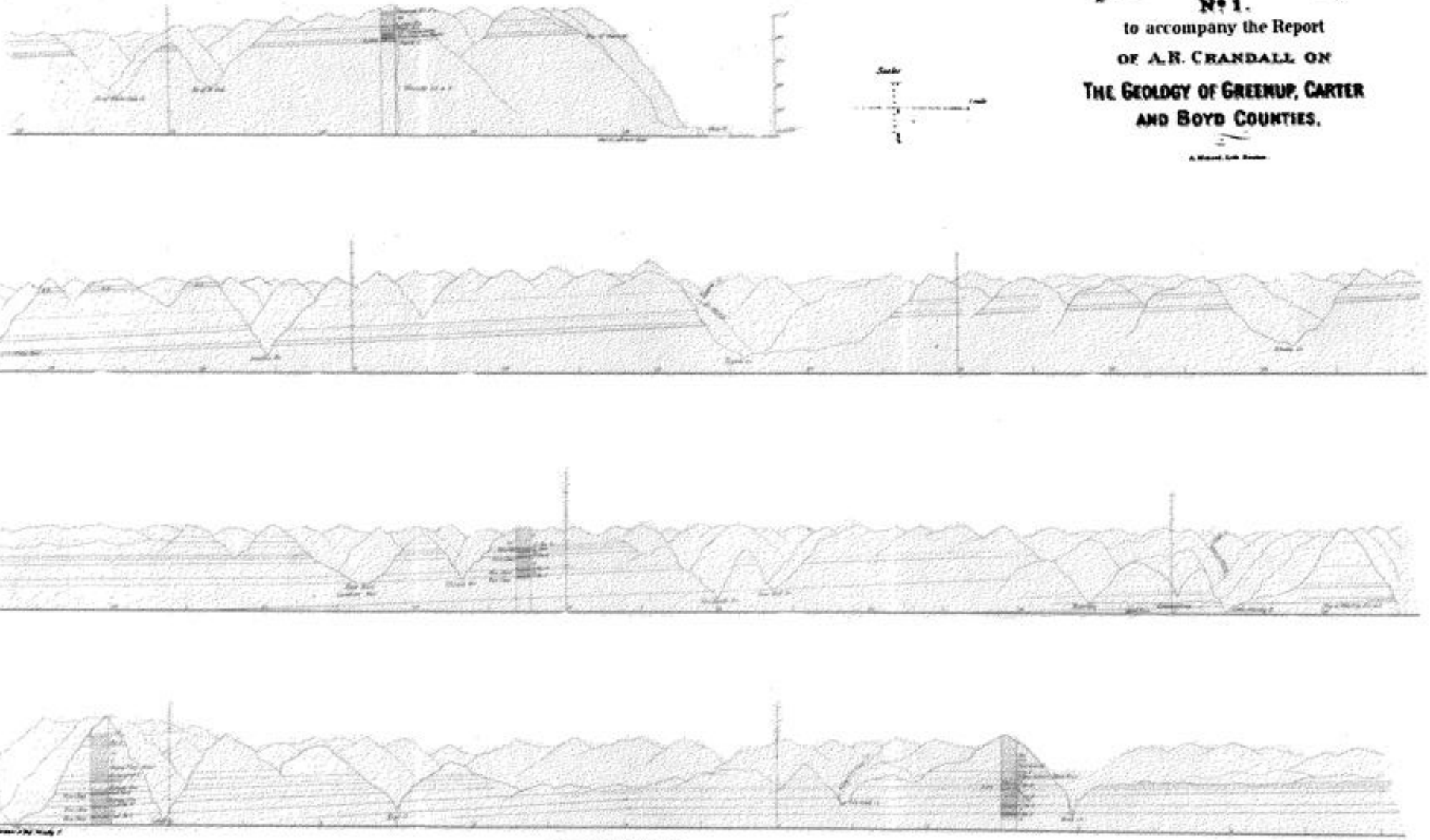
PROFILE SECTION
Nº 1.
to accompany the Report
OF A.R. CRANDALL ON
THE GEOLOGY OF GREENUP, CARTER AND BOYD COUNTIES.



PROFILE SECTION No. 1

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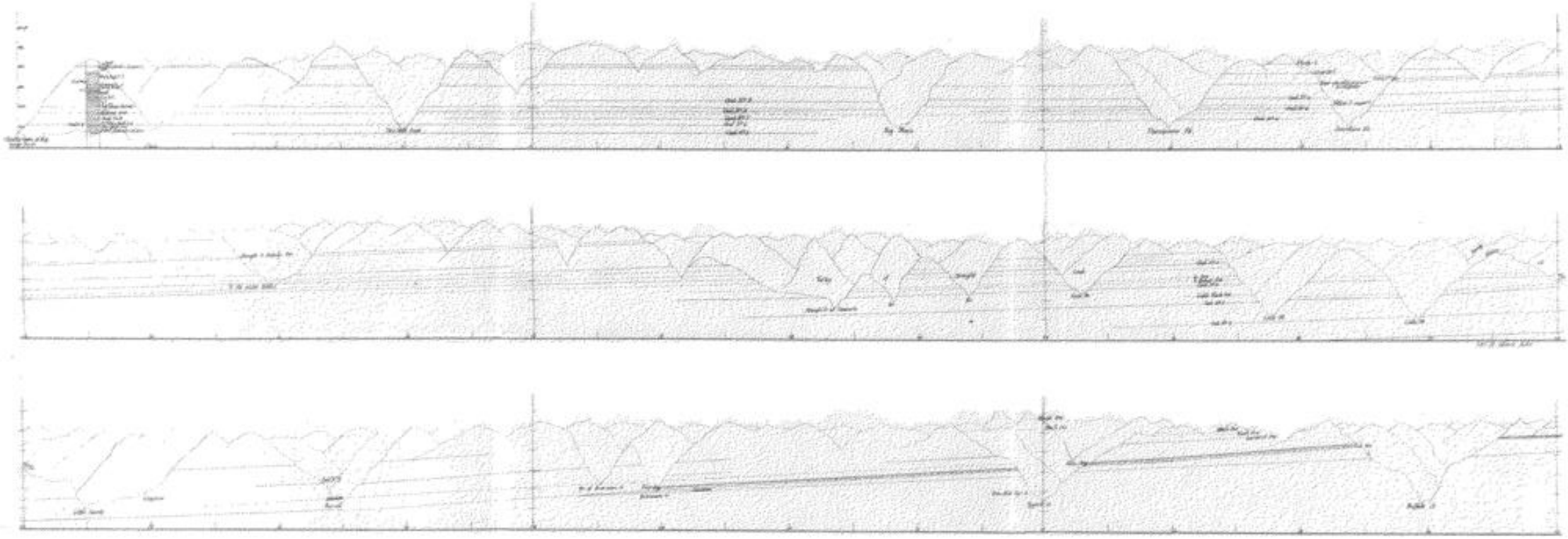

PROFILE SECTION
No 2.
to accompany the Report
OF A.R. CRANDALL ON
THE GEOLOGY OF GREENUP, CARTER
AND BOYD COUNTIES.