

GEOLOGICAL SURVEY OF KENTUCKY.

N. S. SHALER, DIRECTOR.

REPORTS OF PROGRESS.

VOLUME I. NEW SERIES.

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INTRODUCTORY LETTER.

To His Excellency, JAMES B. MCCREARY,

Governor of Kentucky:

SIR: I have the honor to present herewith my Biennial Report on the progress of the Geological Survey. In it will be found a general account of the operations of the Survey during the years 1874 and 1875. The accompanying special reports of myself, my assistants and aids, are submitted in part in a printed form, and part in manuscripts ready for the printer—the whole forming three volumes and a half of reports concerning the economic wealth of the State, and half a volume of the scientific memoirs. When the work now done is completely written up, the fourth volume of reports of the new series, and the first volume of memoirs, will be completed.

The thanks of the Survey are due to the generous citizens, whose names are too numerous for mention, who, by their unfailing kindness, have aided every step of its work. My own gratitude is due, in large measure, to the officers of the Survey, who, by their unfaltering diligence, have made it possible for me to do far more than I expected to accomplish with the limited means that have been at my command.

I am, sir, most respectfully,

Your obedient servant,

N. S. SHALER,

Director of the Kentucky Geological Survey.

FRANKFORT, 27th December, 1875.

III & IV

PREFACE TO FIRST VOLUME.

The reports contained in this volume represent a part of the work done by the Geological Survey in the years 1873 and 1874. The order, or rather lack of order, in the succession of the reports, and the somewhat peculiar paging of the volume, demand some explanation. These volumes of reports are meant to give the results of the field and office work of the Survey quite without order of arrangement, the succession of the reports in the volumes being determined solely by the time at which the work was ready for the press. It is expected that these reports will serve only as preliminary studies of the economic geology of the State. When the work of research is complete, the general and economic geology can then be treated in a connected manner. The scientific papers, which are not distinctly connected with the economic interests of the State, will be printed in quarto form apart from the other reports. This separation is deemed desirable on many accounts.

The system of pagination, wherein the top of the page gives the paging for the separate reports, while the bottom shows the order in the volume, though a great variation from the plan usually followed in such work, has the countenance of the most skillfully conducted geological surveys. The separate publication of the several reports which compose the volumes of the Survey, in order that any memoir or report may be purchased without paying for the other parts of the volume, has served to make this method of paging quite necessary. In accordance with this plan, the reports of the Survey will be furnished in two shapes—as separate reports, each containing the maps and other illustrations connected therewith, and as volumes, each containing about five hund-

red pages of matter. The plates in the volumes of reports are not numbered in connective series, but separately for each report. This also was made necessary by the adoption of the plan of separately printing each report.

At the present writing the following reports and memoirs have been prepared for the press, or are in an advanced state of preparation:

VOLUME I. NEW SERIES.

- PART I. Report on the Timber Growth of Greenup, Carter, Boyd, and Lawrence Counties, in Eastern Kentucky. By N. S. Shaler and Assistant A. R. Crandall.
- PART II. Report of the Botany of Barren and Edmonson Counties. By John Hussey, Botanical Assistant. With an Introduction by N. S. Shaler.
- PART III. Report on the Iron Ores of Greenup, Boyd, and Carter Counties, the Kentucky Division of the Hanging Rock Iron Region. By P. N. Moore, Assistant.
- PART IV. Chemical Report of the Soils, Marls, Clays, Ores, Coals, Iron Furnace Products, Mineral Waters, &c., &c., of Kentucky. By Robert Peter, M. D., &c., &c., Chemist to the Kentucky Geological Survey. Assisted by John H. Talbutt, S. B., Chemical Assistant. The First Chemical Report in the New Series and the Fifth since the beginning of the Survey.
- PART V. The Iron Manufacture of the Kentucky Division of the Hanging Rock Iron Region. By P. N. Moore, Assistant.
- PART VI. Report on the Geology of the Region adjacent to the Louisville, Paducah and Southwestern Railroad, with a Section. By Chas. J. Norwood, Assistant.
- PART VII. Report of a Reconnaissance in the Lead Region of Livingston, Crittenden, and Caldwell Counties, including a sketch of their General Wealth. By Chas. J. Norwood, Assistant.

This volume is already stereotyped.

VOLUME II. NEW SERIES.

- PART I. Report on the Geology of Greenup, Carter, and Boyd Counties, and a part of Lawrence. By Assistant A. R. Crandall.
- PART II. On the Geology of the Edmonson Coal and Iron District. By P. N. Moore, Assistant, and J. R. Proctor, with Map by W. B. Page, Assistant, C. W. Beckham, and John B. Marcou, Aids.
- PART III. On the Chemistry of the Hemp Plant. By Dr. R. Peter, Principal Chemist of the Survey.
- PART IV. On the Airdrie Furnace. By P. N. Moore, Assistant.
- PART V. Topographical Report of W. B. Page, Assistant, for the year 1874.
- PART VI. On the Geology of the Line of the Proposed Railway from Livingston Station to Cumberland Gap. By A. R. Crandall and C. J. Norwood, Assistant.
- PART VII. Geology of the Henry County Lead District. By N. S. Shaler and C. J. Norwood, Assistant.
- PART VIII. On the Geology of the proposed Lexington and Big Sandy Railway. By Assistant A. R. Crandall.

This volume is partly stereotyped.

VOLUME III. NEW SERIES.

- PART I. Report of N. S. Shaler, Director of the Survey, on the Conduct of the Survey for 1873.
 - PART II. Biennial Report of N. S. Shaler, Director of the Survey, for the years 1874 and 1875, giving a summary account of the principal economic results of the Survey during those years.
 - PART III. Notes on the various Problems encountered in the prosecution of the Kentucky Geological Survey. By N. S. Shaler.
 - PART IV. Plan for the organization of a State Cabinet. By N. S. Shaler.
 - PART V. Description of the Preliminary Map of Kentucky. By N. S. Shaler.
- This volume is partly stereotyped.

VOLUME IV. NEW SERIES.

- PART I. Second Chemical Report of Dr. R. Peter and Assistant John H. Talbutt.
- PART II. Report on the Geology of the Counties of Bath, Menifee, Powell, and Lee. By Assistant A. R. Crandall.
- PART III. Report on the Iron Ores in the Region near Cumberland Gap. By P. N. Moore, Assistant.
- PART IV. Report of the Results of a Reconnaissance of the State Line from Cumberland to Pound Gap, and on a Line from Abingdon, Virginia, to Mount Sterling, Kentucky. By P. N. Moore, Assistant.
- PART V. Report on the Breckinridge Coal Mines. By C. J. Norwood, Assistant.
- PART VI. Report on the Geology of the Kentucky Red River Iron District. By P. N. Moore, Assistant.
- PART VII. Preliminary Report on the Geology of Martin County. By A. R. Crandall, Assistant.
- PART VIII. Report on the Geology of the North and South-running Railways of Western Kentucky. By C. J. Norwood, Assistant.
- PART IX. Topographical Report of W. B. Page, Assistant, for 1875.

MEMOIRS OF THE GEOLOGICAL SURVEY OF KENTUCKY.

Volume 1st, 1876, contains Memoirs on various Scientific Questions illustrative of the Geology of the State.

- ✓ PART I. On the Antiquity and History of the Caverns of the Ohio Valley. By N. S. Shaler.
- ✓ PART II. On the History of the Buffalo, with special reference to the Fossils found at Big Bone Lick. By J. A. Allen.
- PART III. On the Brachiopods of the Cincinnati Group of the Upper Cambrian. By N. S. Shaler.
- PART IV. On the Prehistoric Remains of Kentucky. By Assistant Lucian Carr and N. S. Shaler.
- PART V. On the Prehistoric Cavern Dwellers of the Edmonson County Cave District. By F. W. Putnam, Assistant.
- PART VI. On the Zoölogy of the Cavern Districts of Kentucky. By A. S. Packard and F. A. Sanborn, Assistants.

This volume is partly stereotyped, and the plates are ready.

The order of arrangement of the reports in the second and fourth volumes, as well as their titles, may vary somewhat from the list as above given; but the changes will be only

matters of detail. It is expected that all of the above matter will be printed by September, 1876.

The acknowledgments of the Survey, as far as it is possible to give them, for the many favors it has received at the hands of individuals and corporations within or without the State, will be expressed in the Biennial Report of the Director.

The law under which this present Survey acts requires that it shall be a continuation of that begun by Dr. Owen. This requirement has determined the order in which the work has been taken up. By comparison with the reports made under the direction of Dr. Owen, it will be seen that the Survey has been reinstituted on the ground and with the objects which guided him in his incomplete work. The later volumes will show less effect from this limitation.

It is but justice to the Survey to say, that the means at its disposal have been exceedingly limited. The total amount appropriated for all the expenses of the years 1874 and 1875 was thirty-three thousand five hundred dollars. Out of this sum the costs of maintaining a force averaging twelve assistants and aids, the expenses of the State Cabinet, of exhibitions at Louisville, a chemical laboratory, the outfit of camps, instruments, &c., and all the expenses of preparing the results for publication, including the making of lithographic and stereotype plates. Only the most rigorous economy has made it possible to do the large amount of field work that has been done during the last two years; and this saving has been brought about by the devotion and self-sacrifice of my coadjutors of the Survey, who have not only been willing to labor for small compensations, but have unhesitatingly adapted themselves to the rude and comfortless life which has necessarily been followed in order to secure economy and convenience in the work.

N. S. S.

DECEMBER, 1875.

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.*
ALPHEUS SPRING PACKARD, JR., *Assistant in Entomology, temporary.*
FRANCIS SANBORN, *Assistant in Zoölogy, temporary.*
FREDERICK WARD PUTNAM, *Assistant in Ichthyology, temporary.*
JOHN HUSSEY, *Assistant in Botany.*
LUCIAN CARR, *Assistant in Ethnology.*
JOHN HOLLIDAY TALBUTT, *Assistant in Chemistry.*
JOHN ROBERT PROCTER, *Assistant in Geology.*
WILLIAM CUTTER MITCHELL, *Assistant in Topography.*
LEOPOLD TROUVELOT, *Artist of the Survey.*

AIDS.

CHARLES WICKLIFFE BECKHAM.
JOHN ADAIR MONROE.
JOHN BELKNAP MARCOU.
ANTHON LEO JONAS.

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GEOLOGICAL SURVEY OF KENTUCKY.

N. S. SHALER, DIRECTOR.

REPORT ON THE FORESTS

OF

GREENUP, CARTER, BOYD & LAWRENCE COUNTIES.

BY N. S. SHALER AND A. R. CRANDALL.

PART I. VOL. I. SECOND SERIES.

REPORT ON THE FOREST TIMBER
OF
GREENUP, CARTER, BOYD & LAWRENCE COUNTIES.

INTRODUCTION.

The questions, both scientific and economic, which are connected with our forests, are at once numerous and of very great value. The student finds himself led to the study of the laws determining the growth and succession of the trees; the way in which they are connected with the underlying rocks; the history of their creation or appearance in their present places, and many other similar matters. Some of this class of questions are purely scientific; that is to say, they do not connect themselves with any immediate monetary result. The plan of this Survey contemplates their study quite as much as if they were of pecuniary value; but these scientific results will find their place in the memoirs of the Survey which will be specially devoted to purely scientific matters, while the reports are to be given to the questions of economic value. It must not be supposed, however, that the separation of these two classes of treatises will be absolute; science is so far the handmaiden of the arts that it must always go with them if they are to retain their best value. The reader will, for instance, notice, that along with the common names of the trees in this report are given also the scientific names of the species. In no other way would it be possible to make it certain just what sort of tree was meant by the name; for the familiar name of a tree may vary from place to place, while the scientific name is the same for all countries, and enables us to designate the given kind of tree, so that all botanists can make sure of it. The way in which the timber is distributed, with reference to the underlying rock and the quality of the soil, are also

questions at once scientific and economic in their value. These are only a small part of the questions where the scientific and the practical values come together, but they serve in a small way to show the essential connection between the two.

Hitherto all the descriptions given of forest timber have been very indeterminate, as far as concerns the size and number of the different kinds of trees on given areas. In laying out a plan for the work of the Kentucky Survey, it seemed desirable to take an account of our forests in such a fashion that it would be possible to obtain precise statistics concerning every important feature capable of being accurately measured. It was obviously necessary to count the number of trees to the acre on several different exposures in each district, taking account of the different species, so as to show their relative proportions and average size. Mr. Crandall has been charged with the execution of this plan, and he has perfected it in several essential particulars. His method of indicating the distribution of the species of trees on different slopes of the same hill is entirely original, and expresses the facts in an admirable manner. It is in the plan of the Survey to carry this same system of delineation over the whole of the State, with a view to give a record of the present condition of our forests, in order that their changes in coming time may be determined, and especially that their economic value may be properly appreciated. I am satisfied that, by properly husbanding our timber resources, they will in fifty years become one of the most important of the varied sources of wealth to our State. A large part of the eastern coal-field of Kentucky is not tillable land. The lofty and rugged ridges between the valleys are natural nurseries of timber. While they will not serve for other forms of cultivation, they will yet do admirably for the raising of many of the most valuable woods for our various arts. So large a part of the Valley of the Ohio is arable land, that the future sources of timber for its use are very limited. They will be found in the lofty ridges of the Apalachian Mountains where the steepness of the slopes will forbid plow tillage.

I deem it quite likely that within the time of the next generation these hill lands will become as valuable for timber-raising as the average lands of the valley are for other forms of culture. They are naturally suited to all the most valuable woods of the Mississippi Valley. At the present value of black walnut, an acre of this timber forty years old, growing as thickly as it is able to stand, should be worth several hundred dollars; of hickory and locust of second growth the value is about as great. There are few crops of the ordinary soil which will give as great average returns when labor and interest are deducted. A very great advantage in our Kentucky forests is the comparative immunity from fires. In most valuable timber regions this danger is so great as to reduce the value of such lands as investments. In many thousand miles of travel through the timbered districts of Kentucky, I have never seen an acre of forest seriously damaged by fire. In the present state of our American life, when men are hardly willing to wait for the yearly harvests to mature, it seems almost too much to hope for the far-seeing thrift that will look forward to fruits to be gathered at the end of forty years; yet these enterprises that take hold on a distant future will become more attractive, with a growth of capital and an increase of confidence in life. But in fact a large part of the value of such growths as our forests would give when artificially planted would be immediate; at five years young hickories have a value; and the trees removed by trimming out each year, should pay an interest on investment. The black locust becomes valuable in ten years, or nearly as soon as a pear orchard, and for thirty years thereafter should give a steady supply of timber. With each succeeding year these woods become more and more valuable as the original forests become stripped of their scanty supply. The best black walnut is already priced with mahogany in Europe, bringing several dollars per cubic foot. The abundant water-ways of the Ohio Valley will always make its regions of permanent forests of peculiar value.

There is another and most important reason for retaining the forest covering of our eastern hills. The surface of that

country is so rugged that nearly seven eighths of its area lies in slopes of great steepness. If stripped of their timber, the water will not lie on these slopes much longer than on the house tops.

By the forest covering a large part of the water is retained as by a sponge, and is allowed to filter away slowly into the streams. A heavy rain of say five inches in depth, falling within say two days, will have at least one half of the precipitated water retained for some days in the mat of decaying leaves of the forest, which would otherwise be precipitated at once into the streams. To strip away the forests is to double the amount of water thrown at one stroke into the rivers. A glance at the map of the Big Sandy or Chatterawha Valley will show that this stream has a great many branches, and gathers the water from about five thousand square miles of mountainous country. Every part of this area is made up of narrow valleys and steep hillsides. As it is, the floods of the Lower Sandy rise to about fifty feet above the low-water stage of the river, and are formidable in their violence. If the country should ever become stripped of its timber, the consequences would be disastrous in the highest degree. Some of the valleys of a similar character in Europe, which have been recklessly stripped of their timber, have become almost devastated by the violence of the floods. There are several such cases in France where the soil has been in good part stripped away since the timber was removed, and the government has been compelled to intervene in order to restore the forests. When this restoration has been accomplished, an immediate change for the better has been brought about. Thus we see that there are two good reasons for endeavoring to retain the forests of the Big Sandy Valley. Firstly, that they may remain a source of supply for valuable timber, which each year must enhance in price on account of the increasing population of the Ohio and Mississippi Valleys; secondly, on account of the safety of the agricultural and mining interests of the region which must be located along the valleys, and thus be in great danger from any increase of the floods which now sweep them.

It may be urged in addition that the best interests of this valley demand that the streams, even to their second and third branching, should be used as a means of bringing out the mineral and timber stores. This will require the extensive use of locks and dams; and these structures, already difficult to construct on account of the violence of the floods, would become quite impossible if their force is increased, as it will be by the destruction of the forests. The mineral region of Eastern Kentucky has a precious heritage in its forests, ores, and coals. All the skill of legislation, and all the discretion of private enterprise, should be directed to securing the best products from these resources, avoiding destructive waste. This cannot be done except by preserving the forests without great reduction from their present area. If the State, or the counties thereof, still own large tracts of forest timber, it would be clearly in the line of true policy to retain those areas as public domains in the interest of coming generations. Throughout Switzerland and other parts of Europe the communal forests, rarely large in area, are the most precious of the public domains. From them the citizens derive in many cases sums so large as to form a considerable element in their private revenues. Every county in our mountain districts that will put aside as public land ten thousand acres of forest, worth to-day as many dollars, will, at the end of a century, have a princely domain. There is, in a word, no gift that the present generation can make to the future so precious and so noble as untouched areas of our magnificent forests. For us it requires little forbearance to spare what will be to them a most precious heritage.

N. S. SHALER.

INTRODUCTORY LETTER.

Professor N. S. SHALER,

Director of the Kentucky Geological Survey:

The accompanying brief report on the Timber of Eastern Kentucky is made up from observations made during the progress of the geological work in the field which it includes. The work on which it is founded is, therefore, secondary, and somewhat unsatisfactory in details. It may serve, however, as an introduction to a study of the forest growth of this section.

A. R. CRANDALL,
Assistant Ky. Geological Survey.

REPORT ON THE TIMBER GROWTH OF GREENUP, CARTER, BOYD & LAWRENCE COUNTIES, IN EASTERN KENTUCKY.

By A. R. CRANDALL.

The timber of Eastern Kentucky might, from its suitability to meet two classes of wants, be considered with reference to use in iron-making, or as fuel; and with reference to the uses which give rise to a demand for lumber and other forest products. Following this division of the subject, a very large proportion of the forest growth would fall under the latter heading. But as practically the purpose to which it will be turned depends not so much on the character of the timber itself as on the character of the demand for it—a demand shaped largely by such accidents as the facilities, or want of facilities for transportation—it will be as well, perhaps, to treat the subject in a more general way, or simply as to the kinds of forest trees and their distribution.

The difficulties which now stand in the way of bringing the more valuable timber of Eastern Kentucky into market, inevitably turn it to furnace use where furnaces are within reach; and where neither furnaces nor marketing facilities give immediate value to the forests, the timber that is not burned in the ordinary process of clearing and fencing land, or that is not wantonly destroyed, awaits the developments of time only to determine whether the more valuable part shall be turned to use in a wide range of wood manufactures, or consumed indiscriminately with the rest in the smelting of the ores which abound in this region.

The subject may be conveniently divided, however, so as to present it with reference to a number of questions which naturally arise with the study of the forest growth. After the occurrence of species, the number and size of the various trees, of scarcely less importance is their geographical distribution; the effect of varying surface conditions, as found in a hilly country, and also the effect of varying exposure. Not altogether foreign to an economic view of the subject is the question of geological distribution, or the assemblages of species on particular geological formations. It is possible that generalizations may be reached by which the forest growth will give an important clue to geological formations. A sufficient number of observations have not yet been made to warrant such generalizations for this field. But it is important that the facts should be so recorded as to facilitate a careful study in this direction, when additional data shall have been gathered from a wider range of country. This branch of the subject will, therefore, be left for future treatment.

No complete list of the kinds of trees found in this section can yet be given, as, indeed, only a beginning has been made in so considerable a task as is involved in even a preliminary study of the forest trees of so extended and so varied a field. Still enough has been done to foreshadow good results, both economic and scientific.

In the presentation here made, it is taken for granted that the value of the different kinds of wood for the various purposes to which they are suited, is too well known to require special mention. For the present also the question of facilities for transportation and marketing will be left to the enterprising, in the hope that a simple statement of facts will serve equally well to encourage practical solutions of the question to the advantage of all parties interested.

The accompanying tables show approximately the relative abundance of the more common species of trees. These tables are made up from studies made partly by Mr. J. A. Monroe and partly by myself. The timber on an acre (estimated or paced) is included in each observation; and when

practicable, observations were made so as to give an account of the number of trees representing each species. — First, in the bed of the valley, including also, in most cases, about an equal area of slope; second, the side hill at that part of the slope which appeared on all accounts to be most nearly a medium between hill-top and valley; and third, the top of the hill or ridge, including more or less slope. The tables are so arranged as to give the relative abundance of different species for a number of localities at these levels. The per cent. of each species in a given locality, the per cent. of each species at the several levels for all localities included, and the per cent. of each species in the whole timber growth of the country, are also given; the counts chosen being regarded as representative for this part of Eastern Kentucky. It should be remarked here that in some instances an unusual growth of certain species, from some cause to which it is important to call attention, has been included; but with such qualifications as are made in the general mention of species, the tables will be found reasonably correct.

TABLE I.—Old Forest Growth.

SPECIES.	Near head of Irish Creek, Lawrence County.			Blain, 1 mile above mouth of Cherokee Creek, Lawrence Co'ty.			Little Fork of Little Sandy, Graham Hill, Carter Co'ty.			Various localities in Carter, Lawrence, and Boyd.			Slash Branch Laurel Furnace Land, Greenup Co.		
	Per cent. for locality.	Top of hill (horizon of C. No. 7), 250 to 300.	Hillside (horizon of No. 3 C.), 100 to 150, S. W. ex.	Per cent. for locality.	Top of hill (horizon of C. No. 7), 300 to 350.	Hillside (above C. No. 3), S. E. exposure.	Per cent. for locality.	Kidge (horizon of C. No. 8), 300 to 350 above drainage.	Hillside (horizon of L. ore), 150 to 200.	Per cent. for locality.	Divide between Chadwick's and White's creeks, 350.	Head of Lost Fork (Mahoning S. S.), 200, W. exposure.	Per cent. for locality.	Valley (horizon of Cong. S. S.), valley.	Hill (above Cong. S. S.).
White oak	14 20 25 .224	6 25 2 .140	13 35 .157	14 3 13 .140	12 17 8 .177										
Black oak	25 10 .133	3 10 .055	5 11 20 .118	4 12 .075	3 6 10 .091										
Chestnut oak	25 .080	9 48 .243	5 72 .252	4 30 .159	4 17 .100										
Post oak															
Other oaks	6 .023	2 1 .013	1 .003	5 .023	3 .014										
Beech	25 .095	51 3 .229	37 10 .154	16 .075	14 11 .120										
Maple	10 .038	4 5 3 .051	26 2 .092	25 3 .131	4 3 .033										
Chestnut		6 .026	4 .013	4 6 .045	4 .12 .077										
Hickory	25 15 .152	12 21 .140	7 16 4 .095	5 4 .042	10 8 3 .100										
Yellow poplar		3 4 .030	6 3 .029	6 .028	7 4 8 .091										
Gum	3 .011	8 .034	3 6 .029	4 5 2 .057	2 2 3 .033										
Ash		2 .009	1 2 .010	4 3 .033	1 .										
Linden			1 .003	4 8 .056	4 .019										
Sycamore	5 .019														
Buckeye		2 .009													
Elm			1 .004												
Black walnut		2 .017	1 .003	4 .019	2 .010										
White walnut															
Hemlock	18 .068														
Pine	31 10 .156			15 .070	6 .029										
				7 .033	6 .029										

TABLE I.—Old Forest Growth—Continued.

SPECIES.	Raccoon Furnace Lands, Greenup Co.			East Fk., near Cannonsburg, Land of V. Calvin, Boyd County.			Ellington's, Bear Creek, Boyd County.			Per cent. for all localities—valley.	Per cent. for all localities—hillside.	Per cent. for all localities—top of hill.	Per cent. for all localities.
	Per cent. for locality.	Top of hill (horizon of C. No. 3), 300 feet above drainage.	Hillside (between C's No. 2 and No. 3, 200).	Per cent. for locality.	Top of hill (horizon of C. No. 3), 300	Hillside (horizon of No. 8 C.), 100 to 150 S. E. ex.	Per cent. for locality.	Top of hill (above Mahoning S. S.), 300 to 350	Hillside (horizon of Mahoning S. S.), 150 to 250				
White oak	14 17 13 .187	17 19 12 .195	15 19 12 .152	14 9 12 .149	237 .129	.171							
Black oak	12 11 17 .170	12 10 9 .126	11 14 20 .149	.061	.129	.164							
Chestnut oak		1 7 8 .065			.044	.297							
Post oak		3 4 .028		8 .026		.018							
Other oaks	8 14 .090	8 7 5 .081	4 4 10 .060	.017	.046	.055							
Beech	9 12 2 .089	23 .093	21 9 .100	.278	.069	.119							
Maple	3 3 .026	6 9 .061	4 5 .030	.116	.046	.005							
Chestnut	4 9 .055	2 3 2 .028	4 4 6 .046	.020	.032	.053							
Hickory	4 4 9 .072		9 10 .063	.030	.120	.100							
Yellow poplar	13 4 .072	4 7 6 .069	12 14 5 .102	.064	.058	.035							
Gum	3 8 .047	6 3 .037	4 3 4 .036	.031	.046	.026							
Ash			4 4 .026	.007	.018	.006							
Linden	3 2 .021		6 .020	.026	.015	.014							
Sycamore	8 .034	13 .053	9 .030	.062		.022							
Buckeye	7 .030		3 .010	.021		.007							
Elm	3 4 .030	14 8 .089	4 .013	.037	.021	.020							
Black walnut	3 6 .038	3 .012	7 5 .040	.026	.023	.003							
White walnut		2 .008	3 .010	.007		.002							
Hemlock				.047	.009	.019							
Pine	8 .034	4 9 .053	9 17 .086		.067	.106							

Table I is made up from counts of old forest trees. Table II of second growth.

It will be noticed that the white oak (*Quercus alba*, L.) has a wider range and a greater development in numbers than any other species. In size, it ranks with the largest of the hard wood trees, often reaching a diameter of three and a half feet. It is probable that, along with its adaptation to a wide range of surface conditions in its growth, there is some variation in the quality of the wood; but it occurs in nearly all valleys, and well up on the slope of most hills, in such size, and apparently of such quality, as is usually sought after for the purpose for which it is most valued. In many instances of growth on a southern or southwestern exposure, it is comparatively small in size. The same may be said of the tops of many hills; but the average size and height is such as to warrant a very liberal estimate, wherever the forest remains, for that alone which is available for lumber. In point of number the white oak makes up about seventeen per cent. of the forest growth. Its large average size gives it still greater prominence.

The black oak or yellow bark oak (*Quercus tinctoria*, Bertram.) has a range not unlike the preceding. It also constitutes a large per cent. of the forest growth. A considerable number of smallish trees, which doubtless represent to some extent a second growth, are included in most of the observations of Table I, giving undue prominence to this species. It will be noticed that, in the table of second growths, it is still more prominent, showing an adaptation to a wide range of surface conditions. It would seem from these observations that the black oak is less fitted by the strength and durability of its wood to attain great age than is the white oak, though instances are not wanting in which it reaches a size equally as large.

The chestnut oak (*Q. castanea*?) often predominates on the ridges, extending its range downward in a rapidly decreasing proportion, rarely being found in the valleys. In this section, while it frequently attains a large size, it is generally inferior in height to the white or black oak. This is doubtless owing

partly to exposure to sweeping winds, and partly to the rocky character of the ridges on which it abounds. Further back in the country, and especially as noted on Laurel Mountain, where it is abundant over the greater part of the slope, the chestnut oak is not inferior in height to any of the oaks. While this is suggestive as to the cause of the disparity in height noted in the field covered by this report, it also gives rise to questions relating to its distribution, questions which may, however, with the suggestion, be left for further investigation.

The post oak (*Q. obtusiloba*, Michx.), a tree of medium size, is less abundant. It is found in various exposures in scattered growth. Its wood is very close, hard, and durable.

The other oaks noted, but which, for want of accurate distinction in some of the counts, are thrown together in the tables, are the red oak (*Q. rubra*, L.), which is abundant in many places. It reaches dimensions scarcely less imposing than those of the white and black oak.

The Spanish oak (*Q. falcata*, Michx.), which occurs mostly as second growth, but also as large trees, especially in Lawrence county.

The laurel oak (*Q. imbrecaria*, Michx.) also occurs in small size at a number of points in each county. Along Blain, and especially for some distance above the Falls, trees of large size are found.

The black jack or barren oak (*Q. nigra*, L.) occurs in various exposures, but mostly on the more barren and rocky slopes.

The oaks constitute about forty-two per cent. of the forest trees.

The beech (*Fagus ferruginea*, Ait.) ranks with the chestnut oak in abundance; but in distribution it is quite unlike that tree, being found mostly along the foot of the hills. It sometimes becomes prominent well up the slope, and not unfrequently occurs in scattered growth along the highest ridges. It often shows a diameter of three feet, and is on many accounts one of the most interesting trees in this section.

The maple is also abundant in some valleys, having a range not unlike the beech. The sugar tree or rock maple (*Acer*

saccharinum, Wang.) makes up a very large proportion of the maples. Along the banks of streams the white maple (*Acer dasycarpum*, Ehrhart) is common, while an occasional red maple (*A. rubrum*, L.) is found, as also the ash-leaved maple (*Negundo aceroides*, Moench). The latter tree affords a wood that is perhaps better suited for making small patterns or models than any other of our native trees. The numerical proportion of the maple, as of all those trees which have their greatest development along river and creek bottoms, has been greatly reduced by the clearing of land. Good sugar orchards have to be sought for the most part in unsettled localities.

The chestnut (*Castanea vesca*, L.) is found in all localities, and in such size as to give it a prominence much greater than is shown by its percentage in the tabular view. In the table of second growths an increased proportion is shown. The dwarf chestnut or chinquapin (*C. pumila*, Michx.) has not been noticed in this section.

The hickories are represented by many large trees. Table I, however, includes a considerable number of smallish trees, giving, perhaps, undue prominence to the hickories; but this fact is largely offset by the great number of small hickories, which are a common feature of the undergrowth, and which afford a large supply of hoop-poles.

The yellow poplar, the tulip tree or whitewood (*Liriodendron tulipifera*, L.), occurs in all localities. It ranks in size above all the other trees of Eastern Kentucky, unless the sycamore be excepted, which occasionally reaches immense size. The tulip tree ranges in size from two to five feet in diameter, having a cylindrical trunk of great length. The young tree is highly ornamental, both in form and foliage. Few small trees of this species are included in Table I, yet in number of individuals it makes up about five per cent. of the forest growth.

The gum tree or black gum (*Nyssa multiflora*, Wang.) grows in all localities, and is represented here and there by a tree at all levels in nearly all exposures. Its value as a suitable wood for wheel-hubs, and for other purposes for which a cross-fibred

wood is desirable, will doubtless give rise to a demand for this now somewhat despised tree.

The ash (mostly *Fraxinus Americana*, L., or the white ash, but including two or three other species of rarer occurrence) is represented by some trees of large size, but by more of a smallish size, which may be regarded as a second growth in the old forest.

The linden or basswood is abundant in some shaded valleys and on some moist slopes. In the tables it falls below its proportional number, as do some other species, from the difficulty of selecting average localities for all the species.

The sycamore (*Platanus occidentalis*, L.) occurs along the river and creek bottoms as a large tree of irregular growth, sometimes reaching a diameter of six or seven feet. In second growth timber it is sometimes found along the slopes of hills, and even on the tops of ridges, as along the ridge road from Ashland to Clinton Furnace, 350 feet above drainage.

The buckeye (*Æsculus flava*, Ait.) occurs as a large tree low down in the valleys. In second growth it occurs higher up the hillsides, but somewhat rarely.

The elm is represented by several species—the *Ulmus Americana*, L., or the American elm; *U. fulva*, Michx., slippery elm, and *U. alata*, Michx., winged elm. The first named being the common species. The others occur here and there as trees of moderate or small size.

The walnut trees (*Juglans nigra*, L.), black walnut and (*J. cinerea*, L.) white walnut or butternut, have about the same range, the former being most abundant. The value of this wood seems to be little understood in this section, as it is often used for fencing, or wantonly destroyed. It does not occur in great numbers in any particular locality, but is found along the hillsides and in the valleys of the smaller streams scattered among the other trees. Occasionally trees of great size are met with, as notably on Rock-house Branch of Jourdan's Fork, in Lawrence county. In the second growth the walnuts both show an increased percentage. It would certainly prove a wise policy to encourage the growth of both; but particularly of the

black walnut, the demand for which is rapidly outrunning the supply.

The hemlock or hemlock spruce (*Abies Canadensis*, Michx.) is restricted in its range to shaded ravines and rock-bound creeks. Cliffs and ledges of coarse sandstone, and particularly of the conglomerate sandstone, when near the bed of the creek, are often covered or surrounded by an almost exclusive growth of hemlock and laurel—trees and shrubs which make slight competition for the more open soil. The hemlock is not limited to coarse sandstone formations, however. It is found, less frequently, clinging to or growing along ledges of limestone, as on Tygert's creek, where it is associated with cedar, and also covering the steep faces of the Waverly sandstone, as exposed along some of the streams west of Tygert's creek.

The pines are represented by several species; the yellow pine (*Pinus mitis*, Michx.) being the common species. The white pine (*P. strobus*, L.) occurs on Buffalo creek, in Carter county. It is represented here by a few scattered individuals only. The scrub pine (*P. inops*, Ait.) is more common in second growth, as on the hills around Louisa.

The red cedar (*Juniperus Virginica*, L.) grows in many localities low down in valleys or on bluff-like hills; but it has a much more marked development along the outcrop of the sub-carboniferous limestone than elsewhere.

Besides the trees mentioned in the tables, there are others of less common occurrence, as also a number of small trees and of shrubs, which, though they do not largely affect the character of the old forest, are worthy of mention.

The poplar (*Populus grandidentata*, Michx.) occurs at several points on low ground.

The persimmon or date-plum (*Diospyrus Virginiana*, L.) is found in nearly all localities. Attention has been called to this tree by a number of writers as one likely to repay with valuable fruit an intelligent effort to cultivate and improve it.

The cherry is represented by two species (*Prunus serotina*, Ehrhart and *P. Pennsylvanica*, L.), the former occasionally

growing to good size, as instanced by the beautiful tree in front of Mr. Scott's house, at Olive Hill.

The common locust (*Robina pseudacacia*, L.) occurs without apparent regard to level or exposure.

The honey locust (*Gleditschia triacanthos*, L.) is limited to the lower grounds.

The cucumber tree (*Magnolia accuminata*, L.) is found rarely in Carter and Lawrence counties. It is a large tree, and equally as valuable for lumber as the tulip tree.

The umbrella tree (*Magnolia umbrellata*, Lam.) occurs in great numbers on the waters of the Chatterawha or Big Sandy, also on some of the tributaries of the Little Sandy. It is a small but interesting tree, and one that is very desirable for purposes of shade and of ornamentation. In Eastern Kentucky it grows mostly along the streams. In Tennessee I have noticed it covering a hill to the exclusion of other trees. It is likely, therefore, that no difficulty would be experienced in transplanting it to higher land and dryer soil.

The water birch (*Betula nigra*, L.) is abundant on the banks of some of the larger streams, like Tygert's creek, the Little Sandy, and Blain.

The black birch (*Betula lenta*, L.) was noted as a small tree at a number of points.

The hackberry (*Celtis occidentalis*, L.) has an occasional representation of moderate size.

The sweet gum (*Liquidambar styraciflua*, L.) was noted at a number of points along the border of Greenup and Lewis counties as an occasional tree of small growth. It has a considerable development, both in number and size, on Lick creek, near Louisa, in Lawrence county.

The mulberry (*Morus rubra*, L.) is found at wide intervals in the valleys and on the hillsides. A spreading tree, often of considerable size, and always bearing an abundance of rich fruit in its season.

The willows frequently border the streams with various growths, from the shrub to the large tree.

The catalpa (*C. bignonioides*, Walt.) is found both on cultivated and on wild lands. Whether native in the latter instance is uncertain from observations in this field.

The hop hornbeam or lever wood (*Ostrya Virginica*, Willd.) occurs only rarely and in small size.

Water beech (*Carpinus Americana*, Michx.) is abundant everywhere, sometimes reaching eight to ten inches in diameter. It is a very close-grained wood, and may be made valuable for turning by boiling or saturating with water before drying.

The dogwood (*Coruns florida*, L.) is also abundant throughout. It rarely reaches a diameter of ten inches, but it grows a more regular and shaft-like trunk than the preceding, while it is equally close-fibred, and more readily seasoned for use.

The Juneberry or service berry (*Amelanchier Canadensis*, Torr & Gray) has an occasional representative.

Sassafras (*S. officinale*, Nees.) is common, and usually associated with the sour tree or sorrel tree (*Oxydendrum arboreum*, D. C.)

The pawpaw grows in dense thickets along the foot of most hills, extending up ravines and reaching up hillsides in lessening numbers. It is sometimes found near the tops of hills 250 to 300 feet above drainage.

American holly (*Ilex opaca*, Ait.) is usually found associated with hemlock and the laurels in rocky and broken areas.

The redbud (*Circis Canadensis*, L.), the black haw (*Viburnum prunifolium*, L.), spicewood (*Benzoin odoriferum*, Nees.), hazelnut (*Corylus Americana*, Walt.), and the witch hazel (*Hamelis Virginica*, L.) are occasionally met with.

Sumach (*Rhus copalina*, L.), alder (*Alnus serrulata*, Ait.), and several species of thorns, are more common. The hawthorn occurs near Ashland, probably introduced. Leatherwood (*Dirca palustris*, L.) has been noted at several points west of Tygert's creek. The crab apple and the wild plum sometimes make up a part of thickets, which appear to be a wild growth.

Grapevines, the climbing bittersweet, the Virginia creeper, as well as the poison ivy, frequently overrun the smaller trees

and shrubs, or cling to the larger trees. Other climbing vines and many small shrubs might be added, but may well be reserved for a more extended catalogue of plant species.

SECOND GROWTH.

The character of the timber growth, which springs up where old forests have been removed, has been made the subject of some investigation—the furnace lands affording an opportunity for comparing the second and also the third growth with that of the original forest. There seems to be very little difference between the second growth and the third as to the species represented, or as regards the numerical proportion of the species. It is deemed sufficient for the present purpose to present a tabular view of such observations as appear to be representative of the second growth in this section. Table II affords an easy means of comparison with the original growth of timber.

It will be noticed at once that the assemblage of species is very similar to that of the old forest. A little closer comparison will show that the changes indicated are such as to add to, rather than detract from, the value of the second growth. This is equally true, whether regarded as fuel for the furnace or as growing timber for future market.

Those trees, which grow chiefly on bottom lands and near creeks, show a falling off in number for the reason that the lands at this level are so generally under cultivation as to limit observations to the slopes and the tops of hills.

It is well known that in many localities the character of the second growth is quite unlike that of the original forest; and often the new growth is made up of species so inferior for fuel, or any of the purposes for which wood is in demand, that it is of little economic value. An interesting and important field for investigation is opened here; but for the present it will suffice to call attention to the importance of the fact where the second natural growth and the succeeding ones are not inferior to the old forest growth. This is readily seen from an illustration furnished by the locality in question. Notwithstanding

the abundance of mineral coal, the value of charcoal iron is such as to warrant the building of charcoal furnaces where both timber and ores are abundant; and as the consumption of timber in iron-making rapidly sweeps away the old forest, it is of no small importance that nature instantly sets about replacing in kind what is consumed from year to year by the furnace.

The statistics of Mt. Savage Furnace, which may be taken as a representative instance, show a consumption of about twelve thousand cords of wood per year, or for an average blast of a little more than three thousand tons iron product.

Allowing thirty to thirty-five cords of wood to the acre—a low estimate for hill and valley—gives a yearly decrease in forest area of from three hundred and fifty to four hundred acres. From the best information obtained in this furnace region, it appears that from twenty-three to twenty-five years' growth is required to give an average of thirty to thirty-five cords of wood per acre. From this it appears that a tract of nine to ten thousand acres is sufficient for the establishment of a perpetual charcoal furnace of ordinary capacity.

TABLE II.—Second Growth.

SPECIES.	Hunnewell Fur. Lands, 23 years' growth.			Star Fur. Lands, 24 years' growth.			Buena Vista Fur-nace Lands, 22 years' growth.			Buena Vista Fur-nace Lands, Boyd County.		
	Hillside (horizon of No. 3 C.), 100 to 150	Top of hill (horizon of L. ore), 200 to 250	Per cent. for locality	Hillside (horizon of C. No. 7), 100 to 150 above drainage	Top of hill (horizon of No. 8 C.), and above 250	Per cent. for locality	Hillside (horizon of L. ore), 75 to 150	Top of hill (horizon of No. 8 C.), 150 to 250	Per cent. for locality	Hillside (horizon of No. 7 C.), 100 to 200	Top of hill (horizon of No. 8 C.), 250 to 300	Per cent. for locality
White oak	30	34	.194	40	46	.248	38	36	.214	20	34	.172
Black oak	36	40	.237	18	34	.150	28	26	.150	32	20	.165
Chestnut oak	2	4	.019	8	8	.046	12	20	.092	6	..	.019
Post oak	2	..	.006	..	..	..	2	..	.006	..	..	..
Other oaks	42	34	.237	30	24	.127	20	26	.133	16	26	.134
Beech	..	4	.012	12	..	.035	12	..	.035	8	..	.025
Maple	2	..	.006	..	..	..	..	..	..	6	..	.019
Chestnut	4	..	.012	26	16	.121	14	..	.040	12	10	.070
Hickory	10	4	.043	16	18	.098	18	30	.139	20	26	.140
Yellow poplar	9	8	.053	18	8	.075	8	8	.046	6	..	.019
Gum	..	6	.019	..	6	.017	..	..	..	..	..	..
Ash	5	4	.028	6	6	.035	..	..	..	4	..	.013
Linden	..	..	..	..	..	..	..	..	..	..	..	..
Sycamore	..	..	..	..	..	..	..	..	..	..	..	..
Buckeye	..	..	..	..	..	..	..	..	..	..	..	..
Elm	..	..	..	..	..	..	..	..	..	..	..	..
Black walnut	12	8	.062	..	..	..	6	18	.069	20	10	.095
White walnut	4	6	.031	..	..	..	..	..	..	21	..	.067
Hemlock	..	..	..	..	..	..	..	..	..	..	..	..
Pine	..	11	.034	..	16	.046	2	24	.069	8	9	.054

TABLE II.—Second Growth—Continued.

SPECIES.	Clinton Furnace Lands, Boyd C'ty.			N'r Grayson, Car- ter County.			Buffalo Furnace, near head of Old- town Cr'k, North Fork.			Per cent. for all localities—side of hill	Per cent. for all localities—top of hill	Per cent. for all localities
	Hillside (horizon of L. ore and C. No. 7), 50 to 100. . .	Top of hill (horizon of No. 8 C.), 150 to 200.	Per cent. for locality	Hillside (horizon of No. 2 C.), 100 to 150	Top of hill (horizon of No. 3 C.), about 200	Per cent. for locality	Hillside (horizon of No. 2 C.), 100 to 150 above drainage .	Divide (horizon of No. 3 Coal), 250 above drainage	Per cent. for locality			
White oak	32	36	.223	32	22	.160	30	33	.187	.191	.210	.202
Black oak	38	30	.223	32	34	.200	35	36	.211	.189	.191	.190
Chestnut oak . . .	16	4	.066	14	16	.089	. . .	. . .	. . .	.050	.045	.048
Post oak	12	2	.046	6	6	.036	. . .	9	.027	.019	.015	.017
Other oaks	40	16	.184	12	24	.107	10	12	.164	.138	.141	.140
Beech	6	4	.033	22	8	.089	15	. . .	.045	.065	.014	.039
Maple	. . .	2	.007	16	26	.025	11	. . .	.033	.030	.024	.027
Chestnut	8	14	.072	. . .	12	.036	16	30	.137	.069	.071	.070
Hickory	. . .	6	.020	16	16	.095	13	12	.074	.080	.098	.089
Yellow poplar . .	12	. . .	.039	. . .	. . .	. . .	9	12	.062	.054	.031	.042
Gum	4	3	.023	8	3	.032	5	9	.042	.015	.024	.019
Ash	. . .	. . .	. . .	. . .	. . .	. . .	2	9	.033	.011	.024	.016
Linden	. . .	. . .	. . .	. . .	. . .	. . .	. . .	6	.018	. . .	. . .	.003
Sycamore	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Buckeye	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Elm	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Black walnut . . .	12	4	.052	. . .	. . .	. . .	. . .	. . .	. . .	.010	. . .	.005
White walnut . . .	. . .	. . .	. . .	. . .	. . .	. . .	7	9	.048	.049	.043	.046
Hemlock	. . .	. . .	. . .	. . .	. . .	. . .	. . .	6	.018	.022	.010	.016
Pine	. . .	4	.013	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
									.007	.056	.031	

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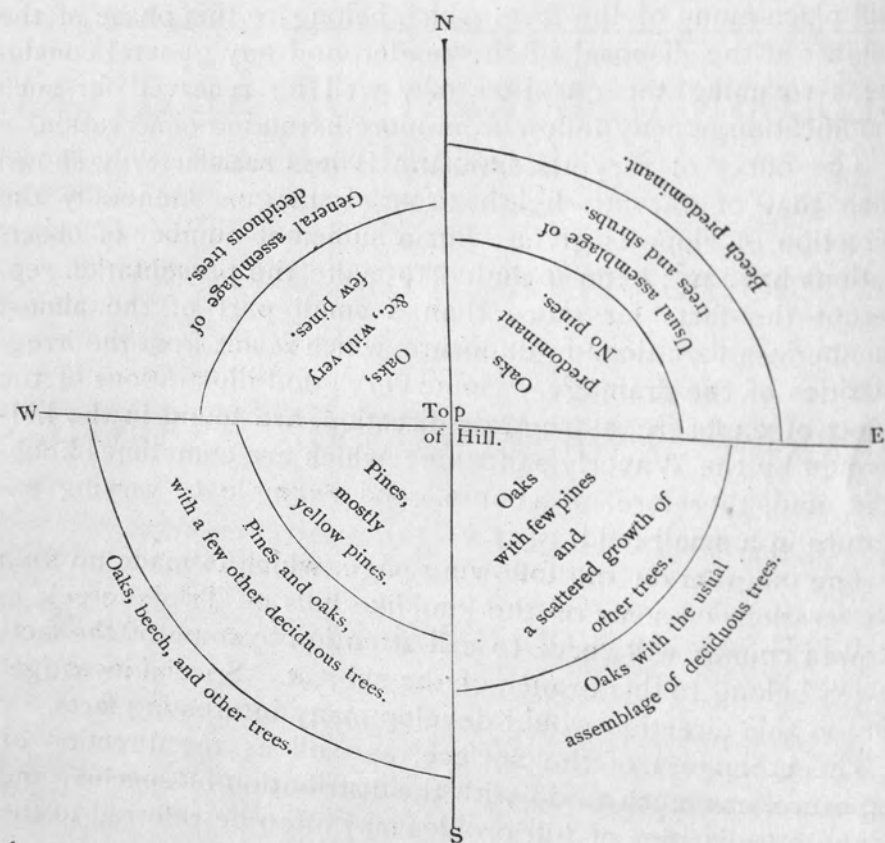
DISTRIBUTION OF SPECIES AS AFFECTED BY TOPOGRAPHICAL FEATURES.

In the first tabular view the effects of these conditions which arise from the hilly character of Eastern Kentucky may be traced in considerable detail. A careful study of this table will place many of the facts which belong to this phase of the subject at the disposal of the reader, and any general conclusions touching the question may well be reserved for such modification as may follow from more extended observation.

The effect of varying exposure is less satisfactorily shown than that of varying height from drainage. Generally the direction of slope is given; but a sufficient number of observations have not been included to make the presentation represent the facts for more than a small part of the almost numberless variations in exposure, which result from the irregularities of the drainage. Some very good illustrations of the effect of exposure, as regards direction, are found in the hills formed by the Waverly sandstone, which are sometimes knob-like, and, therefore, present a good example of varying exposure in a small field.

The diagram on the following page, which is made up from observations on some of the knoblike hills on Triplet creek, in Rowan county, will serve to call attention to some of the facts which belong to this branch of the subject. Special investigation in this direction would develop many interesting facts.

The steepness of the surface, as well as the direction of exposure, has much to do with the distribution of species; and as the peculiarities of hill profiles may often be referred to the character of the rocks out of which the hills are carved, as it were, by the agencies of erosion, the effects of varying exposure are more or less intimately associated and blended with those effects which properly belong to the question of geological distribution. A discussion of the relation of the two phases of the subject may, therefore, be left for a fuller presentation of the whole question.



GEOLOGICAL SURVEY OF KENTUCKY.

N. S. SHALER, DIRECTOR.

REPORT ON THE BOTANY

OF

BARREN AND EDMONSON COUNTIES,

BY JOHN HUSSEY, BOTANICAL ASSISTANT,

WITH AN INTRODUCTION BY N. S. SHALER.

PART II. VOL. I. SECOND SERIES.

INTRODUCTION.

The following report of Professor Hussey, Botanical Assistant of the Survey, is published in advance of the completion of the work of which it forms a part, in order that there may be some immediate record of the economic and scientific value of the forest trees and other plants of Western Kentucky. I am satisfied that the very great importance of the store of woods useful in the arts found in Western Kentucky has been greatly overlooked, and deserves immediate attention. The finest hard-wood forests known to me in any country lie between the Louisville and Nashville Railroad and the Mississippi river. I am confident that there is no other region on this continent where as large a mass of timber useful in the arts, and contiguous to transportation, can be found.

The arts into which these varieties of wood enter are multifarious, and of the greatest economic importance. I am satisfied that there is no point in America where so extensive opportunities exist for the creation of a direct trade in hard-wood with Europe. For many years wine-cask staves have been shipped from this district to New Orleans, and, though by the imperfect organization of the business half a dozen profits are paid before they come to the coopers' hands in France, they pay the best profits that are made on the oak timber in this district. By very little effort the casks could be made on the French models on the ground, and shipped as bundles of staves to Europe. A precisely similar industry exists in the shipment of sugar-boxes from the State of Maine to Cuba, the parts being bound up in "shooks" and bundles. By this arrangement the value of this industry to our people would be greatly increased. The demand from this source is very great, and steadily increasing. Another most promising industry has yet to be begun on this ground, though existing elsewhere in

less favorable portions of this country, viz: the making of carriage-parts hubs, felloes, and other elements in such structures, for export. For this purpose the new growth of timber on the barrens, as well as much of the slow growth oak, hickory, &c., of other parts of this district, is peculiarly fitted, having all the properties of second growth. All along the tributaries of Green river we have admirable trees for such industries; places where water-powers can be utilized at actual contact with permanent navigation for steamers directly connecting with New Orleans by the cheapest possible carriage.

The ample stores of oak and other ship timbers along this stream suggests the possibility of developing another industry here. Good ship timber can be had in this district at one third the lowest prices ruling on the Atlantic seaboard. Food is scarcely half as dear. So I am confident that a given tonnage would not cost one third what it would in transatlantic ports, as far as these elements of cost are concerned. Coal for running saw-mills, where steam-power is preferred, can be had for about two dollars and a half a ton. When built, ships would not want for cargo. They could be laden with timber or grain, and could be taken without risk to New Orleans each winter, though drawing as much as twenty feet of water. This is beyond all needs of vessels of this class. Used in this fashion, there is an immediate and most important source of wealth in our vanishing forests, which exceeds computation. Again and again, on the borders of Green river, I have seen, in a few dozen acres of tobacco clearings, enough noble ship timber going to utter waste by fire or decay to have built half a dozen large merchantmen. If such a demand could be created, there are tens of thousands of acres in every Green River county that would be worth a hundred dollars per acre for their timber alone.

In a certain way, the hard-wood timber of Western Kentucky is a more immediate and satisfactory source of wealth than its coal or iron. It takes less capital to develop an industry in it, and the competition will be far less considerable. At the same time, in the class of population it attracts to the State,

and the variety of industry it brings in its train, the industries in wood are superior to all other forms of manufacturing.

The scientific questions connected with our Western forests are even as interesting as those of an economical nature. While they must be reserved for special discussion in the memoirs of the Survey, where, as matters of purely scientific value, they will find their proper place, a brief statement of some of the most important points may be admitted here. In connection with the ancient barrens or prairies, which gave their name, in itself a misnomer, to Barren county, one of the most fertile regions in the State, we have two important questions: First, as to the origin of the treeless conditions which prevailed there when our race first came into the region; and secondly, how the reforestation was effected. The discussion of the first of these questions will lead us far into the difficult problems connected with the origin of prairies. I would only suggest, that inasmuch as the forests came back on the stoppage of the fires, to which reference is made in the following report of Professor Hussey, it is not unreasonable to look to for sweeping fires as the cause of the first destruction of the timber. We have seen within a few years how forest fires, once gaining headway in an unusually dried forest, may sweep over hundreds of miles of territory. A practice of firing prairies long continued might in time extend their limits from the regions where they are natural, from the absence of sufficient rainfall, over more and more of the forest area, until the prairie area had been driven from the Upper Missouri into the central regions of the Ohio Valley. This seems to me the most satisfactory method of accounting for the change.

The rapid restoration of the timber in Kentucky and parts of Indiana and Ohio, while the prairies of Illinois show but little tendency to restore their timber, is less easily to be explained. I am inclined, after considerable study of the matter, to conclude that the "barrens" or prairies of Kentucky had not been long stripped of their timbering, the period of open conditions having endured for such little time that the seeds of the trees had not all decayed in the soil. In no other way could the

exceedingly rapid return of the forests be explained. It has not yet been possible to adopt the statistical plan of studying our western forests shown in the report on the forests of Greenup county, &c. When this is done, it will be seen that the new or second-growth forests on the "barrens" is not nearly as diversified as the other and older forests; there being far more variety in the trees of the old than there is in the new forests.

Assistant John R. Proctor, of the Kentucky Survey, has made some important observations as to the Western forests of the old "barrens," going to show that the conglomerate or beds just below the coal form a natural limit to this once treeless area on the west. The detail of these observations will properly find a place in the proposed memoirs on the distribution of the forest trees of Kentucky.

N. S. SHALER.

INTRODUCTORY LETTER.

Professor N. S. SHALER—

SIR: The accompanying report is, as you will see, on the basis of actual collection. The number of plants in the list could have been greatly augmented had I placed in it plants observed, but not collected.

The first part is a list of the collections actually made, arranged according to the catalogue of Mr. A. H. Curtiss, which follows the order of Gray's Manual.

The second part is made up of Notes on Distribution, Territory Collected Over, and Botanical and Economical Notes. This part could have been greatly enlarged; but I thought that it would be better to await the results of a further prosecution of the Survey, to enlarge upon the peculiarities, the richness, and the economical value of the Flora of Kentucky.

Respectfully,

JOHN HUSSEY.

LAFAYETTE, IND., March 15, 1875.

REPORT ON THE BOTANY
OF
BARREN AND EDMONSON COUNTIES.

By JOHN HUSSEY.

TERRITORY COLLECTED OVER.

My collections were made in the western part of Barren county, or that part west of the Louisville and Nashville Railroad, in the Cave region, and in the county of Edmonson. My observations in Barren county would lead me to the conclusion that the traditions which are current as coming from the settlers are true; that is to say, that when the whites first came to these parts, it was, indeed, a barren region, destitute at least of trees. On the more level parts of this county the trees are yet small in size and few in species. The size of the trees alone would settle the question as to the length of time in which the present forest has stood, especially when taken in connection with the absence of the remnants of an older forest in the matter of fallen trunks and stumps. On the line of sandstone-capped hills seen rising between the line of the railroad and Green river are to be found larger trees than any in the more level portions of the county, showing that when the rest of the county was bare of trees, there were some crowning these hills. The limited number of species found in Barren county would itself be conclusive of the question of the recent introduction of forest growth into this region. The most of the oaks are of the following species: *Quercus, coccinea, rubra, nigra*—the latter species very numerous. *Alba* is found, but not abundant; also *imbricaria* and *obtusiloba*, about the numerous sinkholes. I saw no poplars, no tulip trees, linn, beech, black walnut, or butternut.

The largest trees are oaks, about fifteen inches in diameter three feet from the ground. I saw scarcely a willow or a maple of any kind. The soil is a stiff limestone, considerably impregnated with iron, making it of a red color, and not highly productive of ordinary cereals. The surface is very uneven, being full of sinkholes, formed by the falling in of the cavernous passages which form a network under this whole district. The celebrated Mammoth Cave is only one of the hundreds of caverns of this remarkable region. Not in the trees only, but also in the herbaceous flora, was the limited number of species noticeable. It is well understood that the aborigines of this country were accustomed to burn over the surface of the prairies; but for what purpose it does not seem to be perfectly understood. There may have been several considerations which led them to this quite universal custom. It has been said that they thus destroyed the old culms of grass, and cleared the way for the springing of the tender shoots in the spring. They may also have had in view the destruction of hurtful insects, as the grasshoppers, by destroying their eggs, or of noxious serpents, which must have been destroyed in immense numbers by the annual fires on the prairies. Another reason may have had consideration; the tall dead grass would be liable to be fired by accident at any time, and thus human life and many villages be endangered in the night, or in times of high winds, with no means of escape; but if at a certain time, when all are on the lookout, the firing should take place, there would be no danger to life or property.

This habit of firing the prairies must have exerted a wide influence on the character and distribution of plants in the parts of our country where prairies existed. Certain plants could not survive the fires. The annuals must have been greatly diminished by the custom. Those which were perennials under ground, would suffer less than any other class of plants. The fire swept off everything above the surface—seeds not covered by the soil, young plants of trees; but the well-protected living roots of herbaceous perennials, with the nourishment of another crop of shoots stored away safely be-

neath the sod, suffered no damage. But as these fires were annually kindled, how did it happen that here and there all over the broad prairies clusters of trees withstood their destructive influence, and lived and flourished? The reason of the deficiency of trees on the prairies has been held by some to be the absence of the nutriment in the soil which they required, or the fineness of the soil, which was supposed to be unfavorable to the growth of timber trees. This latter view, taken in connection with the fact that the knolls on which the clumps of trees are generally found are composed of more porous material, as sand or gravel, seemed to receive confirmation. But the fact that all kinds of trees do grow well when planted and protected in prairie soil, upsets both these theories without further refutation. The soil is not too finely divided; it does not lack the necessary constituents. Not taking into consideration how a country may have been deprived of a forest—whether by the ravages of insects, a succession of unfavorable seasons, or by a conflagration alone, or connected with one or all of the foregoing causes, or by any other cause—when once deprived of a forest, annual fires would likely prevent its restoration while they were continued. If the fires were purposely kindled, and at a certain time, so that the villages could be protected against their ravages, the inhabitants would do it by clearing away the dead grass from the vicinity of their dwellings. In fact the grass would perish to the roots around their villages from being trampled upon and burnt out by the fires in and about their habitations. It is not beyond supposition that the aborigines themselves, for various reasons, might scatter the seeds of trees intentionally or accidentally, from the mast with which they must have provided themselves for winter consumption. They would occupy the knolls, if such there were, for their villages. The aboriginal well knew where the beds of gravel were, as is proved by the use he invariably made of them as repositories of his dead. Throughout Western and Southern Ohio scarcely a terrace gravel-bed has been dug out and removed for road-making, but has been found to have been used as a place of interment for his dead.

I had no opportunity to learn by observation how extensive the prairie was, a part of which extended into that portion of Barren county in which I collected. It evidently extended some distance south or southeast of Bowling Green; but how far it did extend in this direction or eastward, I had no opportunity to observe. To the westward, in Edmonson county, there is evidence of the treeless condition existing. The very numerous ravines, valleys, and hillsides, become covered with tree growth first. The large tulip trees, hemlocks, sugar maples, beeches, and chestnuts found in these less exposed localities, prove that generations of tree growth have passed since their seeds were scattered here; but the uplands show, that long since the deep valleys and hillsides were covered with forest growth, these were almost or entirely bare. Notwithstanding this, however, Edmonson county was forest-covered a generation before Barren county.

Taking the two counties together in which my collecting was done, they differ very much in surface character. In Barren county the prevailing rock is limestone, except on the caps of the high hills, where sandstone is found. But in Edmonson county the heavy conglomerate and sandstone of the carboniferous period prevails at all points. The deep gulches cut by the numerous tributaries of Nolin and Bear creeks give a very different character to the geography of this county from that of Barren. These gulches must considerably modify the climate; at least in them and beneath their immense walls of conglomerate and sandstone the extremes of heat and cold are greatly modified, and protection is furnished to several species of plants not found out of these places in this region.

BOTANICAL NOTES.

The list accompanying this will show the limited number of species found in the counties collected over. To give a correct understanding of the list, I should state that my collecting was confined to the months of May, June, July, and a few of the first days of August. The weather was unusually dry, which I suppose exerted an unfavorable influence upon the number of

species. When it is borne in mind that this region is widely separated from the Allegheny Mountains, that it is not a high region, the presence of *Abies Canadensis* will be unexpected; but this makes a large growth in the gulches of Edmonson county. The *Ilex opaca* attains the size of fifteen to eighteen inches in diameter, and forty to fifty feet in height. The little shrubs, *Mitchella repens* and *Gaultheria procumbens* were found in abundance there. *Kalmia latifolia* is abundant. The *Ptelea trifoliata* grows on the Nolin. I mention this to say that I noticed that the petals did not open in all instances, but cohered at their apices, and were pushed off by the stamens and pistils as in some species of the vitis genus.

The *Spiraea aruncus* was a very common plant, and I noticed a feature of it which I have never seen referred to by any one; it was the occurrence of a small deciduous bractlet on each pedicel, but not touching the flower. The *Leavenworthia Michauxii* was collected by me near the town of Glasgow Junction, just northwest of town, growing in a nearly filled-up sinkhole. This is quite a rare plant, and but few specimens were found. *Trifolium reflexum* occurs in several localities between the railroad and Mammoth Cave, which is in the eastern part of Edmonson county. I mention it because I have never found so many specimens in any one locality before, and also to make a note of the fine rose-pink color it everywhere had. The variety of *Celtis occidentalis*, called *pumila*, commences to appear in Barren county, and extends everywhere through the country as far as Hopkinsville, in Christian county. I did not see the ripe fruit; but shrubs ten feet high were not uncommon, with an abundance of fruit. The leaves are thin, smoother than those of the large form, and much tapering. I did not see a large tree of *Celtis occidentalis* anywhere in this section such as are everywhere seen in creek bottoms north of the Ohio. Among ferns, I found, in Barren county, growing on the extreme eastern end of the sandstone ridge, under which is Short Cave, *Cheilanthes vestita*. The hairs on this fern were distinctly jointed, and between each joint much flattened; but the contiguous sections flattened in different planes. This character

is not given in descriptions, although in other species of the same genus the hairs are called "obscurely or distinctly articulated;" and in one the word "flattened" is added—*vide* Gray's Botany.

The fern *Polypodium incanum* was collected on that ledge of sandstone running between the mouth of Mammoth Cave and Green river, and perhaps two hundred yards from the main entrance to the Cave. It was also found growing on a large sand rock on the west fork of the creek, which flows by the old iron furnace west of Nolin, and about one half mile above the furnace. I did not find it in any other locality in the county. I consequently did not find it growing in the moss on trees or the roots of trees. Those places where I did gather it were very dry; had as little opportunity for moisture as any places I could name. One was on the edge of a sand rock among dried-up moss. With the other was found growing the *Camptosorus rhizophyllus*. Mr. W. T. Knott, of Lebanon, Kentucky, showed me a single frond *Polypodium incanum*, which he had gathered among moss on earth beside a stream. Mr. John Williamson, of Louisville, has found this fern within twelve miles of that city. I found the *Asplenium Bradleyi* on a cliff at the head of Dismal creek. It grew on the face of a steep sand rock exposed to all the vicissitudes of the weather. This limited locality was the only place of its occurrence, according to my observation. It seems here as a relic of a former period, having perished from all these miles of cliff formation, and lingering here awhile before giving up the struggle of existence so far to the north. A hundred or so fronds were all I had heart to gather, not willing to hasten its extermination by any act of mine.

The *Trichomanes radicans*, by a singular coincidence, was found growing near, on, or rather under, the same cliff. This rare fern I found in about a dozen localities in this county, always growing on the under side of an overhanging sand rock, where the moisture trickled down and kept the leaves bedewed with spray. I collected this fern also last year in the extreme eastern part of this State, in Carter county. The fronds evi-

dently remain active for several years. They bear their spore cases on the end of veins on the edges of the fronds. In no case have I ever seen a frond, which seemed recently unfolded, develop its spore vessels. A season of repose, of longer or shorter duration, occurs after its development, before it puts forth its little cups, from the bottom of which the bristle grows, and at the base of which the *sporangia* develop and cluster. But what seemed still more curious to me is the fact that the crops of *sporangia* are not all formed and ripened at once; but they are successively developed at the base of the lengthening bristle. I have seen these bristles more than half an inch long, and still beset at the base with ripening *sporangia*, the scars left by those long since fallen being still visible all along the bristle. I think the life of a fertile frond may be for as long as four or five years. It may not be out of place to add, that the fronds were generally well filled with spore vessels. It is probably due to the fact that the numerous flocks of sheep which find protection under the overhanging cliffs during winter, and feed upon this fern, that its extinction seems so near at hand. There were hundreds of situations where it might flourish as well as where it was found, but where it is not found to grow; and those places where it was found were inaccessible to the sheep, either by being above their reach or too far under the rock. I had often to crawl or draw myself in to where it covered the under surface of the overhanging rock, where there was barely room for my head and shoulders.

ECONOMICAL NOTES.

Turning to the more practical side of my work, I can say that the quantity of valuable timber-trees seems practically inexhaustible.

Soft-wood.—The tulip tree, in the west commonly called poplar (*Liriodendron tulipifera*), is abundant along the tributaries of Green river. The trees are of large size, and make good lumber. Those which grew nearest the river and its principal tributaries have been mostly floated down the river; but in the country back there is still much of this valuable timber.

The *sweet gum* (*Liquidambar styraciflua*) is still very abundant on the river and its tributaries. This tree has not been sought after so much as the tulip tree, and, consequently, has not been removed to so great an extent. It is a soft wood, and valuable for most purposes where poplar has been used. For all kinds of structures, where there is no immediate exposure to the weather, this is a valuable wood. The trees are of immense size, being frequently found in the counties lying next down the river from Edmonson county, four and a half feet in diameter and seventy to eighty feet high, with scarcely a limb. They equal the largest poplars. There is not much *linn* or bass-wood (*Tilia Americana*) found on the tributaries of Green river. The trees found are small and of little value for sawing.

Hard-wood.—The species of oak, known among wood-workers as white oak, attains an enormous development along Green river. The white oak, burr oak, and swamp white oak, form immense trunks, reaching to a height of eighty feet, where they still seem to be three feet in diameter. One could hardly determine which to admire most—their number, their size, or grand uniform straight trunks. Although for thirty years the trade in French butts via New Orleans has existed, one cannot see that even an impression has been made on the supply. Timber which has stood the test for such a long period of time in the manufacture of wine-casks needs no recommendation from any one.

The *Spanish oak* is very plentiful in some localities. The timber of this species of oak is valued for wagon-work of all kinds, and is scarcely, if at all, inferior for such manufactures to white oak. The bark is also used in tanning.

Chestnut oak is abundant on the ridges on both sides of Green river, but especially to the west of it. The largest *beech trees* I have ever seen are very abundant on Green river. Their trunks are finely formed, running up forty to fifty feet without any large branches, and as much as three feet in diameter three feet from the ground.

The *chestnut* is abundant also.

The *hickories* are among the largest trees—very tall, but not so great in diameter as the oaks and sweet gum, but exceedingly numerous. Neither *black* nor *white walnuts* are here found in abundance, and the trees which are found are of inferior size. The *wild cherry* is not abundant. The *sugar maple*, *black birch*, and *hemlock* are common in the gulches. The white soft maple is found everywhere. On the uplands hoop-poles seem quite inexhaustible in quantity, and of very good quality.

Black hickory (*Carya Tomentosa*), when from five to ten inches in diameter near the base, is used for making bent-work in the manufacture of buggies and carriages, and for other uses. In the counties of Grayson and Edmonson there is an immense supply of this class of wood. Much of it is too far from the railroad to bear hauling by wagon, and then car transportation to points where it is manufactured into carriage stuff. If some company would put up machinery in the midst of the material, it would certainly prove remunerative if properly carried on. The timber would cost but a trifle, labor in abundance could be had at a fair price, and fuel would be very low, as in many places coal is to be had for the digging from hillside veins. The manufactured articles could be got away at a small expense compared with that of hauling the rough timber. During the winter and spring months, when the river and its tributaries are in good stage of water, the expense of getting material transported would be comparatively little. The large quantity of the right kind of material found here, the extreme abundance of fuel and cheap labor, would give a well-managed company the control of the market in such manufactures.

White elm, so-called in this State (*Ulmus alata*), is very abundant all through the counties of Grayson and Edmonson, as well as in the other parts of the State, especially along the tributaries of Green river below these counties. This is one of the valuable materials for manufactures found here. The wood fibres of the elm interlace, and render the wood tough and difficult to split, while it is both light and elastic. These are the qualities desired in hubs for carriages, small spring-

wagons, and buggies. No iron bands are required, and they may be very light; at the same time they are strong, and neither split or crack if properly seasoned. A large quantity of this wood is found of the right size for the uses named.

Mulberry, sassafras, chestnut.—The value of the trees just named for fence-posts is not well understood. Mulberry is equal to black locust in all respects, except that it does not become quite so hard. The sassafras is scarcely, if at all, inferior to either, and both are found here in considerable quantities. The sassafras is a tree of rapid growth, and springs up everywhere in old fields and abandoned ground. The wood is light, but tough enough to hold nails, and is very enduring in all exposures. The chestnut is valuable wood for posts, but it should be cut at the season when there is the least sap in the wood to prevent the ravages of insects, and that decay produced by decomposition of the sap. The month of August or September, when the growth of the season is completed, and there is usually a deficiency of moisture in the ground, would be the best time to cut it. By dipping the end of the seasoned wood which is to go into the ground in hot coal-tar, a post will be secured which will outlast a generation. The time is coming when either fencing must be abandoned, or some other material than oak on the one hand, which is too perishable, or locust or cedar on the other, which will be too expensive, must be found. With seasoned posts of either of these trees, and seasoned chestnut boards, a fence will be made which will last a generation.

Turning-wood.—The elm (*Ulmus alata*), which is a fine-grained white-wood, the dogwood (*Cornus Florida*), buckeye (*Aesculus* of several species), the holly (*Ilex opaca*), the hop-hornbeam (*Ostrya Virginica*), and the ironwood (*Carpinus Americana*)—these and other trees, suitable for the manufacture of turned work of various kinds, exist in great abundance. The dogwood is specially abundant, and of large size for that little tree, sometimes eight or nine inches in diameter, and is of well-known properties; the wood is very hard and compact when seasoned, and useful for any kind of turned work requir-

ing fineness of grain and hardness. For work requiring soft white-wood, the elm, holly, buckeye, with many others, such as white soft maple and linn, give a wide range for choice, and all are to be had in considerable quantities.

FRUIT-RAISING.

This branch of industry has been neglected hitherto in the part of the State under consideration. But many localities offer good inducements to persons fitted for, and inclined to, this agreeable and often profitable pursuit. That series of hills known as Muldraugh's Hill, connecting east with the spurs of the Cumberland Mountains, and with more or less altitude extending westward to the Ohio river, are becoming known to be well adapted to the growth of various kinds of fruits, among which are the peach and strawberry. The series of hills in the western part of Barren county, running nearly parallel with Green river, it is also known, are equally adapted to the peach, which seldom fails to produce good crops. The same is true of localities in Edmonson county, near the course of the Nolin, where peach trees are said never to have failed in any season, for forty years, to bear. The distance from good markets is the great hindrance to the extension of this industry. With the use of the new and improved methods of desiccating fruits, perhaps it would be equally profitable to take them to market in a dried condition, especially when we consider the low price of land in settlements remote from railroads and large towns, and the comparative cheapness of labor.

CONCLUSION.

When a full survey of the resources of the State of Kentucky shall have been made, it will be found that the wealth of her forests and the natural productions of her soil will be a matter not insignificant, even when compared with the inexhaustible resources of coal and iron beneath the surface. From the extreme east to the west of this great State every part is clothed with the most valuable kinds of wood, from the bald cypress of the extreme southwest to the white pine in the

Cumberland table-land, and to the inexhaustible oak forests of the Green river counties, and those of the eastern and southeastern part of the State. This timber is not to be regarded as treasured-up wealth—to be preserved and held sacred, and its removal to be deplored—but rather as wealth wasting, as capital lying idle and unproductive. Trees have their period of life—their time of death. Go through the broad forests and see how the giants of vegetation are falling into decay; creaking and dismantled by the storms, or mouldering away prone upon the earth. When any tree is full grown, it should be removed and give place to others striving to exist under its shade. A wise use of the woodman's axe is not to be deplored—it may be a saving as well as a wasting agent.

Ranunculaceæ—

- Clematis Viorna, L.
- Clematis Virginiana, L.
- Anemone Caroliniana, Walt.
- Hepatica triloba, Chaix.
- Hepatica acutiloba, DeC.
- Thalictrum anemonoides, Michx.
- Thalictrum dioicum, L.
- Thalictrum purpurascens, L.
- Thalictrum clavatum, DeC.
- Ranunculus recurvatus, Poir.
- Ranunculus repens, L.
- Isopyrum biternatum, T. and Cr.
- Aquilegia Canadensis, L.
- Hydrastis Canadensis, L.
- Actæa spicata, L., v. rubra, Mx.

Magnoliaceæ—

- Magnolia acuminata, L.
- Magnolia umbrellata, Lam.
- Liriodendron tulipifera, L.

Anonaceæ—

- Asimina triloba, Dunal.

Menispermaceæ—

- Menispermum Canadense, L.

Berberidaceæ—

- Jeffersonia diphylla, Pers.
Podophyllum peltatum, L.

Nymphaeaceæ—

- Nelumbium luteum, Willd.

Papaveraceæ—

- Sanguinaria Canadensis, L.

Fumariaceæ—

- Corydalis glauca, Pursh.
Corydalis aurea, Willd.

Cruciferae—

- Leavenworthia Michauxii, Torr.
Dentaria laciniata, Muhl.
Cardamine rhomboidea, DeC.
Cardamine hirsuta, L.

Violaceæ—

- Viola sagittata, Ait.
Viola pedata, L.
Viola pubescens, Ait.

Cistaceæ—

- Lechea minor, Lam.

Hypericaceæ—

- Ascyrum Crux-Andree, L.
Hypericum prolificum, L.
" " v. densiflorum.
Hypericum corymbosum, Muhl.
Hypericum mutilum, L.

Caryophyllaceæ—

- Silene stellata, Ait.
Silene Pennsylvanica, Mx.
Silene Virginica, L.
Silene antirrhina, L.
Arenaria serpyllifolia, L.
Arenaria patula, Mx.
Stellaria pubera, Mx.
Cerastium nutans, Raf.
Sagina nodosa, Fenzl.

- Anychia dichotoma, Mx.
Mollugo verticillata, L.

Portulacaceæ—

- Portulaca oleracea, L.
Claytonia Virginica, L.

Tiliaceæ—

- Tilia Americana, L.

Linaceæ—

- Linum Virginianum, L.

Geraniaceæ—

- Geranium Carolinianum, L.
Geranium Robertianum, L.

Rutaceæ—

- Zanthoxylum Americanum, Mill.
Ptelea trifoliata, L.

Simarubaceæ—

- Ailanthus glandulosus, Desf.

Anacardiaceæ—

- Rhus glabra, L.
Rhus copallina, L.
Rhus venenata, DeC.
Rhus Toxicodendron, L.
" " v. radicans (L.), Torr.
Rhus aromatica, Ait.

Vitaceæ—

- Vitis æstivalis, Mx.
Vitis cordifolia, Mx.
Vitis vulpina, L.
Vitis indivisa, Willd.
Ampelopsis quinquefolia, Mx.

Rhamnaceæ—

- Ceanothus Americanus, L.

Celastraceæ—

- Celastrus scandens, L.
Euonymus atropurpureus, Jacq.
Euonymus Americanus, L.

Sapindaceæ—

- Æsculus glabra*, Willd.
Æsculus flava, Ait.
Acer saccharinum, Wang.
 " *v. nigrum* (Mx.), Gray.
Acer dasycarpum, Ehrh.
Acer rubrum, L.
Negundo aceroides, Mœench.

Polygalaceæ—

- Polygala ambigua*, Nutt.

Leguminosæ—

- Trifolium reflexum*, L.
Medicago lupulina, L.
Psoralea melilotoides, Mx.
Robinia Pseudacacia, L.
Wistaria frutescens, DeC.
Tephrosia Virginiana, Pers.
Desmodium nudiflorum, DeC.
Desmodium pauciflorum, DeC.
Desmodium rotundifolium, DeC.
Lespedeza repens, T. & G.
Stylosanthes elatior, Swartz.
Vicia Caroliniana, Walt.
Phaseolus helvolus, L.
Clitoria Mariana, L.
Cercis Canadensis, L.
Cassia Marilandica, L.
Cassia chamæcrista, L.
Cassia nictitans, L.
Gymnocladus Canadensis, Lam.
Gleditschia triacanthos, L.

Rosaceæ—

- Prunus Americana*, Marsh.
Prunus cerasus, L.
Prunus serotina, Ehrh.
Spiræa corymbosa, Raff.
Spiræa Aruncus, L.

- Gillenia stipulacea*, Nutt.
Agrimonia Eupatoria, L.
Geum album, Gmelin.
Geum vernum, T. & G.
Potentilla Norvegica, L.
Fragomaria Virginiana, Ehrh.
Rubus villosus, Ait.
 " *v. humifusus*.

- Rubus Canadensis*, L.
Rosa setigera, Mx.
Cratægus Oxyacantha, L.
Cratægus coccinea, L.
Cratægus crus-galli, L.
Pyrus coronaria, L.
Amelanchier Canadensis, T. & G.

Saxifragaceæ—

- Hydrangea arborescens*, L.
Saxifraga Virginiensis, Mx.
Heuchera villosa, Mx.
Heuchera Americana, L.
Mitella diphylla, L.

Crassulaceæ—

- Sedum pulchellum*, Mx.
Sedum ternatum, Mx.

Hamamelaceæ—

- Hamamelis Virginica*, L.
Liquidambar Styraciflua, L.

Onagraceæ—

- Circea lutetiana*, L.
Gaura filipes, Spach.
Oenothera biennis, L.
Oenothera fruticosa, L.
Luwigia alternifolia, L.
Luwigia palustris, Ell.

Melastromaceæ—

- Rhexia Virginica*, L.

Lythraceæ—

Cuphea viscosissima, Jacq.

Passifloraceæ—

Passiflora lutea, L.

Umbelliferae—

Sanicula Canadensis, L.

Daucus carota, L.

Thaspium aureum, Nutt.

Zizia integerrima, DeC.

Erigenia bulbosa, Nutt.

Araliaceæ—

Aralia racemosa, L.

Aralia quinquefolia, G.

Cornaceæ—

Cornus florida, L.

Cornus sericea, L.

Nyssa multiflora, Wang.

Caprifoliaceæ—

Sambucus Canadensis, L.

Viburnum prunifolium, L.

Viburnum nudum, L.

Viburnum acerifolium, L.

Rubiaceæ—

Galium Aparine, L.

Galium concinnum, T. and G.

Galium trifidum, L.

Galium triflorum, Mx.

Galium pilosum, Ait.

Cephalanthus occidentalis, L.

Mitchella repens, L.

Houstonia purpurea, L.

" v. *longifolia*, (Willd.)

" v. *ciliolata*, (Torr.)

Houstonia augustifolia, Mx.

Houstonia cærulea, L.

Compositæ—

Elephantopus Carolinianus, Willd.

Eupatorium perfoliatum, L.

Conoclinium cœlestinum, DeC.

Sericocarpus solidagineus, Nees.

Erigeron bellidifolium, Muhl.

Erigeron Philadelphicus, L.

Erigeron annuum, Pers.

Inula helenium, L.

Polymnia Canadensis, L.

Polymnia Uvedalia, L.

Silphium trifoliatum, L.

Parthenium integrifolium, L.

Rudbeckia hirta, L.

Coreopsis auriculata, L.

Coreopsis senifolia, Mx.

Maruta cotula, DeC.

Achillea millefolium, L.

Gnaphalium decurrens, Ives.

Gnaphalium polycephalum, Mx.

Gnaphalium uliginosum, L.

Senecio aureus, L.

Centaurea Americana, Nutt.

Cirsium Virginianum, Mx.

Cynthia Virginica, Don.

Hieracium Gronovii, L.

Taraxacum Dens-leonis, Desf.

Lactuca Canadensis, L.

Lobeliaaceæ—

Lobelia cardinalis, L.

Lobelia syphilitica, L.

Lobelia puberula, Mx.

Lobelia inflata, L.

Campanulaceæ—

Campanula Americana, L.

Specularia perfoliata, A. DeC.

Ericaceæ—

Vaccinium stamineum, L.

Vaccinium arboreum, Marshall.

Epigea repens, L.
Gaultheria procumbens, L.
Oxydendrum arboreum, DeC.
Kalmia latifolia, L.
Rhododendron maximum, L.

Aquifoliaceæ—

Ilex opaca, Ait.
Ilex mollis, Gray.

Ebenaceæ—

Diospyros virginiana, L.

Plantaginaceæ—

Plantago lanceolata, L.
Plantago virginica, L.
Plantago heterophylla, Nutt.

Primulaceæ—

Dodecatheon Meadia, L.
Lysimachia quadrifolia, L.
Lysimachia ciliata, L.
Lysimachia lanceolata, Walt.
Anagallis arvensis, L.
Samolus valerandi, L., v. *americanus*, G.

Bignoniaceæ—

Tecoma radicans, Juss.
Catalpa bignonioides, Walt.

Orobanchaceæ—

Epiphegus virginiana, Bart.
Conopholis americana, Wallr.

Scrophulariaceæ—

Verbascum Blattaria, L.
Scrophularia nodosa, L.
Collinsia verna, Nutt.
Chelone glabra, L.
Pentstemon pubescens, Soland.
Pentstemon digitalis, Nutt.
Mimulus alatus, Ait.
Conobea multifida, Benth.
Veronica serpyllifolia, L.

Veronica peregrina, L.
Seymeria macrophylla, Nutt.
Gerardia flava, L.
Castilleja coccinea, Spreng.
Pedicularis canadensis, L.

Acanthaceæ—

Ruellia strepens, L.

Verbenaceæ—

Verbena angustifolia, Mx.
Verbena bracteosa, Mx.
Lippia lanceolata, Mx.
Phryma leptostachya, L.

Labiataæ—

Trichostema dichotomum, L.
Pycnanthemum Tullia, Benth.
Pycnanthemum lanceolatum, Pursh.
Pycnanthemum linifolium, Pursh.
Salvia lyrata, L.
Salvia urticifolia, L.
Monarda fistulosa, L.
Blephilia ciliata, Rof.
Nepeta Glechoma, Benth.
Brunella vulgaris, L.
Scutellaria canescens, Nutt.
Scutellaria pilosa, Mx.
Scutellaria parvula, Mx.
Scutellaria galericulata, L.

Boraginaceæ—

Echium vulgare, L.
Lithospermum hirtum, Lehm.
Mertensia virginica, DeC.
Myosotis verna, Nutt.
Cynoglossum virginicum, L.
Cynoglossum Morisoni, DeC.
Hiliotropium europæum, L.

Hydrophyllaceæ—

- Hydrophyllum macrophyllum*, Nutt.
Hydrophyllum appendiculatum, Mx.

Polemoniaceæ—

- Polemonium reptans*, L.
Phlox glaberrima, L.
Phlox pilosa, L.
Phlox procumbens, Lehm.
Phlox divaricata, L.

Convolvulaceæ—

- Quamoclit coccinea*, Mœench.
Ipomea pandurata, Meyer.
Convolvulus arvensis, L.

Solanaceæ—

- Solanum carolinense*, L.

Gentianaceæ—

- Sabbatia angularis*, Pursh.
Frazera carolinensis, Walt.

Apocynaceæ—

- Apocynum cannabinum*, L.

Asclepiadaceæ—

- Asclepias phytolaccoides*, Pursh.
Asclepias variegata, L.
Asclepias quadrifolia, Jacq.
Asclepias tuberosa, L.

Oleaceæ—

- Fraxinus americana*, L.
Fraxinus pubescens, Lam.
Fraxinus viridis, Mx.
Fraxinus quadrangulata, Mx.

Aristolochiaceæ—

- Asarum canadense*, L.

Phytolaccaceæ—

- Phytolacca decandra*, L.

Chenopodiaceæ—

- Chenopodium urbicum*, L.

Polygonaceæ—

- Polygonum hydropiper*, L.
Polygonum aviculare, L.
Rumex crispus, L.
Rumex acetosella, L.

Lauraceæ—

- Sassafras officinale*, Neo.
Lindera Benzoin, Meisner.

Loranthaceæ—

- Phorodendron flavescens*, Nutt.

Saururaceæ—

- Saururus cernuus*, L.

Euphorbiaceæ—

- Euphorbia maculata*, L.
Euphorbia hypericifolia, L.
Euphorbia corollata, L.
Phyllanthus carolinensis, Walt.

Urticaceæ—

- Ulmus fulva*, Michx.
Ulmus americana, L. Walld.
Ulmus alata, Michx.
Celtis occidentalis, L.
 “ “ v. *pumila*, Pursh.
Morus rubra, L.

Platanaceæ—

- Platanus occidentalis*, L.

Juglandaceæ—

- Juglans cinerea*, L.
Juglans nigra, L.
Carya alba, Nutt.
Carya tomentosa, Nutt.
Carya porcina, Nutt.

Cupuliferæ—

- Quercus alba*, L.
Quercus macrocarpa, Mx.
Quercus Prinus, L.
 “ “ v. *monticola*, Mx.

Quercus imbricaria, Mx.

Quercus nigra, L.

Quercus falcata, Mx.

Quercus coccinea, Wang.

Quercus rubra, L.

Castanea vesca, L.

Fagus ferruginea, Ait.

Corylus americana, Walt.

Ostrya virginica, Willd.

Carpinus americana, Mx.

Betulaceæ—

Betula nigra, L.

Alnus serrulata.

Salicaceæ—

Populus tremuloides, Mx.

Populus grandidenta, Mx.

Populus monilifera, Ait.

Populus balsamifera, L.

Coniferae—

Pinus pungens, Mx.

Pinus inops, Ait.

Abies canadensis.

Juniperus virginiana, L.

Taxus baccata, v. *canadensis* (Willd.), Gray.

Araceæ—

Arisæma triphyllum, Torr.

Hydrocharidaceæ—

Vallisneria spiralis, L.

Orchidaceæ—

Liparis liliifolia, Richard.

Cypripedium pubescens, Willd.

Cypripedium spectabile, Swartz.

Amaryllidaceæ—

Hypoxis erecta, L.

Iridaceæ—

Iris cristata, Ait.

Sisyrinchium bermudiana, L.

Dioscoraceæ—

Dioscorea villosa, L.

Smilacææ—

Smilax glauca, Walt.

Smilax tamnoides, L.

Liliaceæ—

Chamælririum luteum, Gray.

Uvularia perfoliata, L.

Allium canadense, Kalm

Juncaceæ—

Luzula campestris, DeC.

Commelynaceæ—

Tradescantia virginica, L.

Tradescantia pilosa, Lehm.

Filices—

Polypodium vulgare, L.

Polypodium incanum, Swartz.

Adiantum pedatum, L.

Pteris aquilina, L.

Cheilanthes vestita, Swartz.

Pellaea atropurpurea, Link.

Asplenium pinnatifidum, Nutt.

Asplenium Trichomanes, L.

Asplenium ebeneum, Aiton.

Asplenium montanum, Willd.

Asplenium angustifolium, Mx.

Asplenium thelypteroides, Mx.

Asplenium felix-foemina, Bernh.

Camptosorus rhyzophyllus, Link.

Phegopteris hexagonoptera, Fee.

Aspidium thelypteris, Swartz.

Aspidium noveboracense, Swartz.

Aspidium spinulosum, Swartz v. *intermedium*, Muhl.

Aspidium Goldianum, Hook.

Aspidium marginale, Swartz.

Aspidium acrostichoides, Swartz.

Cystopteris bulbifera, Bernh.

Cystopteris fragilis, Bernh.
Onoclea sensibilis, L.
Woodsia obtusa, Torr.
Dicksonia punctilobula, Kunze.
Osmunda regalis, L.
Osmunda Claytoniana, L.
Osmunda cinamomea, L.
Botrychium virginicum, Swartz.
Ophioglossum vulgatum, L.

Lycopodiaceæ—

Lycopodium selago, L.
Selaginella apus, Spring.

GEOLOGICAL SURVEY OF KENTUCKY.

N. S. SHALER, DIRECTOR.

REPORT ON THE IRON ORES

OF

GREENUP, BOYD & CARTER COUNTIES,

THE KENTUCKY DIVISION OF THE HANGING ROCK IRON REGION,

BY P. N. MOORE.

PART III. VOL. I. SECOND SERIES.

THE IRON ORES OF THE KENTUCKY DIVISION OF THE HANGING ROCK IRON REGION.

I.

The iron ores of this region belong to the class of earthy carbonates or siderites, known also as clay iron-stone, and limonites or hydrated peroxides, which result from the alteration and oxidation of the carbonates. They are all in what may be properly called stratified deposits; for although some of them do not form connected strata, they all occupy regular, well-defined geological levels, which they hold over wide areas.

They are all found in association with the rocks of the coal measures, beginning at the base with an ore resting on the sub-carboniferous limestone.

There are occasional scattering beds of nodular ore in the shales of the Waverly formation; but they are never extensive enough in this portion of the State to be of any value.

In Kentucky, as in many other States, the ores occur in greatest abundance in the lower coal measures. There is no ore of more than local importance above this level. Some are occasionally found in the middle coal measures, and will be described hereafter; but they are by comparison of very little value, and are not largely worked, as they are inferior in quality and untrustworthy in occurrence.

The usual method of occurrence of the ores of this region is in beds or layers, although there are exceptions to this which will be described. At the outcrop, on the hillsides, where the ore has been exposed to the action of the atmosphere, it is usually a limonite; but as it is followed into the hill where it has been protected by a heavy covering, it occurs as a carbonate or siderite. This is always found to be the case where the ore has been protected from atmospheric influence.

The distance from the outcrop at which the siderite will be found, varies of course with the character of the overlying rock. Where this is a porous sandstone, the limonite will be found

extending a long distance under ground; and if it be near the top of a hill, the whole bed is sometimes found changed to limonite. If a dense, impervious clay shale overlies the ore, the siderite usually extends very nearly to the outcrop, and only a very small band or rim of limonite surrounds the bed.

Where the ore is covered by water for the most of the time, and thus protected from the air, it is usually found as the carbonate. This feature has been noticed at a number of places. Where it is comparatively dry the ore is usually a limonite; but when in a ravine, for instance, where water is constantly percolating through the rocks, keeping them saturated, the carbonate is almost always found.

These facts would seem to indicate that atmospheric influences alone effect the change from carbonate to hydrated peroxide of iron. There are, however, other facts which will be referred to further on, which seem to indicate that it cannot have been altogether effected by this means; and in spite of the seeming contradiction, it must have been assisted by the action of water.

In every instance the limonite has been derived from the carbonate; and in no case whatever has any indication or trace of a change by deoxidation from peroxide to carbonate been observed. The siderite or carbonate of protoxide of iron is the original mineral of these ore beds.

The siderites possess a dense, close structure, with the silicious and other impurities disseminated evenly through the whole mass, and a specific gravity which is much higher in proportion to the per centage of iron than it is in the limonites. This singular fact has been before stated by Andrews in the Ohio Geological Report for 1870, page 214. The limonites show an open, porous structure, with layers of different qualities of ore, and the impurities often segregated to themselves in the center of the specimen. They contain on an average a considerably higher per centage of iron than the siderites, and are much more esteemed by the iron manufacturers of this region. In fact, at the majority of the charcoal furnaces of this region, nothing but the limonite ores are used, as the

managers profess not to be able to produce a coarse-grained foundry iron from the blue carbonate ores. This is generally supposed to be owing to the presence of sulphur. Analyses show that there is usually somewhat more sulphur in the carbonates than in the limonites, which may be sufficient to account for the trouble experienced in working them; but it is also probable that the dense close structure, rendering them difficult of reduction, has much to do with the matter.

The average from a large number of analyses made by Dr. Peter and Mr. Talbutt of ores from this region, gives the relative per centages of metallic iron in the limonites and carbonates as follows:

ORES.	Limonites.	Carbonates.
Limestone ores	46.22	33.60
Upper block ores	44.60	34.42
Lower block ores	33.50	29.73

It will be seen from the above that the average per centage of iron in the limonites is considerably greater than in the carbonates. The specific gravity of the carbonates, as already stated, is higher, in proportion to the amount of iron present, than that of the limonites.

We thus have the singular fact presented of the carbonate ores gaining in the per centage of iron in the change to limonite, while the specific gravity, which is commonly supposed to be somewhat proportional to the per centage of iron, becomes considerably less. This is a fact which is not thoroughly understood and appreciated by the purchasers of ore in this region. They do not realize that the carbonate ores will not yield as much in proportion to their weight as the limonites, and that it is poor economy to pay the same price per ton for both.

THEORY OF FORMATION.

It is generally agreed by geologists that these ores are deposits from aqueous solution, laid down by chemical action.

There seems to be no doubt of this whatever. There are, however, different theories held in regard to the method and

time of this precipitation, and as to the condition of the ore when first deposited. The feature for which it is most difficult to account, is the occurrence of the ores as carbonates.

Under the circumstances at present prevailing, we should expect the ore to be precipitated from solution as a peroxide.

The waters which originally held the iron in solution must have been of wide extent, for we find some of the ores extending over large areas, sometimes covering hundreds of square miles; but whether these waters were oceanic in character, or large, shallow, fresh water lakes, is not well settled. It seems probable, from the occurrence of certain plant remains which are occasionally found in the ores, that the waters were shallow and fresh; but, on the other hand, there are occasional organic remains which are apparently of marine origin. Whence also the oxide of iron was derived, which the waters afterwards spread in so even a coating over the bottom, must be left to conjecture. It is a problem of no small difficulty to account for its so general dissemination and subsequent regular deposition. One theory holds, that the ore beds have all been deposited originally as peroxide of iron, and subsequently changed to carbonates, through the agency of the carbonaceous matter of the interstratified coal beds, and that disseminated through the associated shales and clays.

This theory has in its favor the fact that it is based upon a precipitation of the iron in the condition which we should reasonably expect it to assume; and there is no doubt that carbonaceous matter is competent to effect the change from peroxide to carbonate; but whether it would do so in such great masses, and over so wide a field, is a matter of considerable doubt. Moreover, this theory requires a constant association of carbonaceous rocks with the ores such as we do not find existing in nature. We often find the ores separated by wide intervals from any rocks which contain a perceptible amount of carbon—intervals so great that no possible effect can have been exerted. It is not probable that the carbon of, or the carbonated gases emanating from, a coal situated at a distance

above the ore, can have had any influence upon it; and this is the relative position they often occupy.

It is also extremely probable, or almost certain, if the change had been effected in this way from peroxide to carbonate, that it would not have been perfect in every instance; some local interruption would have interfered, and we should sometimes find places where the ore was in its original condition, or only partially changed to the carbonate. No such specimen, showing an alteration from peroxide to carbonate, has ever been found in this region by any member of the Survey, but in every instance it is found as the unaltered carbonate, or showing change from carbonate to peroxide.

Another theory is, that the ore beds are continental rock, pseudomorphs of carbonate of iron after limestone, or, in other words, that all these deposits were once beds of limestone—now changed to iron ore. It supposes that the iron was disseminated through the shales which had been deposited as a ferruginous mud above a bed of limestone. By a process of segregation, probably acting through the agency of carbonated waters, the ore has been separated and carried down upon the limestone, which in its turn was dissolved and carried away.

We should expect, however, under the conditions most prevalent at present, that the iron would be precipitated as the peroxide; but Bischof has shown* that carbonate of iron is pseudomorphous after carbonate of lime, and that it is deposited where free access of air is prevented through an excess of carbonic acid or other cause. Either the exclusion of the air or the presence of an atmosphere largely composed of carbonic acid must, therefore, have been the condition which enabled the deposition of the iron as carbonate.

This theory explains very satisfactorily the manner of occurrence of a certain large class of the ores of this region, known as the "limestone ores," as will be shown more fully hereafter; but it is improbable that the others can have been formed in this way. If all were thus deposited, we should expect to find them frequently changing to beds of limestone; but the fact

* Chemical and Physical Geology by G. Bischof—English edition, vol. II, 51.

is that certain of the most regular and persistent strata of ore in this region have never yet been traced to a replacement of this kind. They are occasionally found fossiliferous, and sometimes very calcareous; but they always maintain their identity as ore beds, and hold a uniformity of character and thickness such as the limestone ores do not possess. They seem to have been deposited as layers or beds of carbonate of iron in the shape and place we now find them, and before the overlying rocks were laid down. It is a matter of some difficulty to conceive of the conditions which would allow of the deposition as carbonate instead of peroxide over so wide an area; but there seems to be little doubt that it was so deposited.

Still another class, known as the nodular or kidney ores, seem to have been mixed with a great deal of earthy matter, and deposited as a fine ferruginous mud in quiet, fresh water; the iron afterwards segregating into the nodular form, and the earthy matter forming clays and shales.

We thus see that these ores vary considerably in their manner of deposition, while retaining the same general character.

This subject will be referred to again in discussing the general divisions of the ores.*

In the subsequent alteration of these ores, the change from carbonate to limonite, which is even now going on, there are two agencies which seem to share in the work—air and carbonated waters.

The evidence of the effect of atmospheric influence in this alteration has been already stated. It is one of the most powerful agencies; but there are some of the ores which have undergone a rearrangement, such as cannot have been effected by this alone. It must be the result of a solution, more or less complete, and a redeposition in nearly the same place in another chemical and molecular condition. The agent which has accomplished this is probably the same that has so often borne an important part in the original deposition, namely: water charged with carbonic acid. The change which is alluded

* For a fuller discussion of the different theories in regard to the formation of the carbonate ores, see Lesley's Iron Manufacturer's Guide, page 633 et seq.

to is shown by many of the ores, but most perfectly by certain of the upper block ores. It is the concentric arrangement of the layers of limonite, which are often fibrous and nearly pure, and the segregation toward the center of the silicious and earthy matter, which was evenly disseminated through the whole specimen before the alteration was begun. Specimens are frequent showing the change at all stages.

It seems to have taken place from the outside. The carbonated water gaining access to a specimen on all sides by means of the cracks and seams which abound in the ore, dissolves a portion of the carbonate of iron, which, not being protected from the influence of the air, is changed on the escape of the free carbonic acid to a peroxide, and deposited at once as a layer of limonite surrounding the center of carbonate. The carbonated water dissolves readily, carbonate of iron, lime, and magnesia, but has little influence upon alumina and silica. The iron is precipitated, the lime and magnesia are mostly carried off in solution, but the silica and alumina not being affected, are gradually separated toward the center, being surrounded by successive layers of limonite, until finally the iron of the whole specimen is changed to limonite, and we have a hollow ball of ore, in the center of which is a mass of silicious clay surrounded by successive layers of limonite. Of course, during the progress of this change, before it is complete, the carbonate of iron in the center grows more and more silicious. Many specimens have been found showing this to be the case, and showing the successive increase in the proportion of the silicious matter in the center as the change is nearer completed. The analyses of many of the ores in which these features are most common show a decidedly less per centage of lime and magnesia and a much greater per centage of metallic iron in the limonites than in the carbonates, thus corroborating this theory of the method of alteration. This process is of the greatest benefit to the ore; by it the per centage of iron is materially increased, sulphur, lime, and magnesia partially removed, and the silicious impurities separated in such a way, that, after calcining, they can be largely

removed by screening. It is much more complete than any artificial process. It has the disadvantage, however, of rendering the ore brittle and shelly, so that it crumbles to pieces easily after calcining, and a good deal of it is wasted as fine ore and dust.

All of the ores are not altered in this way. Many of them seem to have been acted upon by the air alone, or only slightly assisted by other causes. These show a simple oxidation; sometimes in concentric layers; but their structure is quite homogeneous, and the impurities remain disseminated through the whole mass.

They show a less increase in the per centage of iron, and no marked removal of impurities in the change from carbonate to limonite. The lower block ores are of this class more generally than otherwise, and, as shown already by the average of a number of analyses, the increase in per centage of iron in these is only about half that in some of the other ores.

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GENERAL DIVISION OF THE ORES.

II.

The ores of the region under consideration, which all belong to the same general mineralogical class and geological position, differ considerably, as already shown, in their external appearance, chemical composition, and the circumstances of deposition.

Three general divisions of them are recognized, and will be described under the names commonly applied to them. They are,

- (a) The limestone ores.
- (b) The block ores.
- (c) The kidney ores.

These names are often arbitrarily and incorrectly applied; but they are sufficiently accurate and comprehensive for our purpose, and they possess the additional advantage, that, in their sequence, they approximately represent the geological position, as well as the external appearance.

The limestone ores are so called from their association with limestone, being usually found resting upon it.

The block ores are named from the peculiarity that they possess of cleaving into sharp, square-cornered blocks, as they are raised by the miners.

The kidney ores are so called from the shape which they usually assume.

(a) THE LIMESTONE ORES.

Properly speaking, the name limestone ore is applicable only to an ore which is deposited upon, or very near to, a limestone; but often the ore occurs at the same geological level, in the same position, with reference to the overlying and underlying rocks, over a field wider than the associate limestone. In this case the name is still given to the ore.

Owing to their comparative purity, uniform character, richness in iron, and the ease with which they are worked in the

furnace, these ores are valued more highly by the furnace men of this region than either of the others. They occur both as limonites and unaltered carbonates (or siderites), and each of these shows modifications which are rare in other ores.

The limonites of this division are found (1, and rarely) as lightish brown, semi-concretionary ochreous ores, and (2, more commonly) as a dense, dark red, close-grained ore, giving red streak and powder, but containing about the same per centage of combined water as the other. When of this character, it is often full of seams and crevices, which have been filled with calcite, and it is apt to adhere to the underlying limestone. This variety is known as red limestone ore, and is the most valuable of any found in this region.

The following analyses will serve to show the chemical composition of this variety of ore. In some of the specimens the process of oxidation has not been completed, and there remains a considerable proportion of carbonate of iron; but the samples were taken to represent the ore as fairly as possible, as it is actually mined and paid for by the furnace operators.

These analyses, as well as all the following, unless otherwise specified, were made by Dr. Peter and Mr. J. H. Talbutt, chemists of the Survey.

TABLE I.—LIMESTONE ORES—Limonites.

	1	2	3	4	5	6	7	8	9	10	11
Peroxide of iron	60.576	67.859	46.984	72.95	49.770	81.640	80.040	57.551	51.802	71.680	60.206
Carbonate of iron	15.623	7.890	7.890	7.890	7.890	7.890	7.890	7.890	7.890	7.890	7.890
Alumina	2.860	1.160	5.580	1.660	6.315	3.160	2.680	6.017	4.523	4.155	1.044
Brown oxide of manganese		.980		.640	.640	trace.	trace.	.130		.090	trace.
Carbonate of manganese			.572								
Carbonate of lime	trace.	.120	21.240	.380	.380	.180	trace.	.150	7.480	.380	.285
Carbonate of magnesia	.619	1.275	2.904	.083	.115	.919	.425	.758	.440	.050	.381
Phosphoric acid	.632	.143	.371	.500	.537	.060	.115	.057	.570	.084	.161
Sulphuric acid	not est.	not est.	not est.	.178	not est.	not est.	.264	.105	.089	.270	.852
Silica and insoluble silicates	12.650	15.560	7.860	15.160	33.200	2.60	6.560	25.450	15.730	12.650	25.930
Combined water	*7.040	*12.903	*6.599	8.452	9.020	11.280	10.000	10.300	8.772	10.800	*11.141
Total	100.000	100.000	100.000	100.010	99.606	99.839	100.084	100.518	100.000	100.159	100.000
Metallic iron	49.995	47.501	39.025	51.070	34.739	56.148	56.028	40.285	41.357	50.176	42.144
Sulphur	.276	.062	.161	.218	.234	.026	.107	.042	.035	.108	.341
Phosphorus							.050	.024	.231	.036	.070

*And loss.

No. 1. Sample of limestone ore from Hood's Run, branch of Tygert Creek. Ore used at Raccoon Furnace.

No. 2. Limestone ore from head of Two Lick Creek, Kenton Furnace.

No. 3. Limestone ore from Coon Fork, Kenton Furnace.

No. 4. Limestone ore from Shover Drift, Kenton Furnace.

No. 5. Limestone ore from Powder Mill Hollow, Kenton Furnace.

No. 6. Limestone ore, cabinet specimen, best quality, Boone Furnace.

No. 7. Limestone ore, cabinet specimen, picked to represent the best by Mr. A. R. Crandall, Assistant of the Survey, from land of S. Warnock, Tygert Creek.

No. 8. So-called slate ore, occupying the place of the limestone ore, ridge between Cane Creek and Wilson Creek, Hunnewell Furnace.

No. 9. Limestone ore from Hood's Creek, Bellefont Furnace.

No. 10. Limestone ore from the Graham bank, near Willard, Carter county; average taken from the stock bank at Willard.

No. 11. Limestone ore from Brush Creek, Pennsylvania Furnace property.

All of the above analyses, with the exception of Nos. 6 and 7, were made from average samples taken by myself.

It will be seen that in the average samples the per centage of iron varies from 34. to 51. Silica, alumina, lime, and magnesia are present in exceedingly varied proportions. Silica and alumina are always present in appreciable quantities, but the lime and magnesia vary exceedingly. The amount of sulphur is small; so small as to have little or no influence upon the ore, unless, perhaps, in the case of No. 11.

The amount of phosphorus varies widely, and in some ores is present in sufficient quantities to make a "cold-short" iron.

The unaltered carbonates or earthy siderites occur (1) as amorphous, dense, close-grained ore, varying in color from light brown to dark blue, and commonly known as "blue limestone ore," and (2) as a light-colored, coarse-grained oölitic ore called "grey limestone ore." It consists of grains of siderite, embedded in a light-colored silicious matrix. It is more commonly found associated with the ferriferous than with the sub-

carboniferous limestone. It is highly valued and much used; but it is apt to become suddenly poor in iron and very calcareous, and the character of the ore is such that this change cannot be readily detected by the eye.

The following table of analyses will show the composition of some of the limestone ores, siderites, of this region:

TABLE II.—LIMESTONE ORES—Siderites.

	1	2	3	4	5	6
Peroxide of iron.	4.410	5.945	27.296	26.240	12.784	31.544
Carbonate of iron.	61.220	65.018	44.242	27.511	32.285	30.708
Alumina.	2.260	1.060	1.560	9.021	11.968	1.779
Carbonate of manganese. . .	.150	2.332	.842	.270	.465	.060
Carbonate of lime.	4.480	2.720	6.580	2.320	21.125	2.730
Carbonate of magnesia. . .	trace.	9.038	1.046	2.838	.691	.144
Phosphoric acid.	.313	.255	.732	.499	.377	.421
Sulphuric acid.	not est.	1.280	4.587	.116	.267	.491
Silica and insoluble silicates.	21.260	10.260	11.160	25.180	19.730	25.430
Combined water and loss. .	5.367	2.112	1.955	6.005	.308	6.523
Potash.	.231					
Soda.	.309					
Total.	100.000	100.000	100.000	100.000	100.000	100.000
Metallic iron.	32.577	35.549	40.465	31.598	24.591	36.627
Sulphur.		.533	1.855	.046	.107	.196
Phosphorus.	.136	.111	.319	.217	.164	.184

No. 1. Limestone ore from Old Orchard diggings, Boone Furnace, Carter county. Average sample from the whole bed exposed.

No. 2. Ore from Horsley bank, Boone Furnace. Analysis of a cabinet specimen of the undecomposed carbonate,

No. 3 Average sample from the ore at Horsley bank, Boone Furnace. Only a comparatively small amount of ore was accessible at this point, and it is not unlikely that it may have been unusually sulphurous—more so than the general average of the bed.

No. 4. Blue limestone ore from bank of Tygert Creek, about two miles above Iron Hills Furnace, Carter county.

No. 5. Grey limestone ore from J. P. Jones's drift, near Ashland, Boyd county. Average sample; ore at this place much more calcareous than usual.

No. 6. Grey limestone ore from Mt. Savage Furnace, Carter county. Average taken from ore at the stock pile by Mr. J. A. Monroe, aid of the Survey.

These analyses show a much greater and more constant proportion of lime and magnesia than in the limonites. Sulphur and phosphorus are also somewhat larger.

GEOLOGICAL POSITION.

The limestone ores occur at several well-defined levels; but there are two beds of greatest importance. The first is also the lowest ore of this region. It rests upon the sub-carboniferous limestone, at the base of the coal measures of eastern Kentucky. The other ore rests upon a limestone which has been called the ferriferous limestone by Andrews in the Ohio Geological Reports—a name which will be retained. In addition there are several small beds of minor importance which occur above the ferriferous limestone, but they are of local range, and have small value compared with the others. They will be referred to hereafter. The ore of the sub-carboniferous limestone will be known as the lower limestone ore; that of the ferriferous limestone as the upper or ferriferous limestone ore. The special description of each of these beds will be given hereafter; but this much of a description has been given here, as it is necessary in order to properly discuss the geographical range of these ores, and to the correct understanding of the position of the other ores to be described.

The limestone ores present a greater variation in thickness, and more sudden changes, within a short distance, than any other ore of this region. They vary in thickness from a few inches to as many feet; but the rule usually holds, that the thicker the "pocket" or "roll," the less is its horizontal extent.

There are, however, marked exceptions to this, as, for instance, at Boone Furnace, in Carter county, where, at the head of Grassy Creek, on the ridge forming the divide between the waters of Tygert and Kinnikenick Creeks, the limestone ore occurs very regularly from fifteen inches to two feet in thickness, and often much thicker, in wide pockets. At the Graham

bank, near Willard, Carter county, this ore is found in the usual rolls, some of which measure two to four feet in thickness.

The limestone upon which the ore is deposited presents an exceedingly uneven surface, being full of ridges and depressions.

Into them the ore seems to have settled in greatest quantity, growing thicker over the depressions in the limestone, and thinner over the ridges, until the top of the ore often presents a series of ridges and hollows which are the reverse of those in the limestone. The following sketch will show this feature:



At some places it might be supposed that the ore had flown into the pre-existing irregularities of the limestone in the plastic condition of a recent chemical precipitate. This supposition might explain the fact if we found the top of the ore presenting an even surface; but this is rarely if ever the case. It is usually uneven and irregular, as shown in the cut above.

This supposition is therefore probably untenable. The more probable theory of formation of the limestone ores is, that they have been formed, in most cases, by a segregation of the iron from the shales and clays above the limestone after their deposition. The iron in the form of a carbonate, held in solution by strongly carbonated waters, has been carried down and deposited upon the limestone, which was partially dissolved and carried off by the waters which deposited the iron, thus forming the depressions and irregularities in its surface which have been already described.

This theory of deposition by segregation from the overlying rocks accounts most fully for the following marked peculiarities of the limestone ores; the irregularities of thickness; the tendency to become suddenly calcareous, or to disappear altogether, giving place to a limestone; the comparative freedom from coarse silicious impurity, and the fact that an increase

in thickness is not, as in the block ores, accompanied with a corresponding deterioration in quality and increase in the proportion of sand intermixed,

It furthermore explains the presence of the thick beds of fire-clay in which barely a trace of iron remains, which are so often found above these limestone ores. Marked examples of this occur at Amanda Furnace and on Pea Ridge, between Hunnewell and Pennsylvania Furnaces.

The most common impurities of these ores, which serve to lessen their value at places, are chert (or flint) and lime.

The chert is more commonly associated with the lower limestone ore, which rests upon the sub-carboniferous limestone, than with the ore of the ferriferous limestone. Where present, it is of great injury to the ore; for a very small per centage of chert interferes seriously with the easy working of the ore in the furnace. Lime, on the other hand, is of no injury, save that, by acting as a diluent, it reduces the per centage of iron. The variation in the per centage of lime present is very great, and the change from a rich ore to one more calcareous, from a calcareous ore to a ferruginous limestone, takes place very suddenly. This change is more apt to occur in the siderites than in the limonites; for the agents which have effected the alteration of the ore seem to have also removed the greater proportion of the lime present.

Much of the low-grade calcareous ore, yielding from fifteen to twenty-five per cent. of iron, is now refused by the furnace managers at any price, for the reason that, although they know it could be used profitably as a substitute for limestone as flux, they have no cheap and ready means of determining its value. Another reason is, that the ores vary so suddenly in composition that the proper proportion to be used in the furnace charges would be constantly subject to change. Their value can only be accurately determined by often repeated chemical analyses; and as yet there are no facilities in this region for having such work cheaply done.

There are large quantities of these low-grade limestone ores, or ferruginous limestones, now either left unmined or

When unaltered carbonates, the appearance of ores from the different beds does not vary much, save as the presence of more or less coarse sand gives them the "rough" appearance. After their alteration to limonite, however, they appear very differently. The upper ores are then dense, of a dark reddish brown color, with the cubes into which the ore cleaves weathered in a spheroidal shape, semi-concretionary, and hollow, the interior of them frequently containing small stalactites of limonite, and almost always more or less silicious and earthy matter, which, before alteration, had been evenly disseminated through the whole mass, but not being soluble in the waters which dissolved and re-deposited the oxide of iron, had gradually segregated towards the center, and been surrounded by the pure limonite.

The lower ores, on the other hand, retain their cubical fracture: are dull, yellowish brown and porous, formed of a mass of irregularly curved layers of ochrey limonite, holding the silicious matter disseminated through the whole mass almost as generally as before alteration. Some of them are occasionally micaceous. Occasionally, while undergoing this process of alteration, a bed of block ore will be so completely changed as to present the appearance of, and be difficult to distinguish from, the true kidney ore. When this is the case, it is often called kidney or "kidney-block" by the miners. A bed of this kind can usually be distinguished from a true kidney deposit, to be hereafter described, by the following characteristics: 1st. The ore lies at a uniform level, while the true kidneys are often scattered through a number of feet of shale or rock. 2d. On careful examination one or two plane faces can be found on each fragment, showing the surface of contact with the adjoining ore. The block ores vary in thickness from one or two inches to several feet; but the most valuable beds, those of the best quality and of most reliable extent, are usually from four to ten inches, and occasionally thicker; but, as before noted, the additional thickness is gained at the expense of quality, when a bed elsewhere thin becomes thick.

QUALITY.

The lower block ores, taken as a rule, are inferior to the upper, in the less per centage of iron, and the greater proportion of impurities.

The following tables of analyses, by Dr. Peter and Mr. Talbutt, will show the comparative composition of the lower and upper block ores, both limonites and siderites:

TABLE III.—LOWER BLOCK ORES—Limonites.

	1	2	3	4	5	6	7	8	9	10
Peroxide of iron	54.530	50.506	41.390	40.139	56.670	59.950	41.556	36.985	44.876	42.56
Carbonate of iron				5.731	8.538					
Alumina	2.120	8.317	6.777	8.030	4.405	5.230	8.604	5.508	4.083	
Brown oxide of manganese	1.380		.180	.422	.180			.040	.260	
Carbonate of lime	.040	.380	trace.	.380	trace.	4.580	.180	.520	.990	
Carbonate of magnesia	1.823	.201	.065	.254	.883	.343		.533	.357	
Phosphoric acid	.908	.767	.579	.038	.337	.842	.882	.367	.166	
Sulphuric acid	.336	.356	.154	.177	.130	.837	.851	.116	.123	
Silica and insoluble silicates	28.360	28.820	40.380	37.220	19.480	16.600	38.160	46.760	39.080	
Combined water	10.900	11.760	9.700	*7.609	*9.377		10.100	8.330	9.850	
Total	100.397	100.607	99.225	100.000	100.000		100.333	99.159	99.785	
Metallic iron	38.171	35.00	28.973	29.816	44.736	41.965	29.089	25.889	31.413	29.792
Sulphur	.134	.142	.066	.071	.060	.335	.340	.046	.047	
Phosphorus	.428	.339	.252	.016	.147	.367	.358	.160	.072	

*And loss.

No. 1. Ore from Louder's bank, near Kenton Furnace, Greenup county.

No. 2. Ore from Thompson's bank, near Kenton Furnace.

No. 3. Ore from Allen bank, near Kenton Furnace.

No. 4. Block ore from Perry's branch of Tygart Creek; east slope of Garvin Hill, near Olive Hill, Carter county.

No. 5. Block ore from the outcrop in the road, west side of Garvin Hill.

No. 6. Block ore about ninety feet above the limestone, from the old road across Garvin Hill.

No. 7. Lower block ore from Hood's Run, branch of Tygart Creek, Raccoon Furnace, Greenup county.

No. 8. Rough block ore from below the principal lower block ore, Shelf Fork of Raccoon Creek, Raccoon Furnace.

No. 9. Ore from J. Downs's Oldtown Creek, Greenup county; ore used at Buffalo Furnace.

No. 10. Rough block ore, the upper of two exposed on Darby branch of Clay Lick Creek, near Buffalo Furnace.

All of the above are from average samples taken by myself. The analyses of the lower block ores, unaltered carbonates or siderites, are as follows:

TABLE IV.—LOWER BLOCK ORES—Siderites.

	1	2	3	4
Peroxide of iron	4.989	9.734	6.500	8.648
Carbonate of iron	62.321	47.391	44.678	54.773
Alumina	7.901	4.197	4.178	7.800
Carbonate of manganese	.121	.346	trace.	1.204
Carbonate of lime	12.000	5.220	2.230	3.780
Carbonate of magnesia	.222	7.893	1.903	3.088
Phosphoric acid	.684	.121	.204	.447
Sulphuric acid	.206	.151	.250	.298
Silica and insoluble silicates	10.740	20.230	36.880	20.250
Combined water and loss	.816	4.717	3.177	.....
Total	100.000	100.000	100.000	100.250
Metallic iron	33.348	29.685	26.073	29.851
Sulphur	.082	.06	.104	.105
Phosphorus	.298	.052	.089	.195

No. 1. Blue lower block ore, near J. M. James's, Dry Fork of Little Sinking Creek, Carter county.

No. 2. Blue lower block ore, from near Wm. Everman's, on Sammy's branch of Barrett's Creek, Carter county.

No. 3. Lower block ore from Womack's bank, Oldtown Creek, Greenup county.

No. 4. Blue block ore near the place of the limestone ore, Alcorn Creek, Raccoon Furnace, Greenup county.

Analyses all from average samples taken by myself.

It will be seen, on comparison of the preceding tables, that the average per centage of iron in the limonites is 33.50 against 29.73 in the siderites. The sulphur and phosphorus are nearly the same in both, while the carbonates of lime and magnesia are much greater in the siderites than in the limonites, the other ingredients remaining about the same in both.

The analyses also show, what has been already stated, that the lower block ores are very silicious and poor in iron, in comparison with the ores of the other classes. They are also seen to be somewhat more phosphatic than the others.

The appearance and character of the upper block ores has been referred to; the analyses are here given in Tables V and VI. It will be noted that in Table V, analyses of limonites, several of the specimens contain a considerable proportion of unaltered carbonate of iron:

TABLE V.—UPPER OR MAIN BLOCK ORES—Limonites.

	1	2	3	4	5	6	7	8	9	10	11	12
Peroxide of iron	57.09	65.657	54.703	56.279	64.577	23.396	68.928	71.502	61.316	56.84	69.27	59.349
Carbonate of iron . . . . .	.....	.....	17.758	11.392	.....	14.972	.....	.....	19.435	.....	.....	9.599
Alumina	4.438	4.921	2.30	4.709	not est	4.077	2.768	8.567	3.537	.....	.....	1.957
Br'n oxide manganese	trace.	trace.	.44	trace.	1.360	.421	.290	trace.	.....	.....	.....	.030
Carbonate of lime	trace.	trace.	.34	.180	.440	33.778	.680	trace.	.....	.....	.....	.830
Carbonate of magnesia	.086	.040	.499	.476	.820	.968	.641	.054	.212	.....	.....	2.027
Phosphoric acid	.370	.893	.128	.601	.172	.537	.249	.466	.166	.....	.....	.153
Sulphuric acid	.391	.590	.680	.260	.151	.151	.748	.800	1.009	.....	.....	.302
Silica & insol. silicates	26.760	17.780	15.958	16.930	21.23	16.240	15.240	9.030	10.780	.....	.....	19.810
Combined water	11.100	10.740	*7.194	*9.173	*11.25	*5.463	11.100	9.500	*3.45	.....	.....	*5.945
Total	100.154	100.521	100.000	100.000	100.000	100.000	100.643	99.905	100.000	.....	.....	100.000
Metallic iron	39.963	45.959	46.865	44.896	45.204	23.597	48.249	50.051	48.585	39.788	47.589	45.472
Sulphur	.156	.236	.272	.104	.070	.070	.298	.320	.403	.....	.....	.120
Phosphorus	.161	.391	.055	.262	.074	.224	.098	.203	.072	.....	.....	.066

*And loss.

No. 1. Ore from Stewart's bank, three miles west of Grayson, divide between Barrett's and Everman's Creeks, Carter county.

No. 2. Ore from "Potato Knob," two miles from Iron Hills Furnace, Carter county.

No. 3. Ore from Poynter bank, Raccoon Furnace, Greenup county.

No. 4. Kidney ore associated with the main block ore, Buffalo Furnace, Greenup county.

No. 5. So-called "Kidney Block" Ore, McAlister Point, Buffalo Furnace.

No. 6. So-called "Lime Ore," the main block ore locally thickened and very calcareous, hill three quarters of a mile southeast of Buffalo Furnace.

No. 7. Ore from Little Martin bank, Laurel Furnace, Greenup county; average sample by Mr. J. A. Monroe.

No. 8. Ore from old Mt. Tom, near line between Greenup and Carter counties; ore used at Laurel Furnace; average sample by Mr. J. A. Monroe.

No. 9. Ore from Kibby diggings, divide between Lost and Tygert Creeks; ore used at Laurel Furnace; average by Mr. J. A. Monroe.

No. 10. Ore from Brushy Knob bank, Laurel Furnace.

No. 11. Ore from Osenton bank, Laurel Furnace.

No. 12. Ore from Stinson Creek, known as the "Stinson Creek Little Block Ore;" average sample by Mr. J. A. Monroe, taken from the ore at Mt. Savage Furnace stock pile.

All of the above analyses were from average samples taken by myself, where not otherwise specified.

TABLE VI.—UPPER OR MAIN BLOCK ORES—Siderites.

	1	2	3	4
Peroxide of iron	.204	13.468	.276	21.270
Carbonate of iron	78.722	55.258	66.854	33.321
Alumina	2.746	.670	4.260	4.991
Carbonate of manganese	.421	.060	.572	trace.
Carbonate of lime	2.250	4.880	2.460	.980
Carbonate of magnesia	.380	4.528	4.086	.439
Phosphoric acid	.505	.368	.709	.434
Sulphuric acid	1.160	1.043	.885	1.208
Silica and insoluble silicates	11.340	15.660	18.360	31.730
Combined water and loss	2.272	4.065	1.538	5.627
Total	100.000	100.000	100.000	100.000
Metallic iron	38.146	36.103	32.466	30.975
Sulphur	.524	.416	.354	.483
Phosphorus	.220	.200	.308	.189

No. 1. Blue kidney ore taking the place of the main block ore; drift one mile southeast of Laurel Furnace, Greenup county.

No. 2. Main block ore, Baker bank, Laurel Furnace.

No. 3. Wilson Creek blue block ore, Wilson Creek, Carter county; Star Furnace property.

No. 4. Blue block ore near Amanda Furnace, Greenup county.

All the above analyses from average samples taken by myself.

The analyses show that the high value which is given to these ores by the furnace men of this region is well deserved. They compare favorably with any found in this region.

(c) THE KIDNEY ORES.

The kidney ores are nodular masses of ore, both limonite and siderite, which are named from the shape which they most commonly assume. They are found scattered through the shales and sandstones, at various levels, all through this region, but are by no means uniformly disseminated. They do not form a continuous bed or layer of ore, save in rare instances; but, on the other hand, they frequently occur at certain clearly defined geological levels, and hold the same position over a large territory. When occurring this way they are usually scattered through from three to six feet of shale or sandstone. Such is the uniformity and persistence of some of these ores, that they serve as geological data from which to determine the position and identity of other strata of ore or of coal. As an instance of this, the two kidney ores, which serve to mark the place of the well-known Coalton (No. 7) coal, may be mentioned. These are among the most trustworthy and persistent ores of all this region.

The kidneys or nodules vary greatly in size, though there is a certain uniformity in those of each level; so much so, that local names are applied to the different beds, from the size of the kidneys, and they are known among the diggers as "Little Yellow Kidney," "Big Red Kidney," &c. Individual nodules are often found of large size—several hundred pounds in weight. In shape there is also great variation, but the most prevalent form is an ellipsoid, considerably flattened, with length about twice the breadth and three times the thickness. They often assume a variety of fantastic shapes, and it is noticed that the tendency to assume these is more marked in those which are found in crevices in sandstone than in those which lie bedded in shale.

These ores are not, as the so-called "Kidney Block Ores," already referred to, the result of the alteration and partial destruction of a bed or stratum of ore, but each individual nodule seems to be the result of separate deposition. They are formed by chemical action, which segregates the carbo-

nate of iron from the surrounding material, and, by a process of aggregation or concretion, deposits it around a given center.

This tendency of a substance to separate to itself and form concretions, is of very common occurrence in nature in other materials besides iron ore. In fact, it may be said that it exists in all rocks which are the result of chemical deposition in contradistinction to those which are mechanically deposited. In some concretions a foreign substance often forms the nucleus around which the material is deposited; but although I have diligently examined, I have never, in the hundreds of specimens which I have broken open, found a single well-marked nucleus in one of these nodules of iron ore of this region. They are of homogeneous structure throughout.

The nodules of ore very commonly show weather-cracks running all through them, and forming various fantastic figures on the surface. In these crevices various foreign substances have been deposited. The most common of these is carbonate of lime, but dolomite, gypsum or sulphate of lime, and blende or sulphide of zinc, also are occasionally found.

Occasionally there is found at the bottom of one of these beds of kidney ore, using here the word bed to mean the whole series of kidneys at one level, scattered in the associate rock as already described, a solid layer or plate of block ore, but it is always exceedingly irregular, and can never be relied on to extend any distance.

This bed of ore seems to have been deposited where the amount of iron was greatest and the waters least disturbed, and, like the block ores, it was deposited before the overlying shales

The nodules proper seem to have separated from the ferruginous mud or sand which held the disseminated oxide of iron, perhaps simultaneously with its deposition, perhaps afterward. It is not unlikely that the separation or segregation of the ore took place soon after the mud or sand was deposited, and before a great weight of overlying rocks had compacted them.

so that the separation would be difficult. That the kidneys were formed in some cases after the associate rock was deposited, seems to be pretty certainly proved by the fantastic shapes which they show when filling crevices in sandstone—forms apparently the resultant of the tendency of the ore to assume its normal form, prevented by the shape of the crevice.

GEOLOGICAL POSITION.

Occasional deposits of kidney ores are found, at various levels, in the western part of this region, in the lower rocks of the geological series, but they are usually small and of no value, as they do not exist in sufficient quantity to be worked economically.

The first exception to this rule occurs in the shales above the main block ore, at numerous places west of Little Sandy river. At most of the banks here there is more or less kidney ore overlying the main block ore, and mined with it; but it is subject to great irregularities, and is not very reliable.

It is not until we approach the level of the ferriferous limestone that we find the kidney ores especially valuable. Twenty feet below this limestone occurs an ore which is sometimes a continuous layer or bed of block ore, and sometimes a characteristic kidney ore. It is known by a variety of names, such as "Lime Kidney," "Slate Ore," &c., and is the lowest kidney ore of value. The horizon of the reliable kidney ores may be said to begin about fifty feet above the ferriferous limestone. Below this level, with the exceptions noted, there is no kidney ore of any value. Above this level there is very little except kidney ore of value. There are a few local ores, somewhat similar to the limestone ore, and usually called limestone or bastard limestone ore, but they are not in any great quantity, and, in comparison with the kidney ores, amount to nothing.

Beginning, then, forty to fifty feet above the ferriferous limestone, the kidney ores are found up to about one hundred and fifty feet above. In this distance from three to six beds

of kidney ore are found. From these probably from one half to two thirds of all the native ore used in this region is obtained. It will thus be seen that these ores are of the greatest importance. Accurate statistics, to prove the above statement as to the relative amount of kidney ore mined, it is impossible to obtain, for the reason that the purchasers of ore do not all keep a record of the amounts of ore of each kind received; but it is believed not to be far from the truth.

There is no reliable ore, or ore of more than local extent and value, found above the kidney ore horizon in this region.

The kidney ores, like all the others, are found in all stages of transition from the carbonate to the limonite. The change goes on from the outside in concentric layers, and the surface of these is usually of a bright yellow color, save in some of the beds, which are more calcareous, and weather to a red color.

The quality of the kidney ores is uniformly good; they do not yield so well in the furnace as the limestone ores, or some of the best block ores, but they do not, on the other hand, present such variations in quality as the block ores. The yield in the furnaces, which use these ores almost exclusively, is from thirty to thirty-five per cent., with perhaps an average of thirty-three and a third. The yield of iron is very much reduced by the large amount of adhering dirt and clay, which is more in these than any other ores, owing to the fact that so many of them are small, and surrounded on all sides by the clay, from which it is impossible to entirely free them.

The following analyses show the composition of some of the kidney ores. Although they were all made from samples taken to represent as nearly as possible the average quality of the ore, yet it will be seen that the average per centage of iron, as shown by these analyses, is 42.39, or about nine per cent. greater than the actual yield of the ore in the furnace. This discrepancy is due mainly to the cause above referred to—the presence of clay and dirt with the ore as it goes into the furnace, which was not taken with the sample for analysis in as great proportion as it is when it goes into the furnace:

TABLE VII.—ANALYSES OF KIDNEY ORES.

	1	2	3	4	5
Peroxide of iron	61.344	56.022	58.960	54.055	66.200
Carbonate of iron		8.821			
Alumina	4.236	7.191	7.284	4.919	3.907
Brown oxide of manganese		trace.	.380	.420	.030
Carbonate of lime	.750	2.520	.430	.080	.430
Carbonate of magnesia	.208	1.271	.227	trace.	.345
Phosphoric acid	.795	.526	.376	.076	.130
Sulphuric acid	.041	.090	.206	.096	.182
Silica and insoluble silicates	21.480	13.430	21.210	30.080	16.530
Combined water	11.200	*10.129	10.800	10.450	11.730
Total	100.054	100.000	99.873	100.176	99.484
Metallic iron	42.941	43.473	41.272	37.838	46.34
Sulphur	.016	.036	.082	.038	.072
Phosphorus	.347	.229	.164	.033	.057

*And loss.

No. 1. Yellow kidney ore from Brush Creek, Buena Vista Furnace, Boyd county.

No. 2. Yellow kidney or so-called "Black Vein Ore," from Straight Creek, below Buena Vista Furnace.

No. 3. Yellow kidney ore sampled from a number of localities on the Star Furnace property, Carter county.

No. 4. So-called black kidney ore, from hill back of Star Furnace.

No. 5. Yellow kidney ore from Mt. Savage Furnace, Carter county; average sample selected from the ore at the furnace stock pile by Mr. J. A. Monroe. With the exception of the last, all the above analyses are from average samples taken by myself.

GEOGRAPHICAL RANGE OF THE PRINCIPAL ORE DIVISIONS.

In discussing the range or extent of territory over which the ores under consideration will be found to occur, only that area is considered where the ore is found above the drainage.

The lower ores probably occur at the proper level under the upper, all through this region; but most of them are of such a thickness that at present they cannot be profitably mined under ground by shafting.

In fact, under the present system of mining by stripping, almost nothing of the ores can be counted as of value which is covered with more than twenty feet of overlying material. Improved methods of mining by drifting will, doubtless, eventually be introduced, by which many ores that are now considered as too thin to pay for drifting will be profitably worked.

In describing the area or range of these ores, the most that can be done is to give, with approximate accuracy, the boundaries of each ore field beyond which the ore or ores under consideration will not be found, except perchance in a straggling pocket or outlier. It is not intended to assert that the ore will be found everywhere within the described fields; the character of the ore beds themselves, and what we know of the manner of their deposition, would lead us to expect irregularities such as do actually occur.

The most that can be asserted is, that in the given field there is a strong probability that the ore will be found, if sought for at its proper level.

Inasmuch as the dip of the rocks in this region is gentle and regular, especially on the west, and as the western edge of the fields is usually marked by some well-defined topographical feature, the boundaries of several of the ores lying close together will often be found to be nearly coincident.

The area of each principal ore division will be described here, without reference to the fact that the ores overlap each other, and that sometimes all these varieties of ore occur in the same area.

In showing the ore fields on the map, however, a different system will have to be adopted, which will be described hereafter.

THE AREA OF THE LIMESTONE ORES.

1. The lower limestone ore.

This ore, as already stated, is found resting upon or near the sub-carboniferous limestone, in the western part of this region. It is not, however, always present where the lime-

stone is; and when found, it varies greatly in thickness. This ore, as well as the upper or ferriferous limestone ore, is exceedingly erratic in its deposition, often being absent over large areas where it should be found.

It lies in a belt or zone of which only a portion is shown in the map, extending in a southwesterly direction, the course of the strike of the rocks.

It is not found in any quantity north of a line drawn west from Bennett's Mills on Tygert Creek. North of this, to the Ohio river, there is little ore found of any kind, except occasionally some block ore.

The western limit of this ore is the ridge forming the divide between Tygert and Kinnikenick Creeks. The ore here is found in the very tops of the hills. Of course, when this is the case, only a very small portion of the whole surface is underlaid by the ore; but in this ridge some of the largest and most reliable deposits are found. Those of Boone Furnace, already referred to, are in a spur of this ridge.

This ore extends as far south as our observations have gone; some distance beyond the field of this map, as far as the southern edge of Carter county; and it is known to extend much further. It has been found in considerable quantities around Olive Hill, Carter county, and in the divide between Tygert and Triplett Creeks.

On the east, it is found no further than the western slope of the divide between Tygert Creek and Little Sandy, which is, as will be seen on consulting the map, but a short distance from Tygert Creek; the drainage area of Tygert on the east being small and the hills very steep.

The limestone occasionally occurs east of this, on the Little Sandy slope, as at Bull's Eye Spring on Barrett's Creek, and on Oldtown Creek, but the ore is not usually found in contact with it.

An ore is occasionally found on the Little Sandy slope, which has nearly the same position with reference to the overlying block ores, and is near the Waverly sandstone; but the limestone is wanting, and the ore has the character of a

block ore of medium quality. No. 4, of Table II, analyses of block ores, shows the composition of one of these.

2. The upper or ferriferous limestone ore.

This ore occurs more brokenly and irregularly than the lower ore. Its area is extremely difficult to describe, for, in addition to the irregularity of the ore deposit, the boundary of the field, until we get some distance back from the Ohio river, is not marked by, or coincident with, any prominent topographical feature. The limestone which gives name to this ore is very irregular, and the ore is found often at its proper level where there is no limestone below. Unlike the other, however, it retains a good quality and is still highly valued, but it is apt to be thin.

The northern or northeastern boundary of this ore field is the Ohio river. Its western limit begins on the Ohio river, about a mile below Amanda Furnace; runs nearly west to Caroline Furnace; from there, southwestwardly, passing a little north of old Kentucky Steam Furnace; then south, crossing East Fork of Little Sandy, and following the main divide between Little Sandy and East Fork in a course a little west of south, passes Pennsylvania Furnace and extends out on the spurs of the main ridge toward Little Sandy. From the head of Sandsuck Creek, at the Pea Ridge banks, it follows the ridge between Cane and Williams' Creeks, passing close to Hunnewell Furnace, leaves a few detached outliers on the ridge between Wilson and Cane Creeks; passes around near the head of Wilson Creek, turns more to the west, crosses Stinson Creek and Little Fork of Little Sandy, near the mouth of Straight Creek; follows the divide between Little Fork and Little Sandy river, nearly or quite to the head of Little Fork, where it passes into Lawrence county. This region is not much developed, but enough has been done to prove the presence of this ore beyond doubt.

Toward the east the ferriferous limestone thins out quickly, and we uniformly find the ore extending further in that direction than the limestone, but gradually changing its character and disappearing. The limestone itself is not found in any

thickness on the Williams' Creek side of the ridge. The eastern boundary of the ore is approximately as follows: beginning at the Ohio river, back of Ashland, it follows Little Hood's Creek to its head; crosses in a southwest course to East Fork, near mouth of Williams' Creek; up Williams' Creek to mouth of Rush; then along the ridge between Rush and Williams' Creek; then down into Straight Creek, which it crosses about two miles above the Mt. Savage Furnace; then west of south to the mouth of Lost Creek, and thence nearly south to the county line at the head of Dry Fork. The dip of the rocks in the Little Fork valley, near Willard, is very rapid to the east, so that the area of this ore, which is regular and of very good thickness, is quite narrow in an east and west direction.

In all this area the limestone is very irregular, and from Hunnewell Furnace south to Mt. Savage, especially so. Occasional patches of small extent are found near Mt. Savage, and further south it is much more abundant and regular. From Pea Ridge, between Pennsylvania and Hunnewell Furnaces, north toward the Ohio river, it is much more regular in its occurrence.

As one kidney ore occurs only twenty feet below this limestone, and another, the first one of the great beds of kidney ore, only from forty to fifty feet above, it will be seen that a large portion of the above described field contains the kidney ores as well, and that the western border, as described, is nearly the border of the kidney ores.

THE AREA OF THE BLOCK ORES.

1. The lower block ores.

To the west of Tygert Creek the lower block ores extend over nearly the same area as the lower limestone ore. They are found nearer to the Ohio river, reaching north of the limit of the limestone ore, although not in very great quantity. It is a fact noted by Sidney S. Lyon, of the former Geological Survey, that the ores seem to thin out toward the Ohio river. With all the lower ores this is true, and no ore, until the upper

limestone ore is reached, is found to extend in as great abundance to the river as it is further back.

From about two miles above the mouth of Little Sandy a strip, which is comparatively bare of ores, reaching three or four miles back, extends down the Ohio river to the western edge of Greenup county. In this, occasional deposits of block ore are found, and it will be considered as a block ore field, though not of great value. This thinning out of the ores is probably due to the great thickness of sandstones which occur here, marking a former region of waters disturbed by currents which deposited the coarse sandstones and interfered with the deposition of the ores.

With these qualifications in regard to the region near it, the Ohio river will be considered as the northern limit of the lower block ore field.

The northern boundary is almost the same as that of the lower limestone ores, for as one of the most widely deposited of these is usually only about forty to fifty feet above the limestone, it will not disappear toward the west much sooner. The block ore is found on the ridge between Tygert and Kinnick Creeks, near the corner of Lewis, Rowan, and Carter counties, where it is some fifty to seventy-five feet below the top of the ridge.

Further northeast, at Boone Furnace, it is held only by the very highest points in the ridge, and still further northeast, near Kenton Furnace, it is last seen in the spurs running out toward Tygert Creek before the main ridge is reached. This is also the case in the region at the head and to the west of Shultz Creek. The ore is also wanting in the region immediately south of Springville.

On the south the lower block ores extend uninterruptedly to Barrett's Creek and the head of Little Sinking, and are also found near Little Sandy, about five miles above Grayson. Whether they will be found in the drainage of Big Sinking and the lower part of Little Sinking Creeks, as well as in all the heavy conglomerate region in the valley of Little Sandy to the south, is a question yet unsettled. It is not unlikely that they

are wanting, the place for them being occupied by the heavy conglomerate sandstone.

The eastern boundary of these ores may be approximately given as the Little Sandy river. Although they are occasionally found further east, yet they are not abundant, and not much, if at all, worked at the present time.

2. The area of the upper block ores.

With the same qualifications in regard to the region near it, as was made in the case of the lower block ores, the Ohio river is given as the northern boundary of the upper block ores.

The western boundary is the divide between the waters of Little Sandy and Tygert Creek.

To the south these ores have been found almost to the southern edge of Carter county. There is, however, a large region west of Little Sandy, and south of Little Sinking Creek, where little or nothing is known as to their presence. There has been no development in this locality, as there was no market for the ore, nor means of getting it out readily.

The eastern boundary does not differ very greatly from that of the upper limestone ore already given, for while the block ores average from eighty to one hundred feet below the limestone, and would pass below the drainage some distance before it to the west, yet the limestone ore thins out and disappears on the east, about the same place that the block ores pass under the drainage. It is sufficiently approximate, therefore, to consider it the same.

THE AREA OF THE KIDNEY ORES.

The northern boundary of the kidney ores in this region is the Ohio river.

The western is nearly the same as that just given as the boundary of the upper limestone ore. Where the boundary is any prominent topographical feature, it is usually the same for both limestone and kidney ore, as the distance between them is only from forty to fifty feet. Where, however, the ores run out toward the west on the spurs of the main ridges, the limestone is usually found from one to two miles further

west than the kidney ore. In the extreme southern part of Carter county this ore has not been much developed, but it is known to extend nearly to the Lawrence county line.

To the east the kidney ores extend much further than the limestone. There is an area of many square miles in which they are almost the only ores of any value. They are found along the Ohio river to the mouth of the Big Sandy or Chatterawha river, and up that stream in greater or less quantities, being considerably interrupted by the heavy sandstones which there abound, to the mouth of White's Creek. From here the line runs a little south of west, crosses East Fork near the mouth of Garner Creek, holding the same course to the head of Garner Creek and a little beyond. It then turns more to the south, crossing Straight Creek about two miles below its head, Lost Fork about three miles above its mouth, and thence nearly south or a little southeast to the limits of the map. In the region to the south and southeast of this line, between it and Big Sandy river, the kidney ores are for the most part carried below the drainage by the dip into the Bolts' Fork or East Fork basin. At some places the level of the ore in this region is above drainage, but its place is occupied by one of the heavy sandstones which are so abundant here.

DESCRIPTION OF INDIVIDUAL ORE BEDS.

III.

Having now seen the general features of the ores of this region and their general classification, a brief description of each of the separate beds, or of such at least as are of importance, will be given. This will show somewhat more in detail the character of each ore, its localities of best development, and at what furnace, if any, the ore is used. They will be described in the order of their occurrence geologically, beginning with the lower limestone ore, the first of the series.

THE LOWER LIMESTONE ORE.

The geological position of this ore has been already given in the general description. It rests upon the sub-carboniferous limestone, but is not found wherever the limestone is. Often it disappears entirely, or is represented by a thin band of ferruginous chert. Where we find the conglomerate sandstone or the coarse sandstone which represents the conglomerate, coming close down to, or resting immediately upon the limestone, the ore is much more apt to be wanting than where a considerable thickness of clay shales intervenes between. There are some marked exceptions to this rule, however, where this ore occurs of unusual thickness, with only a few feet of shales between it and the sandstone.

This ore is not found to extend at its proper level beyond the limestone, where that rock is wanting, nearly so often as the ore of the ferriferous limestone.

Its quality is shown by analyses one to seven of the analyses of limestone ores, limonites, and numbers one to four of the analyses of siderites. More than the upper limestone ore, it is apt to be injured by chert, and in the carbonate ores sulphur is sometimes present in quantity sufficient to injure it.

Taken in its general character, it is, however, a most excellent ore, and deservedly holds the highest place in the estima-

tion of the iron manufacturers of this district. It is used almost exclusively at Boone Furnace. It is also used at Kenton and Iron Hills Furnaces, from the banks in the neighborhood, and at Raccoon and Laurel, from banks on Tygert Creek, whence the ore is hauled over the divide to these furnaces. It was used at New Hampshire Furnace when it was in operation, and ore from that property now goes to Kenton. It has not been found in any quantity on the Little Sandy slope; a few deposits which occur near the proper place for it are found, but the ore has the quality and appearance of a block ore. The disappearance of this ore towards the Ohio river has been already noted. It is partly due to the thinning out and disappearance of the limestone, which is present near the river only in patches; but I am informed by Mr. Crandall, that where the limestone does occur, at the lime-kilns below Greenup Court-House, the ore seems to be wanting.

In Ohio, the limestone occurs very irregularly, and this ore is of comparatively little importance. In Kentucky, it is one of the most important and valuable ores of the State.

To the southwest, along the line of outcrop of the coal measures, it occurs in large quantities. It is found in the region around Carter caves, and in the vicinity of Olive Hill, where it seems to be reliable and of a good workable thickness. Still further southwest, in the valleys of the Licking and Kentucky rivers, this ore is found in abundance, and is mined to supply the Bath, Cottage, and Red River furnaces, producing the celebrated Red River pig iron—an iron which has a national reputation, and for certain purposes acknowledges no superior.

THE LOWER BLOCK ORES.

The first of these occurs at a distance of from fifteen to thirty-five feet above the limestone. Its position at several localities is shown by sections of plate No. 1. In quality and general appearance it does not vary greatly from the other ores of this general division.

It occurs in the neighborhood of Iron Hills Furnace, on Barrett's Creek and the head of Little Sinking, and in the

vicinity of Olive Hill. Further north it is not found, and what its extent is towards the south, is unknown. It is not found further east than about three miles west of Grayson, on Barrett's Creek.

Next above this, ranging from forty to seventy feet above the limestone, or when the limestone is wanting, above the Waverly, occur sometimes one, sometimes two beds of block ore, which are the most reliable of this whole division, and have given name and character to it. They are found all over the already described lower block ore field.

When both occur, they are usually from fifteen to twenty feet apart. It is difficult to tell, at some places, whether the lower one of these is not the same ore as that last described, with the rocks between it and the limestone somewhat thickened from its normal distance of fifteen to thirty-five feet, or whether they are separate ores. It is certain that they are both found together at very few places. The two ores just described, however, occur together at a number of places. They are known by a great variety of names, and the names are changed at nearly every locality, or else they are applied indiscriminately to both. They are called "little block," "block," "lower vein," "lower block," "rough block," "big rough block," &c., at different places, or as the ore varies in thickness and quality.

Through the southern part of this region there seems to be but one of these present, and that the lower ore. It is mined on Barrett's Creek and hauled to Grayson, whence the ore is shipped to Hunnewell Furnace. It is found also on Everman's Creek. Around Iron Hills Furnace it occurs, but is very little used, as other ore of equally good quality can be more cheaply obtained. The ore of the McCleese bank, on Tygert Creek, which has been used at both Iron Hills and Laurel Furnaces, is probably of this bed.

At Boone Furnace but one of these is known, and it occurs fifty to sixty feet above the limestone ore. [See sections at Sellard's bank and on Saw-mill branch.] It is very little used in comparison with the limestone ore.

At Kenton Furnace the block ores furnish about two thirds of all the ore received. This is all obtained from a bed fifty feet above the limestone, which is the lower one of these two. The only place where the upper ore is known is at Thompson's bank, one mile below the furnace. Here it occurs about twenty feet above, and is said to be very sandy and "rough." The ore which is mined is called "the little block." It ranges from four to ten inches in thickness, sometimes in several layers of two to three inches thick, with clay shale between. Several analyses of this ore from this locality have been given, which show its quality. The ore above the "little block" is called the "rough block" or "big rough block." This name is commonly given at Kenton Furnace to a coarse sandy ore, which occurs about one hundred feet above the limestone. It occurs at a number of places, but is hardly used at all at present. It is said to vary from six to twelve inches in thickness, but to be so sandy and so poor in iron that it cannot be profitably used at the furnace. Its position with reference to the other ores will be seen on reference to the accompanying sections. No ore corresponding to this one, fifty feet above the "little block," is known to occur at other localities.

At Raccoon Furnace and vicinity the two ores occur respectively at about forty-five to fifty and sixty-five to seventy feet above the Waverly sandstone, the limestone being usually absent. Here, however, unlike it is at Kenton, the lower ore is lean and sandy, while the upper ore is of fair quality, and is worked at the furnace in considerable quantity.

The lower ore has been very little mined lately on account of its leanness. Considerable quantities of it have been dug on Raccoon Creek above the furnace, and the benches where it has been dug show it to have occurred quite regularly. Whether it will be found at its proper level on other parts of the Raccoon property is yet to be determined. In the table of analyses of lower block ores, limonites, number eight is a sample from this bed. It is called at Raccoon the "rough block" ore.

The upper of the two ores is commonly known here as the "lower vein" ore. It has been and is still very extensively mined at a number of points on this property, on Raccoon Creek, Hood's Run, and Alcorn Creek. The benches extend for miles around the hills, keeping the proper level and serving for a well-marked datum for geological sections, as well as giving good opportunities to ascertain the dip of the rocks. The ore usually is from four to six inches thick, and of medium quality. It is apt to become thick and more sandy, and needs to be carefully watched at the furnace, in order to secure it of even average quality.

An analysis of ore from this bed is given in No. 7, of the table of lower block ore analyses. The geological position is seen in the sections of plate 2 and 3.

Near the Ohio river these ores are found, and sometimes of considerable thickness; but they are of no better quality and are quite irregular, as already stated. They have been mined at various places in the past, but not now to any extent.

At Buffalo Furnace there are two, and sometimes three, beds of these ores. The upper one is the best in quality, the thinnest, and the one which has been most used. This holds a position which seems to be considerably above the ore which is most used at Raccoon, although it is difficult to tell with certainty, for the reason that at Buffalo the distance which the ore in question holds above the Waverly cannot be accurately determined. Its position is judged by measuring downward from the main upper block ore and the No. 3 coal. Estimating in this way the upper ore of the three is thirty to thirty-five feet higher than the ore which is supposed to correspond with it at Raccoon Furnace. In quality, appearance, and thickness they are very similar.

The two ores below are thick, sandy, and lean, and very little used. They vary from ten to fifteen inches in thickness. An analysis of a sample taken from the upper of these two rough ores, the middle one of the three, is given in No. 10 of the table of analyses.

This bed corresponds very nearly in position, measuring downwards, as before described, to the main, so-called, lower vein of Raccoon; and the one still below, to the "rough block." The relative position of these ores will be seen on reference to the sections of plate No. 5.

Further south, at Laurel Furnace, we have sometimes one and sometimes two of these lower block ores. The distance between them and the Waverly is much increased, owing to the thickening of the coarse sandstone which represents the conglomerate; but the distance from the ores above remains very nearly the same, and it will be seen, on reference to the accompanying sections, that it is nearly the same as that at Raccoon.

This confirms the statement that the middle of the three ores at Buffalo corresponds to the main lower block ore. They are not largely mined at Laurel Furnace; hence hardly enough was seen to judge of their character; but they are reported to be lean and sandy.

Above the horizon of these ores just described, there has been none found which has any great range and uniformity, until the horizon of the upper block ores is reached; but there are a number of beds of ore which are of considerable importance, although they are of comparatively local extent. They will be described as nearly as possible in the order of their occurrence. It will be seen that several of them occur at widely separated places at nearly the same level, but no equivalency is inferred from this, for there has been no connection traced between them. On the contrary, they seem to have been deposited in local and independent basins.

The first in order, and most important of these, is the Lambert ore.

THE LAMBERT ORE.

On the Iron Hills Furnace property, in the ridge between Clark's branch of Tygert Creek and Buffalo Creek, is a bed of ore which is called, from the name of the former owner, the Lambert ore. It is seventy-three feet from the top of the sub-

carboniferous limestone to the bottom of the ore. The ore itself is of very unusual thickness, measuring at one face in the main opening fourteen feet ten inches. At the main opening on Clark's branch it will average from ten to twelve feet. The ore here is exceedingly clayey and ochreous; in fact, a large proportion of the bed is ochre and sandy clay, so that this great thickness cannot be counted as all available ore.

What the average proportion of good ore in the bed is, there is no accurate means of estimating. The covering of earth above the ore is very slight, so that a thorough oxidation and alteration has taken place with a separation of the most of the silicious matter from the oxide of iron. This natural process has been of great benefit to the ore, as it enables that which is sufficiently rich for smelting to be easily separated from the sand and ochre. As it is, however, a considerable quantity of this foreign matter now goes into the furnace, which could be removed by a proper arrangement for washing the ore instead of separating by hand as is now done.

At the main opening on Clark's branch this ore is seen at its best. At other places where it is found, it ranges from three to five feet in thickness, apparently thinning out in all directions. On Royster branch of Buffalo Creek it is three feet eight inches thick, but more ochreous if possible than at the main opening. Beyond this ridge, between Clark's branch and Buffalo Creek, this ore has not been found.

Its position is so nearly that of one of the lower block ores, that it seems not impossible it may be merely an extension and thickening of one of them, probably the upper of the two most constant.

The accompanying sections, No. 2 of plate 2, and Nos. 1 and 2 of plate 3, will show the apparent equivalency.

This may be merely a coincidence, however, for it is unsafe to assert an equivalency of ores at a great distance apart, unless we have more connecting links than in the present case. Against this equivalency with one of the lower block ores, we have the fact that between the limestone and the Lambert ore there is certainly one and perhaps two block

ores, one at fifteen feet, and the other reported at forty to fifty feet above the limestone.

At a number of places, at some distance from this region, ores have been found which are supposed to be the equivalents of the Lambert ore, but they are all, so far as noted, at a considerable distance above the proper level.

The great thickness of this ore, and the little expense with which it can be mined, make it a deposit of great value, even if it be of low grade, as has been commonly asserted. For the present, and so long as the ore mined is a limonite, the quality of it as it goes into the furnace will depend largely upon the way it is sorted and screened. It is so thoroughly disintegrated, and so mixed with sand, clay, and ochre, that if not carefully treated much of these impurities will go into the furnace. These with careful sorting and washing, or dry-cleaning by machinery, would be removed, to the great benefit of the ore, and improvement of the furnace working.

Where the ore is found as the unaltered carbonate, it is dense, hard, and lean, with the silicious matter, which in the process of alteration to limonite is partially separated, disseminated all through it. When it comes to working this kind of ore, it will be a matter of more difficulty to improve it by treatment before it enters the furnace, and success in using it will depend largely upon proper methods of roasting.

The area occupied by this ore has not been accurately determined, nor can it be, without a detailed topographical survey which will show the contours of the hills with accuracy. It is certain, however, that there is a quantity ample to supply all probable demands upon it for a long time to come, at prices which will enable it to be used in preference to other ores of better quality but higher price.

The following analyses show the quality of the limonite of this bed:

	1	2	3	4	5	6
Peroxide of iron	52.460	52.238	68.61	46.45	77.71	63.80
Alumina	7.304	2.833				
Brown oxide of manganese .	trace.	.130				
Carbonate of lime	trace.	.650				
Carbonate of magnesia . . .	.155	.641				
Phosphoric acid	1.224	1.679				
Sulphuric acid	.268	.230				
Silica and insoluble silicates.	25.360	30.580	11.48	26.13	5.58	12.74
Combined water	12.360	10.650				
Total	99.331	99.631				
Metallic iron	36.722	36.566	47.83	32.52	54.00	44.66
Sulphur	.117	.092	.04	.04	.05	.08
Phosphorus	.534	.733	1.14	.75	.56	.73

No. 1. Average sample, by Mr. J. A. Monroe, of ore from an unroasted kiln on the stock bank, Iron Hills Furnace.

No. 2. Average sample, by myself, taken at the main opening on Clark's branch.

The above analyses are by Dr. Peter and Mr. J. H. Talbutt.

No. 3. Analysis by Dr. C. F. Chandler, of Columbia College, New York, of sample of hard ore from Smith Hill.

Nos. 4, 5, and 6 are analyses by Dr. Chandler of specimens of ore from Wilson Hill. No. 5 is hard; Nos. 4 and 6 soft ore.

The last four analyses were kindly furnished by Mr. H. W. Bates, of Riverton, Kentucky, Vice President of the Eastern Kentucky Railway. They were made from specimens selected by Mr. H. F. Q. D'Aligney, and published by him in a report upon the property of the Iron Hills Company. As to the character of the samples analysed by Dr. Chandler, nothing is stated, but it is probable that they were single specimens only, and that they represent the ore at its best.

The per centage of iron shown by the first two analyses is considerably greater than the ore is supposed to contain by those who worked it at the furnace. The impression is, that it yields a little less than thirty per cent. of iron in actual working in the furnace.

It is possible that the samples, although carefully taken, did not contain as much dirt and clay as the average of the ore; but, on the other hand, it can be said that no trial has ever been made for time sufficiently long to be a fair test, with ore, of which the weight before roasting was known, using it without admixture of other ore.

The furnace ran a few days with Lambert ore alone, but the calculation of the yield was from the weight of roasted ore, guessing at the loss which occurred in roasting. The close resemblance which the two analyses bear to one another, shows at least an approximation to accuracy in the sampling, as they were made by different persons. It is not improbable, however, that they both represent the ore as a little better than it really is, for there is a constant liability in sampling ores, to take them with less adhering dirt and clay than they carry when weighed at the furnace scales.

Much of this ore after its alteration to limonite is of an ochreous semi-concretionary structure, with an outside layer of comparatively pure limonite inclosing a large core of ochre. It was a matter of some considerable interest to know the composition of this, as it is the worst of the ore. A sample was taken by carefully selecting a large number of small pieces of the ochre, excluding any of the denser, purer ore. The locality from which the sample was taken is an opening of the Lambert ore on Royster Hill. The analysis by Dr. Peter and Mr. Talbutt is as follows:

Peroxide of iron	38.285
Alumina	5.455
Brown oxide of manganese	.120
Carbonate of lime	.460
Carbonate of magnesia	.065
Phosphoric acid	1.000
Sulphuric acid	.178
Silica and insoluble silicates	44.760
Combined water	9.500
Total	99.123
Metallic iron	26.799
Phosphorus	.436
Sulphur	.071

This analysis shows a per centage of iron greater than commonly supposed, and differs chiefly from the other ore in the much greater proportion of silicious matter present.

The quality of the undecomposed carbonate ore of this bed is shown by the two following analyses by Dr. Chandler, of New York, made for Mr. D'Aligney. The specimens analyzed were both from test shafts sunk on the main Lambert Hill, but whether taken as carefully averaged samples or not, is unknown.

	1	2
Metallic iron	23.91	34.37
Silica	36.35	11.31
Sulphur	trace.	.36
Phosphorus	.75	1.23
Lime	2.50	

OTHER ORES OF THE LOWER GROUP.

About thirty-six feet above the base of the Lambert ore on Smith Hill, one of the hills between Clark's branch and Buffalo Creek, is a heavy block ore, twelve to eighteen inches thick, called at Iron Hills Furnace the "German ore." It is a porous, semi-oolitic ore, in the alteration of which from carbonate to limonite the silicious matters, instead of segregating in large quantities toward the center, have remained disseminated through the mass in small, white, irregular masses, rarely over one tenth of an inch in diameter, thus giving to the ore a speckled appearance, which is quite characteristic of it, and makes it appear more silicious than it really is. It is not highly valued at the furnace, where it is supposed to be quite lean.

An analysis by Dr. Peter and Mr. Talbutt, of this ore, shows as follows:

Peroxide of iron	57.557
Alumina	2.727
Carbonate of lime	trace.
Carbonate of magnesia	.065
Phosphoric acid	1.746
Sulphuric acid	.185
Silica and insoluble silicates	26.180
Water expelled at red heat	11.700
Total	100.160
Metallic iron	40.290
Sulphur	.074
Phosphorus	.762

This shows a much larger per centage of iron than is commonly supposed, and not unlikely more than the average, owing to the character of the sample, which was probably better than the average of the whole bed.

An analysis of a specimen of this ore made by Dr. C. F. Chandler, of New York, for the Iron Hills Company, and published in the report of Mr. D'Aligney upon the property of that company, is as follows:

Metallic iron	46.50
Silica	17.48
Sulphur	.12
Phosphorus	1.37

Nothing is said as to the character of the sample from which this analysis was made.

At several other places ores occur at nearly the same level as this last described.

On Garvin Hill, west of Olive Hill, Carter county, there is an ore which occurs at from ninety to one hundred feet above the limestone. It seems to be of a good thickness, although it was not opened sufficiently to tell exactly. It is of good quality, as shown by the analysis, No. 6, of the table of lower block ore analyses, limonites. What is its extent in this locality is not known; it was only seen at one or two outcrops. Above the principal outcrop of it there was much scattered surface ore, limonite of the best quality, which was not traced to its place. It may be that it is from the upper portion of

the bed just spoken of. An analysis of a hand specimen of it made for Mr. K. B. Grahn, of Riverton, Kentucky, and kindly furnished by him for publication, gave 53.9 per cent. of iron.

The so-called "big rough block" ore of Kenton Furnace, already referred to, occurs at nearly the same level as this.

An ore on Oldtown Creek, on the land of Mr. J. Downs, an analysis of which is given in No. 9 of the table of lower block ore analyses, also occupies very nearly the same geological position.

On Cumming's branch of Everman's Creek, on the land of Messrs. Means and Russell, is a deposit of hard ore which is seen, about three feet in thickness, in two outcrops at some distance apart. The ore lies in sandstone, which is thin-bedded and shaly above, coarse and heavy below. It is hard, dense, apparently calcareous, and poor in iron. It is, nearly all of it, the unaltered blue earthy carbonate, being very little changed to limonite even at the outcrop.

The analysis of an average sample taken by myself is as follows:

Peroxide of iron	9.255
Carbonate of iron	46.893
Alumina	5.703
Carbonate of lime	12.460
Carbonate of magnesia	.250
Phosphoric acid	.978
Sulphuric acid	trace.
Silica and insoluble silicates	23.530
Water and loss	.951
Total	100.000
Metallic iron	29.116
Phosphorus	.427

This analysis shows the ore, although lean, to be better than generally supposed. The considerable quantity of lime present is noticeable. By roasting properly, the per centage of iron can be raised sufficiently high in the roasted ore to certainly make it pay for working. So far it has never been tried in any furnace.

The exact geological position of this ore is not certainly determined, for the reason that in taking the section at this place, no good datum or starting point was obtained; we only know approximately the place of it. The ore is from ninety to one hundred feet above the bed of Everman's Creek, which is supposed to be not over twenty feet above the top of the limestone, and it may be much nearer. This ore is called the "fox den" ore, from the place where it was first discovered. It has never been found, to my knowledge, except on Everman's Creek. It seems, however, to be a regularly bedded deposit here, and will doubtless be found in considerable quantity.

On the same branch of Everman's Creek is an exposure of an ore, which occurs about one hundred to one hundred and five feet above that just described.

This is not the proper place for its description, for it is not next in geological sequence; but as it seems to be local, and its position is well shown in the section with the last described ore, the proper order will be in this case neglected.

The ore, so far as seen, is all limonite, of open structure, homogeneous in character, not at all inclined to be concretionary, sandy, and ochreous.

It shows a thickness of three feet six inches, and perhaps more. The analysis of it by Dr. Peter and Mr. Talbutt, made from a sample taken by myself, is as follows:

Peroxide of iron.	51.623
Alumina	1.671
Carbonate of lime.	trace.
Carbonate of magnesia.	.483
Phosphoric acid	.081
Sulphuric acid	.408
Silica and insoluble silicates.	36.830
Combined water.	9.230
Total.	100.326
Metallic iron	36.136
Phosphorus.	.035
Sulphur.	.163

This analysis shows the ore to be quite rich enough in iron to be valuable, but the per centage of silicious matter is un-

fortunately high. The ore was seen at but one outcrop, and the structure and appearance of it at this place seemed to indicate that it is a local thickening. It has not, however, been prospected enough to furnish a basis for a reliable judgment as to its extent.

Returning once more to the description of the ore beds in their proper order and to the Iron Hills property, we find occurring next above the so-called "German ore," a layer of ore which is called the "crown ore." This is also found, and found only in this region, in Smith Hill. It is twenty-one feet above the "German ore," and about one hundred and thirty feet above the top of the limestone. It is a block ore of rather better than average quality, showing the semi-concretionary structure with the curving ochreous layers, which is so characteristic of the lower block ores. It is about fifteen inches in thickness, of which the upper half is of good quality and the lower is sandy and ochreous. An average sample was taken from the upper portion of the bed for analysis, which resulted as follows:

Peroxide of iron.	52.736
Alumina	3.534
Brown oxide of manganese	.320
Carbonate of lime.	trace.
Carbonate of magnesia.	.065
Phosphoric acid.	.800
Sulphuric acid	.170
Silica and insoluble silicates.	31.840
Combined water.	10.700
Total.	100.326
Metallic iron	36.815
Phosphorus.	.349
Sulphur.	.068

This shows a good workable per centage of iron, and not enough of phosphorus or sulphur to injure it, but rather too much silicious matter. As stated, this ore has been found only on Smith Hill, where it occurs about twenty-four feet below the top. Other ores which occur near this geological level, so far as they can be placed, are as follows: a bed of ore, not seen, but said to be quite thick and of very good quality, on

the Boone Furnace property, at the head of Smith's branch of Buffalo Creek, in the divide between Buffalo and Tygert Creeks; a rough block ore on the south branch of Everman's Creek; another on Elk Lick branch of Tygert Creek, above the Iron Hills Furnace property, and a block ore of good quality on Whetstone branch of Barrett's Creek. These are not much worked, and in most of the cases the thickness and quality of the ore had to be taken from the report of persons who had seen it.

On the Laurel Furnace lands, about one and a quarter miles southeast of the furnace, is a bed of ore resting upon a coal. The ore is the blue unaltered carbonate, quite sandy and lean in appearance, but it is not so much so as to render it worthless. The thickness was not seen, but it is reported to be from one to two feet. The coal below is reported to be one foot in thickness.

It is not intended to assert any equivalency in these ores; they are only described together because they are near the same geological level.

Further north, on the Raccoon Furnace lands, an ore is found a little above the position of these last described, which is called the "slate ore." It is seventy-nine feet above the main lower block ore, and about one hundred and forty-five to one hundred and fifty above the Waverly sandstone. It has been mined at a number of places in this region, on Hood's run, at the head of Raccoon Creek, and below the furnace; but to nothing like the extent of the main lower block ore.

None of the banks of this ore have been recently opened, consequently, the quality and thickness cannot be given with certainty; but the probability is, that the ore is lean or it would have been more extensively mined.

A thin block ore, only from one to two inches thick, which occurs at Laurel Furnace in the Baker bank section, occupies very nearly the same place as this last described ore with reference to the underlying block ore; but the distance to the Waverly is considerably increased. This ore has been erroneously referred to the level of the Lambert bed.

This properly closes the list of the lower block ores, but there are one or two ores of local importance which occur between this level and the upper block ores. The most important of these occurs on Raccoon Creek, on the Raccoon Furnace lands, Greenup county. Its normal distance above the main lower block ore is one hundred and thirty-five feet. It rests in clay shales, containing a considerable amount of bituminous matter, under a layer of close-grained sandstone, which is used at the furnace for hearth rock. The ore is coarse-grained carbonate of very good quality, and is remarkable for the number of casts of *stigmara* which occur in it. The thickness is said to vary from two to twenty-four inches. It is more irregular in thickness than the block ores generally, but does not present the changes of quality which they so often show. It is known only in this vicinity; at other places it has not been found, although often sought for.

The following is an analysis of this ore by Dr. Peter and Mr. Talbutt:

Carbonate of iron	64.024
Peroxide of iron	4.044
Alumina	4.414
Carbonate of lime	1.340
Carbonate of magnesia	.836
Phosphoric acid	.217
Sulphuric acid	.563
Silica and insoluble silicates	20.310
Water and loss	4.252
Total	100.000
Metallic iron	33.627
Phosphorus	.095
Sulphur	.225

There are some other local deposits of ore in the space between the lower and upper block ore series, but they are usually poor and of small extent, and hardly worth description here. Taking the greater portion of the region west of Little Sandy, we find a space of from one hundred and fifty to two hundred and forty feet between the two block ore horizons, which is comparatively bare of ore beds. In this space most

of the local ores which have been just described occur, but it will be noticed that they do not all occur at one place; on the contrary, where one or two of them are found, the others seem to be wanting. It is possible that upon more careful and intelligent prospecting, the ores which are now supposed to be local will be found over the whole field, but there is a presumption against it.

Above this belt of non-ferriferous rocks we come to the horizon of the upper block ores. These occur at several levels, all of them within a section of one hundred and twenty feet.

The upper block ores differ from the lower in that they are usually thinner and of much better quality. They furnish to Raccoon, Buffalo, and Laurel Furnaces their principal supply of ore, and to most of the other furnaces now in operation in this region, a greater or less quantity.

There is one of these that is of the most value and the greatest regularity of occurrence, which has been called the "main block ore." This has associated with it at different places one or two other beds which, although valuable and of uniformly good quality, do not have anything like its range.

These will be first described, as the most important of them occurs at some distance below the main block. This is an ore bed which is pretty generally found over all of the upper block ore field south of Laurel Furnace. It is from two to ten inches thick, and generally of most excellent quality. Its usual distance above the sub-carboniferous limestone, or when the limestone is wanting, above the Waverly sandstone, is from two hundred and fifty to two hundred and ninety feet, and sixty feet below the main block ore. North of Laurel Furnace it rarely occurs, although it is possible that the ore which is found below the Old Tygert drift, at the head of Alcorn Creek, on the Raccoon Furnace property, may be its representative. In the immediate neighborhood of Raccoon Furnace the place of the ore is occupied by a coarse heavy sandstone. At Laurel Furnace and vicinity it occurs quite regularly. It is the ore principally mined on the ridge between Lost Creek and Crane Creek, towards Hopewell, and at Far Mt. Tom at the head of

Crane Creek. It is also found at the Stewart bank, between Barrett's and Everman's Creeks, three miles from Grayson, and at the Potato Knob bank at the head of Everman's Creek, two miles from Iron Hills Furnace. It has no local names except at Laurel Furnace, where it is called the "Hickory Flat," or "Far Mt. Tom" ore, from the localities where it is found in greatest abundance.

Its geological position will be seen from the sections showing the upper block ores in this region. About fifteen feet below the main block ore, in some of the hills between Everman's Creek and Little Sandy, is a bed of ore which is reported to be thin and of excellent quality, but it has not been found over any great area by any member of the Survey.

We come now to the principal bed of this division, the main block ore. The appearance and quality of this ore have been pretty well described in the general discussion of the ore beds, Part II, and the composition shown by two tables of analyses of samples from a large number of localities. The geological position of this ore will be seen from the accompanying sections, which show its position with reference to the rocks below. All of the first series of sections are west of Little Sandy, the region of greatest development of the block ores. Those showing the rocks above were taken on the east side of Little Sandy—some of them at a considerable distance east, where the ore has been brought by the dip of the rocks nearly to the level of the drainage.

It will be seen from these sections that this ore varies from three hundred and ten to three hundred and fifty feet above the limestone or Waverly sandstone, where that can be determined. It is from two hundred and forty to two hundred and ninety feet above the main lower block ore. A decrease in these distances will be noticed in the sections at Buffalo Furnace, where the distance is at its minimum. It is greater at Raccoon to the north, and considerably greater to the south at Laurel Furnace and beyond. This last increase is due to the thickening of the conglomerate sandstone, which is present on Oldtown Creek, at the furnace, and on some of the branches of

Everman's creek. This ore is about thirty-five feet above the No. 3 coal, and the two hold this relation over a wide area. The coal is found at Raccoon, Buffalo, and Laurel Furnaces, and at one locality on the head of Barrett's Creek; but in the most of the region south of Oldtown Creek it has not yet been discovered, but probably will be, when sought for in the proper place. East of Little Sandy, however, the coal and ore are shown together in a large number of places; and this occurrence together, often serves to identify them both, and gives a reliable datum point for sections of the rocks above. It is one of the best marked and most regular geological associations of this region.

This ore is found at its proper level above drainage, over from two hundred and fifty to three hundred square miles in this region. The total area of the ore is of course nothing like so large as this, for the very tops of the hills, in a portion of this region, are only covered by the ore, and the area of the valleys and the slopes of the hills below the ore is much greater than that of the ore itself. It has been, however, originally deposited over all this region, but has been since carried away by the slowly acting erosive agencies which have cut out the valleys.

The best development of this ore is in the ridges between, and at the head of, the branches of Little Sandy on the west. It is in this region that Raccoon, Buffalo, and Laurel Furnaces are situated. They draw their ore from banks on the neighboring hills. Toward the Ohio river, as already noted, the ore seems to be wanting. It is first found in any quantity at the head of Alcorn Creek, and between Alcorn and Raccoon Creeks. South of this, in the drainage of Raccoon, Clay Lick, and Oldtown Creeks, this ore is at its very best. It is of uniformly good quality, and lies so near the tops of the hills that the overlying earth and shale does not soon become too thick to be cheaply removed.

At Raccoon Furnace the ore has been mined for over forty years. The Company, Raccoon and Brown banks on this property, have furnished many thousand tons of ore. It is of very

good quality, although at the Company bank it becomes quite calcareous. It varies from seven to twelve inches in thickness, and is occasionally thicker. Often scattered kidneys are found in the shales above. When this is the case, the kidneys are commonly of better quality than the block, especially if it be of unusual thickness.

At the Brown bank a thin coal is found above the ore, with the intervention of a few feet of shales. The coal is six inches thick; above it is four feet of shale, and then eight feet of sandstone, which is full of impressions of *Lepidodendra*. The usual roof of the ore is a clay shale. Mining has been carried on so long at these banks that the ore in them, which is available by stripping or benching as it is called, is becoming exhausted, and it is now necessary to drift for it.

At Buffalo Furnace, the principal banks where this ore is obtained are south of the furnace, between Clay Lick and Oldtown Creeks. Here the ore is often in two beds, with from one to three feet of shale between. The kidneys occur above the upper of these with a good deal of regularity. The lower of these two ore beds is very often quite thick and sandy, while the upper bed and the kidneys are uniformly of good quality. It is said by the miners, that where the kidneys are large and numerous, lying thickly packed together, the underlying block ore is apt to be thin; and vice versa, where the kidneys are small and scattering, the block ore is usually thick.

At a bank near the furnace, the ore shows another of the changes to a locally calcareous deposit. An analysis of this is given in No. 6 of the table of analyses of upper block ores. The change is accompanied by a considerable thickening.

Laurel Furnace is supplied with this ore from banks in all directions from it. On the north the Buck Smith, Baker, and other banks, have furnished large amounts of ore. The Buck Smith bank is now worked out. The Baker bank is still yielding a considerable amount, which is obtained by drifting, all the ore which is available by benching having been some time since exhausted. The ore now obtained is all the unaltered carbonate, of very good quality. It ranges from five to ten

inches in thickness, and rests upon a coal of about six inches thickness.

An analysis of the Baker bank ore is given in No. 2 of the table of analyses of upper block ores, siderites. There are numerous openings of this ore near the head of Oldtown and Lost Creeks, and on the Tygert Creek ridge. One of the best known of these is called Mt. Tom, and is near the head of Lost Creek. Other banks are opened on the ridge south of Oldtown Creek below the furnace.

This ore at Mt. Tom is of most excellent quality. It lies so near the top of the hill that it has been all altered to limonite, and in the process converted into the so-called "kidney block" ore, in which the blocks into which the stratum weathers, are changed to a semi-concretionary form, with the silicious and earthy impurities separated into the center.

On the Everman's Creek hills this ore is found regularly at its proper level. It was opened at a number of places in the time of the operation of old Pactolus Furnace. On the divide between Everman's and Tygert Creeks, within a short distance of Tygert Creek, this ore is opened on a hill called the Potato Knob, one of the highest of this region, and the only one in this vicinity which is high enough to hold the ore. The ore obtained from this bank is used at Iron Hills Furnace, distant therefrom about two miles. It has the same character as the Mt. Tom ore, being all limonite, of a dark red color and excellent quality. Instead, however, of being one thick bed, the ore with a total thickness of from eight to twelve inches, is split up into two or three layers, with a small thickness of shale between. An analysis of this ore, as well as of that from Mt. Tom, is given in the table of analyses of upper block ores, limonites. Between Everman's and Barrett's Creek this ore is finely shown at the Stewart bank. It also occurs at the head of Barrett's Creek, and on the divide between Barrett's and Little Sinking Creeks. It is mined considerably in this region and hauled to the railroad at Grayson for shipment. Further south, in the drainage of Big and Little Sinking Creeks, it is reported to be present, but has not been much developed.

The probability is that it will be found there wherever the ridges above the conglomerate are sufficiently high; for it is found in abundance, at its proper place on the east side of Little Sandy, some distance above these Creeks.

East of Little Sandy this ore occurs with great regularity over a large field, but is carried down by the dip of the rocks, and overlaid by numerous other ores. As a general rule it is thinner on the east of Little Sandy than it is on the west. Moreover, the slope of the hills is such that the stripping soon becomes too deep for profitable mining, and, as the higher ores are of equally good quality and often thicker, the block ore assumes a minor importance. Nevertheless, it is mined in considerable quantity at many places. In this region it is usually called the "little block" ore.

Beginning, then, at the southern part of this region, in the valley of Little Fork of Little Sandy river, near Willard, Carter county, we find the ore well developed. It has not yet been largely mined in this neighborhood, but whenever it has been sought for in its proper place, it has been found. It has been opened at quite a number of places in this region—enough to ascertain its presence. If it is present it has not been much mined below Mt. Savage Furnace, on Straight Creek. Above the furnace, however, and on the branches from the north, this ore is found quite regularly, until it is carried below the drainage by the dip of the rocks.

On Stinson Creek it is quite abundant, and of very good quality. It is mined in considerable quantity and carried to Mt. Savage Furnace. Usually it is from three to eight inches thick. The quality is shown by analysis No. 12 of the table of upper block ore analyses, limonites.

On Wilson Creek the ore is found in considerable quantity; usually thicker than on Stinson Creek. It has been mined until nearly all the limonite has been exhausted, and the unaltered blue carbonate is now only found. The quality of it is shown by analysis No. 3 of the upper block ores, siderites. The ore obtained from this region was formerly used at Star Furnace. It now goes to the Norton Iron Works at Ashland.

On the upper part of Cane Creek this ore is not much mined. Lower down, near Hunnewell Furnace, it occurs quite regularly, and at many places all that is obtainable by benching or stripping has been mined.

On Turkey Lick Creek the ore is found quite regularly; also, between Hunnewell Furnace and Little Sandy River.

On Brush Creek, a branch of Williams' Creek, on the Buena Vista property, the ore is found at a number of places, but it has not been mined to anything like the extent that it has been on the Little Sandy slope. This statement may be made a general one. Although the ore is found at a number of places on Williams' Creek and its branches, it is nowhere so valuable or so regular as on the immediate branches of Little Sandy.

On Sandsuck and Culp Creeks it is found, and has been mined in large quantities for Pennsylvania Furnace. Its quality is about the same all through this neighborhood. Its thickness is also quite regular, ranging from four to eight inches. The No. 3 coal has been opened at a large number of places, almost always holding its proper distance below, and serving as an additional evidence of the identity of the ore.

In the valley of the East Fork, below Williams' Creek, the ore has been considerably mined, as also on Indian Run and Ash Creek. In the neighborhood of old Steam Furnace there are a number of banks where it has been and still is worked. West of this and east of Little Sandy river, below the mouth of East Fork, there does not seem to be a great amount of this ore. This is probably the eastern end of the barren territory along the Ohio river; for east of this the ores extend to the banks of the river in as great abundance as found anywhere.

At Amanda Furnace, on the very bank of the Ohio river, this ore is found in unusual thickness. It measures from ten to twelve inches, and sometimes thicker. Nearly all the limonite has been exhausted, and only the blue carbonate is now obtained. This is a coarse-grained ore, somewhat silicious, and rather below the average of this bed, as is shown by No. 4 of the table of analyses of upper block ores, siderites. At this place it contains a number of fossils, a feature which is

exceptional in this ore. It is not far above the level of high water-mark in the Ohio river. East of this the ore disappears below the drainage.

There is no ore of any importance above the main block ore, for a distance of from sixty-five to eighty feet. At this level occurs an ore which has been referred to already in the description of the kidney ores. It is known by a variety of names, such as "slate ore," "lime kidney," "grey lime," &c. It is usually found about twenty feet below the ferriferous limestone. It is sometimes a regular block ore, but oftener occurs as a kidney deposit, and generally of good quality. It does not occur with the regularity of many of the other ores, but, on the other hand, it is considerably more than a local deposit. It is found quite generally in the region around Bellefont Furnace, on Hood's Creek, Chinn's branch, and around Caroline and Steam Furnaces. On the Pennsylvania Furnace lands it is found at the head of Culp Creek and other places. It occurs on Williams' Creek, Buena Vista Furnace property, and also on Straight Creek. Around Hunnewell Furnace it seems to be frequently wanting. On the head of Cane Creek, Star Furnace property, it is well developed as a block ore. It is found at a number of places on the Mt. Savage property, and is well developed around Willard, Carter county.

An analysis was made of an average sample of this ore, from the head of Cane Creek, with the following result:

Peroxide of iron	53.653
Alumina	4.324
Brown oxide of manganese	.368
Carbonate of lime	trace.
Carbonate of magnesia	.101
Phosphoric acid	.313
Sulphuric acid	.220
Silica and insoluble silicates	30.940
Combined water	10.150
Total	100.069
Metallic iron	37.551
Sulphur	.086
Phosphorus	.136

THE UPPER OR FERRIFEROUS LIMESTONE ORE.

This ore has been already described, in some detail as to quality and manner of occurrence, in the general description, and a number of analyses given.

Some discussion of the geological position and the distribution will be all that is necessary here. It rests upon the feriferous limestone, which holds a place in the general section about four hundred feet above the base of the coal measures. Its normal distance above the main block ore is about ninety feet; although it varies somewhat.

The limestone and its equivalency have been already described in the report of Mr. Crandall. It is rarely over five feet thick, and oftener thinner, frequently disappearing altogether. The ore is usually overlaid by a heavy bed of white marl or fire-clay; and when, in the cases already referred to, the limestone is absent and the ore extends beyond the area of the limestone at the same level, the fire-clay is almost always present above the ore, and often serves to identify it.

Beginning at the Ohio river, below Amanda, the ore is found in the hills along the river back of, and to some distance above, Ashland, when it becomes irregular, and is only occasionally found, or when found the limestone is wanting. Mr. Crandall found the ore as far up the river as Key's Creek, but it is not in any great quantity, as it seems to occur only in small detached beds, in which the ore is quite thin and only of medium quality. Although the limestone is wanting, the characteristic white clays are still found above the ore.

Back of Amanda the ore and limestone occur quite regularly, underlying a large part of the so-called "Flat Woods," in the neighborhood of Bellefont and toward Caroline Furnace.

Back of Bellefont Furnace, in the valley of Hood's Creek, and towards East Fork, the ore is found quite regularly; but east of Hood's Creek the limestone thins out and disappears, and we then have only occasional patches of the ore with associate white clay.

Large quantities of this ore have been mined for Bellefont Furnace, in the valley of Hood's Creek, but the stripping now

necessary in order to reach the ore has become so deep, that the kidney ores are more profitable to mine; so that the proportion of limestone ore now received at the furnace is not so great as formerly. At Amanda Furnace the ore is overlaid by two or three beds of fire-clay of different quality, some ten to fifteen feet thickness in all. This clay is largely used for the manufacture of fire-brick at the Bellefont works, and for pottery in Cincinnati.

As it is quite valuable it pays for the stripping, and thus the ore can be profitably mined, even when the stripping is carried to the unusual depth of twenty to twenty-five feet. At one of the benches back of Amanda the following section was shown:

	Feet.	Inches.
Soil	4	
Clay shale	6	
Coal		4
No. 2 fire-clay	3	
Pottery clay	4	
No 1 fire-clay	3	
Limestone ore		8
Top of ferriferous limestone.		

Around Caroline and old Steam Furnaces, and in the hills to the south towards East Fork, on Indian and Ash Creeks, this ore occurs very regularly, and usually in quite heavy beds. The ore has been mined in this region for nearly fifty years, however, so that all, or nearly all that is available by stripping, has been removed. There is an abundant supply of the ore yet remaining, but it will have to be won by drifting, and it is nearly all the blue unaltered carbonate. It is usually sufficiently thick to pay for drifting, ranging from one to three feet, and occasionally higher, at some of the banks. This was the ore relied upon for the main supply at these furnaces when they were in operation; but they went out of blast upon the exhaustion of the limonite, not being able, as they supposed, to successfully use in charcoal furnaces the blue carbonate ore for the production of a coarse-grained foundry iron.

Across East Fork, on the Pennsylvania Furnace lands, this ore is generally found at its proper level. As at Bellefont however, the proportion of limestone ore obtained in the past was greater than at present, for the supply available by stripping has been nearly exhausted, and as yet it has not been much drifted for. The principal deposits are on the ridge between East Fork and Little Sandy, but best developed on the Little Sandy side. This holds good along the whole length of this ridge. South of this furnace, at the head of Culp and Sandsuck Creeks, on Pea Ridge, as it is called, the ore is well developed and has been extensively mined. It is now mined by stripping twenty to twenty-five feet of overlying fire-clay, shale, and sandstone. Both the ore and the limestone are mined, the limestone being used for flux at the furnace.

The ore here is overlaid by a series of fire-clays very similar to those at Amanda. As yet they have not been put to any profitable use. The time will doubtless come when they will be made a source of profit.

The limestone here varies from two to five feet in thickness, and the ore from four inches to twenty, with an average, so far as seen, of about eight. South of Pea Ridge, the limestone ore is somewhat irregular and uncertain. It is found at a large number of places along the ridge, between Williams' and Cane Creeks, but is not now mined in any great quantity.

It occurs at the head of Brush and Straight Creeks, on the Buena Vista Furnace property, and in small patches, well down toward Williams' Creek, but the limestone is generally wanting and the ore is of minor importance. Around Hunnewell Furnace it is well developed, and has been considerably mined, more in the past than at present, as the supply of limonite from this bed is nearly exhausted, and the furnace does not use the carbonate. There are large quantities of the carbonate ore in this region, which could be profitably obtained by drifting if there were any demand for it.

West of Cane Creek the ore occurs without the limestone, and is known as the slate ore. It is of good quality, as shown by analysis No. 8 of the table of analyses of limestone ores,

limonites. Toward the head of Cane Creek, and on Wilson Creek, the limestone ore is rarely found. On Williams' Creek, above Rush Station, it is found sometimes as a dense calcareous ore, but with no underlying limestone. The ore consists of a light-grey calcareous matrix inclosing small sub-crystalline specks of a darker color.

An analysis of an average sample, taken from the Star Furnace stock pile, is as follows:

Peroxide of iron	21.433
Carbonate of iron	19.802
Alumina	1.193
Carbonate of lime	30.205
Carbonate of magnesia	trace.
Carbonate of manganese	.240
Phosphoric acid	.257
Sulphuric acid	.157
Silica and insoluble silicates	23.080
Combined water and loss	3.633
Total	100.000
Metallic iron	23.109
Sulphur	.062
Phosphorus	.112

At other places on the Star Furnace property the ore loses this calcareous nature and occurs as a thin block ore, when it is known as the "slate ore" or "little block." This is another instance of the careless and incorrect manner in which names are applied to the ores all through this region. On Wilson and Stinson Creeks the ore seems to be generally wanting or if it be present, it has been very little worked. Further south in the Mt. Savage Furnace region, on the branches of Straight Creek, the ore and limestone are found, but they occur irregularly and in patches. The limestone is usually thin, and is more uncertain than the ore. The so-called "grey limestone ore," or "limestone kidney ore," which has been already described as occurring from fifteen to twenty-five feet below the limestone, is here more regular and in greater quantity than the limestone ore itself. Still further southeast, in the region around Reedville Station and Willard, the ore has a fine development, and occurs with as great regularity and

thickness as anywhere in these counties. At the Reed and Graham banks, and many other localities, it is extensively mined. East of Willard the ore is carried below the drainage by the dip of the rocks, while to the south, up Little Fork and Dry Fork, the change of dip which here occurs, carries it rapidly up and gives a large outcrop area above the drainage. This is one of the most promising undeveloped localities in this region. The ridge between Little Fork and Little Sandy is the western boundary of this ore.

The Graham bank is situated upon a spur of this ridge. The ore here shows from one to three feet thickness, and sometimes is even thicker, all of most excellent quality. An analysis of ore from this bank is given in the table of limestone ore analyses, limonites, No. 10.

The ore is found in very promising outcrops at the head of Little Fork of Little Sandy, and on the head of Cherokee Fork of Blain Creek. I am informed by Mr. Crandall that it also is present in considerable quantity, and quite regularly, on nearly all of the upper branches of Blain Creek, in Lawrence county. At none of these places has it been mined, but it is found scattered over the surface in considerable quantity, and can be traced to its place above the limestone, which is usually present, thus increasing the probability that the ore will be found in abundance when mining operations are undertaken.

From the above somewhat detailed description of the distribution of the limestone ore in these counties it is seen, that while nearly always of remarkable good quality, it is somewhat uncertain in its occurrence and irregular in its thickness, and for this reason is of less value, taking it through the whole of the three counties, than some of the other ores. Where it does occur in any quantity there is no ore in this region of so much value,

In portions of this region it is now, and always will be, the ore of most value, for it will yield a regular supply of ore by drifting. It is probable, also, that in many other places where the available supply of this ore is considered to be exhausted,

because the stripping is now too deep for profitable mining by benching, it will be found that it can be profitably mined by drifting, systematically carried on, although now supposed to be too thin to pay for working in that way.

THE KIDNEY ORES.

We come now to the examination of this interesting class of ores, the occurrence of which, in any workable quantity and great regularity, properly begins above the horizon of the limestone ore. What the circumstances were, which, from the time of the deposition of the ferriferous limestone, induced the deposition of all the ore, or so large a proportion of it as to leave the remainder hardly worth mentioning, as nodular segregations instead of the strata which had formed the larger portion before that time, we are unable to tell. Certain it is that there has been such a change, and that we no more find layers of block ore, extending regularly through the hills; but in their place, at certain well-defined levels, masses of nodular ore, often in quantity sufficient to form unusually heavy beds, were all of it condensed into a connected stratum. These nodules, unlike the block ores, preserve a uniform character, even when the size is greatly increased; or, speaking more accurately, the quality does not seem to be affected by the size of the deposit.

The first of these deposits is found about fifty feet above the limestone ore, ranging, however, from forty to sixty. It generally consists of two layers or beds of nodules, lying in shale, and separated from two to eight feet. Often the kidneys are scattered through the whole space, and do not separate into layers or "runs," as they are called by the miners. There is a great confusion in the names applied to this ore. It is called by different names at different places, and then again separate names are given to the two members of it. It is called the yellow kidney ore pretty generally through the southern part of this region, and the black kidney or the "black vein" nearer the Ohio river; while at some places the name yellow kidney is applied to the lower member and "black vein" to

the upper. In referring to it here, the name yellow kidney or kidney ore, No. 1, will be applied to both members, considering them as one ore, as they essentially are.

The nodules or kidneys are, before alteration to limonite, usually of a dark brown or blueish color, and quite fine-grained, though occasionally they show a coarse structure, somewhat oölitic and sandy. In alteration from the carbonate to limonite the ore oxidizes in concentric layers, and between each of these layers there is a thin coating of bright yellow ochre, which is the most conspicuous feature of the ore when a specimen is broken open. From this the name yellow kidney has been applied. All of the deposits of nodular or kidney ore show this feature, to a greater or less degree, so that the name yellow kidney is not at all distinctive, but might be equally well applied to all. It is only used in this instance because it is more commonly applied than any other.

As already stated, this ore, although not a continuous stratum, is still one of the most reliable, regular, and persistent deposits of this whole region. It shows a much greater regularity than the limestone ore below it. It occurs from fifteen to twenty-five feet below the coal No. 7, the well-known Coalton coal, and often serves, by this occurrence, to identify the coal at widely separated localities.

It is found, with exceedingly slight variations, over a large area, from two hundred to two hundred and seventy-five square miles in all, above drainage; beginning on the west, in the spurs of the divide between East Fork and Little Sandy, towards Little Sandy, and extending to the eastward until it is carried below the drainage or reaches the boundary of the State. It extends to the Ohio river in almost as great a development as it shows in any portion of this region. Along the river it is first found in the river hills back of and below Amanda. It is here held only by the highest hills, close to the river, and is not found in the so-called "Flat Woods," a range of low, flat hills extending back about two or three miles. It occurs in the hills back of the river above Ashland, and in the valley of Key's and Catlett's Creeks, gradu-

ally descending with the dip of the rocks until it is nearly at the level of high water in the Ohio river, below Catlettsburg. In the immediate neighborhood of Catlettsburg the ore seems to be absent, a coarse, heavy sandstone occurring in its place. Back of the Ohio river from Catlettsburg, the line along which the ore passes below the drainage runs in a southwest course, crossing Shope's Creek and Marsh Run near the head, and East Fork near the mouth of Old Trace Creek. From here it crosses Rush Creek, about two miles above its mouth, Williams' Creek, near its head, Straight Creek, between three and four miles from its head, and Lost Fork, about two miles from its mouth. It then turns south and passes out of Carter county near the mouth of Bell's Trace Creek.

The kidney ores and some of the local limestone ores, which are found high up in the series in the middle coal measures, are all that are found in the neighborhood of Clinton Furnace, and were the ores used at that furnace when in operation. The yellow kidney ore is well developed in this region, lying in large nodules and very close together. At this place, in the kidneys, large numbers of impressions of ferns and other plants were found. West of Clinton Furnace, in the valley of Hood's Run and East Fork, on the Bellefont Furnace property, this ore is very abundant and is mined in large quantities. By far the greater proportion of all the ore used at Bellefont Furnace is kidney ore. This ore is found over nearly the whole of this property, with the exception of that portion of it which lies in the "Flat Woods," already referred to.

Around Caroline and Steam Furnaces it occurs in the tops of the highest hills, and the area covered by it, in proportion to the whole, is small. South and east, however, towards East Fork, it is found in great abundance.

South of East Fork, on the Pennsylvania Furnace lands, it is present in large quantity and is extensively mined. To the west it reaches well toward Little Sandy, on the Culp and Sandsuck Creek hills, but is found in largest quantity at the head of these creeks, and on the East Fork and Brush Creek

slopes. Like Bellefont, Pennsylvania Furnace uses more of the kidney ores than any other class.

On the Hunnewell property this kidney ore is found along the main divide between Williams' Creek and Little Sandy, and on some of the hills between Cane Creek and Little Sandy. This furnace uses probably a greater variety of ores than any other charcoal furnace of this region, having the block, limestone, and kidney ores on its own lands, and receiving large quantities of both upper and lower block ore by railroad; but of that now mined on its own property probably two thirds or more is kidney ore.

This kidney ore is found on all portions of the Buena Vista Furnace property, and has been extensively mined. It extends to the east beyond Williams' Creek and East Fork, to some distance beyond Cannonsburg. On East Fork, above Cannonsburg, the ore goes under the drainage at about the mouth of Old Trace Creek.

The valley of Williams' Creek shows the most extensive workings of the kidney ores of any portion of this region. On the lands of the Buena Vista and Star Furnaces, and the Ashland Coal Company, they are mined in large quantities, and very little ore except of this kind is obtained. There are from three to five beds of kidney ore in this region, and the hills are terraced, bench above bench, for miles around the contours by the diggings for these ores. Probably nine tenths of all the ore received at Star Furnace, Coalton, and Buena Vista, is of this class.

The yellow kidney ore passes below the drainage on Rush Creek, about two miles above its mouth, and is not found on Garner Creek or Bolt's Fork; but on Garner Creek some of the higher kidney ores occur. It is found regularly on Williams' Creek nearly to its head, and on the hills toward Wilson, Stinson, and Straight Creeks. On Wilson and Stinson Creeks it has not been much mined, except toward their heads. Toward Little Sandy, on the ridge between these creeks, the dip soon brings the lower rocks to the top of the ridge, and the ore is no more found. Between Stinson and

Straight Creeks it has been much more extensively mined. It is found in the main ridge from the head of Gum branch of Straight Creek, eastward, for about four miles, when it goes under the drainage on Straight Creek. Large amounts of it are obtained in this region for Mt. Savage Furnace. It is also mined on Davy Run. It is found on Lost Fork and Dry Fork quite regularly, but has not been as yet extensively mined.

THE RED KIDNEY ORE.

As will be seen from a number of sections accompanying this report and that of Mr. Crandall, there is a second bed of kidney ore usually occurring about fifty feet above the first, or yellow kidney, and thirty feet above the No. 7 coal. This will be here called the "red kidney ore." This name is not applied all through this region, but it is probably used more than any other. Often it is called the little yellow kidney ore, and at some places where the first bed of kidney ore is called the "black vein," the name "yellow kidney" is given to this. It is, however, easy of identification, as a separate bed, from its position above the No. 7 coal, and in the localities where that coal is most largely mined it is usually known as the red kidney. In character it is often very similar to the yellow kidney, but the ochreous coating which covers the layers into which it weathers is usually of a darker color, and often quite red. From this feature it derives its name of red kidney.

When weathering to a dark color, it is usually found to be calcareous. This ore shows, for the first time, a tendency which is more common in the beds above, to grow very calcareous at places, and change finally to a bed of cherty limestone nodules. This tendency has not been observed in the yellow kidney ore. The individual nodules of this bed are next in size to those of the yellow kidney ore; but they show a decrease, which continues and is more marked in the beds above, showing a regular diminution in size from the yellow kidney upward. Where there is the greatest number of these beds, the nodules of the upper ones, which are not found at

many other places, are of very small size, rarely weighing more than a few pounds.

The red kidney ore ranks in value next to the yellow. It is almost as regular in its occurrence, and the area over which it is found is very nearly the same, or, if anything, a little larger; for in places the western boundary is the same for both ores, being determined by a topographical feature—the main ridge between East Fork and Little Sandy—while it extends some distance further east.

The fields of the two ores are so nearly identical that the area of this ore will not be given in detail, for the description of the yellow kidney ore will answer for both, with the following points of difference: the red kidney ore does not usually extend out to the westward on the spurs of the divide between East Fork and Little Sandy, but is confined to the main ridge. It is not found, except in a very few of the highest points, in the neighborhood of old Steam and Caroline Furnaces, nor at Amanda, and is first known near the Ohio river, in the hills back of Ashland. It extends to the Big Sandy river at Catlettsburg, and along that river for some distance, being found above the drainage some distance beyond where the yellow kidney disappears, as the dip is here very gentle. It is found on the Big Sandy river nearly as far up as the mouth of White's Creek. To the south it is found on Garner Creek, and on East Fork, some distance above where the yellow kidney disappears, finally going under between the mouth of Garner Creek, and Bolt's Fork. It is found on the Mt. Savage Furnace property in considerable quantities. Around Willard it has been seen at many places, but is not as yet mined to any extent.

OTHER KIDNEY ORES.

Above the red kidney ore, at a distance ranging from ten to twenty-five feet, is another bed of ore of this class, which is found at many localities in this region, but by no means so generally as the beds just described. It is at its best on the Buena Vista, Star, Hunnewell, and Mt. Savage Furnace properties.

It is known as the black kidney at Star Furnace, but at other localities the more generally applied name is the bastard limestone ore, or, as the miners call it, the bastard lime kidney. This name is given from the usual association of the ore with, and occasional replacement by, silicious limestone nodules. Sometimes the limestone occurs as a connected stratum, and the ore overlies it as a limestone ore, but this is rare. The size of the nodules of ore is usually small, and the quantity not sufficiently great to pay for deep benching; yet it has been, nevertheless, largely mined at a number of places in this region, notably in the Williams' Creek valley, which is the only region where it is of any importance.

From twenty-five to forty feet above this last described ore occurs another, which is known as the "little yellow kidney" more generally than by another name. This has its best development in the Williams' Creek valley, but is known at other places, as for instance, on Gum branch of Straight Creek, Mt. Savage Furnace property.

South and east of this, however, where the Mahoning sandstone is present as a heavy conglomeratic rock, this ore is wanting, as it properly occurs about the level of this sandstone. In the region where this ore occurs the sandstone seems to be replaced by a series of shales, which carry the ore.

This ore is somewhat more regular in its mode of occurrence and its quality, than that last described. The size of the nodules is usually small, rarely exceeding a few pounds in weight, but the quality is uniformly good; and it happens that in a large part of the region where it is found; it occurs so near the tops of the hills that the covering of shale and earth above it is very light, and it can be mined over a large area by benching. Large quantities of it are thus obtained at Buena Vista and Star Furnaces, and at Coalton for the Ashland Furnace.

This properly closes the list of the kidney ores, although there is another bed still higher, reported at a few localities, which is called the "top hill kidney" or the "little red kidney," but it has not been identified as a separate bed by any member

of the Survey. This is also the last and highest of the ores of the lower coal measures, and the last ore of anything more than local range or value. This as already stated, occurs very near the place of the Mahoning sandstone. Above it the middle or so-called barren coal measures, prove to be barren of ore as well as coal. There are, however, in these measures, a number of limestones which are, occasionally, accompanied by ores. These are at places of very good quality, and resemble the regular limestone ore, but usually they are excessively calcareous and quite poor in iron. In addition to the inferior quality, they are, as a rule, irregular in their occurrence, so that no reliance can be placed upon them. Sometimes they are of unusual thickness, so that they have been drifted for, but these "pockets" are usually not extensive. The Oakland and Sandy Furnaces, which were built relying upon these ores for their main supply, were both compelled to suspend operations after a short time, as they could not profitably work them alone. They are often quite fossiliferous, and then seem to be little more than ferruginous limestones. Ores of this class are found, and have been considerably mined, on some of the highest hills south of Straight Creek, on Buena Vista Furnace property; also, on White's, Chadwick's, and Peterman's Creeks, whence the ore went to Oakland Furnace.

To the south but one of these is usually found. It lies above a fossiliferous limestone eighty feet above the Mahoning sandstone, and is called the Rough and Ready ore. It is found on Straight Creek (Mt. Savage), Lost Creek, and at the head of Dry Fork, above Willard, Carter county. On Bolt's Fork it is better developed than at any other locality. It is here quite a reliable bed, and is said to range from eight inches to two feet in thickness. All the old workings have fallen in, so that no opportunity was afforded members of the Survey to ascertain the thickness, by measurement, for themselves.

It was to use this ore that the Sandy Furnace was established. The quantity of ore proved ample, but the quality was such the furnace never was able to produce a first-class foundry iron. The ore was so calcareous that it more than

fluxed itself, producing a thin fluid slag, which, by its continually running off, cooled the furnace and resulted in the production of a hard, brittle, white iron. The furnace, after about three years unsuccessful working, went out of blast, and has never since been started. Were there a cheap and ready means of transportation this ore could be very successfully used for a mixture, in furnaces where the other ores used were silicious or argillaceous, and it would be of considerable value, especially to furnaces using stone-coal.

With this closes the list of the ore beds of Greenup, Boyd and Carter counties. It is the highest and last ore of any importance in this region.

It is believed that in the foregoing pages all the ores which occur in this region in anything more than local extent, and even some of them, have been described. There have been found at a few places ores which have not been described, but they seemed to be of such limited range that they were not considered of sufficient importance to receive a special description, or a place in the general section. It may be that future developments will show these to be more extensive than now supposed, and thus add to the number of ores of the general section. The region, however, taken as a whole, has been pretty thoroughly prospected, and it is believed that the list is nearly complete.

METHODS OF MINING.

IV.

The method of mining in general use through this region is, as already stated, by stripping or benching. This, while the most economical for a time, is unavailable to any great depth, and by it only a very small per centage of the ore present in a given area is available, for when the overlying material reaches a thickness of from ten to fifteen feet, varying of course with the thickness of the ore bed, the ore will no longer pay for its removal. The slope of the hills is generally such that, with rare exceptions, such as occur where the ore lies near the top of a hill and can all be removed, this depth of stripping is reached when the width of the bench or terrace is from thirty to forty feet. A strip of ore then, in width from thirty to forty feet, and in length equal to the contour of the hill at that level, is all that is usually attainable by this method of mining.

It is unfortunate that we have not a detailed topographical map from which we could measure, with accuracy, the proportion which this bears to the whole amount of ore present in the hill; but in the lack of this nothing but an estimate can be given, and this estimate must of course be only the rudest sort of an approximation. It is believed that the amount which can be mined in this way will not exceed five to ten per cent. of the whole, if it even reaches the lower figure. The necessity then, especially at some of the older furnaces, where the ore which can be reached by benching is becoming exhausted, for a better method of mining, is becoming apparent. That this must be found in carefully planned, well-conducted, underground work, there is no doubt. Mining by drifts has been carried on at many places in this region, where the ores show an unusual thickness, but it has all been done in a hap-hazard way, the miners being left to conduct their drifts as they pleased, without any supervision.

No systematic underground mining for iron ore, under the direction of the companies owning the land, through competent mining superintendents, has ever been carried on in this region. Such operations would undoubtedly be profitable at many localities in these counties. There are two serious obstacles, however, to underground work: one is the thinness of the ore beds; the other the character of the roof, which is usually a soft, crumbling shale, or, as sometimes in the case of the limestone ore, a fire-clay.

What is the limit of thickness below which an ore cannot be profitably mined underground will have to be proved by trial, but there seems to be little doubt, that with properly conducted operations, it will be considerably less than now supposed. As a rule at present, no ore is drifted for which is less than from one foot to eighteen inches in thickness, although at some places an ore averaging not more than from six to eight inches is mined in that way, at a cost for mining of from three to four dollars per ton.

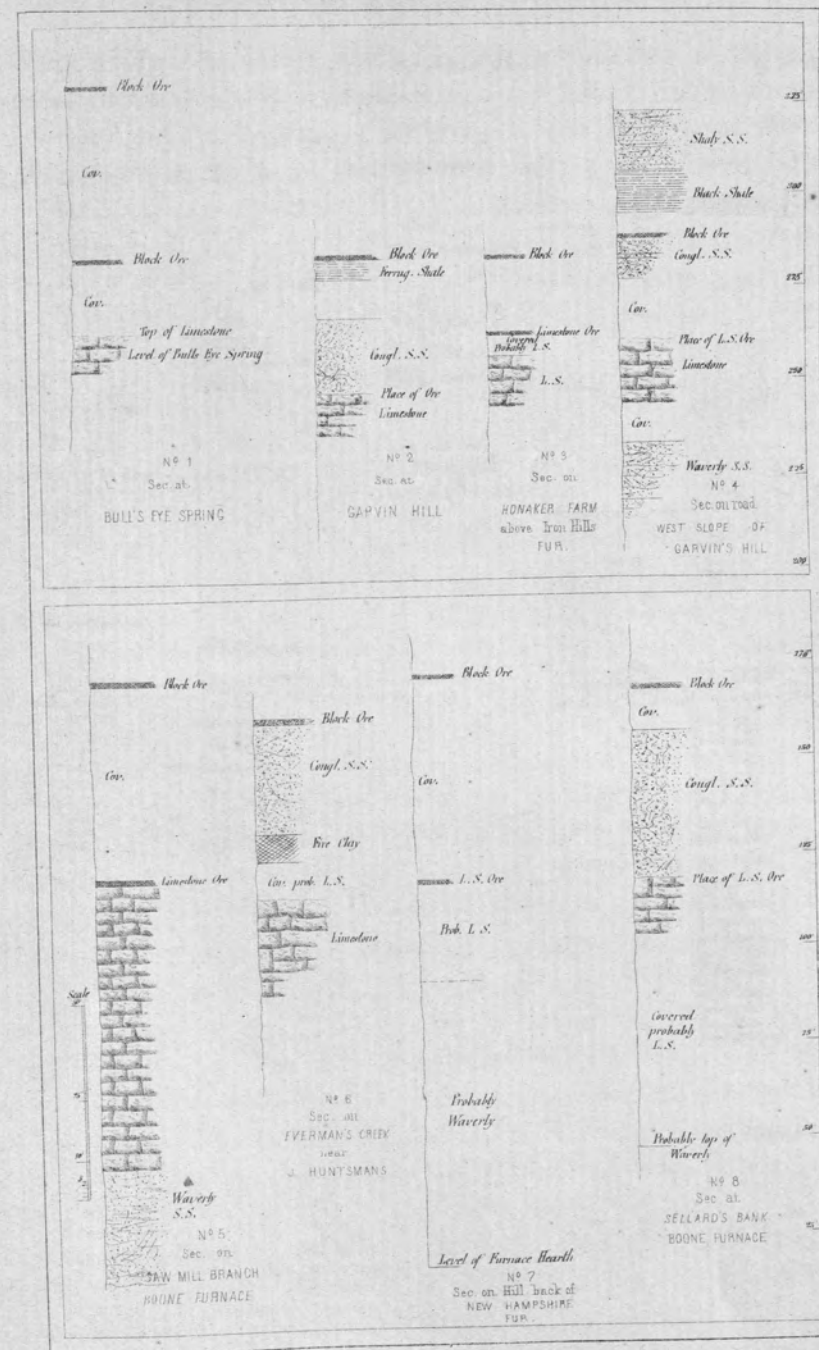
As yet the method of longwall mining, which is so commonly employed abroad in working thin beds of ore, has never been tried in this region. Were the same amount of skill devoted to mining the ores of this region as is expended in coal mining, it would be found that they could be mined much more cheaply than commonly supposed; and thus large quantities of ore which are now considered of no value, being thought too thin to work, would be rendered available sources of wealth.

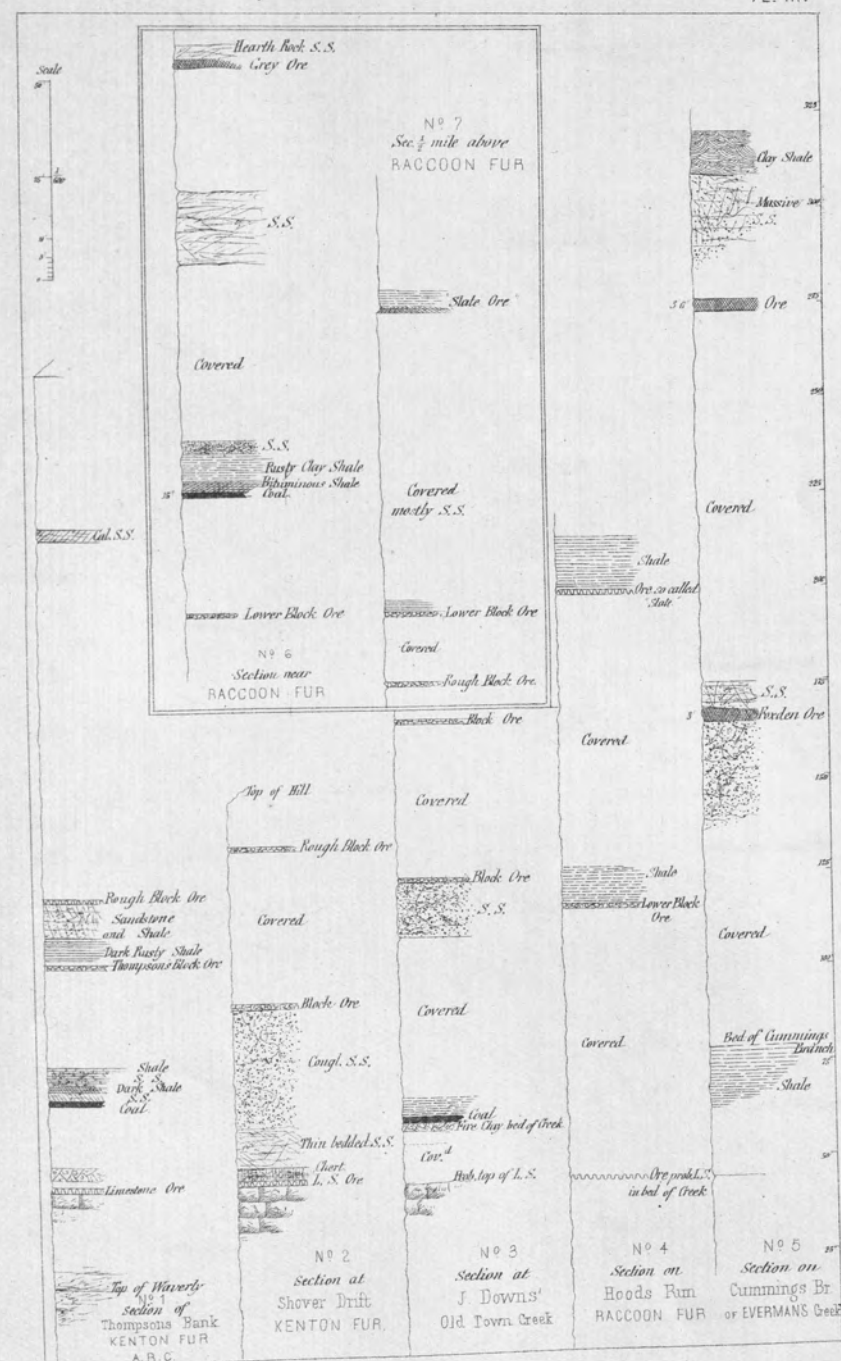
The limestone and block ores have been already mined by drifting at a number of places, and in future will be much more extensively worked in this way. Whether the kidney ores will ever pay for underground exploitation is an open question, as the experiment, so far as the writer knows, has never been tried.

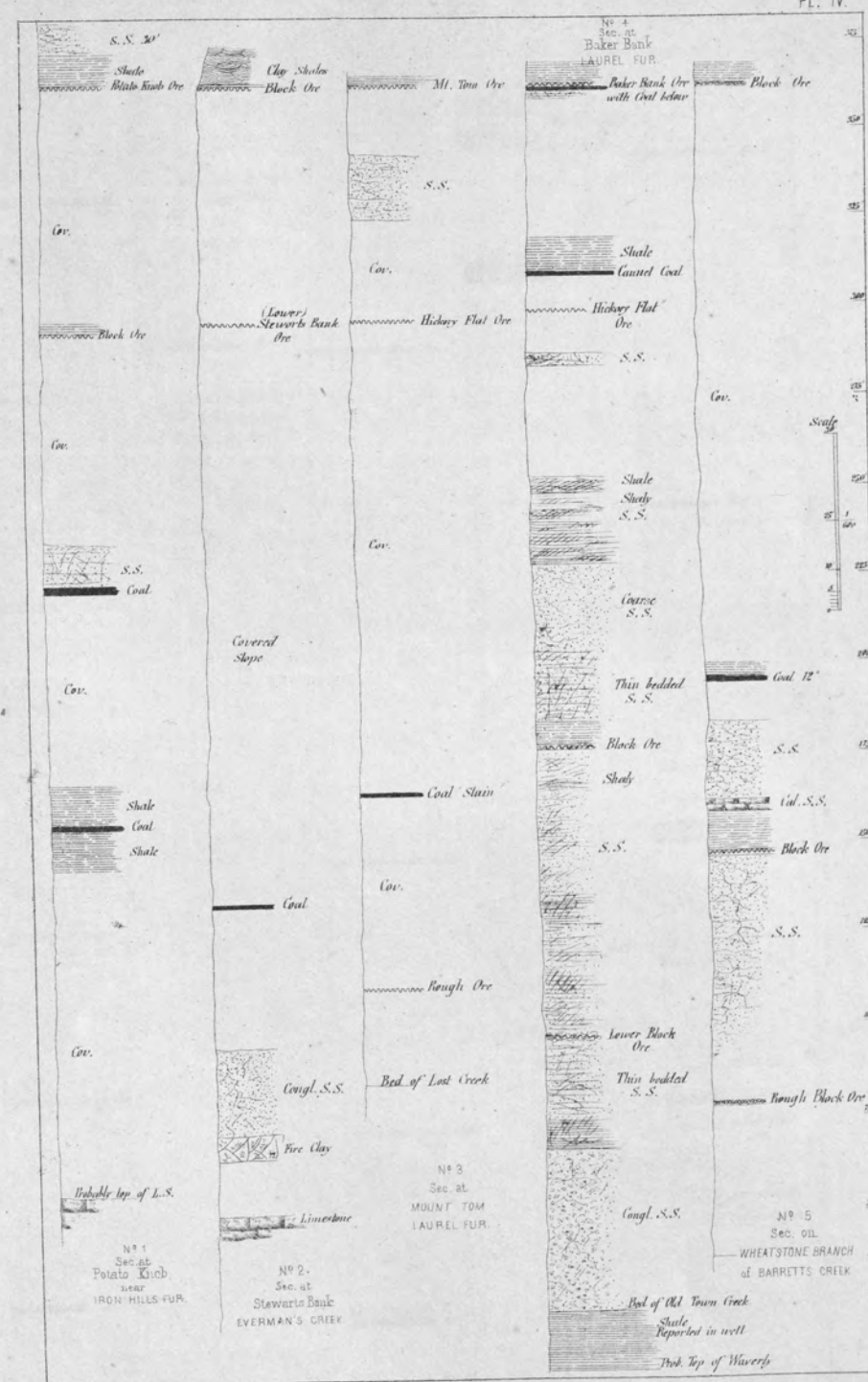
In cases where the kidneys are of large size, and concentrated in a few feet of shale, it seems not improbable that it might be successfully done, but in the majority of cases the amount of ore would prove so small, in proportion to the shale necessary to be moved to reach it, that it would not pay. The

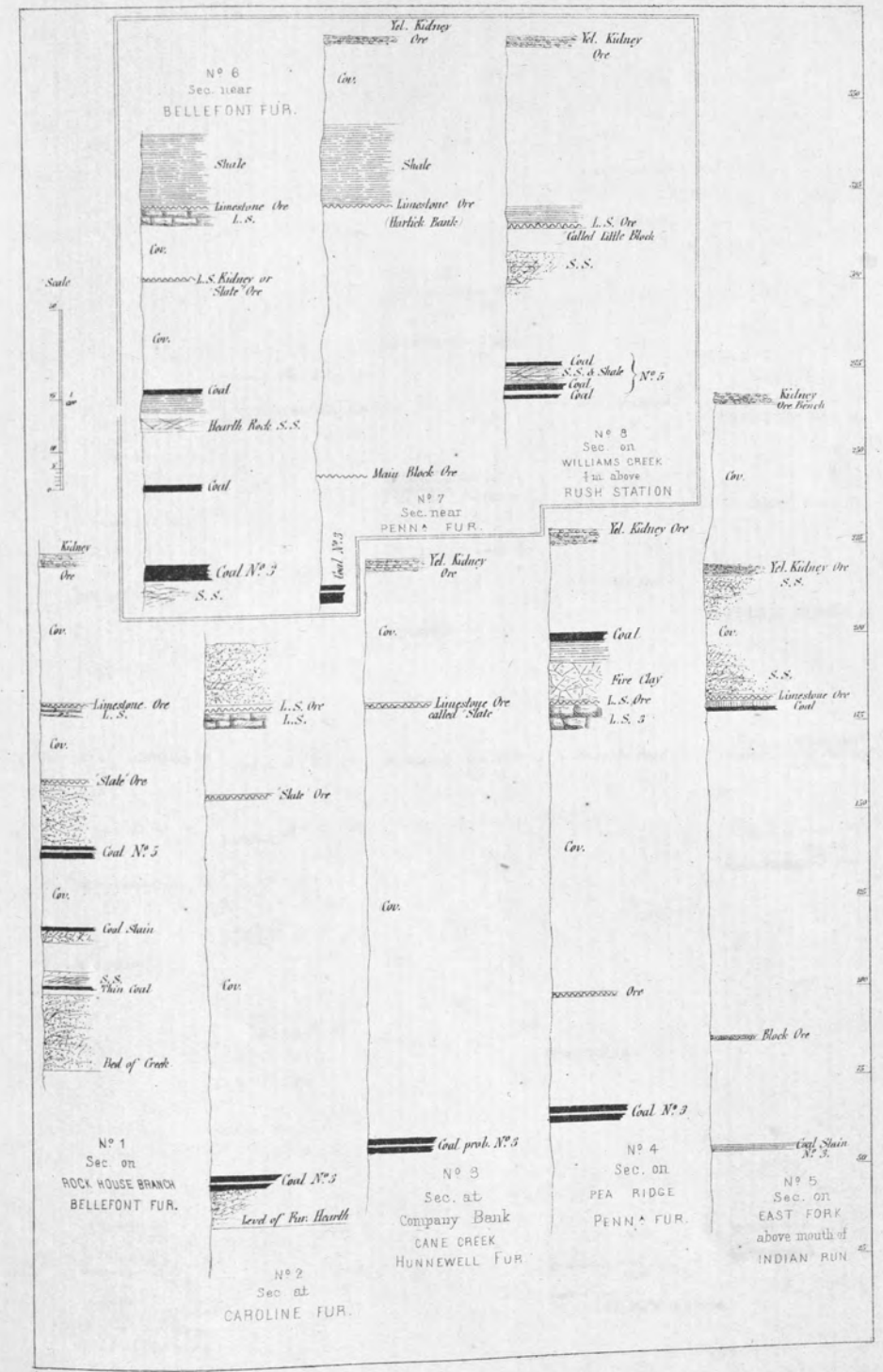
amount of ore in one of the kidney beds, in a given area, has never been accurately determined. No calculation can be made of it with any degree of accuracy. The only way to determine it is to strip a measured area of considerable size and weigh the ore found.

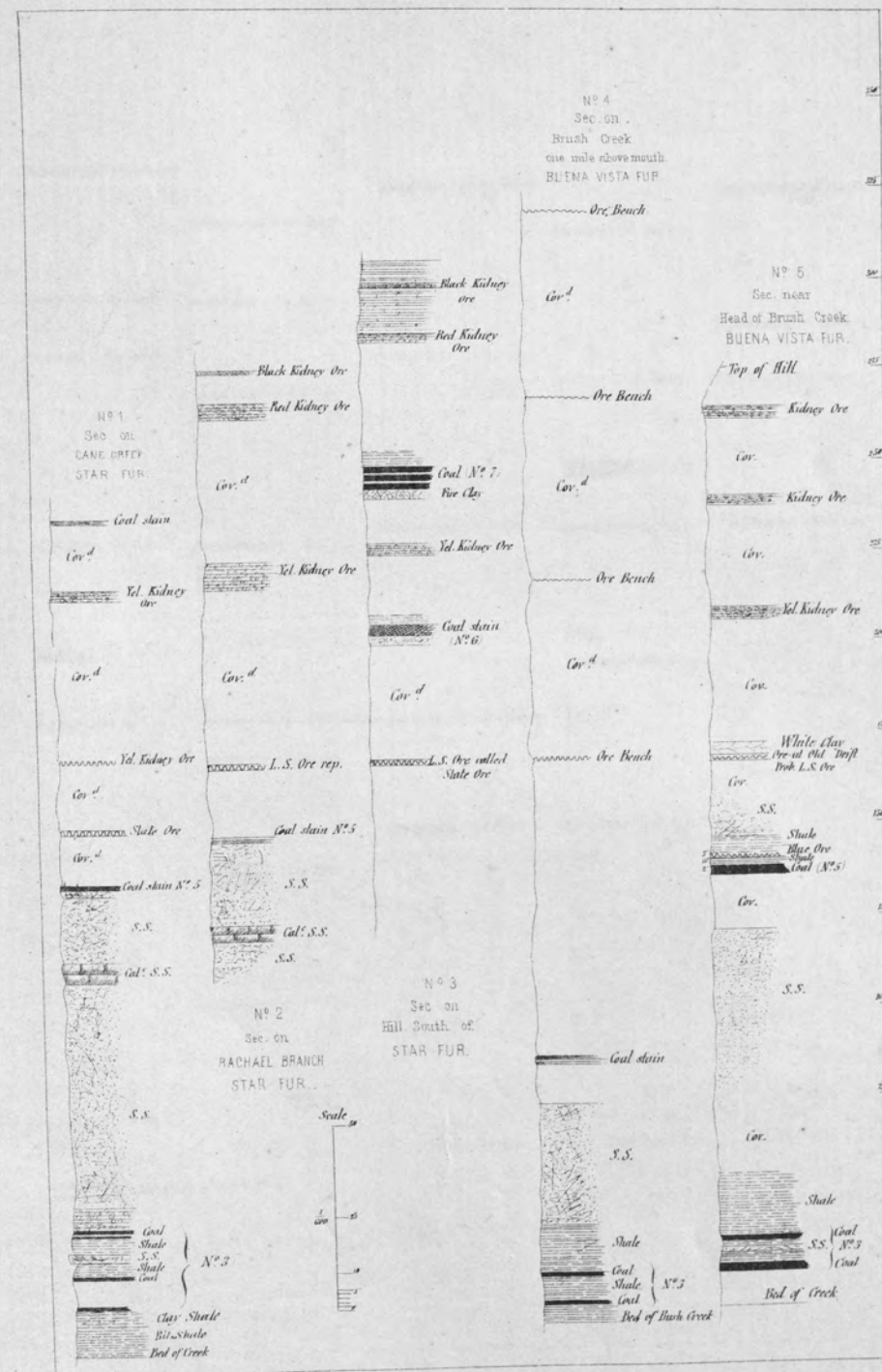
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GEOLOGICAL SURVEY OF KENTUCKY.

N. S. SHALER, DIRECTOR.

CHEMICAL REPORT

OF THE

SOILS, MARLS, CLAYS, ORES, COALS, IRON FURNACE PRODUCTS, MINERAL WATERS, &c., &c.,
OF KENTUCKY,

BY ROBERT PETER, M. D., &c., &c.,

CHEMIST TO THE KENTUCKY GEOLOGICAL SURVEY.

ASSISTED BY

JOHN H. TALBUTT, S. B., CHEMICAL ASSISTANT.

THE FIRST CHEMICAL REPORT IN THE NEW SERIES AND THE FIFTH SINCE THE
BEGINNING OF THE SURVEY.

PART IV. VOL. I. SECOND SERIES.

INTRODUCTORY LETTER.

CHEMICAL LABORATORY OF THE
KENTUCKY STATE GEOLOGICAL SURVEY,
LEXINGTON, KY., April 19th, 1875. }

Professor N. S. SHALER, *Chief Geologist, &c.*:

DEAR SIR: I have the pleasure herewith to report the results of the chemical work performed in this laboratory, for the State Geological Survey, since September, 1873, to nearly the present date. So much could not have been effected but for the able and efficient assistance of Mr. John H. Talbutt, who has given his constant attention to this labor.

Very respectfully,

ROBERT PETER.

CHEMICAL REPORT

OF THE

SOILS, MARLS, CLAYS, ORES, COALS, IRON FURNACE PRODUCTS, MINERAL WATERS, &c., &c.,
OF KENTUCKY.

By ROBERT PETER, M. D., &c., &c.

In the eighty-six *soil* analyses, which are appended, only a portion of ten counties of the State is represented, and the greater number of these soils are not to be classed amongst our most fertile. The limits of the range of variation of their several constituents is shown in the following table, viz:

	Pr. ct.	No.	County.		Pr. ct.	No.	County.
Organic and volatile matters vary from	7.985	in 1300	of Boyd	to	1.815	in 1398	of Carter.
Alumina and iron and manganese oxides vary from	15.763	in 1396	of Carter	to	2.740	in 1571	of Hardin.
Lime carbonate varies from	3.890	in 1330	of Campbell	to	.045	in 1572	of Hardin.
Magnesia varies from	.520	in 1329	of Campbell	to	.034	in 1298	of Boyd.
Phosphoric acid varies from	.555	in 1424	of Fayette	to	.045	in 1396	of Carter.
Potash varies from	.662	in 1396	of Carter	to	.062	in 1566	of Hardin.
Soda varies from	.286	in 1407	of Carter	to	trace.	in 1325	of Campbell.
Sand and insoluble silicates vary from	74.840	in 1396	of Carter	to	92.455	in 1327	of Campbell.
Water expelled at 380° F. varies from	2.650	in 1558	of Hardin	to	.225	in 1567	of Hardin.
Water expelled at 212° F. varies from	5.075	in 1329	of Campbell	to	.800	in 1634	of Ohio.
						in 1571	of Hardin.

The extremes may represent very rich and very poor soils; but not the general character of the soils of the counties named.

The *method* of analyses of the soils does not vary much from that described in volume III of the Kentucky Geological Reports. The principal object was, as there stated, to obtain *comparative results*, which would enable the scientific agriculturist to form an opinion as to the *chemical constitution* of our soils in their relation to husbandry; without attempting to perform the almost hopeless task of giving all the minuter constituents of each, or of presenting all those *physical conditions* which exert so great an influence on their practical fertility. To this end the several soils were treated as nearly alike as possible: air-dried together, digested for an equal time at nearly the same temperature in acid of a uniform strength, &c., &c. The specific gravity of the chlorohydric acid used being about 1.10.

The process of digestion in water, containing carbonic acid, was not employed in all, because of the press of work in the laboratory, mainly. There can be no doubt, however, that, used with proper care, this process will indicate the relative proportion of soluble plant food in the soil at the time. As this may very well vary, under different physical atmospheric conditions, it was not considered of essential value in the comparative analyses.

The well-known fact that various *physical conditions* exert a powerful influence on the productiveness of soils which have a similar chemical composition, has, in recent times, singularly perverted the minds of chemists, and consequently of agriculturists, in relation to the value of soil analyses. Because the *chemical conditions* of a soil are not the *only ones* necessary to productiveness, they have, by a perverted logic, jumped to the conclusion that these conditions are of no consequence whatever.

But if these *chemical conditions* are *indispensable* to the fertility of the soil, how much injury has been done in recent years to the scientific study of the soil and of agriculture, by the great outcry which has been raised against this kind of investigation! The comparative chemical examination of the soils of a State or country can only be made under the patron-

age of the government. Individual efforts are inadequate to effect it; nor could they, if adequate, so economically conduct it. The writer believes that the geological survey of any region should always include this study of the soils; yet very little has been done in this direction in all the recent State surveys, and a valuable opportunity has been lost, which in many instances cannot recur, of studying the chemical conditions of the virgin soil of various parts of our country.

Chemists are naturally somewhat averse to soil analysis; it requires so much time and labor, so much care must be taken to secure accuracy, and there is so little variety in the work, and so small an appreciation of its value and significance amongst the people when done, that they gladly avoid it. But, in the course of time, most of them who are not too much prejudiced against the teachings of experience, arrive at the same conclusion with Prof. Aug. Voelcker, of the English Royal Agricultural College: "There was a time when I thought with many other young chemists, that soil analyses would do every thing for the farmer; three or four years of further experience and hard study rather inclined me to side with those men who consider that they are of no practical utility whatever; and now, after eighteen years of continued occupation with chemico-agricultural pursuits, and, I trust, with more matured judgment, I have come to the conclusion that there is hardly any subject so full of practical interest to the farmer as that of the chemistry of soils. The longer and more minutely soil investigations are carried on by competent men, the greater, I am convinced, will be their practical utility."—*Jour. of Roy. Agr. Soc. of Eng.*, 1865.

Even Prof. S. W. Johnson, whose somewhat harsh criticism, in 1861, of some of the former labors in this field of the writer, seemed to sound the key-note of the clamor against this kind of study in this country, has so far yielded his opposition as to give us in his valuable work, "*How Crops Feed*," 1870, the comparative analyses of several soils, and to point out the significance of their chemical composition. But he is careful to caution the reader, page 368, that although the analysis may

show the amount of the mineral fertilizers in a soil, it cannot tell how much of them "is at the disposal of the present crop;" and on page 271: "These facts show how very far chemical analysis, in its present state, is from being able to say definitely what any given soil can supply to crops, *although we owe nearly all our precise knowledge of vegetable nutrition directly or indirectly to this art.*"

He might very truly have added, that we should not be able to say that a suitable *chemical* composition of a soil was not the only condition necessary to its fertility, unless we had thoroughly studied that condition. It is only by means of chemical analyses that we find out the equally indispensable nature of the physical conditions. He cannot fail to admit that it is impossible to make progress in our knowledge of the soil and its actions and conditions without a thorough study of its chemical characters.

In accordance with this outcry against this sort of investigation the difficulties of obtaining good samples for analyses has been exaggerated. In a country like that of most of this State, where there is comparatively but little quarternary or transported material constituting the soil, and especially before its character has been much altered by a dense population, there is little difficulty, with the use of necessary precautions, in obtaining representative samples of large areas similar in character and position. In many large districts in our State the soil has been formed in place by the disintegration of the rocks. In other parts, where surface action has been greater, more judgment and care must be exerted in the collection of the soils; but in no part of the State, probably, is so great local variety to be seen in the soils as frequently may be observed in the northeastern States, where the transporting action of water and of ice, in former epochs, has produced a high degree of local irregularity in the nature of the surface deposits.

In the collection of the samples of our Kentucky soils the causes of local and accidental differences of composition were, as much as possible, avoided.

Because of the very small proportion of the essential ingredients of the soil, which are carried off in crops, as compared with the whole amount of the earth, taken to the depth through which the roots of plants absorb nourishment, it has been denied that it is possible by chemical analysis to show their diminution in the old field soil, as compared with the virgin soil. Indeed it has been *logically* demonstrated to be impossible. But, it should be recollected that when, by the acid digestion, we separate these essential soluble ingredients from the greater mass of the soil, left as *sand and insoluble silicates*, which amount to from about seventy-five to ninety-two per cent. of the whole, the probabilities of error in the determination of these minuter ingredients must not be calculated into the whole weight of the soil, but into that smaller part which we have thus extracted from it.

Logic apart, the *fact* still remains, that in one hundred and forty-nine duplicate analyses, made by the writer for the Kentucky, Arkansas, and Indiana Surveys, in which the chemical composition of the virgin soil was compared, under similar conditions of treatment, with soil of a neighboring old field in the same locality, one hundred and twenty-two out of the one hundred and forty-nine showed a marked diminution of most of the essential ingredients of the soil in that of the old field as compared with the virgin soil. This certainly is not an accidental result.

In the soil analyses at present reported the results are not so striking in this relation. Partly because the samples had not, in several cases, been collected with special reference to this investigation, and partly because of greater local variations of the soil in the regions in which they were obtained.

In calculating the probable amount of exhaustion of the essential soil ingredients, it should be recollected that as much, and sometimes more, may be alienated from the soil by the solvent action of the atmospheric agents, while the surface is much exposed in the cultivation of hoed crops, than is absorbed and removed by the products. Hence the exhaustion of the soil is much more rapid under these cir-

cumstances than is generally allowed. In other words, the exhaustion of the soil when under cultivation in hoed or plowed crops, during which time a large portion of its surface is kept bare of vegetation and subjected to the leaching action of rains, is much greater than can be accounted for by the amount of the essential ingredients which are taken from it in its products.

In several instances, in the analyses of the soils described above, the "sand and insoluble silicates," left after digestion, for ten days in the acid, were analyzed by the admirable process of Professor J. Lawrence Smith, for the determination of the amount of fixed alkalies held in the form of insoluble silicates. As will be seen, in the detailed report and in the tables, the quantity of potash and soda thus held in the soil in the samples in question are, in most cases, considerable, ranging from 0.485 to 2.731 per cent. of potash to the whole soil, and 0.165 to 1.306 per cent. of soda.

It is evident that, although at *present insoluble*, and hence unavailable for plant nourishment, these alkalies are doubtless gradually released and brought into a soluble form by weathering and under the influence of the products of vegetable decay, so that they tend to prolong the fertility of the soil.

The seventeen *limestone* and *lime* analyses, of specimens from nine counties only, represent but a small part of our various lime rocks. But even these exhibit their great industrial value, including, as they do, limestones useful for the fluxing of our iron ores, as well as for purposes of construction in the form of building stone or cement, while some of them would be valuable as fertilizers on the land. The so-called lithographic stone of Barren county and of other corresponding localities may, for some purposes, with well-selected samples, replace the more costly foreign stone.*

The eighty-two *iron ores* which have been analyzed are from eleven counties, principally of the northeastern portion of the

*NOTE.—I have found it impossible to use this stone for crayon or transfer work.

N. S. SHALER.

State. Sixty-four of these are limonite ores; twenty-seven are clay ironstones or carbonate ores; and only one, to be found probably only in limited quantity in Lawrence county (see No. 1594), is of the red hematite variety.

The proportion of metallic iron, in the limonite ores examined, varies from 19.344 per cent. to 57.148 per cent. In the carbonate ores analysed the per centage of metallic iron ranges from 10.960 per cent. in what may be termed only a ferruginous limestone, up to 40.465 per cent.

Of the one hundred and ten specimens of *coal*, &c., which were examined by proximate analysis, eighty-nine were from eleven counties in Kentucky; of which five counties, viz: Boyd, Carter, Greenup, Lawrence, and Menifee, are in our northeastern coal field; and six, viz: Butler, Edmonson, Grayson, Hopkins, Muhlenburg, and Ohio counties, are in the southwestern coal field. All these coals are of the splint, dry coal, or semi-cannel coal variety; cleaving generally into thin layers, which have more or less fibrous coal between them. Although some of them make a good coke, they do not generally soften or swell much when heated or burnt, and hence, when they do not contain an unusual quantity of sulphur, they can be used, without preliminary coking, for the smelting of iron. Some of these coals, however, are quite sulphurous, and some contain a large proportion of ash,[†] but the better samples compare favorably with the best coals of the neighboring States.

For the purpose of this comparison seven of the best coals of the State of Ohio, two of the best of those of Illinois, and four of the celebrated "block coals" of Indiana, used there for iron smelting, &c., were submitted to similar processes of analysis with our Kentucky coals. We give the general comparative results in the following tables:

[†] In some cases, as the samples for analysis were taken from new and imperfect openings, it is more than probable the coals will be found to be better than is represented in the analyses given.

AVERAGE COMPOSITION OF THE COALS FROM THE NORTHEASTERN KENTUCKY COAL FIELD.

COUNTIES.	Number of samples analyzed.	Specific gravity.	Volatile combustible matters.	Fixed carbon in the coke.	Per cent. of ash.	Per cent. of sulphur.
Boyd	13	1.337	33.43	54.35	* 8.46	† 2.292
Carter	16	1.331	33.39	53.45	8.17	† 1.886
Greenup	14	1.375	34.50	52.20	9.37	3.165
Lawrence	6	1.326	36.27	53.85	6.86	1.285
Menifee	2	1.319	33.55	53.42	10.36	2.544
General average . .	51	1.3376	34.23	53.45	8.62	2.234

AVERAGE COMPOSITION IN THE SOUTHWESTERN COAL FIELD.

COUNTIES.	Number analyzed.	Specific gravity.	Volatile combustible matters.	Fixed carbon.	Per cent. of ash.	Per cent. of sulphur.
Butler	1	1.378	30.66	54.94	11.00	2.544
Edmonson	8	1.360	34.01	52.34	10.56	3.312
Grayson	8	1.385	31.17	49.78	‡ 14.38	2.083
Hopkins	2	1.385	32.95	52.55	11.20	5.019
Muhlenburg	11	1.312	36.42	53.26	6.74	2.949
Ohio	3	1.362	34.90	53.77	8.16	3.103
General average . .	33	1.3636	33.70	52.77	10.34	3.166

* By leaving out the exceptional ash of No. 1291, the average is = 7.94.

† Without No. 1291 this average would be = 2.036.

‡ This is the average of fifteen of the coals only.

§ By leaving out the exceptional ash of No. 1454, the average would be = 12.21.

AVERAGE COMPOSITION OF THE SELECTED COALS FROM NEIGHBORING STATES.

STATES.	Number analyzed.	Specific gravity.	Volatile combustible matters.	Fixed carbon in the coke.	Per cent. of ash.	Per cent. of sulphur.
Ohio	7	1.327	34.51	55.17	6.43	1.494
Illinois	2	1.310	31.95	59.06	5.96	1.924
Indiana	3	1.313	35.93	54.24	7.23	1.946
General average . .	12	1.317	34.13	56.12	6.54	1.768

This comparison is more or less imperfect, because the samples, which were too few in number to make it complete, were not averaged with special reference to it. Yet it measurably corroborates opinions held by geologists and others in regard

to our two coal fields. For instance, it will be seen in the general averages that the coals of the southwestern field have more ash and sulphur, and a higher specific gravity, than those of the northeastern, and that the relative proportions of the combustible matters, volatile or fixed, are less in the former. The differences, however, are not very remarkable.

In each of these particulars the coals from our neighboring States of Ohio, Illinois, and Indiana, show less difference than might have been expected, in view of the fact that they had been collected from some of the most celebrated coal mines, as representing the *best coals* of those States. The following tables illustrate this:

TABLE OF THE EXTREMES OF COMPOSITION OF THE COALS.

COUNTIES.	Volatile combustible matters. From	Fixed carbon. From	Ashes. From	Sulphur. From
Boyd	29.70 to 36.70	46.86 to 57.90	5.10 to 14.74	1.285 to 5.361
Carter	27.22 to 36.26	44.64 to 58.88	3.20 to 12.10	.724 to 3.483
Greenup	31.66 to 37.70	47.00 to 56.70	5.40 to 13.00	.746 to 5.934
Lawrence	33.90 to 39.00	47.84 to 57.80	1.80 to 13.70	.736 to 3.785
Menifee	33.06 to 34.04	50.24 to 56.60	7.40 to 13.06	.997 to 4.092
Greatest extremes . . .	27.22 to 39.00	44.64 to 58.88	1.80 to 14.74	.724 to 5.361
Butler	30.66	11.00	2.544	
Edmonson	32.00 to 39.00	45.46 to 54.26	6.94 to 14.34	1.059 to 8.685
Grayson	25.86 to 35.80	40.14 to 55.52	7.50 to 29.60	.777 to 3.565
Hopkins	30.00 to 35.90	51.10 to 54.00	6.90 to 15.50	2.759 to 7.280
Muhlenburg	30.60 to 43.08	49.80 to 58.80	3.72 to 11.80	.640 to 4.032
Ohio	33.50 to 36.20	52.20 to 55.10	7.10 to 9.00	2.837 to 3.332
Greatest extremes . . .	25.86 to 43.08	40.14 to 58.80	3.72 to 29.60	.640 to 8.685
State of Ohio	29.68 to 36.68	54.16 to 57.06	4.20 to 8.72	.756 to 2.247
State of Illinois	31.86 to 32.04	55.64 to 59.54	5.16 to 6.76	1.376 to 2.472
State of Indiana	35.10 to 36.38	53.50 to 53.58	5.28 to 9.00	1.664 to 2.373
Greatest extremes . . .	29.68 to 36.38	53.50 to 59.54	4.20 to 9.000	.756 to 2.472

TABLE OF THE COMPOSITION OF ELEVEN SELECTED KENTUCKY COALS FROM SEVERAL COUNTIES.

COUNTIES.	Number.	Specific gravity.	Volatile combustible matters.	Fixed carbon in coke.	Per cent. of ash.	Per cent. of sulphur.
Boyd	1286	1.308	33.30	57.60	5.80	2.480
Boyd	1289	1.320	34.50	55.40	5.10	1.285
Carter	1346	1.288	34.36	54.60	4.40	.724
Carter	1347	1.290	27.22	55.88	7.50	.973
Carter	1353	1.274	34.50	58.50	3.20	2.164
Edmonson	1418	1.336	35.14	54.26	6.94	2.706
Greenup	1492	1.292	33.90	56.70	6.20	.746
Greenup	1493	1.289	34.96	55.54	5.40	1.590
Hopkins	1579	1.322	35.90	54.00	6.90	2.759
Lawrence	1589	1.281	35.30	57.80	1.80	.736
Lawrence	1593	1.284	39.00	54.76	3.74	1.066
General average		1.298	34.36	56.18	5.18	1.566

To show the great importance of collecting true and faithful *average samples* of the coal beds, for the purpose of analysis, *two picked cabinet specimens* were taken and analyzed, to-wit:

No. 1280 (b). Coal No. 7, from Turkey-pen Hollow, Boyd county.

No. 1348 (b). Coal No. 7, Pritchard's coal, Mt. Savage Furnace, Carter county.

The comparative results of the analyses are as follows—thoroughly air-dried:

	Picked sample. No. 1280 (b).	Ave'ge sample. No. 1280 (a).	Picked sample. No. 1348 (b).	Ave'ge sample. No. 1348 (a).
Specific gravity	Not determ'd.	1.358	Not determ'd.	1.435
Hygroscopic moisture	4.70	3.40	4.50	5.40
Volatile combustible matters	34.30	32.30	37.10	32.70
Coke	61.00	64.30	58.40	61.90
Total	100.00	100.00	100.00	100.00
Total volatile matters	39.00	35.70	41.60	38.10
Carbon in the coke	59.04	55.40	56.40	52.52
Ash	1.96	8.90	2.00	9.38
Total	100.00	100.00	100.00	100.00
Per centage of sulphur	0.983	1.230	0.571	2.356

As the value of a coal bed bears a very near relation to that of its average product, it is easily to be understood that the analysis of a *selected* sample may be of very little utility. On the other hand, the selection of a true average sample of the bed may often be a task of considerable difficulty.

The determination of the proportion of *sulphur* in coals has been much neglected in this country; and where it has been done the method generally used has been to oxidate the powdered coal in strong nitric or nitro-hydrochloric acid. This mode of analysis is not so perfect as fusion with a mixture of nitre, carbonate of soda, and salt, &c., which always, when properly managed, brings all the sulphur into the form of soluble sulphate, in whatever state it may have existed in the coal. This exhaustive mode was employed in all our estimations of this substance, and hence the quantities obtained may seem greater than are shown to exist in similar coals which have been treated with the acids.

As has now been extensively demonstrated, the sulphur in coals is rarely all combined with iron as sulphide or bi-sulphide. Some frequently exists in a free or uncombined condition, as is shown in an analysis described in the following pages. Some of it is frequently in the form of lime sulphate.

When it is recollected that vegetable matters, decomposing in a solution of sulphates of lime, magnesia, iron, &c., reduce these salts to sulphides, with the production of hydrogen sulphide in the case of the earthy salts, and when we reflect that this gaseous compound, HS, is decomposed, with the deposition of free sulphur, on contact with the air, we can easily understand how most of our coals must contain not only pyrites but free sulphur.

In the thirty-four *marls, marly shales, sands, and silicious concretions*, which have been analyzed, we find a general prevalence of lime, fixed alkalies, phosphoric acid, sulphuric acid, &c. Some of the marls and shales contain these in such considerable proportions as to make them locally useful for the amelioration of poor sandy land. Some of these find an application as mineral paint, for which they are adapted by their

agreeable tint and other properties. Some of the more silicious could be used in the manufacture of glass, as well as for other purposes; some of post-tertiary silicious clays, or soft sandstones, might be made into bricks for scouring purposes, &c., while others, which contain but little lime, magnesia, oxide of iron or alkalies, would prove quite refractory in the fire.

But the *fire-clays* and *plastic clays* of the coal fields, of which the analyses of sixteen are appended, are especially deserving attention; and from their abundance, superior quality, and vicinity to fuel, should form the basis of extensive industries. Amongst them may be found some of the best of fire-clays, as well as some well-fitted to the manufacture of pottery ware of various kinds, including the better sorts of delf, stone china, or queensware. Skill, capital, and enterprise are all that are needed, on these somewhat neglected deposits, to make them of very great value to individuals as well as to the public. Only the want of these essentials causes us to pay a heavy tax to foreign nations for our pottery ware, when the materials for the manufacture lie measurably neglected at home. It is simply the history repeated of the importation of bricks from Holland to build houses in Albany, and the packing of English bricks, on the backs of horses, over the Alleghenies, to construct the barracks at old Fort Duquesne on the Ohio.

The nineteen samples of *pig iron* which have been analyzed are mostly of the kind known as foundry iron. On reference to the general table of their composition, it will be seen that they present considerable variety in this respect; as for example:

The per centage of iron ranges between	85.455 to 95.840
“ carbon “	2.040 to 4.400
“ phosphorus “	0.123 to 1.029
“ sulphur “	a trace to 0.150
The specific gravity “	6.406 to 7.782

Of the numerous *mineral waters* of our State the analyses of twenty-one are given in the present report, mostly from one locality.

BATH COUNTY.

No. 1269—LIMONITE IRON ORE. "*From Block-house ore bank, one and a half miles from the Old Slate Furnace, Bath county. Bed ten to twelve feet thick; on the Clinton Group. Collected by Philip N. Moore.*"

Ore generally dense and dark-colored, with some dark ochreous ore. Structure cellular and oölitic.

COMPOSITION, DRIED AT 212° F.

Iron, peroxide	76.077 = 53.254 per cent. of iron.
Alumina	2.592
Manganese, brown oxide	.430
Lime, carbonate	.130
Magnesia	.281
Sulphuric acid	.030 = 0.011 per cent. of sulphur.
Phosphoric acid	.731 = .319 per cent. of phosphorus.
Water, expelled at red heat	12.300
Silica and insoluble silicates	8.180 = 6.160 per cent. of silica.

100.751

The phosphoric acid determination was made by Chancel's process, viz: by means of acid nitrate of bismuth solution, after the separation of the iron oxide, and is believed to be nearly correct. The iron ore in the Clinton Group, especially the "dye-stone ore," is usually quite phosphatic. This does not prevent it from being quite valuable for the production of iron for many purposes, although it may not be made to yield the higher grades of bar iron or steel.

BARREN COUNTY.

No. 1421—LIMESTONE. "*Oölitic Limestone. Upper layers of upper sub-carboniferous limestone. Glasgow Junction, Barren county. Collected by Prof. N. S. Shaler.*"

A compact, nearly white, fine oölitic limestone, with a ferruginous stain on the exposed surfaces probably derived from the superincumbent soil.

No. 1422—LIMESTONE (compact). "*Upper Sub-carboniferous Limestone. Glasgow Junction. Collected by N. S. Shaler.*"

A light-grey, fine granular, or compact limestone, which might be a good lithographic stone but for the presence of some imbedded fossils and minute specks of iron peroxide.

No. 1423—LIMESTONE. Labeled "*Lithographic Stone; below the building stone. Upper sub-carboniferous limestone. Glasgow Junction. Collected by Prof. N. S. Shaler.*"

A light-grey, compact, or very fine granular rock, which might be a perfect lithographic stone but for the minute imbedded fossils and the small occasional specks of iron peroxide, &c., which it contains. Some layers, however, are reported measurably free from these imperfections, and found to be good enough, on actual trial, for some ordinary lithographic purposes.

COMPOSITION OF THESE BARREN COUNTY LIMESTONES, DRIED AT 212° F.

	No. 1421.	No. 1422.	No. 1423.
Specific gravity	2.678	2.721	2.689
Lime, carbonate	98.050	77.550	82.960
Magnesia, carbonate	.363	13.214	7.655
Alumina, and iron and manganese oxides	.511	2.680	2.680
Phosphoric acid	.051	.051	.115
Sulphuric acid	.260	.192	.260
Potash	.115	.154	.135
Soda	.327	.188	.156
Silica and insoluble silicates	1.060	6.060	6.160
Total	100.737	100.189	100.121
Per centage of lime	50.428	43.428	46.457
Per centage of phosphorus	.022	.022	.050
Per centage of sulphur	.104	.077	.104

No. 1421 would yield a very pure white lime.

BOYD COUNTY.

No. 1270—CLAY IRON-STONE, &c. Labeled "*Grey Limestone Ore. J. P. Jones' drift, near Ashland. Average sample selected by P. N. Moore.*"

A mixed sample, with oölitic carbonate of iron, dark grains united with a whitish cement, portions of compact carbonate, and of limonite ore.

No. 1271—CLAY IRON-STONE. *Labeled "Wilson Creek Blue Block Ore. Average sample, taken from Star Furnace stock pile, by P. N. Moore."*

A fine-granular ore of various shades of dark-grey, with some slight incrustations of limonite. Not adhering to the tongue.

No. 1272—CLAY IRON-STONE. *Labeled "So-called Limestone Ore, from Williams' Creek. Star Furnace stock pile. Averaged by P. N. Moore."*

A granular and oölitic proto-carbonate of iron (containing much carbonate of lime). Oölitic grains nearly black, in a whitish cement.

SUMMARY OF THE COMPOSITION OF THESE BOYD COUNTY CLAY IRON-STONES, DRIED AT 212° F.

	No. 1270.	No. 1271.	No. 1272.
Iron, carbonate	32.285	66.854	19.802
Iron, peroxide	12.784	.276	21.433
Alumina (by difference)	11.968	4.260	1.193
Lime, carbonate	21.125	2.460	30.205
Magnesia, carbonate	.691	4.086	a trace.
Manganese, carbonate	.465	.572	.240
Phosphoric acid (anhydr.)	.377	.709	.257
Sulphuric acid (anhydr.)	.267	.885	.157
Silica and insoluble silicates	19.730	18.360	23.080
Water and loss	.308	1.538	3.633
Total	100.000	100.000	100.000
Per centage of iron	24.591	32.466	23.109
Per centage of phosphorus	.164	.308	.112
Per centage of sulphur	.107	.354	.063
Per centage of silica . . . . .	.....	15.500	18.960

Of these ores, No. 1271 would be the best, as it is the richest; but its considerable proportions of phosphorus and sulphur will somewhat injure the toughness of the iron it

yields. No. 1272 is not so objectionable in this respect. This ore as well as No. 1270, containing a large proportion of lime, although comparatively poor in iron, may yet be profitably smelted, especially in mixture with richer ores. They will obviously require less fluxing material than the other ores.

No. 1273—LIMONITE. *Labeled "Slate Ore. Head of Cane Creek, on the road to Star Furnace, Boyd county. Average sample selected by P. N. Moore."*

In irregular curved layers, varying in hardness and color from yellowish-brown to blackish-brown; frequently inclosing soft ochreous nodules.

No. 1274—LIMONITE. *Labeled "Yellow Kidney Ore, sampled from a number of places by P. N. Moore. Star Furnace property."*

Irregular curved layers of dark-colored limonite (brown hæmatite), incrustated by and inclosing soft ochreous ore.

No. 1275—LIMONITE. *Labeled "Limestone Ore;" average sample selected by P. N. Moore. Bellefont Furnace.*

Ore varying from brownish-yellow to dark brown (mostly dark brown), with some proto-carbonate of iron, ferruginous limestone, and a little calc. spar intermixed.

No. 1276—LIMONITE. *Labeled "Yellow Kidney Ore;" average sample selected by P. N. Moore. Buena Vista Furnace.*

Irregular curved layers of limonite, varying from soft, brownish-yellow to dense, dark brown ore.

No. 1277—LIMONITE, &c. *Labeled "Yellow Kidney Ore, or Kidney Ore below the No. 7 Coal." Straight Creek, Buena Vista Furnace. Average sample collected by P. N. Moore.*

Limonite layers of various depth of color, with some fine granular carbonate of iron and thin veins of calc. spar.

No. 1278—LIMONITE. Labeled "*Black Kidney Ore.*" Average sample, from *Stock Branch Hollow*, just south of *Star Furnace*. Collected by *P. N. Moore*.

In irregular curved layers, generally of a dark purplish-brown color, with some soft ochreous nuclei and layers.

SUMMARY OF THE COMPOSITION OF THESE BOYD COUNTY LIMONITES,
DRIED AT 212° F.

	No. 1273.	No. 1274.	No. 1275.	No. 1276.	No. 1277.	No. 1278.
Iron, peroxide	53.653	58.960	51.802	61.344	56.022	54.055
Iron, carbonate			10.594		8.821	
Alumina (by difference) . .	4.324	7.284	4.523	4.236	7.194	4.919
Manganese, brown oxide . .	.368	.380	a trace.	a trace.	a trace.	.420
Lime, carbonate	a trace.	.430	7.480	.750	2.520	.080
Magnesia	.101	.227	.440	.208	1.271	a trace.
Phosphoric acid (anhydr.) .	.313	.376	.570	.795	.526	.076
Sulphuric acid (anhydr.) . .	.220	.206	.089	.041	.090	.096
Combined water	10.150	10.800	8.772	11.200	10.126	10.450
Silex and insoluble silicates .	30.940	21.210	15.730	21.480	13.430	30.080
Moisture and loss		.127				
Total	100.069	100.000	100.000	100.054	100.000	100.176
Per centage of iron	37.551	41.272	41.357	42.941	43.473	37.838
Per centage of phosphorus . .	.137	.164	.231	.347	.229	.033
Per centage of sulphur	.086	.082	.035	.016	.036	.038
Per centage of silica	29.560	19.980	13.160	18.560	11.660	24.260

These are all good ores; Nos. 1273 and 1278 being the poorest in iron and the most silicious. The proportion of *sulphur* is small in all of them, and of phosphorus is probably not enough to injure the iron for ordinary uses. Nos. 1275 and 1277 would probably be improved for smelting by a previous roasting.

No. 1279—COAL. Labeled "*Coal No. 7, from drift one quarter mile above the store, on Furnace Branch of Straight Creek, Buena Vista Furnace.*" Average sample of both parts of the bed, by *P. N. Moore*."

No. 1280—COAL. Labeled "*Coal No. 6, from Turkey-pen Hollow; Old Clinton Tract; Bellefont Furnace.*" Averaged by *P. N. Moore*."

No. 1281—COAL. Labeled "*Coal No. 7, three feet thick, no parting; Chadwick Creek.*" Average sample, selected by *A. R. Crandall*."

No. 1282—COAL. Labeled "*Coal No. 5, eighty-five feet below the yellow kidney ore, drift south side of Straight Creek, one third of a mile from Buena Vista Furnace.*" Averaged by *P. N. Moore*."

No. 1283—COAL. Labeled "*Keys Creek Coal, No. 6.*" Average sample collected by *A. R. Crandall*."

No. 1284—COAL. Labeled "*Coal No. 3, from drift on Hood's Creek, one third of a mile southeast of Bellefont Furnace.*" Average sample collected by *A. R. Crandall*."

A splint coal, exhibiting some fibrous coal and fine particles of pyrites between the layers.

No. 1285—COAL. Labeled "*Coal No. 6, from Horse Branch (or Run), near Catlettsburg, Boyd county.*" Average sample, collected by *A. R. Crandall*."

A splint coal. Some fibrous coal between the layers, with a little ferruginous incrustation.

No. 1286—COAL. Labeled "*Coal No. 7, from the Ashland Company's mine No. 4, Coalton, Boyd county.*" Average sample, by *P. N. Moore*."

A dark, glossy, splint coal, with some fibrous coal between the layers.

No. 1287—COAL. Labeled "*Coal No. 7, from entry No. 4; cross-entry; slate roof; Dry Branch.*" Average sample, by *P. N. Moore*."

A jet-black pure-looking coal.

No. 1288—COAL. Labeled "Coal No. 7, three hundred yards from the end of No. 4 entry. Trace Creek, Boyd county. Averaged by P. N. Moore."

A pure jet-black coal. Very little fibrous coal or pyrites apparent.

No. 1289—COAL. Labeled "Coalton Coal, No. 7. Two hundred and fifty yards from west end of No. 4 entry, &c. Averaged by P. N. Moore."

Contains more fibrous coal and pyrites than the two preceding.

No. 1290—COAL. Labeled "Coalton Coal, No. 7, from Mr. Bryan's Bank, Four Mile Creek, Boyd county. Collected by A. R. Crandall. Average sample."

Jet black. Contains very little pyrites or fibrous coal.

No. 1291—COAL. Labeled "Coal No. 11. Wm. A. Bolt's coal. East Fork of Little Sandy river, above Bolt's Fork, Boyd county. Average sample, collected by A. R. Crandall."

A jet-black coal. But little fibrous coal or pyrites apparent.

[See Appendix, No. 1645, for analysis of another Boyd county coal.]

COMPOSITION OF THESE BOYD COUNTY COALS, DRIED AT 212° F.

	No. 1279.	No. 1280.	No. 1281.	No. 1282.	No. 1283.	No. 1284.	No. 1285.	No. 1286.	No. 1287.	No. 1288.	No. 1289.	No. 1290.	No. 1291.
Specific gravity	1.328	1.358	1.304	1.360	1.279	1.366	1.315	1.308	1.340	1.336	1.320	1.365	1.404
Hygrosopic moisture.	6.50	3.40	3.50	3.20	2.94	3.20	2.70	3.30	4.40	4.06	5.00	4.00	2.60
Volatile combust. mat'rs.	33.90	32.30	34.16	32.30	32.50	29.70	36.70	33.30	31.10	34.44	34.50	34.06	35.80
Coke	59.60	64.30	62.34	64.50	64.50	67.10	60.60	63.40	64.50	61.70	60.50	61.94	61.60
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Total volatile matters .	40.40	35.70	37.66	35.50	35.50	32.90	39.40	36.60	35.50	38.30	39.50	38.06	38.40
Fixed carbon in coke .	52.78	55.40	55.30	53.00	56.70	55.10	52.60	57.60	57.90	54.70	55.40	53.20	46.86
Ashes	6.82	8.90	7.10	11.50	7.74	12.00	8.00	5.80	6.60	7.00	5.10	8.74	14.74
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Character of the coke .	Dense.	Dense.	Dense.	Dense.	Spongy.	Friable.	Spongy.	Mod. dense.	Spongy.	Spongy.	Spongy.	Spongy.	Spongy.
Color of the ash . . .	Light lilac-grey.	Light purple-grey	Purple-grey.	Lilac-grey	Lilac-grey.	Drab-grey.	Dark lilac-grey.	Light lilac-grey.	Lilac-grey.	Lilac-grey.	Light br'wn-grey.	Dove colored.	Brownish grey.
Per centage of sulphur.	3.765	1.230	2.370	1.999	1.972	1.793	1.711	2.480	2.095	1.854	1.285	1.890	5.361

With a few exceptions these may all be considered very good coals. These few contain rather too large a proportion of ash. This will not prevent them from being very good fuel for ordinary purposes. Some of them have a notable proportion of sulphur, which may render them measurably unsuitable for the working of iron, but which will not be otherwise injurious. It may be remarked, however, that the estimation given above is of the *total amount* of sulphur in the coal, in whatever form of combination it may exist. The analyses for the determination of the sulphur having been made by deflagrating the powdered coal with a mixture of nitre, carbonate of soda, and common salt (each chemically pure, of course), and not by the usual process of oxidation with nitric acid, &c., the extraction of the sulphur is therefore more complete than usual. These are all splint coals.

The relation between the specific gravity and the proportion of ash does not seem to be a constant one, as may be seen in the following statement:

Specific gravity	1.279	Per centage of ash	7.74
"	1.304	"	7.10
"	1.308	"	5.80
"	1.315	"	8.00
"	1.320	"	5.10
"	1.328	"	6.82
"	1.336	"	7.00
"	1.340	"	6.60
"	1.358	"	8.90
"	1.364	"	11.50
"	1.365	"	8.74
"	1.366	"	12.00
"	1.404	"	14.74

In the appendix are given, for comparison, the analyses of some of the most celebrated Indiana, Ohio, and Illinois coal, which are used in the smelting of iron, &c.

No. 1292—MARLY SHALE. *From near the top of the ridge between Clinton Furnace and Cannonsburg, Boyd county.*

A friable indurated marly clay, of dirty-greenish and brownish colors.

COMPOSITION DRIED AT 212° F.; AS DETERMINED BY DIGESTION IN CHLOROHYDRIC ACID, &c.

Alumina, and iron and manganese oxides	12.643
Lime, carbonate	.480
Magnesia	.929
Phosphoric acid	.217
Sulphuric acid	.079
Potash	1.387
Soda	.080
Water expelled at red heat	5.830
Silica and insoluble silicates	77.560
Loss	.795

100.000

On treating this marl, by ignition with carbonate of lime and chloride of ammonium, for the complete separation of its alkalies, according to the method proposed by Prof. J. Lawrence Smith, we obtained a total of 3.989 per cent. of *potash* and 0.639 per cent. of *soda*. So that about two thirds of the potash is in such a state of combination, in the silicates of this marly clay, as to resist the solvent action of chlorohydric acid, of specific gravity 1.1, although digested for eight or ten days in the sand-bath heat. Possibly admixture with slacked quicklime might help to set free this considerable proportion of alkali, and make it an available mineral fertilizer for exhausted light soils.

No. 1293—PIG IRON. "*Hot Blast No. 1, Bellefont Furnace, Boyd county. Collected by P. N. Moore.*"

A moderately coarse-grained dark-grey iron. Yields to the file, and extends somewhat under the hammer.

No. 1294—PIG IRON. "*Hot Blast No. 1, Foundry, Buena Vista Furnace. Collected by P. N. Moore.*"

A coarse-grained grey iron. Yields to the file; extends a little under the hammer.

No. 1295—PIG IRON. "*Mill Iron No. 1, Ashland Furnace, Boyd county. Stone-coal Iron. Sent by Col. Douglas Putnam, jr.*"

A very fine-grained light-grey iron. Yields to the file. Brittle.

No. 1296—PIG IRON. "*Mill Iron No. 2. Stone-coal Iron. Ashland Furnace. Sent by Col. Douglas Putnam, jr.*"

Not quite so fine-grained as the preceding. Light-grey. Yields to the file. Brittle.

No. 1297—PIG IRON. *Foundry Iron. Ashland Furnace, &c., &c. (as above). Coarser-grained than the preceding.*

Yields to the file. Brittle.

COMPOSITION OF THESE BOYD COUNTY PIG IRONS.

	No. 1293.	No. 1294.	No. 1295.	No. 1296.	No. 1297.
Specific gravity	7.132	7.127	6.410	6.503	6.406
Iron	93.208	93.712	91.420	90.899	89.731
Graphite	3.350	2.990	2.460	2.560	1.660
Combined carbon	.220	.210	.240	.160	.790
Manganese	.054	.056	.195	.236	.471
Silicon	2.389	1.908	3.709	5.121	6.308
Slag	1.160	.600	.540	.760	1.120
Aluminum	.193	.644	Not est.	Not est.	Not est.
Calcium	.144	.104	.176	.072	.152
Magnesium	.095	.095	.233	.106	.060
Potassium	.047	.063	Not est.	Not est.	Not est.
Sodium	.032	.010	Not est.	Not est.	Not est.
Phosphorus	.194	.380	.385	.394	.461
Sulphur	.005	.066	.082	.045	.015
			Loss .560		
Total	101.091	100.838	100.000	100.353	100.768
Total carbon	3.570	3.200	2.700	2.720	2.450

No. 1298—VIRGIN SOIL. *"From woods in the valley of East Fork of Little Sandy river, taken to six inches below the surface. Farm of Vincent Calvin, near Cannonsburg, Boyd county. Collected by J. A. Monroe."*

Soil of a dirty-buff color. All passed through the coarse sieve (289 meshes to the inch).

No. 1299—SUB-SOIL of the preceding, &c., &c.

Of a buff color; lighter in tint than the preceding. All passed through the coarse sieve.

No. 1300—VIRGIN SOIL. *"Southeastern slope of hill sixty feet above the bed of the creek. V. Calvin's farm, &c., &c. Sample taken six inches from the surface by J. A. Monroe."*

Of a dark dirty-drab grey color. The coarse sieve removed from it a considerable proportion of small fragments, many of which are angular, of ferruginous sandstone.

No. 1301—SUB-SOIL of the preceding, taken two feet below the surface, &c., &c.

Lighter colored than the preceding; dirty-drab grey. Sifted out more of ferruginous sandstone fragments than from the preceding.

No. 1302—OLD FIELD SOIL. *"Surface soil from a field forty-five years in cultivation, on East Fork of Little Sandy. Farm of V. Calvin, near Cannonsburg."*

Soil of a dirty dark-buff color. All passed through the coarse sieve.

No. 1303—"SUB-SOIL of the next preceding, taken two and a half feet from the surface, &c."

Of a dirty-buff color, lighter in tint than that of the surface soil. All passed through the coarse sieve.

COMPOSITION OF THESE BOYD COUNTY SOILS, DRIED AT 212° F.

	No. 1298.	No. 1299.	No. 1300.	No. 1301.	No. 1302.	No. 1303.
Organic and volatile matters.	3.140	3.085	7.985	5.190	4.915	4.905
Alumina, and iron and manganese oxides	5.091	6.642	7.425	9.984	9.019	9.675
Lime, carbonate	.214	.116	.571	.392	.259	.276
Magnesia	.034	.178	.352	.251	.333	.053
Phosphoric acid	.134	.083	.208	.191	.156	.160
Sulphuric acid	trace.	trace.	trace.	trace.	.038	trace.
Potash	.317	.307	.435	.205	.344	.282
Soda	.076	.099	.045	.050	.027	.176
Sand and insoluble silicates .	90.490	88.420	81.410	83.230	83.765	83.385
Water expelled at 380° F. .	.650	.525	.915	.500	1.235	1.315
Loss . . . . .	.....	.545	.554	.007	.....	.....
Total	100.146	100.000	100.000	100.000	100.091	100.227
Hygroscopic moisture . . .	1.375	1.735	2.225	1.700	2.335	2.840
Potash in the insol. silicates.	Not estimated.					
Soda	Not estimated.					
Character of the soil . . .	Virgin soil. Valley.	Sub-soil.	Virgin soil. Slope of hill.	Sub-soil.	Old field.	Sub-soil.

These soils, if sufficiently drained and properly cultivated, may be made quite productive, although the silicious material is in rather large proportion in some. By comparing the composition of the virgin soil No. 1300, with that of the corresponding old field soil No. 1302, it will be seen that cropping, without the use of manures, has notably diminished the phosphoric acid, potash, and lime carbonate, while the relative proportion of the sand and silicates is increased.

[For Bourbon County Limestone, see the Appendix.]

BRACKEN COUNTY.

No. 1304—SOIL. *Labeled "Top Soil, one to eight inches from surface. Old field in grass; thin and bare in places. Sample from a fertile corner, beyond the fence where it had been out of culture for five years or more." Collected by Prof. N. S. Shaler.*

Of a dark grey-buff color. Contains no gravel or coarse sand.

No. 1305 — "SUB-SOIL of the preceding; taken fourteen to eighteen inches below the surface, just above the rock substratum. It has some faint traces of original bedding, showing that it had been formed by decomposition of rock in place. Collected by Prof. N. S. Shaler."

Of a handsome yellowish-buff color. No gravel.

No. 1306—TOP SOIL of the field No. 1304; taken in a worn place; has been longer in cultivation and is much more worn than that. Will not hold sod. Has been in cultivation over twenty years. Collected by Prof. N. S. Shaler."

Of a yellowish-buff color, very little darker than that of the sub-soil. Contains a small quantity of small fragments of red ferruginous shale.

EXTRACTED FROM 1000 PARTS OF THESE SOILS (AIR DRIED) BY DIGESTION IN CARBONIC ACID WATER.

	No. 1304.	No. 1305.	No. 1306.
Organic and volatile matters	0.483	0.600	0.294
Alumina, and iron and manganese oxides	.013	.013	.010
Lime, carbonate	.496	.040	.080
Magnesia	.030	.023	.014
Potash	.030	.010	.020
Soda	.020	.020	.020
Soluble silica	.060	.130	.110
Phosphoric, sulphuric, and nitric acids and loss	.184	.130	.118
Total extract from 1000 parts.	1.316	0.960	.666
Color of the extract.	Light brown.	Light brownish grey.	Brownish grey.

COMPOSITION OF THESE BRACKEN COUNTY SOILS, DRIED AT 212° F.

	No. 1304.	No. 1305.	No. 1306.
Organic and volatile matters	4.140	4.775	3.335
Alumina	5.837	5.513	3.837
Iron, peroxide	7.150	6.025	3.965
Manganese, brown oxide	.225	.170	.070
Lime, carbonate	a trace.	a trace.	a trace.
Magnesia	.297	.269	.268
Phosphoric acid	.233	.424	.217
Sulphuric acid	a trace.	a trace.	a trace.
Potash	.110	.197	.135
Soda	a trace.	.174	.076
Sand and insoluble silicates	82.140	81.970	87.815
Water expelled at 380° F.	1.015	1.100	not est.
Total	101.147	100.617	99.718
Water expelled at 212° F.	2.200	3.200	2.300

These soils are all deficient in lime. Top-dressing with this material would doubtless greatly improve their productiveness. This should, however, be accompanied with the use of clover or other green fertilizing crops, to increase the proportion of humus, which is also deficient in the soils. The difference in the amount of soluble matters extracted by digestion in water charged with carbonic acid, as well as the relative proportions of the potash, &c., in that extracted matter, and the amount

of sand and silicates, correspond with the observed relative productiveness of the soils.

No. 1307—SILICIOUS MUDSTONE (of Dr. Owen). *Rock below Soil No. 1304; averages from twenty-eight to thirty-five inches. Uniform. Some of the layers completely decomposed; all of them softened by decay. Three miles northwest of German-town. Collected by Prof. N. S. Shaler.*

A dirty grey-buff, friable, sandy shale. Adhering to the tongue. Many fossils in the laminæ.

COMPOSITION, DRIED AT 212° F.

Silica	76.060
Alumina, and iron and manganese oxides	14.959 (by difference).
Lime, carbonate	.500
Magnesia, carbonate	.345
Phosphoric acid	.486
Potash	2.735
Soda	1.515
Water expelled at red heat	3.400
	100.000

This analysis having been made by fusion, instead of digestion in acids, &c., &c., gives the *total* contents of alkalies and phosphoric, as well that quantity which may be immediately available for plant nourishment as that which for the present is locked up in firm combination in the silicates, which can only become available in the natural course of long weathering.

BRECKINRIDGE COUNTY.

No. 1308—"RED UNDER CLAY, from near Brandenburg. Collected by Mr. G. E. Chick.

A somewhat adhesive ferruginous clay, of a dark brick-red color; containing some fragments of weathered chert.

COMPOSITION, DRIED AT 212° F.

Organic and volatile matters, mostly water	9.000
Alumina, and iron and manganese oxides	20.860
Lime, carbonate	1.060
Magnesia	.684
Phosphoric acid	.230
Sulphuric acid	.061
Potash (including that in the silicates)	.982
Soda (including that in the silicates)	.501
Sand and insoluble silicates	66.680
	100.058

Although this clay contains a considerable per centage of potash, nearly one per cent., it is not probable that it could be profitably used as a fertilizer, because of the fact that a very large proportion of its alkalies is in the insoluble silicates, where they would not be immediately available for plant nourishment.

It might be employed, however, to improve the condition of light sandy soils.

BUTLER COUNTY.

No. 1309—LIMONITE. *Labeled "Ore from the farm of Jas. E. Taylor, near the mouth of Little Reedy; one mile and a half from Green river. Average sample by J. R. Proctor."*

Limonite in irregular laminæ; with much softer ochreous ore.

No. 1310—LIMONITE. *Labeled "Ore above the upper coal. Stevens' coal mine, near the mouth of Bear Creek. Average sample by P. N. Moore."*

In dense, curved, dark-brown laminæ, incrustated by and inclosing softer ochreous ore.

COMPOSITION OF THESE LIMONITES, DRIED AT 212° F.

	No. 1309.	No. 1310.
Iron, peroxide	48.049	44.794
Alumina	.171	2.391
Manganese, brown oxide	.140	a trace.
Lime, carbonate	.540	.643
Magnesia	.195	.234
Phosphoric acid	.345	.535
Sulphuric acid	.473	.158
Water expelled at red heat	9.750	7.700
Silica and insoluble silicates	31.900	44.180
Alkalies, &c., and loss	.437	
Total	100.000	100.815
Iron, per centage	33.634	31.482
Phosphorus, per centage	.150	.233
Sulphur, per centage	.189	.063
Silica, per centage	29.460	42.200

The somewhat large proportion of *phosphorus* in these two ores may make the iron obtained from them somewhat "cold-short," and the sulphur in No. 1310 is in rather too large quantity. In other respects these ores are good, and they might be profitably smelted for ordinary foundry iron.

No. 1311—CLAY IRON-STONE. Labeled "Ore from Jno. Hudson's on Young's Ferry road. Average sample by P. N. Moore."

A dark grey, fine-granular iron carbonate, partly converted into limonite.

No. 1312—CLAY IRON-STONE. Labeled "Ore resting on the coal at Knob Lick, half a mile from Big Reedy Creek, near road to Young's Ferry. Average sample by P. N. Moore."

Granular iron carbonate, somewhat oölitic, partly converted into limonite, and containing small fragments of fibrous coal.

COMPOSITION OF THESE CLAY IRON-STONES, DRIED AT 212° F.

	No. 1311.	No. 1312.
Iron, carbonate	29.914	22.583
Iron, peroxide	17.945	17.313
Alumina	3.583	.835
Lime, carbonate	12.036	6.714
Magnesia, carbonate	3.677	2.830
Manganese, carbonate	a trace.	a trace.
Phosphoric acid	.467	.972
Sulphuric acid	.381	.473
Silex and insoluble silicates	28.040	44.240
Water and loss	3.957	4.040
Total	100.000	100.000
Iron, per centage	27.041	22.969
Phosphorus, per centage	.204	.423
Sulphur, per centage	.152	.189
Silica, per centage	25.260	42.760
Specific gravity	not est.	not est.

No. 1313—COAL. Labeled "Stevens' coal. Stevens' bank, Bear Creek, two miles from Green river, Butler county. Average sample by P. N. Moore."

A deep-black coal, breaking into thin layers under the hammer. Fibrous coal and fine-grained pyrites between the laminae. Contains a little shale.

COMPOSITION OF THE AIR-DRIED COAL.

	No. 1313.
Specific gravity	1.378
Hygroscopic moisture	3.40
Volatile combustible matters	30.66
Coke	65.94
Total	100.00
Total volatile matters	34.06
Fixed carbon in the coke	54.94
Ashes	11.00
Total	100.00
Character of the coke	Spongy.
Color of the ash	Brownish lilac-grey.
Per centage of sulphur	2.544

No. 1314—LIMESTONE, from Barren river, near the mouth of Gasper Creek; sub-carboniferous. From the stock pile of Airdrie Furnace. Sampled by P. N. Moore."

A light-grey, fossiliferous limestone.

COMPOSITION, DRIED AT 212° F.

Lime, carbonate	93.020 = 52.091 per cent. of lime.
Magnesia, carbonate	2.088
Alumina, and iron and manganese oxides	.917
Phosphoric acid	.243 = 0.106 per cent. of phosphorus.
Sulphuric acid	.604 = .242 per cent. of sulphur.
Silica and insoluble silicates	2.760
Water and loss	.368
Total	100.000

CALDWELL COUNTY.

GALENA (lead sulphide), selected from specimens sent by S. Marble & Son, Princeton, Kentucky, from their lead mine in this county. The vein is in the sub-carboniferous limestone, described as generally five feet wide. The mine has a twenty feet drift, forty-five feet wide. The gangue of the ore is principally fluor-spar, containing more or less zinc blende.

This ore was examined principally for its proportion of silver; and by a careful analysis of the lead, obtained from it by reduction with the usual flux (of soda carbonate, potash nitrate, and sodium chloride), solution of the reduced metal in diluted nitric acid, and precipitation of the filtered solution by means of a very dilute solution of lead chloride, a very small proportion of silver was obtained, not exceeding in amount two hundred and sixty-six (266) grains to the ton (of 2,000 pounds) of the selected galena. As is well-known, pure galena contains from eighty-one to eighty-six per cent. of lead in general.

This mine cannot, therefore, be profitably worked for silver; but if fluor-spar is found to be practicably valuable for the purification of iron from phosphorus, &c., this, as well as the lead, may be advantageously explored.

CAMPBELL COUNTY.

No. 1315—MARLY SHALE. Labeled "*Clay Marl, from Cincinnati Group; quarter of a mile from Newport, on the Alexandria Turnpike; upper blue clay.*" Collected by Prof. N. S. Shaler." Lower Silurian.

A dark-grey, soft shale. Adhering to the tongue.

No. 1316—MARL. Labeled "*Marl, from the silicious mud-stone of Dr. Owen, ten feet from the surface. Not distinctly stratified. Gallows Gap.*" Collected by Prof. N. S. Shaler."

Buff-colored; friable; fine-grained.

No. 1317—CLAY SHALE. Labeled "*Newport Reservoir; three hundred and forty feet above the Ohio river. A mixture of the clays in a set of beds, containing a few limestone layers, six feet from the surface to twelve feet.*" Collected by Prof. N. S. Shaler.

A yellowish, soft shale, with some softer ferruginous clay mixed. Adhering to the tongue.

No. 1318—CLAY SHALE. Labeled "*Newport Reservoir, upper blue clay, three hundred and twenty feet above high water in the Ohio river.*" Collected by Prof. N. S. Shaler.

A dark, bluish-grey soft shale. Adhering to the tongue.

No. 1319—CLAY. Labeled "*Brick Clay, about three feet above high water in the Ohio river; Newport, Kentucky.*" Collected by Prof. N. S. Shaler.

A light, ferruginous, yellow silicious clay.

No. 1320—SANDY FERRUGINOUS CLAY. Labeled "*Sandy Clay, three feet from surface; Mt. Vernon road, half a mile from Alexandria Turnpike.*" Collected by Prof. N. S. Shaler.

Of a light reddish-brown color.

No. 1321—FERRUGINOUS CLAY, &c. Labeled "*Ferruginous Conglomerate; side of road, one mile north of Grant's Creek. North head waters of Phillips' Creek.*" Collected by Prof. N. S. Shaler.

Ferruginous clay, with nodules of impure hydrated peroxide of iron included.

No. 1322—SAND. Labeled "*Moulding Sand, Columbia Trace, half a mile northeast of Newport Water-Works Reservoir.*" Collected by Prof. N. S. Shaler.

A fine sand of a dirty-salmon color, composed mainly of minute rounded quartz grains.

No. 1323—SAND. Labeled "*Sand beneath the Brick Clay. Section on Columba corner of Harris street; Newport, Kentucky.*" Collected by Prof. N. S. Shaler.

A moderately fine sand, of a dirty-buff color. Examined with the glass it showed mostly rounded grains of hyaline, yellow and milky quartz, with dark grains of some ferruginous mineral.

COMPOSITION OF THESE CAMPBELL COUNTY MARLS, CLAYS, AND SANDS,
DRIED AT 212° F.

	No. 1315	No. 1316	No. 1317	No. 1318	No. 1319	No. 1320	No. 1321	No. 1322	No. 1323
Silica	47.320	68.760	58.080	51.420	72.660	82.560	57.160	81.660	85.840
Alumina, and oxides of iron and manganese	28.050	12.050	31.490	29.450	20.500	12.223	33.540	12.700	3.500
Lime, carbonate	13.490	9.860	.660	6.850	a trace.	.160	.860	a trace.	7.400
Magnesia, carbonate	1.135	3.859	1.135	1.256	.832	a trace.	1.776	a trace.	.296
Potash	3.254	1.329	3.045	4.124	1.243	.675	2.698	.756	not est.
Soda	.640	.976	.986	.567	not est.	.282	.555	.637	not est.
Phosphoric acid	.345	.223	.255	.122	.192	not est.	not est.	a trace.	not est.
Sulphuric acid	Not estimated.								
Water expelled at red heat	4.800	2.200	4.700	4.400	4.200	4.100	3.411	4.400	2.200
Loss	.966	.743		1.811	.373				.764
Total	100.000	100.000	100.351	100.000	100.000	100.000	100.000	100.153	100.000

These marly shales, marls and clays, are not especially valuable as fertilizers, although some of them contain considerable proportions of potash and phosphoric acid. The former, however, is mostly in firm combination in the silicates, which are insoluble in acids, so that it can only be made available by long weathering, or, possibly, by the action of lime, &c.

No. 1315 appears to be the best of them. They all would be useful as top-dressing for improving light sandy soil.

The sands have no peculiar interest, although useful for many well-known purposes.

No. 1324—SOIL. Labeled "*Virgin Soil, in open woods, farm of Gen. G. B. Hodge. Flat Woods; waters of Phillips' Creek; one and a half miles southeast from Grant's Lick. Timber—white oak, hickory, small beech, and walnut.*" Collected by Prof. N. S. Shaler.

Soil of a warm yellowish-drab color. It all passed through the coarse sieve (of 289 meshes to the inch), except some

rootlets, a very small quantity of shot-iron ore, and a few small rounded pebbles of milky quartz.

No. 1325—SOIL. Labeled "*Old Field Soil. Field adjoining the woods whence came No. 1324. Cultivated in corn and tobacco for more than forty years. No manuring. Still brings a little corn. Sample one to seven inches from the surface.*" Collected by Prof. N. S. Shaler.

Soil of a warm yellowish-drab color. All passed through the coarse sieve except a few fragments of wood, two or three small water-worn pebbles of milky quartz, and some small angular fragments of decomposing chert. It also contains some fine shot-iron ore.

No. 1326—SOIL. Labeled "*Same old field as the preceding. Plowed in 1871 to the depth of twenty inches and sub-soiled. Now (1873) in timothy grass. Seems to want lime.*" Collected by Prof. N. S. Shaler.

Color, &c., much as in preceding soil.

No. 1327—SOIL. Labeled "*Sub-soil, twelve inches from the surface, same field as preceding, forty years in cultivation. Silicious mudstone beneath.*" Collected by Prof. N. S. Shaler. Soil of a yellowish-drab color; more yellowish than preceding. All of it passed through the coarse sieve, except a very small quantity of shot-iron ore.

No. 1328—SOIL. Labeled "*Spur of hill sixty feet above the position of the preceding soils. In corn for two years. Twenty bushels to the acre this year (1873); bad culture. Surface soil.*"

Soil of drab color. Lighter colored than any of the preceding soils. Moist soil cakes in the bag like clay. It mostly passed through the coarse sieve, leaving only some shot-iron ore and small quartz pebbles, &c.

No. 1329—SOIL. Labeled "*Virgin Soil, border of cultivated field, newly cleared. Slope faces southwest. Land reputed rich; but in the midst of much poor land. Sells for two hundred dollars per acre. Youtsey's land, eight miles from Newport, Alexandria Turnpike.*" Collected by Prof. N. S. Shaler.

A clay soil of a dark buff-grey color. Aggregated, on drying in the bag, &c., into quite hard, irregular and angular small lumps. Makes a very tenacious, sticky clay when wet.

No. 1330—SOIL. Labeled "*Sub-soil (under the preceding soil) two feet from the surface, &c.*" Collected by Prof. N. S. Shaler.

A clay soil of a light grey-buff color; aggregating into pretty compact lumps on drying.

See No. 1334 for composition of the limestone underlying this land.

No. 1331—SOIL. Labeled "*A curious gravelly loam, two feet below surface, with bits of chert, from the sub-carboniferous of Upper Licking. Silicious mudstone and limestone below. Upper waters of Pond Creek, near Pond Creek Post-office, on new turnpike, about four miles southwest of Alexandria.*" Collected by Prof. N. S. Shaler.

A deep yellow-buff colored sub-soil, containing nearly one sixteenth of its weight of fragments of ferruginous shaly sand rock, rounded quartzose pebbles, and shot-iron ore.

No. 1332—SOIL. Labeled "*Old field in grass. Slope of 10° south. Resting on river detritus. Side of run near Newport, Kentucky.*" Collected by Prof. N. S. Shaler.

Soil of a dark grey-buff color. All of it passed through the coarse sieve.

No. 1333—SOIL. Labeled "*Bottom field of the next preceding, taken two feet from the surface. Detrital grit. Twenty feet above high water of Ohio river.*"

Soil of a handsome orange-grey, or grey-orange-buff color. Aggregated into friable clods.

COMPOSITION OF THESE CAMPBELL COUNTY SOILS AND SUB-SOILS, DRIED AT 212° F.

	No. 1324	No. 1325	No. 1326	No. 1327	No. 1328	No. 1329	No. 1330	No. 1331	No. 1332	No. 1333
Extracted from 1,000 parts by carbonated water	2.290	1.700	1.220	0.830	1.860	2.700	5.650	0.716	1.080	1.200

COMPOSITION OF THE CARBONIC ACID WATER EXTRACT.

Organic and volatile matters	1.060	1.030	0.580	0.530	0.720	0.690	0.490	0.316	0.396	0.815
Alumina, oxd. iron, &c.	.320	.130	.110	.040	.080	.020	.050	.010	.060	.030
Manganese oxide	.060	.070	not est.	not est.	not est.	not est.	not est.	not est.		
Lime, carbonate	.610	.400	.260	.090	.760	1.620	4.440	.180	.430	.280
Magnesia	.080	.036	.004	.040	.010	not est.	.450	.030	.010	.040
Nitric acid	Not estimated.									
Phosphoric acid	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.	
Sulphuric acid	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.	
Chlorine	Not estimated.									
Potash	.060	.070	.050	.010	.050	.030	.020	.020	.037	.020
Soda	.010	.050	.040	.030	.020	.040	.020	.040	.015	.020
Soluble silica	.122	.090	.055	.150	.170	.070	.180	.130	.080	.067
Loss			.021		.050	.230			.052	
Total	2.322	1.876	1.220	0.890	1.860	2.700	5.650	0.726	1.080	1.272

COMPOSITION OF THESE SOILS, DRIED AT 212° F.

Organic and volatile matters	3.650	2.555	2.540	2.435	8.965	7.615	5.960	5.160	2.775	2.135
Alumina	3.375	3.415	3.900	3.868	4.040	5.175	5.323	3.815	1.587	2.737
Iron oxide	3.125	3.038	3.274	3.972	4.787	6.750	6.890	4.300	2.980	4.465
Manganese, br. oxide.	.059	.037	not est.	.427	.471	.260	.080	.390	.070	.320
Lime, carbonate	.130	.090	.125	.125	.450	.990	3.890	a trace.	a trace.	a trace.
Magnesia	.034	.496	.008	.250	.250	.520	.500	.474	.191	.300
Phosphoric acid	.145	.109	.093	.122	.093	.483	.313	.420	.256	.240
Sulphuric acid	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.
Potash	.120	.062	.064	.062	.240	.726	.593	.443	.115	.125
Soda	.047	.132	.160	.109	.071	a trace.	.019	.045	.048	.106
Soluble silica	.045	.090	.055	.015	.170	.070	.180	.130	.080	.067
Sand and insoluble silicates	87.545	89.335	88.395	87.560	78.963	75.590	75.415	83.775	91.655	89.040
Water expelled at 380° F.	1.160	1.110	1.020	1.040	1.500	1.850	1.017	1.250	1.035	1.010
Loss	.565		.366	.015						
Total	100.000	100.469	100.000	100.000	100.000	100.000	100.180	100.202	100.792	100.545
Water expelled at 212° F.	1.765	1.550	1.665	2.235	2.550	5.075	4.300	4.825	1.400	2.215
Potash in insoluble silicates	not est.	1.311	not est.	1.477	not est.	2.731	not est.	not est.	not est.	not est.
Soda	not est.	.700	not est.	.389	not est.	.929	not est.	not est.	not est.	not est.
Character of soil	Virgin soil.	Old field	Old field	Sub-soil.	New soil	Virgin soil.	Sub-soil.	Gravelly loam.	Old field	Old field

* It is proper to state, that this quantity does not represent the "soluble silica" which might have been extracted by boiling the "silicious residue" in solution of carbonate of soda, &c., but simply the amount which was held in the acid solution of the soil. But little importance was attached to this determination, not because its existence in the plant is considered by many modern agricultural chemists as "an accident" and "unessential," if not "useless" (see "How Crops Feed," by Prof. S. W. Johnson, page 353); but because it is to be found, ordinarily, dissolved in all waters which percolate soils. Moreover, Prof E. A. Hilgard shows that the amount of soluble silica in the silicious residue of a soil usually bears a pretty constant relation to the quantity of lime in it. Its proportion at any given time doubtless depends on the relative decomposition of the silicates of the soil at that time.

In addition to the determinations given in the preceding table of the composition of these soils, the "sand and insoluble silicates" were analyzed, by the method of fusion, &c., &c., with the following results, viz:

COMPOSITION OF THE SAND AND INSOLUBLE SILICATES IN THE 100 PARTS, DRIED AT 212° F.

	No. 1325.	No. 1327.	
Silica	89.560	88.660	
Alumina, &c., &c.	7.650		
Lime	.324	9.310	
Magnesia	.260		
Potash	1.464	1.684	= 1.311 and 1.477, severally calculated into 100 parts of the soil.
Soda	.743	.346	
Total	100.001	100.000	

An attempt was also made, with the use of the celebrated Nobel's apparatus, to submit some of these soils to silt analysis; *i. e.* to determine the relative proportions of the fine and coarser earthy material contained in them; but the results of comparative operations on the same soil were so discordant that no value whatever could be attached to them.

The writer regrets that he was not able, for want of time, &c., to apply to the silt analyses of some of these soils the improved apparatus devised by Prof. Eugene W. Hilgard, and used by him in his researches on the soils and clays of Mississippi, while he was the State Geologist, as described by him in a paper read by him at the Portland meeting of the *American Association for Advancement of Science*, August, 1873, and published in *American Journal of Science and Arts*, October and November, 1873.

The chemical analyses were conducted very much as is described in volume III of Kentucky Geological Reports, except that a larger quantity of the soil was digested in water containing carbonic acid, charged under the atmospheric pressure only, and found by analysis to contain about 0.9 of its volume of this gas. Instead of filtering the solution, a proportional quantity of it was drawn off from the residue by means of a pipette of proper construction.

The residue obtained by evaporating this solution, frequently *deflagrated* when ignited, showing the presence of *nitrates*.

This was observed, in a marked degree, with the extracts from Nos. 1324, 1325, 1326, 1327, and 1329.

The above table of the results of the analyses of these soils is interesting, as demonstrating, what has frequently been called in question by agricultural chemists in recent times, the possibility of ascertaining the agricultural capabilities of soils by chemical analysis; having due reference, of course, to the physical conditions.

For the purpose of more ready comparison of some of the results of these analyses, we copy in the following table the proportions of some of the most essential ingredients and educts of these soils:

No.	Extracted by carbonated water from 1,000 parts.	Extracted by acids from 100 parts.			
		Organic and volatile matters.	Lime, carbonate.	Phosphoric acid.	Potash.
1324, virgin soil	2.322	3.650	0.130	0.145	0.120
1325, old field, same locality . . .	1.876	2.550	.090	.109	.062
1326, old field, same locality . . .	1.220	2.554	.125	.093	.064
1327, sub-soil, same locality . . .	.891	2.435	.125	.122	.062
1328, new field, same locality . . .	1.860	8.965	.450	.093	.483
1329, virgin soil (Youtsey's), high priced; considered rich . . .	2.700	7.615	.990	.483	.726

Youtsey's land will be seen, by reference to Appendix No. A. 12, to be strikingly like the California adobe soil in composition and consistence. It also resembles good blue grass soil. The others show a deficiency of lime, potash, and organic matters, or *humus*, except that of the "new field," which, like No. 1325, is apparently deficient in phosphoric acid, and which would be much more productive under better culture than it has received, and with the application of phosphate or superphosphate of lime. The use of lime, wood ashes, and of green crops, especially of clover, would be beneficial to these soils of Col. Hodges?

No. 1334—LIMESTONE. Labeled "*Blue Limestone (Cincinnati Group)*", just below soils Nos. 1329 and 1330. Youtsey's land, Alexandria Turnpike, eight miles from Newport, Campbell county." Collected by Prof. N. S. Shaler.

A firm coarse-grained semi-crystalline, dark-grey limestone, full of fossils, corals and shells, with some included nodules of light olive-grey granular material.

COMPOSITION DRIED AT 212° F.

Lime, carbonate	93.200	= 52.192 per cent. of lime.
Magnesia, carbonate	2.291	
Alumina, and iron and manganese oxides	1.700	
Sulphuric acid	.535	= .214 per cent. of sulphur.
Phosphoric acid	.076	= .033 per cent. of phosphorus.
Potash	.173	
Soda	.384	
Silex and insoluble silicates	2.360	
	100.719	

A limestone not very rich in mineral fertilizers, which would yield a good lime for building purposes.

No. 1335—"MARLY SHALE, from two miles south of Newport, Licking Three Mile Creek. Geological position, 'Cincinnati Group,' fifty feet above high water mark of the Ohio river." Collected by Prof. N. S. Shaler.

A friable shale of a handsome light olive-grey color, containing fragments of small encrinital stems and of *orthis multicostrata*.

No. 1336—"MARLY SHALE, from Licking Three Mile Creek, two miles back of Newport (Cincinnati Group). About sixty feet above high water mark of the Ohio river. The beds are about thirty feet thick, with thin partings, and can be easily stripped. Test their value as marl." Collected by Prof. N. S. Shaler.

Of a light olive-grey color. The laminae are thinner than in the preceding.

COMPOSITION OF THESE MARLY SHALES, DRIED AT 212° F.

	No. 1335.	No. 1336.
Silica	54.160	57.260
Alumina	12.269	16.782
Iron peroxide, with some manganese oxide	15.550	11.500
Lime, carbonate	7.800	4.560
Magnesia	.165	.778
Phosphoric acid	.281	.008
Sulphuric acid	.659	.233
Potash	3.298	4.471
Soda	.926	1.072
Water expelled at red heat and loss	4.892	3.336
Total	100.000	100.000

These marly shales resemble in composition the marls and clays reported above.

CARTER COUNTY.

No. 1337—CLAY. Labeled "*Fire-clay; average sample from the upper bed, four feet thick, on both sides of the hill. Ridge between Grassy and Three Prong Creeks, Boone Furnace property. Whole bed eight to ten feet thick. Collected by Philip N. Moore.*"

The dried clay is quite compact, scarcely to be scratched with the nail; has a soapy feel; not adhering to the tongue. Breaks into sharp angular fragments. It is of a light-grey color.

No. 1338—CLAY. "*From ridge between Grassy and Three Prong Creeks, Boone Furnace property. Lower bed. Collected by P. N. Moore.*"

Compact, breaking into sharp angular fragments; hardly to be scratched with the nail; slightly adhering to the tongue; has a somewhat soapy feel. Presents, in parts, an approach to an oölitic structure. Color dark-grey, passing into dove-color.

No. 1339—CLAY. "*From same locality as preceding. Rougher part of the upper layer, &c., &c. Collected by P. N. Moore.*"

A light-grey compact rock, of a harsh gritty feel; not to be scratched with the nail. Under the glass showing many

rounded grains of quartzose sand. Ferruginous incrustation on the surface.

No. 1340—CLAY. "*Fire-clay under coal. Old Orchard Diggings, Boone Furnace property, Carter county. Collected by P. N. Moore.*"

A compact shaly clay, with some of the lamellar surfaces polished in various planes. Has a soapy feel, and no grit. Of a dull dove-grey color.

No. 1341—CLAY. "*Fire-clay from same bed as Nos. 1337, 1338, and 1339. A dark-colored sample from the lower part of the deposit.*" Collected by P. N. Moore.

Compact fine-granular; hardly scratched with the nail; adhering very slightly to the tongue. Of a dark brownish-slate color.

No. 1342—CLAY. "*Fire-clay under the twelve inch coal Geo. Osenton's land, near Grayson, Carter county. Sampled by J. A. Monroe.*"

A grey or ash-grey clay in a pulverulent condition.

No. 1343—CLAY SHALE. Labeled "*Argillaceous Shale, with some Lingulae near the top. Railroad cut, half mile south of Station (Eastern Kentucky Railroad), Grayson, Carter county. Collected by Prof. N. S. Shaler.*"

A soft friable shale of a light buff-grey color, mottled and colored between the laminæ with ferruginous and black.

COMPOSITION OF THESE CLAYS, &c., OF CARTER COUNTY, DRIED AT 212° F.

	No. 1337.	No. 1338.	No. 1339.	No. 1340.	No. 1341.	No. 1342.	No. 1343.
Silica	48.560	45.960	54.620	62.460	45.560	64.260	66.060
Alumina	37.471	38.531	32.466	27.203	43.775	24.604	23.726
Iron, oxide	a trace.	a trace.	a trace.	a trace.	a trace.	not est.	not est.
Lime	.112	.145	a trace.	a trace.	.145	.538	8.300
Magnesia	a trace.	a trace.	a trace.	a trace.	a trace.	.209	8.121
Phosphoric acid	.255	.563	.243	.147	.307	.946	.127
Sulphuric acid	not est.	not est.	not est.	not est.	not est.	.157	not est.
Potash	.289	.250	.212	1.850	.963	.751	2.093
Soda	.283	.341	.679	.584	.728	.515	2.273
Water expelled at red heat	13.030	14.210	11.780	7.756	8.522	8.300	5.300
Total	100.000	100.000	100.000	100.000	100.000	100.280	100.000

* Carbonates.

The composition of these clays indicate that most of them are highly "refractory" or fire-clays, and that all could be used for the manufacture of stone-ware, terra cotta, &c. Those which burn white might be used for "delf ware," or "queen's-ware," so called.

The most refractory are, probably, Nos. 1337, 1338, and 1339; the next, Nos. 1342, 1341, and 1340. The least refractory of all is the clay shale, No. 1343, which, however, notwithstanding its more than two per cent. each of potash and soda, would answer for the manufacture of stone-ware, and, most probably, of ordinary fire-brick.

It is found that a large relative proportion of silica or sand increases the refractory quality of the clay, and, according to the experiments of E. Richters* (1868), this quality is least affected by magnesia; more so by lime; still more by iron oxide; and most by potash. The influence of phosphates has not been fully determined.

For comparison, the analyses of two of the best Kaolin clays of France, of the best Stourbridge clay of England, and of a crucible clay, are here appended:

	(a)	(b)	(c)	(d)
Silica	48.68	55.30	63.40	47.50
Alumina	36.92	30.30	31.70	34.37
Iron oxide	2.00	2.00	3.00	1.24
Lime	not given.	not given	not given.	.50
Magnesia	.52	.40	not est.	1.00
Phosphoric acid	not given.			
Sulphuric acid	not given.			
Potash	not est.	1.10	1.90	not est.
Soda	.58	2.70		not est.
Water expelled at red heat	13.13	8.20	not given.	1.00

(a) Porcelain clay of Saint Yrieix; analyzed by Forchhammer.

(b) Porcelain clay of China; analyzed by Ebelmann and Salvétat.

(c) Stourbridge fire-clay; analyzed by Prof. F. A. Abels.

(d) Crucible clay. Almerode, in Kurhessen.

It is evident our fire-clays do not suffer in comparison with these, and that the industrial value of these large deposits in our coal measures is very considerable.

[For other fire-clays see Greenup county, &c.]

* R. Wagner's Chemical Technology, American edition, page 294.

COALS OF CARTER COUNTY.

No. 1344—"COAL, probably sub-conglomerate, at Old Orchard Diggings. (Eight inches of coal, four inches of slate, six inches of coal.) Boone Furnace property."

A dull slaty coal, having much fibrous coal between the laminae. Exterior stained with iron oxide.

No. 1345—"COAL, No. 7, from old entry back of Star Furnace. Upper layer twenty inches thick (Coalton coal). An average sample, collected by A. R. Crandall."

Breaks easily into thin irregular laminae, with some fibrous coal between. Incrusted somewhat with iron oxide.

No. 1346—"COAL, No. 7, from old entry back of Star Furnace. Bottom layer, two feet two inches thick. Collected by A. R. Crandall."

A pure-looking coal; fracture glossy and pure black, somewhat like that of asphaltum. Very little fibrous coal, pyrites, or ferruginous incrustation apparent.

No. 1347—"COAL, No. 7, from entry back of Star Furnace. Middle layer, two feet thick. Collected by A. R. Crandall."

Appears to be intermediate in quality to the two preceding.

No. 1348—"COAL, No. 7 (Coalton). Average sample from Wiley Pritchard's bank, near Mount Savage Furnace, Carter county. Collected by J. A. Monroe."

No. 1349—"COAL, No. 7. Average sample of the six feet Coalton coal, from all parts of the bed. Divide between Stinson and Straight Creeks. (Two hundred and seventy-five feet level.) Mount Savage property. Averaged by P. N. Moore."

No. 1350—"COALTON COAL (No. 7 coal), from drift on Gum branch of Straight Creek. Mount Savage Company drift, lower part of the bed. Averaged by P. N. Moore."

No. 1351—"COALTON COAL (No. 7 coal), from drift on Gum branch of Straight Creek. Upper part of bed, Mt. Savage property. Averaged by P. N. Moore."

No. 1352—"Average sample of Coalton coal (No. 7), Watson Bank, Willard, Carter county. Averaged by J. A. Monroe."

No. 1353—"COAL (No. 1) from Graham bank, Little Fork of Little Sandy river, near Willard. Average sample by P. N. Moore."

[See appendix, Nos. 1646 and 1647, for the analyses of two other samples of the coal from this bank.]

No. 1354—"COALTON COAL (No. 7), from main entry, west of Dry Fork, Willard. Averaged by P. N. Moore."

A jet-black pure-looking coal, showing iridescent colors on portions, and having very little fibrous coal or pyrites.

No. 1355—"COALTON COAL (No. 7) from Old Lost Creek drift, near Willard. Averaged by P. N. Moore."

Of rather a rusty black color; shows but little fibrous coal or ferruginous stain.

No. 1356—"COAL (No. 2) from Kibby drift, Everman's Creek, two miles from Grayson, Carter county. Average sample by J. A. Monroe."

No. 1357—"COAL (No. 1) from Stone-coal branch of Tygert Creek, Carter county. Averaged by P. N. Moore."

No. 1358—"COAL (probably No. 2) from a quarter of a mile north of N. Lewis' house, Barrett's Creek, Carter county. Averaged by P. N. Moore."

No. 1359—"COAL (probably No. 3) from Carter farm, two miles east of Grayson, on Dr. Jones' land (not a very good average sample). P. N. Moore."

COMPOSITION OF THESE CARTER COUNTY COALS, AIR DRIED.

	No. 1344	No. 1345	No. 1346	No. 1347	No. 1348	No. 1349	No. 1350	No. 1351	No. 1352	No. 1353	No. 1354	No. 1355	No. 1356	No. 1357	No. 1358	No. 1359
Specific gravity	1.330	1.377	1.288	1.290	1.435	1.347	1.340	1.323	1.326	1.274	1.352	1.337	1.289	1.298	1.307	1.388
Hygroscopic moisture	7.00	7.70	6.60	6.40	5.40	6.90	6.40	6.06	4.40	3.80	3.20	3.70	4.10	4.60	4.20	3.00
Volatile combustible matters	36.56	28.16	34.36	27.22	32.70	33.96	31.40	32.94	23.60	34.50	35.06	35.96	34.60	33.50	33.70	30.20
Coke	56.74	64.14	59.04	66.38	61.00	59.14	62.20	61.00	62.00	61.70	61.74	60.34	61.30	61.90	62.10	60.80
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Total volatile matters	43.56	35.86	40.96	33.62	38.10	40.86	37.80	39.00	38.00	38.30	38.26	39.66	38.700	38.10	37.90	30.20
Carbon in the coke	44.64	53.04	54.64	58.88	52.52	51.04	57.66	54.80	52.86	58.50	54.40	55.94	56.525	51.60	51.40	49.24
Ashes	12.10	*11.10	14.40	7.50	9.38	8.10	4.54	6.20	9.14	3.20	7.34	7.40	4.775	10.30	10.70	11.56
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.000	100.00	100.00	100.00
Character of the coke	Pulverulent.	Very friable.	Dense porous.	Very friable.	Dense porous.	Dense porous.	Dense porous.	Dense porous.	Dense porous.	Dense porous.	Spongy.	Dense spongy.	Dense porous.	Dense porous.	Spongy.	Spongy.
Color of the ash	Nearly white.	Lilac-grey.	Light grey.	Light brown.	Lilac-grey.	Yellowish lilac-grey.	Purplish grey.	Dark purplish grey.	Brownish-grey.	Brownish-grey.	Lilac-grey.	Grey-brown.	Lilac-grey.	Yellowish-grey.	Brownish-grey.	Lilac-grey.
Per centage of sulphur	not est.	1.055	0.724	0.973	2.356	2.430	1.670	1.867	2.210	2.164	2.631	2.727	1.414	1.200	3.483	1.381
Composition of the ash of	No. 1345	No. 1346														
Silica	5.38	2.00														
Alumina and iron oxide	5.12	2.20														
Lime, carbonate	0.32	a trace.														
Loss	0.28	.20														
Total	11.10	4.40														

No. 1360—"COKE, made from the No. 7 coal, in oven, by Mr. Bates, Willard, Carter county. Collected by A. R. Crandall."

A bright-looking coke somewhat dense.

COMPOSITION, AIR-DRIED.

Hygroscopic moisture	2.46
Volatile combustible matters	1.84
Coke (dry)	95.70
Total	100.00
Total volatile matters	4.30
Fixed carbon	87.34
Ashes	8.36
Total	100.00
Color of the ash	Lilac-grey.
Per centage of sulphur	2.026

The proportion of sulphur has been but slightly reduced by the coking of this coal. It is probably mostly in combination with iron, as iron proto-sulphide, and may not seriously injure this coke as fuel for the smelting and working of iron.

IRON CARBONATE ORES AND FERRUGINOUS LIMESTONE OF CARTER COUNTY.

No. 1361—FERRUGINOUS LIMESTONE. Labeled "Limestone Ore, from Old Orchard Diggings, Boone Furnace property. Averaged by P. N. Moore."

A dull-looking, fine-grained or compact ferruginous limestone, of a light-grey color, varied in parts by infiltrated hydrated oxide of iron. Fracture somewhat hackley. Specific gravity = 2.879.

No. 1362—CLAY IRON-STONE. Labeled "Limestone Ore from drift at Old Orchard Diggings, head of Grassy Creek, Carter county. Undecomposed ore. Average sample from various parts of bed No. 1. Boone Furnace property. Collected by P. N. Moore."

Irregular nodules and masses of clay iron-stone; varying in color from light-grey to blackish; mixed with some hydrated iron peroxide.

No. 1363—CLAY IRON-STONE. *Labeled "Kidneys in shale below the coal described, No. 1344, at Old Orchard Diggings, Boone Furnace property, &c. Shale, with the kidneys, four inches thick. Collected by P. N. Moore."*

Irregularly shaped nodules of fine-granular clay iron-stone superficially coated with hydrated brown iron oxide.

+ No. 1364—CLAY IRON-STONE. *Labeled "Limestone Ore (No. 1), Horsley bank, Boone Furnace property, &c. The undecomposed carbonate. Collected by P. N. Moore" (for a cabinet specimen).*

A fine-granular ore, varying from light-grey to purplish-grey, and incrustated in parts with limonite.

No. 1365—CLAY IRON-STONE AND LIMONITE MIXED. *Labeled "Average sample of Limestone Ore (No. 1), Horsley bank, Boone Furnace property, &c. Collected by P. N. Moore."*

A mixture of fragments of clay iron-stone and limonite ores.

No. 1366—CLAY IRON-STONE. *Labeled "Blue Limestone Ore, from west bank of Tygert Creek, about two miles from Iron Hills, Carter county. Average sample by P. N. Moore."*

Fragments of clay iron-stone nodules, invested externally with limonite layers.

No. 1367—CLAY IRON-STONE. *Labeled "Lower Block Ore, on Dry Fork of Sinking Creek, Carter county. J. M. James' land (six inches of undecomposed siderite). Average sample, by P. N. Moore."*

Compact clay iron-stone, with some little limonite.

No. 1368—CLAY IRON-STONE. *Labeled "Foxden Ore. Means and Russel land, Cumming's branch of Everman's Creek, Carter county. Averaged by P. N. Moore."*

The undecomposed carbonate covered with layers of limonite of various tints, some of which are ochreous.

No. 1369—CLAY IRON-STONE. *Labeled "Grey Limestone Ore, Mount Savage Furnace. Average sample, by J. A. Monroe."*

Grey granular and oölitic carbonate, with more or less limonite ore.

No. 1370—CLAY IRON-STONE. *Labeled "Lower Block Ore. Mr. Everman's Sammy's branch of Barrett's Creek, Carter county. Averaged by P. N. Moore."*

Mostly dark-grey, fine-granular carbonate ore, with some incrustation of limonite.

SUMMARY OF THE COMPOSITION OF THESE CARTER COUNTY CLAY-IRON-STONE ORES, &c., DRIED AT 212° F.

	No. 1361	No. 1362	No. 1363	No. 1364	No. 1365	No. 1366	No. 1367	No. 1368	No. 1369	No. 1370
Iron, carbonate	24.408	61.220	62.662	65.018	44.242	27.511	62.321	46.893	30.708	47.391
Iron, peroxide		4.410	10.024	5.945	27.296	26.240	4.989	9.255	31.544	9.734
Alumina	.560	2.260	1.600	1.060	1.560	9.021	7.901	5.703	1.779	4.197
Lime, carbonate	45.200	4.480	.240	2.720	6.580	2.320	12.000	12.460	2.730	5.220
Magnesia, carbonate . .	24.328	a trace.	2.838	9.038	1.046	2.838	.222	.250	.144	7.893
Manganese, carbonate . .	.391	.150	3.251	2.332	.842	.270	.121	not est.	.060	.346
Phosphoric acid (anhydr.)	.147	.313	.127	.255	.732	.499	.684	.978	.421	.121
Sulphuric acid (anhydr.)	.439	not est.	.521	1.280	4.587	.116	.206	a trace.	.491	.151
Silica and insol. silicates	2.420	21.260	13.720	10.260	11.100	25.180	10.740	23.510	25.430	20.230
KO = .135; NaO = .204	.339	.540		2.112						
Water and loss	1.768	5.367	3.017		1.955	6.005	.816	.951	6.523	4.717
Total	100.00	100.000	100.00	100.000	100.000*	100.000	100.000	100.000	100.000	100.000
Per centage of iron . . .	10.960	32.578	37.285	35.549	40.465	31.598	33.348	29.116	36.627	29.685
Per ct. of phosphorus . .	0.064	0.136	0.055	.111	.321	.208	.298	.427	.184	.052
Per centage of sulphur . .	0.203		.208	.533	1.855	.046	.082		.196	.060
Per centage of silica . . .						23.80	8.980	20.860	10.560	19.760

* This sample had in it visible fragments of pyrites, and hence the above may not be an exact determination of the average sulphur of this ore.

No. 1361 would be unobjectionable as flux for richer ores, were it not for its considerable proportion of sulphur. It would make good lime for agricultural uses; which would make a strong cement with sand for all building purposes, where its color would not be objectionable.

The Horsley bank ores Nos. 1364 and 1365, although rich enough in iron, also contain quite large proportions of sul-

phur, exceeding in this respect all these ores; many of which may be considered quite good of their kind, as may be seen on examination of this table.

LIMONITE IRON ORES OF CARTER COUNTY.

No. 1371—LIMONITE. Labeled "*Limestone Ore from Horsley bank, Boone Furnace property. (A cabinet specimen.) Collected by P. N. Moore.*"

In irregular curved laminæ of various tints, from dark brown to red and light yellow; with some soft ochreous ore.

No. 1372—LIMONITE. Labeled "*Average sample of Lambert Main Block Ore, Potato Knob Hill. From the stock pile, Iron Hills Furnace, Carter county. Collected by J. A. Monroe.*"

Ore varying from dense dark chocolate-brown, irregular laminæ and grains, to brownish-yellow soft ochreous.

No. 1373—LIMONITE. Labeled "*Potato Knob Iron Ore. Average sample. Iron Hills Furnace, &c.*"

In nodules varying from one to six inches in diameter. Exterior of hard dark-brown limonite; interior nodules soft and porous, of yellowish and reddish-brown colors.

No. 1374—LIMONITE. Labeled "*Main Block Ore, Stewart bank. Divide between Barrett's and Everman's Creeks, three miles west of Grayson, Carter county. Average sample.*"

The irregular laminæ and concretions varying in color from dark chocolate-brown or purplish to greyish-yellow.

No. 1375—LIMONITE. "*From Royster Hill Lambert bed. Iron Hills Furnace. The ochre from the lower part of the bed.*"

Porous and showing a small oölitic structure. Color brownish and greyish-yellow.

No. 1376—LIMONITE. Labeled "*German Ore. Smith Hill. Taken from an imperfectly shown bed, possibly not fully representing the whole bed, except that the ore seems very uniform. None of the blue ore, or kidneys above the main bed, included in this sample. Iron Hills, Carter county. Collected by P. N. Moore.*"

Ore generally porous or ochrey, of a yellowish-brown color mottled with light-grey. Some few laminæ of hard limonite.

No. 1377—LIMONITE. Labeled "*Crown Ore. Smith Hill. Iron Hills, &c. Average sample, from upper part of the bed only, by P. N. Moore.*"

Composed of irregular laminæ of dense dark-brown limonite, with cavities and included soft ochreous ore.

No. 1378—LIMONITE. Labeled "*Lower Block Ore. Perry's branch of Tygert Creek, west of Olive Hill. Land of Tygert Valley Iron Company. Average sample by P. N. Moore.*"

Fragments of dense limonite laminæ mixed with some small clay iron-stone nodules.

No. 1379—LIMONITE. Labeled "*Average sample of Lower Block Ore, from road on west side of Garvin's Hill, west of Olive Hill. Land of Tygert Valley Iron Company.*"

Fragments of limonite laminæ and clay iron-stone nodules.

No. 1380—LIMONITE. Labeled "*Block Ore from Garvin's Hill, west of Olive Hill. Land of Tygert Valley Iron Company. Average sample.*"

No. 1381—LIMONITE. Labeled "*Main Block Ore; Old Mount Tom Ore, Carter county. Averaged by J. A. Monroe.*"

A very dense ore, in curved irregular laminæ of deep bluish and brownish colors, with some dark-brown softer ore between.

No. 1382—LIMONITE, &c. "*Main Block Ore with associated overlying Kidney Ore, from Kibby Diggings. Divide between Lost and Tygert Creeks. Carter county. Averaged by J. A. Monroe.*"

Small nodules of fine-granular grey carbonate ore, surrounded by curved irregular laminæ of dense limonite, frequently separated by soft ochreous ore.

No. 1383—LIMONITE. "*Rough Ore, one hundred feet above the Foxden Ore (see clay iron-stones), on Means and Russel's land, Cumming's branch of Everman's Creek. Averaged by J. A. Monroe.*"

In irregular hard thin laminæ of dark-brown to brownish-yellow colors; with some soft ochreous ore.

No. 1384—LIMONITE. "*Red Limestone Ore from Graham bank. Average sample from the stock pile, by P. N. Moore.*"

In curved, irregular, hard laminæ; varying in color from yellowish and reddish-brown to deep brown and almost black, with soft, lighter colored ochreous ore incrusting and included.

No. 1385—LIMONITE. "*Yellow Kidney Ore, Mount Savage Furnace, Carter county. Average sample, by P. N. Moore.*"

In irregular curved laminæ, involving nuclei of softer ore. Color varying from deep brown and red to yellowish.

No. 1386—LIMONITE. "*Main Block Ore, Stinson Creek. Mount Savage Furnace. Average sample, by J. A. Monroe.*"

Curved irregular laminæ of dense limonite; generally dark colored, including light-grey nodules of porous carbonate of iron ore.

No. 1387—LIMONITE. "*Ore seventy-three feet above the sub-carboniferous limestone. On Clark's branch of Tygert's Creek, two miles from Iron Hills Furnace. Average sample, by P. N. Moore.*"

Varying from dense, dark-colored limonite laminæ to soft ochreous ore.

As will be seen, on examination of the following table of their composition, these limonite ores of Carter county are generally good, and may be profitably worked with proper management in the smelting; although some of them contain too much sulphur and phosphorus to make very tough iron.

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COMPOSITION OF THESE CARTER COUNTY LIMONITES, DRIED AT 212° F.

	No. 1371	No. 1372	No. 1373	No. 1374	No. 1375	No. 1376	No. 1377	No. 1378	No. 1379	No. 1380	No. 1381	No. 1382	No. 1383	No. 1384	No. 1385	No. 1386	No. 1387
Iron, peroxide	81.640	52.460	65.657	57.090	38.285	57.557	52.736	40.139	56.670	59.950	71.502	61.316	51.623	71.680	66.200	59.347	52.238
Iron, carbonate	3.160	7.504	4.021	4.203	5.455	2.727	3.531	8.030	4.495	5.230	8.557	3.537	1.671	4.155	3.907	9.599	4.512
Alumina	1.80	a trace.	a trace.	a trace.	.460	a trace.	a trace.	.360	a trace.	4.580	a trace.	a trace.	a trace.	.090	.030	1.037	1.130
Manganese, brown oxide	.180	a trace.	a trace.	a trace.	.065	.065	.065	.380	.883	.343	.054	.212	.483	.380	.430	.830	.650
Lime carbonate	.919	.155	.040	.086	.065	.065	.065	.254	.883	.343	.054	.212	.483	.380	.430	2.027	.641
Magnesia	.060	1.264	.893	.370	1.000	1.746	.800	.038	.337	.845	.466	.166	.081	.084	.130	.153	1.695
Phosphoric acid	not est.	.268	.694	.391	.071	.185	.171	.177	.130	.845	.800	1.069	.408	.270	.182	.302	.230
Sulphuric acid	11.280	12.360	10.740	11.100	9.500	11.700	10.700	7.669	9.377	11.800	9.500	3.545	9.330	10.800	11.730	5.945	10.650
Combined water	2.600	25.360	17.780	26.760	44.760	26.180	31.840	37.220	19.480	16.860	9.030	10.760	30.830	12.650	16.530	19.810	30.580
Silex and insoluble silicates	.161	.669			.884						.091				.033		
Moisture and loss	100.000	100.000	100.635	100.000	100.000	100.760	100.103	100.000	100.000	100.510	100.000	100.000	100.326	100.159	100.000	100.000	100.119
Total	100.000	100.000	100.635	100.000	100.000	100.760	100.103	100.000	100.000	100.510	100.000	100.000	100.326	100.159	100.000	100.000	100.119
Per cent. of iron	57.148	36.722	45.959	39.963	26.799	40.290	36.815	29.816	44.736	41.965	50.031	48.585	36.136	50.176	46.340	45.347	36.566
Per cent. of phosphorus	.026	.534	.391	.161	.436	.762	.344	.013	.147	.367	.203	.072	.035	.036	.057	.066	.740
Per cent. of sulphur		.107	.241	.156	.030	.074	.068	.071	.060	.335	.320	.403	.163	.108	.072	.120	.091
Per cent. of silica	not est.	23.980	15.960	22.256	40.960	not est.	27.360			16.860	7.640	9.960		11.560	13.860	15.060	24.260

* Carbonates.

LIMESTONES OF CARTER COUNTY.

No. 1388—"LIMESTONE used as a flux at Boone Furnace when in operation. Collected by P. N. Moore."

A hard, compact, light buff-grey limestone. Fracture somewhat conchoidal.

No. 1389—"LIMESTONE (sub-carboniferous) to be used as flux by the Iron Hills Furnace. Averaged by P. N. Moore."

A compact or fine granular limestone, of a light-grey color.

No. 1390—"LIMESTONE used as flux at Mount Savage Furnace. Average sample, by J. A. Monroe."

A compact limestone of a dark-grey color, mixed with fragments of ferruginous sandstone and chert.

COMPOSITION OF THESE LIMESTONES, DRIED AT 212° F.

	No. 1388.	No. 1389.	No. 1390.
Specific gravity	2.624	2.700	not est.
Lime carbonate	97.720	95.150	75.750
Magnesia, carbonate	not est.	.245	.575
Alumina, and iron and manganese oxides	.300	1.390	6.403
Phosphoric acid (anhydrous)	.083	.130	.057
Sulphuric acid (anhydrous)	not est.	a trace.	.775
Potash	.115	not est.	not est.
Soda	.167	not est.	not est.
Silica and insoluble silicates	1.560	3.060	14.700
Soluble silica	.120	not est.	*1.740
Total	100.065	99.975	100.000
Per centage of lime	54.723	53.284	42.420
Per centage of phosphorus	.036	.056	.032
Per centage of sulphur	not est.	a trace.	.310

* Water and loss.

Nos. 1388 and 1389 are very pure limestones, and very suitable for use as flux in the iron furnace; but No. 1390 is quite objectionable, because of its considerable proportion of sulphur, and its nearly fifteen per centage of silicious matters.

PIG IRONS OF CARTER COUNTY.

No. 1391—PIG IRON. "Foundry No. 2, made at Boone Furnace, Carter county, in 1870."

A brilliant grey iron; moderately coarse-grained. Yields to the file; but breaks readily under the hammer.

No. 1392—PIG IRON. "Foundry Iron No. 1, made at Boone Furnace in 1870."

Darker colored, somewhat finer-grained, and softer than the preceding; flattening somewhat under the hammer.

No. 1393—PIG IRON. "Hot Blast, No. 1 Foundry ("sow"), Iron Hills Furnace, Carter county. Collected by P. N. Moore."

Rather coarse-grained; with brilliant grains. Yields to the file, but is somewhat hard. Flattens but little under the hammer.

No. 1394—PIG IRON. "Hot Blast, No. 1 Foundry, Mount Savage Furnace. Collected by P. N. Moore."

A brilliant coarse-grained iron. Hard, but yields to the file. Extends but little under the hammer.

	No. 1391.	No. 1392.	No. 1393.	No. 1394.
Specific gravity	6.423	6.905	7.021	6.889
Iron	90.958	93.212	92.387	91.502
Graphite	2.164	2.940	3.340	2.670
Combined carbon	.116	.060	.760	.030
Manganese	.115	.083	.056	.123
Silicon	2.682	1.634	2.240	4.470
Slag	4.180	2.460	.620	1.160
Aluminum	.479	.330	.120	.128
Calcium	not est.	not est.	.120	.144
Magnesium			.056	.112
Potassium			.080	.076
Sodium				.023
Phosphorus	.304	.486	.836	.203
Sulphur	not est.	.079	.057	.041
Total	100.998	101.284	100.672	100.680
Total carbon	2.280	3.000	4.100	2.700

SOILS OF CARTER COUNTY.

No. 1395—SOIL. "*From the farm of Jas. W. Scott, near Lower Tygert bridge, near Olive Hill, Carter county. Top soil in oak woods, sixty feet above the bed of the creek. Limestone slope southward. Drainage between the slope and the sandstone capping the hills. Sample to depth of six inches. Collected by Prof. N. S. Shaler.*"

Virgin soil. Soil of a greyish orange-buff color, with streaks and mottlings of dark-grey. Compacted into clods in the bag. The coarse sieve (289 meshes to inch) removed about six per cent. of ferruginous and decomposing cherty fragments.

No. 1396—SOIL. Labeled "*Sub-soil of the preceding, one foot below the surface, &c.*"

This sub-soil is of an orange-red, or bright red ochre color. Compacted into clods in the bag.

The coarse sieve removed from it a very small quantity of small fragments of weathered chert, &c.

No. 1397—"SOIL *from the farm of Jas. W. Scott (locality as above). Old field, in pasture for eighteen, and cultivated for five years. Slope from height of limestone bench and sandstone beyond. Northern exposure, thirty feet above Tygert Creek. Collected by N. S. Shaler.*"

Soil of a dirty-grey buff color. Sifted out about five per cent. of cherty and ferruginous small fragments, with the coarse sieve.

No. 1398—"SUB-SOIL *of the next preceding, one foot below the surface, &c.*"

Sub-soil colored like next preceding; slightly more reddish. Sifted out, with the coarse sieve, about twenty-three per cent of small fragments, more or less rounded, of ferruginous sandstone, iron ore, and weathered chert.

No. 1399—"TOP SOIL. *Woods near Iron Hill, Carter county. From eastward slope, ravine to southward. Limestone above, twenty-five feet thick. Conglomerate still above. Oak and beech woods, about one hundred feet above Tygert Creek. Collected by J. A. Monroe.*"

Soil of a grey-buff color. Sifted out, with the coarse sieve, about sixteen per cent. of shaly ferruginous sandstone fragments.

No. 1400—"SUB-SOIL *of the next preceding, taken eighteen inches below the surface, &c., &c.*"

Sub-soil of a lighter color than the surface soil and more adhesive. Contains fragments of sandstone.

No. 1401—"TOP SOIL, *for six inches below the surface, from an old field on Riggs' farm at Iron Hills. From the slope of hill toward Tygert Creek. Limestone one hundred feet or more above, and sandstone above that. Woodland a few rods off to top of the hill. This field has been cultivated in corn for many years.*" Collected by J. A. Monroe.

Soil of a grey-buff color. Sifted out of it, with the coarse sieve, about twenty per cent of fragments of ferruginous sandstone, &c.

No. 1402—"SUB-SOIL *of the next preceding, taken eighteen inches from the surface, &c., &c.*"

Of a handsome yellowish-buff color. Compacted into friable lumps in the bag. Sifted out, with the coarse sieve, about ten per cent. of fragments of ferruginous sandstone and iron ore.

No. 1403—"SURFACE SOIL, *from woodland on farm of William Abbott, five miles west of Olive Hill, Carter county. One hundred and fifteen feet above the west branch of Tygert's Creek. Slope northwest. Limestone on top of the hill. Collected by A. R. Crandall.*"

Soil of a grey-buff color. The coarse sieve removed a considerable quantity of small ferruginous and cherty fragments.

No. 1404—"SUB-SOIL of the next preceding. One foot from the surface, &c., &c. Collected by A. R. Crandall."

Of a buff color. Contains angular fragments of ferruginous sandstone.

No. 1405—"OLD FIELD SOIL. Farm of William Abbott, west branch of Tygert's Creek, &c. Field fifty-five feet above the bed of the creek; on bench of Waverly sandstone. Tops of the hills capped with limestone. Surface soil; has been cultivated sixty years; was once an orchard." Collected by A. R. Crandall.

Soil of a light grey-buff color; aggregated into friable clods in the bag. The coarse sieve removed from it less than two per cent. of small silicious sandstone, cherty, and ferruginous fragments.

No. 1406—"SUB-SOIL of the next preceding; one foot below the surface, &c." Collected by A. R. Crandall.

Sub-soil of a lighter and more clear buff color than the surface soil; contains less than two per cent. of small cherty and ferruginous gravel.

No. 1407—SOIL from an old field on Widow Garvin's farm, four miles west of Olive Hill. Ten feet above the bed of Tygert's Creek. On Waverly sandstone; with limestone and coarse sandstone near the tops of the hills. Surface soil. Collected by A. R. Crandall."

Soil of a grey-buff color, contains about four per cent. of small rounded ferruginous sandstone and cherty fragments.

No. 1408—"SUB-SOIL of the next preceding, one foot to eighteen inches below the surface. Collected by A. R. Crandall."

Sub-soil of a lighter color than the preceding surface soil; in friable clods.

Sifted out, with coarse sieve, about eight per cent. of ferruginous, cherty, and sandstone fragments.

No. 1409—SOIL. Labeled "Sub-soil of bottom land, two feet from the surface; twenty-five feet above Little Sandy river, Grayson, Carter county. The surface soil was not collected on account of accidents affecting its composition." Collected by Prof. N. S. Shaler.

Sub-soil of a light buff-grey color; nearly white; in friable lumps. Seems to be mainly composed of fine grains of sand.

COMPOSITION, DRIED AT 212° F.

Volatile and combustible matters, expelled at red heat . .	2.500	
Alumina, and iron and manganese oxides	11.500	
Lime carbonate	.560	= .313 per cent. of lime.
Magnesia	.121	
Phosphoric acid	.223	
Sulphuric acid	not est.	
Potash (total obtained by fusion)	.366	
Soda (total obtained by fusion)	.587	
Silica (separated by fusion)	84.000	
Loss	.143	
	100.000	

This sub-soil having been analyzed by fusion with the mixed alkaline carbonates, and not by digestion in chlorohydric acid, as the other soils of this county were treated, could not be tabulated with them.

The proportions of potash and soda given above appear large, as compared with those found in similar sandy soils by digestion in acids; but these represent the *total amount* of these alkalies, contained not only in the soluble portion of the soil, but also in the insoluble silicates; the process of J. Lawrence Smith for the separation of the alkalies from silicates, viz: fusion with a mixture of lime carbonate and ammonium chloride, having been employed in the above analysis.

COMPOSITION OF THESE CARTER COUNTY SOILS AND SUB-SOILS, DRIED AT 212° F.
Extracted from 1000 parts of the air-dried soil, by digestion in water containing carbonic acid in solution.

	No. 1395.	No. 1396.	No. 1397.	No. 1398.	No. 1399.	No. 1400.	No. 1401.	No. 1402.	No. 1405.	No. 1406.	No. 1407.
Organic and volatile matters	0.500	0.420	0.500	0.370	lost.	0.350	1.120	0.320	0.700	0.340	0.800
Alumina, oxide of iron, and phosphoric acid	.030	.010	.010	.010	lost.	.020	lost.	.020	lost.	.020	.070
Brown oxide of manganese	.050	.010	.080	.030	lost.	.030	lost.	.060	lost.	.040	.200
Lime carbonate	.710	.130	.660	.330	lost.	.300	lost.	.030	lost.	.020	.720
Magnesia	.040	.010	.050	.020	lost.	.020	lost.	.030	lost.	.020	.100
Phosphoric acid	not est.	not est.	not est.	not est.	lost.	not est.	lost.	not est.	lost.	not est.	not est.
Sulphuric acid	a trace.	a trace.	a trace.	a trace.	lost.	a trace.	lost.	a trace.	lost.	a trace.	a trace.
Choline	a trace.	a trace.	a trace.	a trace.	lost.	a trace.	lost.	a trace.	lost.	a trace.	a trace.
Nitric acid	not est.	not est.	not est.	not est.	lost.	not est.	lost.	not est.	lost.	not est.	not est.
Potash	.060	.060	.090	.050	lost.	.040	lost.	.040	lost.	.050	.050
Soda	.050	.030	.030	.040	lost.	.010	lost.	a trace.	lost.	.020	.020
Soluble silica	.070	.080	.110	.050	lost.	.030	lost.	.020	lost.	.030	.020
Loss	.090		.130	.120	lost.	.020	lost.	.060	lost.		
Total extract, dried at 212° F.	1.600	0.770	1.660	1.020		0.820	2.870	0.570	1.180	0.540	2.070
Color of extract.	Dark brown.	Brownish white.	Dark umber.	Brownish grey.		Yellowish-white	Umber (dark).	Yellowish-white	Brownish white.	Brownish white.	Dark umber.

GENERAL COMPOSITION OF THESE CARTER COUNTY SOILS, DRIED AT 212° F.

	No. 1395.	No. 1396.	No. 1397.	No. 1398.	No. 1399.	No. 1400.	No. 1401.	No. 1402.	No. 1403.	No. 1404.	No. 1405.	No. 1406.	No. 1407.	No. 1408.
Organic and vol. matters	3.110	4.800	2.250	1.815	4.165	2.200	3.925	2.315	4.685	2.625	2.860	2.000	3.740	2.200
Iron peroxide	7.405	17.360	4.777	6.409	7.595	8.406	6.637	8.375	4.013	5.410	4.540	5.890	6.115	5.600
Manganese, brown oxide	.420	.270	.880	.680	.320	.155	.180	.095	.109	.109	.145	.080	.245	.220
Lime carbonate	.272	.124	.057	.155	.088	.142	.051	.153	.050	.061	.035	.086	.115	.118
Magnesia	.060	.045	.093	.076	.160	.109	.118	.115	.147	.163	.125	.103	.070	.086
Phosphoric acid	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.	.000	.046	not est.	not est.	not est.	not est.
Sulphuric acid	.293	.062	.213	.255	.275	.385	.279	.273	.153	.371	.111	.204	.279	.366
Potash	.148	.149	.132	.151	.186	.160	.163	.076	.032	.046	.157	.131	.286	.048
Soda	.170	.095	not est.	.145	.245	.160	.145	.145	not est.	not est.	.131	.020	.220	.120
Soluble silica	87.630	74.840	91.690	90.515	85.495	87.340	88.140	87.740	89.515	89.940	91.240	91.575	89.390	91.215
Sand and insoluble silicates	1.400	1.400	.600	.480	1.100	.605	.900	.555	.990	.770	.690	.450	.828	.450
Water expelled at 380° F.	.885	.255			.341	.369		.158	.246	.459				
Loss														
Total	100.393	100.000	100.692	100.681	100.000	100.000	100.538	100.000	100.000	100.000	100.123	100.569	101.294	100.483
Moisture lost at 212° F.	2.020	2.354	1.125	1.270	1.945	1.400	1.475	1.495	1.380	1.270	1.215	1.275	1.350	1.035
Potash in insoluble silicates	.584	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.
Soda in insoluble silicates	.165	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.
Character of soil	Virgin soil	Sub-soil.	Old field.	Sub-soil.	Virgin soil	Sub-soil.	Old field.	Sub-soil.	Virgin soil	Sub-soil.	Old field.	Sub-soil.	Old field.	Sub-soil.

Although these Carter county soils cannot be classed with the naturally very rich soils, there is no apparent reason, in view of their composition, why they may not be made quite profitably productive, under proper culture and by the observance of the golden rule of agriculture viz: to restore to the soil in manures, &c., the essential ingredients which are removed from it in the crops. These soils are measurably deficient in *humus* or organic matters, and contain rather more than the normal proportion of sand and silicates. These defects may be remedied in some localities, where the sub-soil contains more clay, &c. (as is the case with No. 1396), by gradually bringing up the sub-soil, in the annual plowings, with the simultaneous use of clover and other green crops. It appears also from the analyses, that while lime and potash seem to be in sufficient abundance, phosphoric acid is rather deficient in most of these soils. The use of bone-dust, or other phosphatic fertilizers, would doubtless be beneficial.

The influence of cropping on the composition of the soil may be measurably observed by comparing the analyses of the virgin soils and the old field soils, as given above. In all the proportion of organic matters is found to be reduced, and that of the sand and silicates increased, in the old field, as compared with the virgin soil; and in most of them a reduction in quantity may be seen in the potash and phosphoric acid of the old field; showing the exhausting influence of cropping without the use of manures.

EDMONSON COUNTY.

No. 1410—LIMONITE. Labeled "*From Bythe Meredith farm. Collected by Prof. N. S. Shaler (Nolin).*"

Composed partly of elliptical hollow concretions of dense dark reddish-brown laminæ, with some softer ochreous ore.

No. 1411—LIMONITE. Labeled "*Proctor Ore Bank, Sycamore Creek. Collected by Prof. N. S. Shaler and J. R. Proctor.*"

Principally in dark brown dense laminæ, forming an irregular stalactitic, hollow columnar structure with septæ (or irregularly

large cancellated), incrustated with some softer yellowish and brownish ochreous ore.

No. 1412—LIMONITE. Labeled "*Frederick's Bank, Beaver Dam Creek. Two hundred feet above the limestone. Collected by Prof. N. S. Shaler. (Five feet ore. Uniform.)*"

Generally of a yellowish-brown color, porous and cellular; but with some dark hard laminæ, small whitish oölitic concretions some of which are hollow, and brownish and yellowish ochreous material. Contains some fossil shells, &c.

COMPOSITION OF THESE EDMONSON COUNTY LIMONITE ORES, DRIED AT 212° F.

	No. 1410.	No. 1411.	No. 1412.
Iron, peroxide	55.028	76.284	52.926
Alumina	1.006	2.361	4.792
Manganese, brown oxide	.040	.030	.210
Lime carbonate	a trace.	.180	.180
Magnesia	.108	.068	.425
Phosphoric acid	.312	1.055	.355
Sulphuric acid	.133	.151	.143
Water expelled at red heat	8.300	12.000	10.400
Silex and insoluble silicates	35.180	7.951	30.580
Total	100.107	100.080	100.011
Iron, per centage	35.519	53.399	37.048
Phosphorus, per centage	.135	.460	.154
Sulphur, per centage	.053	.059	.057
Silica, per centage	33.700	7.660	29.160

These are good iron ores. No. 1411 is more than usually rich in iron, but it contains more phosphorus than is desirable.

[See Appendix for other iron ores of this county.]

No. 1413—COAL. "*From Tar Lick, Davis Creek, Edmonson county. Five and a half feet thick. Collected by Prof. N. S. Shaler.*"

A glossy splint coal, breaking into thin irregular laminæ, with tar (petroleum) and fibrous coal—the remains of reedy leaves—and more or less fine-granular pyrites between them.

No. 1414—COAL. "*Found on Mill branch. Level of main Nolin coal. Collected by Prof. N. S. Shaler.*"

Splint coal. Separates under the hammer into thin irregular laminæ, with fibrous coal, containing fine-granular pyrites between.

No. 1415—COAL. "*Found on the surface. Has been longer exposed and more weathered than the preceding. Mill branch. Collected by Prof. N. S. Shaler.*"

No. 1416—COAL. "*From Knob Lick, Dismal Creek. Geological level of main Nolin coal. Collected by Prof. N. S. Shaler.*"

A weathered specimen of splint coal, incrustated with ochreous iron oxide on the surface. Separating into thin irregular laminæ, with fibrous coal between.

No. 1417—COAL "*At Gross', one hundred and eighty feet above Bear Creek. Collected by Prof. N. S. Shaler and J. R. Proctor.*"

A splint coal, breaking into thin irregular laminæ, with fibrous coal and much fine-granular pyrites between.

No. 1418—COAL. "*Shoal branch, Nolin coal. Collected by Prof. N. S. Shaler and J. R. Proctor.*"

Splint coal, breaking into thin laminæ, with fibrous coal and but little pyrites between them.

No. 1419—COAL. "*Tar Lick Coal, branch of Davis. (Main Nolin coal.) Collected by J. R. Proctor. Five and a half feet thick.*"

A deep-black coal, with soft bituminous matter between the thin laminæ, and but little fibrous coal or pyrites.

No. 1420—COAL. "*From Mill branch of Bear Creek. Average sample, by P. N. Moore.*"

Much of it breaks into thin laminæ, with but little fibrous coal, and some fine-granular pyrites between.

COMPOSITION OF THESE EDMONSON COUNTY COALS, DRIED AT 212° F.

	No. 1413	No. 1414	No. 1415	No. 1416	No. 1417	No. 1418	No. 1419	No. 1420
Specific gravity	1.282	1.350	1.367	1.345	1.429	1.336	1.335	1.437
Hygroscopic moisture	2.30	3.60	3.20	2.60	1.20	3.66	4.06	4.06
Volatile combustible matters	32.10	33.00	33.80	33.80	39.00	35.14	33.24	32.00
Coke	65.60	63.40	63.00	63.60	59.80	61.20	62.70	63.94
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Total volatile matters	35.40	36.60	37.00	36.40	40.20	38.80	37.30	36.06
Fixed carbon in the coke	56.30	54.40	52.60	53.14	45.46	54.26	51.70	50.84
Ashes	9.30	9.00	10.40	10.46	14.34	6.94	11.00	13.10
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Character of the coke	Cellular.	Spongy.	Moderately dense.	Spongy.	Dense.	Light cellular.	Spongy.	Light spongy.
Color of the ash.	Light lilac-grey	Lilac-grey.	Lilac-grey.	Light-grey.	Dark greyish-purple.	Lilac-grey.	Light lilac-grey.	Grey-lilac.
Per centage of sulphur	1.059	2.101	2.923	2.425	8.685	2.706	1.670	4.938
Per centage of phosphoric acid.	not est.	not est.	not est.	not est.	0.178	not est.	not est.	not est.

These Edmonson county coals answer very well for the ordinary purposes of fuel, and those which do not contain an inordinate quantity of sulphur will doubtless answer well for the working of iron. No. 1417, however, contains more than eight per cent. of this ingredient, and more than fourteen per cent. of ashes, containing a notable proportion of phosphoric acid. Yet even this impure coal contains more than eighty-four per cent. of combustible matters, including part of the sulphur (some of which, however, remains in the ashes combined with iron), and may answer for ordinary fuel.

[For other Edmonson county ores, see Appendix.]

CAST IRON from Baker Furnace. Some fragments from this old furnace, which had been exposed to the weather for twenty

years, were collected by Prof. Shaler, for examination of its general quality.

It is a fine-grained, light-grey iron, which is more tenacious and extends more under the hammer than most samples of best pig iron. Possibly it has been improved in this respect by its long weathering in thin pieces. The analysis of a piece of the pig iron from this furnace will be found in the Appendix.

[For Nos. 1421, 1422, and 1423, see Barren county.]

FAYETTE COUNTY.

No. 1424—"SURFACE SOIL to depth of one foot, of a field which has not been very long in cultivation, principally in hemp, of which it no longer produces very good crops. Blue-grass land, seven miles from Lexington on the Newtown Turnpike. Sub-stratum, Lower Silurian blue limestone. Land of E. M. Coleman." Why is it not very good hemp land?

Soil of a light greyish-brown color. It all passed through the coarse sieve, of 289 meshes to inch, except a small proportion of shot-iron ore and irregular fragments of chert.

No. 1425—"SOIL to the depth of four inches from an old field fifty years or more in cultivation almost without intermission, without manure of any kind, principally in hemp and corn, with occasionally small grain. Farm of R. Peter, formerly of the late Col. S. Meredith, on the Newtown road, six and a half miles from Lexington; blue-grass land. Sub-stratum, blue limestone of the Lower Silurian formation."

Soil of a warm grey-brown color; containing only a few small angular fragments of weathered and porous chert.

This field was selected by my son, Benj. D. Peter, for some experimental agricultural operations, which he has reported to Prof. Shaler.

COMPOSITION OF THESE FAYETTE COUNTY SOILS, DRIED AT 212° F.

	No. 1424.	No. 1425.
Organic and volatile matters	6.340	6.575
Alumina, and iron and manganese oxides.	8.890	8.200
Lime carbonate	.745	.440
Magnesia	.366	.221
Phosphoric acid	.550	.316
Sulphuric acid	.065	.036
Potash	.169	.247
Soda	.057	.263
Sand and insoluble silicates.	81.467	83.340
Water and loss	1.556	.362
Total	100.000	100.000
Potash in the insoluble silicates	0.905	1.256
Soda in the insoluble silicates	.844	.101

The apparent paucity of potash in No. 1424 may account for its failure to produce good hemp crops.

As compared with the original virgin soil of the same locality, these soils contain much less *organic matters* (*humus*), and a smaller amount of *potash*, than that. These essential materials are especially influential in hemp production, as the presence of these and of lime seems to be necessary to a *vigorous* growth of this plant; the only kind of growth considered profitable by our farmers.

The current belief amongst our hemp-growers is, or has been, that this crop does not rapidly exhaust the soil, provided the hemp is spread for rotting on the field which produced it.

The rotting process does undoubtedly restore to the soil, in an available condition for plant nourishment, a considerable proportion of the fertilizing principles which had been withdrawn from it in the crop; but in the operation of braking the hemp, the hemp herds and rough tow being generally burnt on the spots where the process is performed, the alkaline and earthy ingredients of these become irregularly deposited, and much of the soluble fertilizing mineral matter of the ashes is liable to be washed down into the sub-soil, to become for the time unavailable; while a large quantity of vegetable matter,

which ought to be employed in returning to the soil the *humus*, which has been destroyed during the growth of the crop, is converted into atmospheric gases by burning.

The adoption of some plan by which our hemp-raisers may restore the organic matter of the hemp herds, &c., to the soil, in the form of *humus*, would tend to retard the exhaustion of the hemp land. But there exists a prejudice among them that hemp herds are injurious to the land, which is probably not based upon fact.

The *insoluble silicates* left after thorough digestion of these soils in warm chlorohydric acid assisted by a little nitric acid, was found upon analysis by fusion, to contain quite a large proportion of alkalies. In both cases these silicates contained *about five times as much potash* as was dissolved out from the soils by the acids. This quantity of the alkalies, in combination in the *insoluble silicates*, so-called, is not *immediately available* for plant nourishment, but yet serves to prolong the fertility of the soil; for these silicates, although not easily decomposable by acids, are gradually decomposed by the atmospheric agencies, and especially under the influence of alkaline substances.

Hence the application of lime, for instance, to soil of this kind, which has been measurably exhausted of its immediately available alkalies, may, by partial decomposition of these silicates, bring more of these alkalies into a soluble condition, and thus temporarily increase its fertility.

These insoluble silicates, left after the acid digestion, when examined with the lens, exhibit small grains, which look like partly decomposed feldspathic mineral, sometimes of different tints, mixed with minute rounded or angular grains of hyaline and milky quartz, &c.

These facts, especially that of the existence of so much potash and soda in these insoluble silicates of the soil, throw some light on the origin of soils; as they tend also to aid us in scientific agriculture.

No. 1426—QUICKLIME, obtained by the calcination of limestone of some of the fossiliferous layers of the blue limestone of the Lower Silurian formation. Cliff on Elkhorn Creek, northeast boundary of the above named farm. Also some milky calcareous spar, from a four to six feet wide vein at the same locality, which was mixed and calcined with the limestone.

This lime, not perfectly calcined, was used on the experimental field above mentioned.

Its composition was found to be as follows:

Lime	68.804
Magnesia	.241
Alumina, and iron and manganese oxides	4.565
Phosphoric acid	.415
Sulphuric acid	.446
Carbonic acid	11.450
Potash	1.330
Soda	.099
Silex and insoluble silicates	6.130
Water and loss	6.520
Total	100.000

This lime was not submitted to analysis until after it had been exposed to the air for a few days.

It will be seen from this analysis, that lime from these fossiliferous layers of our limestone may prove a valuable fertilizer, on fields which have been impoverished by too much cropping. For, not only will it, by its decomposing action on the insoluble silicates, render a new quantity of alkalies available for plant food, but its own considerable proportions of phosphoric and sulphuric* acids, and of potash and soda, will greatly aid in the amelioration.

No. 1426—CALCAREOUS SPAR (*above mentioned*) from the vein, nearly vertical, in the blue limestone on North Elkhorn Creek, land lately belonging to R. J. Breckinridge's estate (Bradallane).

Analyzed by my son, Alfred M. Peter, as was also the quicklime.

*The considerable proportion of sulphuric acid given in the preceding analysis is probably partly derived from iron sulphide sometimes diffused in this limestone.

COMPOSITION, DRIED AT 212° F.

Lime carbonate	96.610 = 54.101 per cent. of lime.
Magnesia, carbonate	.401
Alumina, and iron and manganese oxides	1.740
Phosphoric acid	.057
Sulphuric acid	not est.
Potash	.443
Soda	.275
Silica and insoluble silicates	.360
Loss	.114
	100.000

This nearly opaque, milky calc. spar is much stained superficially with iron oxide, &c. The analysis shows a much smaller amount of phosphoric acid than is contained in the limestone layers; but the proportion of alkalies, if no error is made, is quite considerable.

WATERS OF FAYETTE COUNTY.

As is well known, the spring and well waters of this blue limestone region are what are denominated "hard waters," containing a considerable quantity of dissolved carbonates of lime and magnesia, &c.

As a type of these limestone waters, that of a remarkable spring, the "Big Spring," on the writer's farm, about six and a half miles from Lexington, on the Newtown Turnpike, was selected for chemical analysis.

This "Big Spring" is a perennial stream of considerable force, boiling up in the bottom of a sink-hole, which is some fifty to sixty feet deep, and flowing through underground channels and caverns a considerable distance, to be discharged into the North Elkhorn Creek.

The water was taken after the long dry season of our late summer and autumn, and was remarkably clear; as it always is except after heavy rains. The temperature of it was noted during one of our late protracted cold spells; and when the temperature of the atmosphere was at zero and only ten degrees above, it maintained that of fifty-three or fifty-four; very little below the mean of the temperature of this region.

The analyses of this water and of the waters of the bored wells given below, were made by my youngest son Alfred

Meredith Peter, under my inspection, as a chemical exercise, and were very carefully and faithfully performed.

The results show that the hard waters of our springs and wells might not only be fertilizers, when used for irrigating growing crops, but that, as was first noted by the celebrated Boussingault, they may supply to growing animals necessary earthy salts which may be deficient in their food. That, especially, they may supply lime to animals fed on Indian corn, which food is found to be somewhat deficient in this ingredient.

COMPOSITION OF THE BIG SPRING WATER IN 1000 PARTS.

No. 1427.	Held in solution by free carbonic acid.
Lime, carbonate	0.2027
Magnesia, carbonate	.0227
Iron, carbonate	.0027
Manganese, carbonate	.0003
Alumina	.0012
Phosphoric acid	.0001
Silica	.0011
Total of sediment formed on boiling	0.2308
	Contained in the boiled water.
Lime, sulphate	0.0208
Potassium, chloride	.0012
Sodium, chloride	.0018
Magnesium, chloride	.0027
Silica	.0074
Organic matters	.0086
Lithia	a trace.
Total saline matters	0.2733

The total saline matters amount to about sixteen grains to the wine gallon of water. They are doubtless derived from the soil and the limestone rock.

As was stated in the previous volumes of Kentucky Geological Reports, the water obtained in this region by boring into the limestone substratum is always more or less salt, and is frequently accompanied with gas (carburetted hydrogen), the flow of which, however, is not very durable. During the late very dry season a number of borings were made in this neighborhood (near Lexington), with the same results; the water smelling strongly of petroleum, and sometimes of sulphuretted hydrogen, being always more or less brackish, and there being generally a temporary emission of gas.

The waters of three of these bored wells were analyzed by my son (A. M. Peter), with the following results, viz:

No. 1428—"WATER from a bored well of Mr. Sutton's, about ninety-eight feet deep, on the Leestown road, near the Scott county line."

A weak sulphur water.

No. 1429—"WATER from a bored well of Mr. Edward P. Gains, about one hundred feet deep, on the Georgetown Turnpike, about nine miles northwest of Lexington, near Donerail."

The water rose about thirty feet in the well. Specific gravity = 1.035.

No. 1430—"WATER from a bored well, about ninety-six feet deep, on the farm of Mr. Price McGrath, two and a half miles from Lexington, on the Newtown Turnpike."

The water rose to within about twenty-eight feet of surface. Gas was evolved in considerable quantities during the boring.

COMPOSITION OF THESE WELL WATERS.

Held in solution by free carbonic acid.

	No. 1428.	No. 1429.	No. 1430.
Lime, carbonate	0.1008	0.0104	0.1711
Magnesia, carbonate	.0882	.0018	.0053
Iron, carbonate	.0042	.0008	.0062
Manganese, carbonate			.0005
Phosphoric acid	a trace.		.0002
Silica	.0078	.0038	.0017
Total sediment on boiling	0.2010	0.0168	0.1850

In solution in the boiled water.

Lime, sulphate		0.6263	0.0309
Magnesia, sulphate			
Potash, sulphate	0.0541		
Soda, sulphate	.0355		
Soda, carbonate	.0600		
Calcium, chloride	.1448		
Magnesium, chloride		3.0246	.5794
Sodium, chloride		2.9881	.7837
Potassium, chloride	1.9409	34.4313	10.1040
Magnesium, bromide		.1883	.1120
Magnesium, iodide		.0157	a trace.
Lithium, chloride		.0096	a trace.
	a trace.	.0181	a trace.
Total saline matters	2.4363	41.3188	11.8750

The water from Mr. Sutton's well smells strongly of hydro-sulphuric acid; which was not estimated, because this could only be done correctly at the well. All these waters contain, in addition, a little *organic matter*, and a little *silica* in the boiled water.

The amount of saline matters in Mr. Gains' well water is remarkable, being about five ounces and a half to the wine gallon. The saline matters in quantity and in kinds resemble those of the oceans; and doubtless had their origin in the ancient sea under which our rock strata were deposited.

Another well bored by Mr. Wm. Adams, on his farm next adjoining that of Mr. McGrath, gave water at the depth of about seventy-eight feet; which rose fifty feet in the bore. Much gas was blown out during this boring also.

The water of this well contained 0.54 of saline matter in the thousand of the water; which, tested qualitatively, was found to contain sulphuric, carbonic, and phosphoric acids, chlorine, lime, magnesia, potash, iron oxide, and a trace of lithium. It doubtless resembles that of Mr. McGrath, but is weaker. It, like that, smells strongly of petroleum.

Mr. Jno. Keiser bored to the depth of about two hundred and sixty feet, on an elevated ridge on his farm, about six miles from Lexington, on the Newtown Turnpike, and obtained only a very small quantity of brackish water, which gradually rose to within sixty feet of the surface. Some of the borings, taken at various depths, were preserved for examination. They indicate the usual layers of limestone, with thin marly shales and occasional silicious beds, of the formation in this region.

FRANKLIN COUNTY.

No. 1431—"GREEN MARLY SHALE from below the Arsenal at Frankfort. Bed about eight inches thick (Upper Cambrian Group). Collected by Prof. N. S. Shaler."

A friable shale of a greyish-green color.

No. 1432—"MARLY SHALE. *Same locality as the preceding, but lying above that. Collected by N. S. Shaler.*"

Quite friable. Of dull olive and brownish colors.

No. 1433—"MARLY SHALE. *Used as a paint at Frankfort, &c. Sent by Mr. James L. Sneed for analysis.*"

Of an olive-grey color, with some brownish-yellow mixed.

No. 1434—"MARLY SHALE. *From Armstrong farm, Bridgeport. Geological position Cincinnati Group, just below the silicious mudstone. In same position as the marl near Newport. Collected by Prof. N. S. Shaler.*" *Used for paint. Said to be good for polishing iron, &c.*"

Of a handsome light olive-grey color.

COMPOSITION OF THE FIRST TWO OF THESE MARLY SHALES, DRIED AT 212° F.

	No. 1431.	No. 1432.
Alumina, and iron and manganese oxides	10.415	15.395
Lime, carbonate	1.440	*.875
Magnesia	.800	2.298
Phosphoric acid	.435	.460
Sulphuric acid	.738	.570
Potash	3.488	3.565
Soda	.042	.318
Water expelled at red heat	5.350	6.400
Silex and insoluble silicates	77.380	70.060
Total	100.088	99.941
Per centage of potash in the silicates	4.991	3.565
Per centage of soda in the silicates	.654	.430

* Lime.

These marly shales are remarkable for their large per centage of potash; which probably may make them valuable for application to exhausted land of a light and sandy nature. A previous moderate calcination with lime intimately mixed, might, if practicable, make them more available in this respect by setting free more or less of the potash locked up in the insoluble silicates. It will be seen that No. 1431 contains in

all, as much as 8.479 per cent. of potash, and No. 1432 a total amount of 7.130 per cent.

These, and similar marly shales, have been used as pigments; for which purpose they are quite appropriate, if of an agreeable tint, as they will not decompose the oil with which they are mixed, are not readily altered by atmospheric agencies under such conditions, and contain nothing of a poisonous nature. Their use for scouring or polishing depends on the very fine silicious sand contained in them.

COMPOSITION OF THE LATTER TWO OF THESE FRANKLIN COUNTY MARLY SHALES, DRIED AT 212° F.

	No. 1433.	No. 1434.
Silica	50.360	52.060
Alumina	16.816	18.831
Iron and manganese oxides	6.997	9.200
Lime	8.736	3.666
Magnesia	.936	1.210
Phosphoric acid	.217	.319
Sulphuric acid	2.280	.920
Potash (total)	3.623	5.402
Soda (total)	1.731	.720
Carbonic acid	8.304	7.672
Water and loss		
Total	100.000	100.000
Per centage of phosphorus	.095	0.139
Per centage of sulphur	.912	.368

Although the sulphur and iron in these marls are calculated in these analyses as sulphuric acid and iron oxide, severally, a portion of each, not determined, is combined as iron sulphide. These two analyses are tabulated separately from the first two of similar marls of this county, because in these latter analyses the method of *complete* decomposition by fusion was employed, while the first two were analyzed by digestion of the marls in acids, and the subsequent fusion of the insoluble silicious residue for the determination of the total amount of the alkalis. The remarks appended to the first two apply equally to these.

No. 1435—"WATER from a bored or driven well, near the Kentucky river. Water stands about thirty-four feet from the surface of the ground, which is twelve to fourteen feet above low water level in that river. The height of the well water is affected by that of the river. Used in the steam boiler of the Frankfort Cotton Mill Company."

The sample of the water, together with some of the white powdery sediment and hard scale of the boiler, were sent to the laboratory by Mr. Milton McGrew, President of the company.

Nothing had been added to the water in the boiler, and the sediment and scale had been taken out of the boiler after running with this water for two weeks.

COMPOSITION OF THE WELL WATER IN 1000 PARTS.

Held in solution in the water by the free carbonic acid deposited on boiling.

Free carbonic acid	not est.
Lime carbonate	0.2493
Magnesia, carbonate	.0032
Silica	.0005
Sediment on boiling	0.2530

Contained in the boiled water.

Lime sulphate	0.1100
Calcium chloride	.0254
Magnesium chloride	.0174
Sodium chloride	.0460
Potassium chloride	.0142
Soda carbonate	.0413
Nitric and phosphoric acids	a trace.
Silica	.0006
	0.2549

Total saline contents of the water, 0.5079 to the thousand parts. The fresh water gives a slight alkaline reaction with reddened litmus; the soda, stated as carbonate above, is doubtless present in it as bi-carbonate.

On examination of the *white powdery boiler sediment*, it was found to be mainly lime carbonate, with about five per cent. of magnesia carbonate, two to three of lime sulphate, more than one per cent. of alumina and iron oxide, with a trace of phosphoric acid, a little silica, and traces of the alkalies.

The hard *boiler scale*, on the contrary, was found to be mainly lime sulphate, with small proportions of lime and magnesia carbonates, and traces of silica, phosphoric acid, &c.

It is evident that the hard scale, which is the most injurious to the boiler, may be prevented by the addition to the water of enough carbonate of soda, say in the form of cheap soda ash, to decompose the lime sulphate. This would probably cause the sediment to be wholly powder.

No. 1436—SULPHUR MINERAL WATER from a bored well, ninety-six feet deep, at Fleetwood Farm of Col. J. W. Hunt Reynolds, near Frankfort.

The water stands at about twenty-five feet from the bottom.

COMPOSITION OF THIS WATER.

	In 1000 parts.	In a wine gallon (231 cubic inches).
Free hydrosulphuric acid gas	0.0343 parts.	1.9981 grains.
Free carbonic acid gas	.2772 "	16.1730 "

Held in solution by the free carbonic acid.

Lime carbonate	.1397 parts.	8.1350 grains.
Magnesia carbonate	.1029 "	6.0030 "
Iron and manganese carbonates	marked traces.	marked traces.
Total sediment on boiling	0.2426	14.1380
Potash sulphate	.2535 parts.	14.7800 grains.
Sodium sulphide	.1057 "	6.1670 "
Sodium chloride	1.0152 "	59.2140 "
Potassium chloride	.0798 "	4.6580 "
Calcium chloride	.0713 "	4.1620 "
Magnesium chloride	.0228 "	1.3330 "
Silica	.0343 "	2.0000 "
Organic matters	a trace.	a trace.
Bromine, iodine, and lithium	marked traces.	marked traces.
Total	1.8250 parts.	106.4420 grains.

A very good saline sulphur water, which may be useful in cutaneous and parasitic diseases, granular sore eyes, some forms of neuralgia and rheumatism, &c., &c., when employed

externally or internally under the advice and direction of a physician.

This water was analyzed by the writer, for Col. Reynolds, before the reorganization of the Geological Survey; but it has been reexamined recently in this laboratory, and, in addition to the ingredients reported to him, notable quantities, not quantitatively estimated, of iodine and lithium, were observed in it. The water acquires a yellowish tint on standing in bottles; doubtless owing to the formation of sulphuretted sulphide of sodium by the decomposing influence of the atmospheric oxygen on the hydrosulphuric acid.

FULTON COUNTY.

No. 1437—SOIL. Labeled "Sub-soil of an old tobacco field. The soil proper has been washed away. Field about one hundred and fifty feet above the Mississippi river, four miles east of Hickman. Collected by Prof. N. S. Shaler."

This sub-soil is of a brownish dark-buff, or light yellowish-brown color.

COMPOSITION, DRIED AT 212° F.

Organic and volatile matters	2.250
Alumina, and iron and manganese oxides	6.005
Lime carbonate	.230
Magnesia	.414
Phosphoric acid	.172
Sulphuric acid	not est.
Potash	.159
Soda	.072
Sand and insoluble silicates	90.490
Water expelled at 380° F.	.650
Total	100.442
Hygroscopic moisture, per cent.	2.250
Potash in the insoluble silicates, per cent.	1.479
Soda in the insoluble silicates, per cent.	1.306

It will be seen that in this sub-soil, which contains a very large proportion of fine sand and insoluble silicates, and which

only gave up 0.159 per cent. of its potash after long digestion, with heat, in chlorohydric acid, there is yet a reserve supply of that alkali of more than nine times that quantity, locked up in the insoluble silicates. This potash, although not immediately available for the use of plants, will doubtless be gradually brought into an available condition, under the slow but certain action of the atmospheric agencies and under that of humus, &c.

No. 1438—MINERAL WATER. "Chalybeate water, sent by Mr. B. R. Walker, from Nick Combs' Spring, four miles southwest of Hickman, Fulton county."

This chalybeate water contains free carbonic acid and 0.302 of saline matters in the one thousand of water. This consists of iron, manganese, lime and magnesia carbonates, with some lime and magnesia sulphates, &c. The quantity sent was too small for a thorough analysis.

It is probably a valuable chalybeate water.

No. 1439—"INDURATED SILICIOUS CLAY. From the bluffs, one hundred feet above low water mark, Hickman, Fulton county. Tertiary formation. Collected by Prof. N. S. Shaler."

Of a light-grey color, with ferruginous infiltrations. Breaks readily, with an irregular fracture. Adheres slightly to the tongue. Is somewhat plastic when powdered and rubbed up with water. When calcined, is of a light buff color.

No. 1440—"SILICIOUS CONCRETION or soft sandstone from the Bluff at Hickman, fifty feet above low water. Tertiary. Collected by Prof. N. S. Shaler."

A whitish, porous, and friable silicious rock or concretion; adheres to the tongue. Only slightly plastic when powdered and rubbed up with water. Burns of a light buff color.

No. 1441—"SILICIOUS CONCRETION or soft sandstone, from Chickasaw Bluff, eight miles south of Hickman. Tertiary. Bed ten feet thick. Collected by Prof. N. S. Shaler."

A light-grey or dove-colored soft and porous silicious rock, adhering to the tongue. Scarcely at all plastic when powdered and rubbed up with water.

No. 1442—"SOFT SANDSTONE. *Chickasaw Bluff, near the base, eight miles south of Hickman.*"

A dull light-yellowish-grey porous soft sandstone; adheres strongly to the tongue. Composed of minute rounded quartzose grains, with a whitish cement.

COMPOSITION OF THESE FULTON COUNTY SOFT SANDSTONES AND SILICIOUS DEPOSITS, DRIED AT 212° F.

	No. 1439.	No. 1440.	No. 1441.	No. 1442.
Silica	74.960	81.060	89.160	94.060
Alumina, and iron and manganese oxides . .	18.350	13.609	7.809	3.129
Lime carbonate	.560	.560	.380	.380
Magnesia	.309	.139	.086	.173
Phosphoric acid	.051	.051	.051	.051
Sulphuric acid	.501	.844	.707	.981
Potash	.230	.231	.115	.230
Soda	.124	.021	.080	.124
Water expelled at red heat	5.800	3.600	2.400	1.600
Total	100.885	100.115	100.788	100.728

These silicious deposits do not contain enough mineral fertilizing ingredients to make them valuable for application to the soil, nor enough alumina to constitute good plastic clay. Yet they may be made useful in tempering clay which contains too much alumina, or for the formation of common glass and for scouring purposes. Some of them are plastic enough to enable them to be moulded, and the silicious material is fine enough, in some, to permit them to be used as "Bath Brick" for household scouring. Common brick could probably be made out of No. 1439.

Some of these layers, in which the proportions of alkalis, lime, magnesia, and iron oxide are small, may perhaps be manufactured into a kind of fire-brick.

Part of the sulphur which appears in the above summary of analyses as sulphuric acid, is doubtless in combination with some of the iron in the sandstone, in the form of iron sulphide;

the oxidation of which may account for a portion of the excess in the total.

No. 1443—"CLAY from the foot of Grand Chain, Illinois. Post Tertiary. Collected by Prof. N. S. Shaler."

Of a light-grey-dove color, with brownish incrustations. Fracture large conchoidal-hackly; quite porous; adheres strongly to the tongue; grinds easily into a tough plastic mass with water. Calcines of an orange-buff color; but fuses before the blow-pipe. *Specific gravity*, in its porous state = 1.764. Contains minute glimmering scales of mica.

COMPOSITION, DRIED AT 212° F.

Silica	70.660
Alumina, and iron and manganese oxides	20.309
Lime carbonate	.960
Magnesia	.307
Sulphuric acid	1.188 = .475 per cent. of sulphur,
Phosphoric acid	.051
Potash	.819
Soda	.487
Water expelled at red heat, and loss	5.219
	100.000

This clay, which was collected for comparison with the Fulton county tertiary deposits, would prove of no especial value as a fertilizer, except on very sandy soils to improve their consistence. It would probably answer for common pottery or bricks; but is too fusible for fire-brick. It compares pretty well with No. 1439.

GRAYSON COUNTY.

No. 1444—CLAY IRON-STONE "*From three miles south of Litchfield. A six inch layer, on the land of Jno. H. Higden, in the carboniferous limestone. On the old Brownsville road. Collected by Prof. N. S. Shaler.*"

Fine granular, or compact. Dark grey.

COMPOSITION DRIED AT 212° F.

Iron, carbonate	60.466	} = 33.630 per cent. of iron.
Iron, peroxide	6.536	
Alumina	7.179	
Lime carbonate	4.050	
Magnesia, carbonate	6.378	
Manganese, carbonate	a trace.	
Phosphoric acid	.102	= 0.035 per cent. of phosphorus.
Sulphuric acid	.054	= .022 per cent. of sulphur.
Silica and insoluble silicates	14.450	= 11.900 per cent. of silica.
Water and loss	.785	
	100.000	

Quite a good ore of its kind.

No. 1445—LIMONITE IRON ORE. "From north side of Grindstone branch of Rock Creek. Hill below Owen Whittrie's. Grayson county. Collected by P. N. Moore."

A porous and cellular limonite, varying in color from dark brown and steel black to reddish-brown and ochreous.

COMPOSITION, DRIED AT 212° F.

Iron, peroxide	27.192	= 19.344 per cent. of iron.
Alumina	4.299	
Manganese, brown oxide	a trace.	
Lime carbonate	.410	
Magnesia	.317	
Phosphoric acid	.249	= 0.109 per cent. of phosphorus.
Sulphuric acid	.103	= .041 per cent. of sulphur.
Water expelled at red heat	5.600	
Silica and insoluble silicates	61.730	= 25.500 per cent. of silica.
Moisture and loss	.100	
	100.000	

This ore is too poor in iron and too silicious to be of much value.

[See Appendix for other Grayson county iron ores.]

No. 1446—MARLY SHALE. "From Sunset Lick, a mile and a half west of Litchfield. Geological position the carboniferous formation. Collected by Prof. N. S. Shaler."

A friable marly shale of a greyish and brownish-olive color. This marl, when analyzed by digestion in acids, &c., gave the following results, dried at 212° F., viz:

Alumina, and iron and manganese oxides	19.133
Lime	.269
Magnesia	.353
Phosphoric acid	.267
Sulphuric acid	.027
Potash	2.910
Soda	.052
Water expelled at red heat	6.230
Silica and insoluble silicates	71.580
Total	100.821

The *silica and insoluble silicates*, when *sintered* with lime carbonate and ammonium chloride, &c., &c., yielded 1.205 per cent of *potash*, and 0.55 per cent. of *soda*, in addition to that given above as extracted by digestion in acids. So that the *total* amount of potash in the marl appears to be 4.115 per cent. and that of soda 0.602 per cent.

Some of the same marly shale, from this locality, subsequently collected by Mr. P. N. Moore, was analyzed by fusion with the mixed alkaline carbonates; *sintering* with lime carbonate and ammonium chloride, &c., &c., and gave the following results, viz:

Alumina	14.130
Iron and manganese oxides	13.480
Lime	.538
Magnesia	1.158
Phosphoric acid	.280
Sulphuric acid	.204
Potash	4.625
Soda	.783
Water, &c., expelled at red heat	6.000
Silica	60.060
Total	101.258

The apparent excess in the total may be partly due to oxidation of combined iron and sulphur in the marl, and probably, also, to an over-estimation of the water.

Its considerable proportion of *potash* might make it useful as a fertilizer on impoverished land, were this alkali all in an *available* condition. But the analyses show that a great portion of it is in firm combination, in the silicates insoluble in acids; only to be released, and made available for plant growth, by the slow process of weathering, under the influence of atmospheric agencies, *humus*, &c. Whether lime could be profitably employed to decompose these silicates and set free the alkalies, is yet to be tried.

The remarks given under the head of marly shales of Campbell and Franklin counties, as to their use as "mineral paint," &c., apply to this marly shale also.

No. 1447—"SOFT SANDSTONE; a micaceous, uncemented sand rock, from Horse Branch, on the Elizabethtown and Paducah Railroad. Border of Grayson and Ohio counties. Very friable. Can be shoveled like sand. Collected by Prof. N. S. Shaler. Geological position carboniferous."

Of a light drab, or grey-buff color, consisting of small quartz grains, mostly rounded, some spangles of mica, some few grains of blackish and greenish ferruginous mineral, and a fine powder, somewhat ferruginous, which can easily be washed out from the quartz sand, &c., by water. Water disintegrates the lumps.

This soft sand rock, dried at 212°, gave the following results, on analysis by acid digestion, &c.:

Sand and insoluble silicates	87.700
Alumina, colored with iron oxide	7.040
Lime (estimated as carbonate)	.100
Magnesia	.245
Phosphoric acid	.370
Sulphuric acid	.049
Potash	.975
Soda	.401
Water, &c., expelled at red heat	3.000
Loss	.120
Total	100.000

This would undoubtedly answer well for the manufacture of common glass. Its considerable proportion of potash, nearly one per cent. extracted by acids, has probably been mainly derived from the mica which it contains, while the phosphoric acid, also considerable for a sand, has doubtless been mostly extracted from the dark greenish mineral. This sand would prove a useful addition to heavy clay soil. No doubt analysis by fusion would show that it contains a much larger proportion of potash than digestion in acids demonstrates.

No. 1448—COAL. Labeled "Tar Lick Coal, Dismal Creek, Grayson county. Average sample, by P. N. Moore."

Mostly in thin laminæ, with some bituminous matter, fibrous coal, and fine-granular pyrites between them. Generally of a deep-black color, with occasional ferruginous stains.

No. 1449—COAL. "Gravelly Lick, Miller's Fork of Bear Creek. Average sample, by P. N. Moore."

Splitting into thin laminæ, with a little fibrous coal and fine-granular pyrites between.

No. 1450—COAL. "Near the School-house, on Brushy branch of Calloway Creek, W. B. McGrew's. Collected by P. N. Moore."

Much weathered.

No. 1451—COAL (impure) "Copperas bank, branch of Hunting Fork of Rock Creek, above the conglomerate. Collected by P. N. Moore."

Mostly in thin laminæ, some of which are shaly. Some ferruginous incrustation.

No. 1452—COAL. "L. Higdon's, Pearson's branch of Rock Creek. Below the conglomerate. About fifteen feet above the limestone. Collected by P. N. Moore."

A jet-black coal; generally breaking into thin laminæ, some of which are somewhat shaly. Not much fibrous coal or granular pyrites apparent. Some ferruginous incrustation.

No. 1453—COAL (impure) "From Gum Spring Fork of Cane Camp Creek, Nolin Furnace property. Sample from above the slate parting only. Collected by P. N. Moore."

A much weathered coal, in thin laminæ, much tarnished with ferruginous and aluminous incrustations.

No. 1454—COAL (impure) "From same locality as preceding. Sample from below the slate parting only. Collected by P. N. Moore."

In thin laminæ, some shaly; weathered dull and stained with ferruginous and clayey incrustation.

COMPOSITION OF THESE GRAYSON COUNTY COALS, AIR-DRIED.

	No. 1448.	No. 1449.	No. 1450.	No. 1451.	No. 1452.	No. 1453.	No. 1454.
Specific gravity	1.305	1.395	1.346	1.378	1.364	1.446	1.512
Hygroscopic moisture . .	4.70	4.14	6.26	3.50	3.60	6.50	4.40
Vol. combustible matters .	31.40	30.52	32.44	33.40	35.80	29.10	25.86
Coke	63.90	65.34	61.30	63.10	60.60	64.40	69.74
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Total volatile matters . .	36.10	34.66	38.70	36.90	39.40	35.60	30.26
Carbon in the coke . . .	52.20	50.08	53.80	47.50	49.40	49.60	40.14
Ashes	11.70	15.26	7.50	15.60	11.20	14.80	29.60
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Character of the coke . .	Spongy.	Dense spongy.	Light friable.	Light spongy.	Light spongy.	Friable.	Friable.
Color of the ash	Light brownish grey.	Brownish grey.	Greyish-salmon.	Lilac-grey.	Light chocolate	Light brownish	Nearly white.
Per centage of sulphur . .	1.945	3.565	1.476	2.041	3.158	0.818	0.777

No. 1455—"COAL, remarkable for being found in the sub-carboniferous limestone; about seventy-five to a hundred and twenty feet below the Chester Group. Collected by C. J. Norwood."

A much weathered specimen; splitting easily into thin laminæ, with very little fibrous coal or pyrites between. Some little ferruginous stain.

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COMPOSITION—SPECIFIC GRAVITY = 1.338.

Hygroscopic moisture	4.24
Volatile combustible matters	30.82
Coke (light friable)	64.94
Total	100.000
Total volatile matters	35.06
Carbon in the coke	55.52
Ashes (brownish salmon-grey)	9.42
Total	100.00
Per centage of sulphur	2.892

Interesting only because of its unusual position.

GRAYSON SPRINGS MINERAL WATERS.

These waters were mostly collected and tested qualitatively, at the springs, by Mr. Jno. H. Talbutt; who spent several days in this work and in the evaporation of a quantity of some of the principal ones, for the purpose of determining the more rare ingredients. The quantitative analyses were performed at our chemical laboratory in Lexington.

No. 1456—"SULPHUR WATER from the Centre Spring, a natural spring, the most popular of the Grayson Springs."

Inclosed in a "gum" three feet deep and one and a half feet in diameter. Flows in a perennial stream, of about half an inch diameter. Gas bubbles up frequently, in moderate intermittent bursts. The water is of nearly a constant temperature of 61° F.; clear, depositing in its channel a dark-grey slimy sediment; and on the gum an incrustation varying in color from blackish and brownish to greenish and pinkish.

The spring is about two hundred yards southeast from the hotel. Has a reputation as diuretic, aperient, &c., &c. Reaction of the recent water is neutral with litmus paper, but when it has been partly evaporated it is slightly alkaline.

No. 1457—SULPHUR WATER from the Moreman Spring.

A natural spring, inclosed in a sycamore "gum" (twenty-two inches deep by eleven in diameter). Stream constant the

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year round, through a three-quarter inch hole. Bubbles of gas rise intermittently. Sediment in the channel of overflow, whitish; that at the bottom of the gum greenish-black, and slimy. Temperature of the water 66° to 67° F., nearly constant.

Considered one of the best of the waters for cutaneous diseases. Acts pretty constantly as aperient. Reaction of the recent water, neutral.

No. 1458—SULPHUR WATER *of the McAtee* Sulphur Spring.*

A natural spring (said to have two sources, one warm the other cold), located at the base of the hill, farthest of all from the house, nearest to the creek; near the bath-house. Included in a wooden box, fourteen by twenty-two inches, and twenty inches deep. The flow is about sufficient to fill a half inch pipe. There is a slight intermittent evolution of gas. Temperature, said to be invariable, at 60° F. The sediment in the box is dark green, with much pinkish; slimy. The incrustation on the box, greenish of various tints and shades. This water is not quite so strong as that of the "Center Spring."

No. 1459—SULPHUR WATER *of the "Stump Spring."*

A natural spring, included in a sycamore "gum," twelve inches in diameter and twenty deep. The flow is about a quarter to half inch in diameter. There is a slight evolution of gas in bubbles. Temperature of the water 64° F., said to be invariable. The sediment in the gum is blackish and slimy. The incrustation very slight, and nearly black. The taste of the water is sweetish-brackish. Reaction with litmus papers, neutral.

No. 1460—SULPHUR WATER *of the "Jar Spring."*

A natural spring, nearest to the house (near the Stump and Big Gum Springs), included in a gum twelve inches in diameter

* Called by Dr. Owen "Macatine." Volume 1, Kentucky Geological Reports, page 270.

and twenty-six deep. Flow of water from quarter to half an inch in diameter. Slight evolution of gas in bubbles, smelling strongly of sulphuretted hydrogen, as do all the others. Temperature of the water 63° F., said to be constant. Taste sweetish. Reaction, neutral. The sediment is dark-colored; slimy. The incrustation on the gum whitish, with greenish and purplish tints.

No. 1461—SULPHUR WATER *from the "Eye Spring."*

A natural spring, included in a "gum" ten to eleven inches in diameter and twenty deep. The flow of water is about a quarter of an inch in diameter. Temperature of the water, 66° F., said to be invariable. (The temperature of the atmosphere, at the time of observation, was 86° F.) Very little evolution of gas bubbles. The sediment in the gum is dark, and slimy. The incrustation on the gum dark green, yellowish, and purplish, and dirty-whitish. Taste brackish. Reaction, neutral.

No. 1462—SULPHUR WATER *from the "White Sulphur Spring," near the "Big Gum," and between it and the Moreman Spring, to the left of the walk.*

Flow about quarter to half an inch in diameter. A slight intermittent evolution of gas bubbles. Temperature 62° F., said to be invariable. Incrustation whitish. Sediment greenish near the gum. Tastes and smells stronger of sulphuretted hydrogen than any of the other springs. Reaction, neutral. Water not at present used.

No. 1463—SULPHUR WATER *from the "Hymenial Spring."*

A feeble spring, situated about ten feet from the "Center Spring." Temperature of the water 65° F., said to be invariable. Sediment greenish-black, with pinkish portions, and slimy. Incrustation on the "gum" dark-green and dirty-white. Reaction, neutral.

No. 1464—SULPHUR WATER from the "Rock Spring."

The original spring of the group. Situated at the base of the hill. Flows out from the rock in a constant stream, which might fill an inch pipe. Temperature 58° F., said to be invariable. A whitish scum on the water in the channel of out-flow; no gas bubbles evolved. Sediment bluish-blackish. Reaction, *neutral*. Not very strong in sulphuretted hydrogen.

No. 1465 — SULPHUR WATER from an Artesian Well, one thousand feet deep, and six inches in diameter, completed in 1865.

Bored for "oil" on Hunting Fork, a tributary of Rock Creek, near Mr. H. Haynes', six miles from Grayson Springs, on the property of the Boston Kentucky Central Rock Oil Company, H. W. Fuller, President. At first the water spouted twenty feet above the surface of the ground, from the two-inch tube. The tube is now out, and the hole has been widened for six feet down and cased with an eight-inch square wooden box. The water now flows out in a six-inch stream. Temperature 61.5° F. Gas is evolved constantly in large bubbles. The incrustation on the boxing, &c., is blackish, and is to be seen in the channel of the stream for half a mile down. The water is clear and colorless, and gives an *alkaline reaction*. A salt water stream is said to enter the well about one hundred and fifty feet below the surface.

COMPOSITION OF THESE SULPHUR WATERS OF GRAYSON COUNTY IN 1000 PARTS.

Name of spring	Centre.	More-man.	McAtee.	Stump.	Jar.	Eye.	White Sulphur.	Hymenial.	Rock.	Artesian
	No. 1456	No. 1457	No. 1458	No. 1459	No. 1460	No. 1461	No. 1462	No. 1463	No. 1464	No. 1465
Specific gravity of water	1.0022	1.0011	1.0015	1.0016	not est.	not est.	not est.	not est.	not est.	not est.
Free carbonic acid gas .	0.1950	0.1234	0.1500	0.1650	0.2020	not est.	not est.	not est.	not est.	not est.
Free sulphuretted hydrogen gas	.0200	.0248	.0203	.0410	.0265	0.0239	0.0270	not est.	not est.	0.0380
Lime carbonate	0.1736	0.1952	0.1806	0.2002	0.1632	0.1872	0.1832	0.1525	0.1660	0.1360
Magnesia carbonate . .	a trace.	.0512	.0002	a trace.	.0345	.0042	.0018	not est.	.0118	.0228
Iron, and manganese carbonates and phosphates	.0027	.0048	.0078	.0066	.0072	.0096	.0096		.0072	.0116
Silica	.0022	.0094	.0028	.0008	.0032	.0036	.0104		.0022	.0260
Organic matters and loss	not est.	not est.	.0022	.0268	.0271	.0096	.0090		.0304	.0038
Total sedi'nt on boiling	0.1785	0.2606	0.1914	0.0342	0.2352	0.2132	0.2140	not est.	0.2176	0.1992
Lime sulphate	1.1649	0.4541	0.4528	0.6291	0.5078	0.6683	0.6505	0.9001	0.5946	1.3044
Magnesia sulphate . . .	.5774	.3768	.4616	.6093	.5781	.7542	.6522	.8835	.4704	.8778
Potash sulphate			.0024	.0023	.0045	.0017		.0085	.0011	not est.
Soda sulphate			.0126	.0374		.0147			.0288	not est.
Iron, manganese and alumina sulphates and phosphates	.0034	.0007	.0192	not est.	traces.	traces.	traces.	traces.	traces.	traces.
Sodium sulphide	.0521	.0409	not est.	not est.	.0207	.0100	.0257	.0220	.0059	.0254
Soda combined with organic acids	.0044	.0066								
Potash	.0009	.0038								
Sodium chloride		.0145								
Magnesium chloride . .	0.1898	.0029	.0060	.0022	.0008	.0058	.0158	.0032	.0048	.0056
Silica	.0034	not est.	not est.	.0200	.2029	.0222	.1777	not est.	.1484	not est.
Organic matters and loss	not est.	not est.	not est.	.0200	.2029	.0222	.1777	not est.	.1484	not est.
Total saline matters .	2.0748	1.1609	1.3252	1.5740	1.6260	1.7960	1.7470	1.9974	1.4800	2.7084
Lithium, iodine and bromine	traces.	traces.	traces.	traces.	not est.	not est.	not est.	not est.	not est.	not est.
Temperature of spring, F.	61°	66°, 67°	60°	64°	6°	66°	2	15°	57°	61°, 65°

The small quantities of lithium compound, indicated in the above table, were detected by means of the spectroscope, after proper treatment of the saline residuum obtained by the evaporation of from ten to twenty litres of the water. The bromine and iodine traces could only be observed by the appropriate tests after a similar evaporation.

The *organic matters* recorded in the table are composed of *apocrenic* and *crenic* acids and the singular substance called *Barégine*, from the fact that it was first observed in the sulphur water of the celebrated Barège Springs of the Pyrenees.

This *Barégine* is found in solution in many of the sulphur waters of the world; more especially in the thermal waters.

On evaporation of such waters they assume a yellowish tint and leave a yellowish-brown residue, which, on calcination, gives out ammoniacal fumes and the odor of burnt horn; leaving a very large proportion of ash, mainly silicious. This organic matter, approaching to the nature of the albuminoid or gelatinous principles, is what is called Barégine.

By exposure of these waters to the air this dissolved nitrogenous matter undergoes a change; becomes less soluble and forms a sediment, or deposit, in the spring and its channel, of a slimy nature, which is called *glairine*, and which is usually combined with other precipitated materials from the water, such as iron and manganese sulphides, lime and magnesia carbonates, free sulphur, &c., &c., and probably changes, by gradual decomposition, into *crenic* and *apocrenic acids*, &c.

Glairine, with crenic and apocrenic acids, and other substances mentioned above, were abundantly found in the unctuous slimy sediment of these Grayson sulphur springs. Generally more of the latter than of the crenic.

This sediment was collected by Mr. Talbutt from the bottom of the water in the "gum" usually, from the following springs, viz: "Centre," "Moreman," "McAtee," "Stump," and "Hymenial," and brought to the laboratory for examination, in close bottles, with some of the water of the spring included.

On examination, some weeks afterward, the supernatant water was found to be glairy in all except that from the *Stump* Spring. In those from the Centre and Moreman springs the water over the sediment was of a dirty-olive green color, of a sulphurous and putrescent odor, *glairy*, and as thick as ordinary white of egg. When this was poured off and the sediment agitated with more distilled water, this also became glairy and colored, on standing; and the same result was obtained in a second and third operation of the kind; the quantity of the dissolved organic matter appearing gradually to be diminished. The "Centre" sediment gave the most of this glairy material; that of the "Moreman," "McAtee," and "Hymenial" gave less, and that of the "Stump," although it colored the water slightly, did not make it glairy or communi-

cate to it the semi-putrescent, sulphurous odor, so marked with the others.

The glairy colored solution, poured off from the sediment, was evaporated and analyzed. The dark brownish solid residuum, obtained by evaporation, presented the usual properties of *glairine*. It burnt with a burnt-horn, ammoniacal odor, leaving a large quantity, more than forty per cent., of whitish ash. This ash was largely *silicious*, but contained also *alumina*, *iron* and *manganese oxides*, *lime*, *magnesia*, and *phosphoric* and *sulphuric acids*. The glairley soluble matter also contained apocrenic acid.

The dark colored original sediments, which had thus been washed with water to remove some of the glairine, &c., were found to contain much *apocrenic* and *crenic* acids, especially the former, with alumina, iron and manganese oxides, lime, magnesia, phosphoric and sulphuric acids, sulphur, &c. Becoming somewhat charred when calcined and giving off the odor of burnt animal and vegetable matters. That from the "Centre" Spring giving more of the odor of burnt animal matter. Those of the others giving mostly the odor of burnt vegetable matter.

Doubtless the other sulphur waters of this locality also contain these remarkable organic ingredients, or most of them. What influence they have in therapeutic applications of these waters has not been determined. It is probable, however, that this decomposable organic material, from whatever unknown source derived, may, by reaction upon the dissolved earthy sulphates of the water, produce some of the sulphydric acid which it contains.

It may be interesting to append the chemical composition of *glairine* of three different varieties, as determined by J. Bouis. ("Comptes Rendus," XLI, page 116.)

	Carbon.	Hydrogen.	Nitrogen.	Ashes.
Glairine, pulpy, grey	48.69	7.70	8.10	30.22
Glairine, fibrous, red	44.06	6.69	5.57	35.00
Glairine, pulpy, green	45.20	6.95	5.60	40.07

No. 1466—CHALYBEATE WATER, *from the chalybeate well at Grayson Springs.*

Well ten feet deep; walled up with rock, three feet square. Water about four feet deep in well. It is said that three streams of chalybeate and one of fresh water flow into it. A very slight occasional evolution of gas. Temperature of the water, 71° F. The water is raised with a wooden pump. The sediment or deposit, where the water flows from the pump and trough, is ferruginous, brownish-red. Reaction, *neutral*.

No. 1467—CHALYBEATE WATER, *from a well near Grayson Springs; sent by Mr. Van Meter, proprietor of the springs, for examination.*

This, like the preceding, deposited a flocculent light-brown ferruginous sediment in the containing bottle.

No. 1468—CHALYBEATE WATER, *from "Indian Spring," a natural source, near Jones' Mill; head of Sunfish Creek, five miles from Paducah and Louisville Railroad. Sent for examination by Mr. H. Haynes.*

This also deposited a brownish ferruginous sediment in the bottle.

COMPOSITION OF THESE CHALYBEATE WATERS, IN 1000 PARTS OF THE WATER.

	No. 1466.	No. 1467.	No. 1468.
Free carbonic acid	0.207	not est.	not est.
Lime carbonate	0.1251	0.2580	0.0076
Magnesia carbonate	a trace.	.0020	a trace.
Iron and manganese carbonates and phosphates, with traces of alumina	.0118	.0800	.0133
Silica	.0022	.0180	.0028
Total, held in solution by carbonic acid	0.1391	0.3580	0.0237
Lime sulphate	0.0110	2.328	0.0692
Magnesia sulphate	a trace.	.741	a trace.
Potash sulphate	a trace.	.063	a trace.
Soda sulphate	a trace.	1.130	a trace.
Sodium chloride	.0081	.1510	.0423
Potassium chloride	.0076	.	.0038
Silica	not est.	.0150	.0086
Total saline contents	0.1658	4.786	0.1476

From these analyses, which can only be considered approximate, it appears that the water from the well near Grayson Springs is the strongest and the most aperient. The small quantity of the water sent, and the alterations which always take place in waters of this kind, under the influence of the atmosphere, prevent these examinations from being entirely conclusive.

No. 1469—SOIL. "*Sample to the depth of eight inches from an old field, fifty years in cultivation, which has been lying uncultivated for the last fifteen years. Collected by C. Schenk.*"

Situated twenty-five hundred feet west of the twenty-first mile-post on the Louisville and Paducah Railroad; west of Big Clifty. Locality, six hundred and seventy feet to the right of that road and four feet above the level of the rail. Underlying rock, *sandstone*. Timber of the locality, mostly black oak, with some white and red oak; with a few poplars on the creeks. *Undergrowth* sumach, dogwood; much sassafras and persimmon. *Rotation of crops*: 1. Tobacco; 2. Corn; 1. Oats; sometimes with clover. No manure. *Yield*: of corn and oats, of each ten bushels to the acre. Soil of a yellowish light-umber color.

No. 1470—SOIL. "*Sub-soil of the preceding, taken at a depth of from eight to forty inches. Collected by C. Schenk.*"

Sub-soil of a dull-light-brick color.

No. 1471—"VIRGIN SOIL. *Sample to depth of six inches. Collected by C. Schenk.*"

From a point two hundred feet east of the twenty-second mile-post, on above named railroad; two hundred and fifty feet to the right of the road, and four feet above the level of the rail. Underlying rock, *sandstone*. Has been two years in cultivation. Usual yield of this locality, according to report of the farmers, of corn and oats, each ten to twenty bushels, and of wheat five to ten bushels. It yields tobacco only when manured. Timber same as in preceding.

Soil of a greyish-brown or light umber color. The coarse sieve (two hundred and eighty-nine meshes to inch) removed from it a few rounded ferruginous particles only.

No. 1472—"Sub-soil of the next preceding; taken to the depth of from six to thirty-six inches. Collected by C. Schenk."

Sub-soil of a light greyish-buff color. Contains a few small rounded ferruginous particles.

No. 1473—"VIRGIN SOIL, three years in cultivation. Collected by C. Schenk."

Sample to the depth of seven inches, from a locality one thousand feet west of the twenty-sixth mile-post, on the Louisville and Paducah Railroad, and three hundred and sixty feet to the left of that road, at the level of the rail. Drainage slope = 1:150. Substratum, *limestone*. Timber, red, black, and white oak, with sugar-tree and poplar. Timber full of holes, except the poplar. Undergrowth, dogwood, sassafras, persimmon. Sometimes one hundred cords of wood to the acre.

Rotation of crops: two years in corn; yield, twenty-five bushels to the acre; one year in oats; same yield. New land here yields fifteen to thirty bushels of corn, twenty to thirty of oats, and eight hundred to a thousand pounds of tobacco, per acre.

Soil of an umber color; darker than the preceding virgin soil. It contains a few rounded ferruginous particles.

No. 1474—"Sub-soil of the next preceding, taken at the depth of from seven to thirty-six inches. Collected by C. Schenk."

Sub-soil of a light grey-buff color. Contains a few small rounded ferruginous particles.

No. 1475—SOIL. "Sample to the depth of five and a half inches, of an old field, forty years in cultivation. Collected by C. Schenk."

Near the Grayson Spring Station, Louisville and Paducah Railroad, four hundred and fifty feet to the right of that road,

at a point five hundred and thirty feet east of the twenty-six mile-post. Fifteen feet above the level of the rail. Drainage slope = 1:30. Substratum, *limestone*. Rotation of crops: two years in corn, one in oats and clover (sometimes tobacco first). Field has been in grass for the last three years. Yield: corn, twelve to twenty bushels; wheat, eight; and oats, fifteen per acre.

Dried soil of a brownish-grey color. Sifted out very few small rounded ferruginous particles.

No. 1476—"Sub-soil of the next preceding, taken from five and a half to thirty-six inches below the surface. Collected by C. Schenk."

Sub-soil of a grey-buff color. Contains but few rounded ferruginous particles.

NOTE.—For the rest of this serial collection of soils, &c., made by Mr. Schenk, on and near the line of the Elizabethtown and Paducah Railroad, see Hardin and Ohio counties.

COMPOSITION OF THESE GRAYSON COUNTY SOILS, &c., DRIED AT 212° F.

	No. 1469	No. 1470	No. 1471	No. 1472	No. 1473	No. 1474	No. 1475	No. 1476
Organic and volatile matters	3.850	3.375	4.850	3.200	4.950	3.350	4.500	3.275
Alumina, and iron and manganese oxides	7.215	10.990	5.515	7.497	6.195	6.647	4.172	6.022
Lime carbonate	.345	.195	.145	.045	.340	.020	.220	.145
Magnesia	.240	.159	.140	.140	.176	.104	.167	.125
Phosphoric acid	.076	.166	.125	.093	.125	.093	.118	.093
Sulphuric acid	Not estimated.							
Potash	.243	.308	.112	.105	.327	.105	.120	.405
Soda	.125	.104	.051	.044	.023	.070	.045	.045
Sand and insoluble silicates	86.850	84.490	88.790	87.565	86.780	88.965	90.640	89.580
Water expelled at 380° F.	.925	.425	1.325	.875	1.075	1.100	1.100	.350
Loss	.131			.436	.009			.005
Total	100.000	100.212	101.053	100.000	100.000	100.454	101.082	100.000
Moisture expelled at 212° F.	2.025	2.925	2.125	2.700	1.950	1.650	1.775	3.500
Potash in the insoluble silicates	1.0395		1.002					.828
Soda in the insoluble silicates	0.479		.377					.624
Character of the soil.	Old field soil.	Sub-soil	Virgin soil.	Sub-soil	Virgin soil.	Sub-soil	Old field soil.	Sub-soil

Although these Grayson county soils cannot be classed amongst the naturally very rich soils, because they are rather too sandy; yet, if they are well drained, they may be made quite profitable with proper management and by the judicious

use of fertilizers. There is no reason, except unskillful culture, why they are not at present more productive than is represented above. Their near vicinity to good markets should introduce a more scientific husbandry.

GREENUP COUNTY.

No. 1477—CLAY. Labeled "Fire-clay, Louder's land, near Kenton Furnace. Collected by P. N. Moore."

A compact, fine-grained, non-plastic clay-stone of a light-grey color; hardly adhering to the tongue; breaking readily into sharp angular fragments; fracture somewhat conchoidal. This, when reduced to powder, easily works up with water into a plastic mass, which is the case with the other samples of this kind described below.

No. 1478—"FIRE-CLAY, two feet above the limestone ore; head of Powder-mill hollow, two miles from Kenton Furnace. Collected by P. N. Moore."

An olive-grey shaly clay, breaking easily into layers, but not so easily across them; adhering to the tongue.

No. 1479—"CLAY, fourth above the limestone and limestone ore, on Pea Ridge. Thickness two to two and a half feet. Weathering white. Collected by J. A. Monroe."

A whitish clay, in soft friable lumps; colored with oxide of iron in the crevices.

No. 1480—"CLAY; thin bed, resting on limestone ore of Pea Ridge, near Hunnewell."

A soft friable plastic clay; colored olive-green and brownish and yellowish-grey.

No. 1481—"CLAY. Two and a half feet bed; second above limestone ore. Pea Ridge. Collected by J. A. Monroe."

Olive-brownish-grey. Harsh to the feel. Breaks in angular fragments.

No. 1482—"CLAY, fourteen inches thick. Third bed above the limestone ore at Pea Ridge. Collected by J. A. Monroe."

A brownish-grey compact clay, breaking into irregular layers, which are polished on their surfaces; adheres slightly to the tongue.

No. 1483—CLAY. "Fire-clay. Thomas' bank. Average sample of upper layer; five feet above the cherty limestone. Head waters of Wing's branch of Shultz Creek. Collected by P. N. Moore."

A compact clay-stone of a light-grey color (yellowish and bluish); even fracture; soapy feel; not scratched by the nail; scarcely adhering to the tongue.

COMPOSITION OF THESE GREENUP COUNTY CLAYS, DRIED AT 212° F.

	No. 1477	No. 1478	No. 1479	No. 1480	No. 1481	No. 1482	No. 1483
Silica	49.680	62.920	66.560	47.060	67.700	55.560	47.560
Alumina	35.281	20.735	22.679	36.620	22.092	31.027	40.661
Iron oxide, &c.	a trace.	3.820	a trace.	a trace.	a trace.	a trace.	a trace.
Lime	.213	.213	.157	.615	.101	.325	.280
Magnesia	.136	2.281	.605	.389	.285	.403	.497
Phosphoric acid	.626	.371	.563	.626	.498	.358	.249
Sulphuric acid	not est.	not est.	not est.	not est.	not est.	not est.	a trace.
Potash	.193	2.601	1.946	1.156	1.156	1.167	.308
Soda	.211	.659	.690	.234	.268	.560	.409
Water expelled at red heat, and loss	13.660	6.400	6.800	13.300	7.900	10.600	10.036
Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000

On submitting these clays to the action of the blow-pipe, No. 1480 was found to be most softened by the heat, while Nos. 1477, 1481, and 1483 were most refractory; the others occupied an intermediate position. They all burnt nearly white, but No. 1478 burnt of a light-buff color, and No. 1479, No. 1480, and No. 1483 acquired a very light pink tint on being calcined. They are undoubtedly all very good clays, and the more silica they contain, within certain limits, and the smaller their proportions of potash, soda, oxide of iron, lime, magnesia, and phosphoric acid, the better they withstand the melting influence of fire.

[See Carter county for other clays of this kind.]

No. 1484—"COAL, No. 1, used at Kenton Furnace. Average sample."

A brittle coal, breaking into irregular layers; fractured surface dark, glossy, asphaltum-like. Impressions of reedy leaves on the laminæ, and some fine-grained pyrites.

No. 1485—"COAL, average sample, from J. Thompson's bank, near Kenton Furnace. Bed sixteen inches thick. Collected by J. A. Monroe."

A brittle coal, breaking into thin irregular layers, which have much pulverulent mineral charcoal between them.

No. 1486—COAL, No. 3. "Average sample of the main coal of Raccoon Furnace. Below the shale parting."

A dark colored coal, breaking easily into thin layers. Separated by much fibrous coal, with some fine-grained pyrites diffused in it.

No. 1487—COAL, No. 3. "Average sample of the upper part of the coal used at Raccoon Furnace. Mine one and a third miles east of southeast of the furnace. The upper twenty inches of the thirty-six inch bed. Collected by P. N. Moore."

Much like the preceding.

No. 1488—COAL. "Main coal, No. 3; lower part below the shale parting. Buffalo Furnace. Averaged by P. N. Moore."

No. 1489—"MAIN COAL, No. 3; above the shale parting. Buffalo Furnace. Averaged by P. N. Moore."

No. 1490—COAL. "Alcorn Creek coal; probably sub-conglomerate. Raccoon Furnace. Averaged by P. N. Moore."

No. 1491—COAL, No. 1. "Hanna bank coal. Average of the upper portion of the bed, from the stock pile, by P. N. Moore."

No. 1492—"Hanna bank coal, &c. Averaged from the lower part of the bed, from the stock pile, by P. N. Moore. Coals identified by Mr. Witherow."

No. 1493—"COAL, probably No. 3; thirty feet below the Kidney ore, Laurel Furnace. Average from coal shed, by P. N. Moore."

No. 1494—COAL, No. 6; from the hill back of Amanda Furnace. Average sample from all parts of the bed, by A. R. Crandall."

A bright, jet-black, splint coal, with but little fibrous coal between the layers. Some slight ferruginous external stain.

No. 1495—COAL, No. 6; from branch above the shops, Hunnewell Furnace. Averaged from the upper part of the bed only, by A. R. Crandall."

Splint coal. Has but little fibrous coal between the laminæ. Slight external ferruginous stain.

No. 1496—COAL, No. 3. "From drift near Pennsylvania Furnace. Averaged by P. N. Moore."

A glossy jet-black coal, with fibrous coal and very little appearance of pyrites between the thin laminæ.

No. 1497—COAL, No. 6. "From a new opening one mile above the shops at Hunnewell Furnace. (Old Greenup Furnace.) Average sample."

A glossy pitch-black splint coal; shows but little fibrous coal or pyrites.

[See Appendix for other Greenup county coals.]

COMPOSITION OF THESE GREENUP COUNTY COALS, AIR DRIED.

	No. 1484	No. 1485	No. 1486	No. 1487	No. 1488	No. 1489	No. 1490	No. 1491	No. 1492	No. 1493	No. 1494	No. 1495	No. 1496	No. 1497
Specific gravity	1.316	1.345	1.250	1.420	1.374	1.389	1.374	1.389	1.292	1.289	1.335	1.365	1.300	1.355
Hygroscopic moisture	4.82	4.06	4.80	4.28	3.20	2.90	3.30	4.00	3.20	4.10	4.04	4.30	3.20	3.80
Volatile combustible matters	32.90	32.08	34.64	36.52	30.26	33.76	31.80	31.66	33.90	34.06	33.62	35.60	36.60	37.70
Coke	62.28	62.06	60.56	59.20	60.54	63.34	64.80	64.34	62.90	60.94	62.34	60.10	60.20	58.50
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Total volatile matters	37.72	37.04	39.44	40.80	39.46	36.66	35.20	35.66	37.10	39.06	37.66	39.90	39.80	41.50
Carbon in the coke	55.18	55.46	52.58	47.00	47.54	51.34	52.20	53.44	56.70	55.54	53.34	50.24	53.14	47.20
Ash	7.10	6.60	7.98	12.20	13.00	12.00	12.60	10.90	6.20	5.40	9.00	9.86	7.06	11.30
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Character of the coke	Friable	Light spongy	Dense	Dense	Spongy	Dense	Friable	Spongy	Spongy	Spongy	Dense	Spongy	Dense spongy	Spongy
Color of the ash	Chocolate	Lilac-grey	Lilac-grey	Lilac-grey	Dark lilac-grey	Dark lilac-grey	Lilac-grey	Dark lilac-grey	Lilac-grey	Dark brick	Light lilac-grey	Grey-purple	Lilac-grey	Dark-brown purple
Per centage of sulphur	1.409	4.774	1.331	5.934	3.647	4.911	2.507	4.633	0.746	1.590	1.318	5.263	2.264	4.213

These comparative analyses show how much the coal of a given bed may vary in its different layers in the proportion of sulphur, ashes, &c. These Greenup county coals are generally very good coals, well suited to the working of iron. Some of them, however, are rather too sulphurous for this purpose.

A certain correspondence, not perfect, is to be observed in these coals, between their *specific gravity* and proportion of *ash*, as is shown below:

Specific gravity.	Per centage of ash.	Specific gravity.	Per centage of ash.
1.250	7.98	1.355	11.03
1.289	5.40	1.365	9.86
1.292	6.20	1.374	12.60
1.300	7.06	1.374	13.00
1.316	7.10	1.389	10.90
1.335	9.00	1.389	12.00
1.345	6.60	1.420	12.20

No. 1498—LIMESTONE. "*Average sample of the ferruginous limestone from Pea Ridge. Collected by J. A. Monroe.*"

A compact, or fine-granular, brownish-grey limestone. Non-fossiliferous. Varying in tint.

No. 1499—LIMESTONE. "*Sub-carboniferous; used as flux at the Raccoon Furnace. From the head of Old Town Creek.*"

A compact or fine-granular limestone, varying in color from light reddish-grey to darker greenish-grey. Contains chert.

No. 1500—LIMESTONE. "*Sub-carboniferous. Average sample of the limestone used as flux at Kenton Furnace. Collected by J. A. Monroe.*"

A compact or fine-granular limestone, of a light-grey color.

No. 1501—LIMESTONE. "*Ferruginous. Buffalo Creek, Boone Furnace.*"

A compact or fine-granular limestone; grey-buff, varying in tint.

COMPOSITION OF THESE GREENUP COUNTY LIMESTONES, DRIED AT
212° F.

	No. 1498.	No. 1499.	No. 1500.	No. 1501.
Specific gravity		2.680	2.700	2.770
Lime carbonate	88.140	88.150	92.050	60.750
Magnesia carbonate	.797	.385	.220	25.656
Iron carbonate				3.420
Alumina				4.167
Iron peroxide	3.760	.152	1.490	
Manganese oxide				
Phosphoric acid	.178	.051	.128	.013
Sulphuric acid	.044	not est.	.199	.315
Potash	.269	not est.	not est.	not deter'd.
Soda	.240	not est.	not est.	not deter'd.
Silica and insoluble silicates	5.960	9.560	4.460	5.680
Loss	.612	1.702	1.453	
Total	100.00	100.00	100.000	100.001
Per centage of lime	49.358	49.359	51.548	34.020
Per centage of phosphorus	.077	0.022	.056	.005
Per centage of sulphur	.017	not est.	.079	.126

These limestones are quite pure enough and quite good for use as flux in the iron furnace. No. 1501 is a magnesian limestone. The proportions of phosphorus and sulphur are low in all of them. Nos. 1499 and 1500 would yield a very pure white lime on calcination.

No. 1502—CLAY IRON-STONE. Labeled "Lower block ore, near the level of the limestone ore. Alcorn Creek, Raccoon Furnace."

A fine-granular, dark-grey ore; adhering slightly to the tongue.

No. 1503—CLAY IRON-STONE. Labeled "Blue kidney ore, locally replacing the main block ore; from drift one mile southeast from Laurel Furnace."

A fine-granular ore, of a grey color more or less deep; with very thin incrustation of limonite ore. Some portions adhere to the tongue.

No. 1504 — CLAY IRON-STONE. Labeled "Main block ore, Amanda Furnace. Averaged by P. N. Moore."

A dark-grey granular proto-carbonate ore, with some dense irregular laminæ of limonite ore.

No. 1505—CLAY IRON-STONE. Labeled "Conglomerate ore, on Darby branch of Clay Lick, Buffalo Furnace. Average sample."

Principally grey granular proto-carbonate ore, with some limonite.

No. 1506—CLAY IRON-STONE. Labeled "Lower block ore," Womack's bank ore, Old Town Creek. Sample from ore weathered six months. Collected by P. N. Moore.

Mostly dense, dark-grey, fine-granular clay iron-stone, with some coarser grained and softer, with a little limonite.

No. 1507—CLAY IRON-STONE. Labeled "Grey ore, or main block ore, Baker bank drift, Laurel Furnace. Averaged by P. N. Moore, from the stock pile. Identified by Mr. G. Coxe."

Mostly proto-carbonate ore, containing many encrinital fossils, with some little limonite.

No. 1508—CLAY IRON-STONE. Labeled "Grey ore from under the hearth rock sandstone, near Raccoon Furnace. Collected by P. N. Moore."

Mainly brownish-grey fine-granular carbonate, with a whitish cement. Contains some little bituminous matter. Incrusted somewhat with reddish-brown limonite ore.

COMPOSITION OF THESE GREENUP COUNTY CLAY IRON-STONES, DRIED
AT 212° F.

	No. 1502	No. 1503	No. 1504	No. 1505	No. 1506	No. 1507	No. 1508
Specific gravity	3.280	3.297			3.263		
Iron carbonate	54.773	78.722	33.321	30.516	44.678	55.258	64.624
Iron peroxide	8.648	.204	21.270	14.271	6.500	13.468	4.044
Alumina	7.800	2.746	4.991	6.197	4.178	.670	4.414
Lime carbonate	3.780	2.250	.980	16.980	2.230	4.880	1.340
Magnesia carbonate	3.088	.380	.439	.591	1.903	4.528	.836
Manganese carbonate	1.204	.421	a trace.	a trace.	a trace.	.660	not est.
Phosphoric acid	.447	.505	.434	.614	.204	.368	.217
Sulphuric acid	.298	1.160	1.208	2.330	.250	1.043	.563
Silica and insol. silicates	20.250	11.340	31.730	28.980	36.880	15.660	20.310
Water, bituminous matters, and loss		2.272	5.627		3.177	4.065	3.650
Total	100.288	100.000	100.000	100.429	100.000	100.000	100.000
Per centage of iron	29.851	38.146	30.975	22.270	26.073	36.103	33.627
Per centage of phosphorus	.195	.221	.189	.267	.089	.200	.095
Per centage of sulphur	.105	.524	.483	.905	.104	.416	.225
Per centage of silica	18.560	9.700	29.520	27.360	34.360	13.360	14.440

Some of the carbonate ores, which contain a larger proportion of iron peroxide, will be found described with the limonite ores. Phosphorus is in rather large proportion in Nos. 1502, 1503, 1504, and 1507, and sulphur exceeds in 1503, 1504, and 1505. Possibly some of this latter may be driven off in the process of roasting the ore. No. 1505, which contains the smallest proportion of iron, having nearly seventeen per cent. of carbonate of lime, may yet be profitably smelted, especially mixed with richer ores.

No. 1509—LIMONITE. "*Limestone ore, Samuel Wamock's land, Tygert Creek. Bed one foot thick. Collected by A. R. Crandall. Not an average sample.*"

Generally of a dark reddish-brown, varying to blackish and yellowish colors. In irregular laminæ. Adhering to the tongue.

No. 1510—LIMONITE. Labeled "*Average sample of lower Block ore, from branch of Tygert Creek.*"

Varying in color, hardness, &c., from dark-brown, hard, irregular laminæ, to yellowish-red and brownish ochreous. Powder of a brownish-yellow color.

No. 1511—LIMONITE (*with some proto-carbonate ore*); labeled "*Limestone ore, Hood's branch of Tygert's Creek. Average sample. Used at Raccoon Furnace.*"

In irregular laminæ of various tints of yellowish and reddish brown, with some portions of clay iron-stone.

No. 1512—LIMONITE, &c. "*Average sample. Poynter bank. Raccoon Furnace.*"

Dark brownish-red fragments, mixed some of clay iron-stone.

No. 1513—LIMONITE. "*Average sample of Two Lick 'Limestone ore,' Kenton Furnace. Averaged by P. N. Moore, from the stock pile.*"

Generally of a dark-brown color, with incrustations of soft ochreous ore.

No. 1514—LIMONITE. Labeled "*Lower block ore,*" from Louder bank. Averaged by P. N. Moore.

In irregular dark-brown laminæ, with softer ochreous and grey material intermixed and incrusting.

No. 1515—LIMONITE. "*Average sample of Coon Fork Limestone ore; taken from the unburnt kiln at Kenton Furnace by P. N. Moore, and identified by Mr. Folson.*"

A dense, chocolate-red ore, scarcely adhering to the tongue. Contains some iron proto-carbonate.

No. 1516—LIMONITE. Labeled "*Shover drift Limestone ore. Average sample, by P. N. Moore, Kenton Furnace.*"

No. 1528—LIMONITE. "*Lower Block ore, on J. Downie's land, Old Town Creek. Averaged by P. N. Moore.*"

Mostly porous, ochreous ore, with some dense limonite laminae included.

No. 1529—LIMONITE. "*Limestone ore; called slate ore. Ridge between Cane Creek and Wilson Creek, Hunnewell Furnace. Average sample, by P. N. Moore.*"

Mostly moderately dense, irregular laminae, of a handsome brownish-purple color, with some ochreous ore.

No. 1530—LIMONITE. Labeled "*Lime kidney ore, Brush Creek, Pennsylvania Furnace. Average sample, by P. N. Moore.*"

Principally in irregular curved laminae, of a dark color; somewhat oölitic; inclosing, and incrustated with, some little undecomposed clay iron-stone.

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COMPOSITION OF THESE GREENUP COUNTY LIMONITES, DRIED AT 212° F.

	No. 1509	No. 1510	No. 1511	No. 1512	No. 1513	No. 1514	No. 1515	No. 1516	No. 1517	No. 1518	No. 1519	No. 1520
Iron, peroxide	80.040	41.556	60.576	54.703	67.859	54.530	46.984	72.957	49.770	50.006	41.390	23.396
Iron, carbonate			15.623	17.758	1.160	2.120	7.890	1.660	6.315	8.317		14.972
Alumina	2.680	8.604	2.860		.980	1.380	5.580	.640	.640	a trace.	6.777	4.077
Manganese, brown oxide	not est.			.440	.120	.040	21.240	.380	.380	.380	a trace.	1.421
Lime carbonate	a trace.	.180	a trace.	.340	.120	.040		.380	.380	.201	.065	33.775
Magnesia	.425	not est.	.619	.499	1.275	1.823	2.904	.083	.115	.767	.579	†968
Phosphoric acid	.115	.882	.632	.128	.143	.908	2.904	.500	.166	.356	.154	.537
Sulphuric acid	.264	.851	not est.	.680	not est.	.336	not est.	.178	a trace.			.157
Alkalies	*.584											
Combined water	10.000	10.100	77.040	†7.194	†12.993	10.900	†6.599	9.340	9.020	11.760	9.700	†5.457
Silex and insoluble silicates	6.560	38.160	12.650	15.958	15.560	28.360	7.860	15.160	33.200	28.820	40.380	16.240
Moisture and loss									.394		.775	
Total	100.668	100.233	100.100	100.000	100.000	100.397	100.000	100.898	100.000	100.607	100.000	100.000
Per centage of iron	56.280	29.089	49.945	46.865	47.501	38.171	39.025	51.070	34.839	35.004	28.973	23.597
Per centage of phosphorus	.050	.358	.276	.055	.062	.428	.131	.218	.072	.339	.252	.224
Per centage of sulphur	.107	.340	not est.	.272	not est.	.134	not est.	.071	a trace.	.142	.061	.070
Per centage of silica	not est.	not est.	not est.	12.960	11.560	not est.	not est.	not est.	32.960	not est.	not est.	13.530

* Potash = 0.346; soda = 0.238.

† Carbonates.

† And loss.

	No. 1521.	No. 1522.	No. 1523.	No. 1524.	No. 1525.	No. 1526.	No. 1527.	No. 1528.	No. 1529.	No. 1530.
Iron, peroxide.	68.928	56.279	56.84	67.984	42.560	64.577	36.985	44.876	57.551	60.206
Iron, carbonate		11.392	not deter'd.	not deter'd.	not deter'd.	not est.	5.508	4.083	6.017	not est.
Alumina	2.768	4.709	not deter'd.	not deter'd.	not deter'd.	1.360	.040	.260	.130	1.044
Manganese, brown oxide	.290	a trace.	not deter'd.	not deter'd.	not deter'd.	.440	.520	.990	.150	a trace.
Lime, carbonate	.680	.180	not deter'd.	not deter'd.	not deter'd.	.820	.533	.357	.758	.285
Magnesia.	.641	.476	not deter'd.	not deter'd.	not deter'd.	.172	.367	.166	.057	.381
Phosphoric acid	.249	.601	not deter'd.	not deter'd.	not deter'd.	.151	.116	.123	.105	.161
Sulphuric acid	.748	.260	not deter'd.	not deter'd.	not deter'd.	*11.250	8.330	9.850	10.300	.852
Combined water.	11.100	*9.173	not deter'd.	not deter'd.	not deter'd.	21.230	46.760	39.080	25.450	9.500
Silicic and insoluble silicates	15.240	16.930	not deter'd.	not deter'd.	not deter'd.		.841	.215		25.930
Moisture, carb. acid, and loss										1.641
Total	100.644	100.000				100.000	100.000	100.000	100.518	100.000
Per centage of iron	48.249	44.896	39.788	47.589	29.792	45.204	25.889	31.413	40.285	42.144
Per centage of phosphorus	.098	.262	not deter'd.	not deter'd.	not deter'd.	.075	.160	.061	.025	.070
Per centage of sulphur	.299	.104	not deter'd.	not deter'd.	not deter'd.	.070	.046	.049	.042	.341
Per centage of silica	13.600	15.260	24.060	12.900	40.160	18.600	44.460	35.960	18.860	20.860

* And loss.

Although some of these ores contain too much phosphorus to make tough iron, they are generally good and profitable. The intelligent reader can estimate their relative value by this table.

[See Appendix for other Greenup county ores, &c.]

No. 1531—PIG IRON. "*Hot blast, No. 1 Foundry. Probably made in 1872 or 1873, Buffalo Furnace. Collected by P. N. Moore.*"

Quite a coarse-grained, brilliant, grey iron. Yields to the file; flattens a little under the hammer.

No. 1532—PIG IRON. "*Cold blast, No. 1 Foundry, Buffalo Furnace. Collected by P. N. Moore.*"

A moderately fine-grained, dark-grey iron, which yields easily to the file.

No. 1533—PIG IRON. "*Silver-grey hot blast iron. Made when working very hot, so that it is very cold-short. Buffalo Furnace. Collected by P. N. Moore.*"

A mottled, nearly white, silvery iron. Soft enough to yield to the file, but quite brittle. Scarcely flattening at all under the hammer.

No. 1534—PIG IRON. "*No. 1 Foundry, hot blast iron, Kenton Furnace. Collected by P. N. Moore.*"

A moderately coarse-grained, grey iron. Hard, but yields to the file. Extends considerably under the hammer.

No. 1535—PIG IRON. "*Hot blast, No. 1 Foundry iron; made at the fifth casting after thirty-six hours stoppage, on full burthen. The third casting gave grey iron. Collected by P. N. Moore.*"

A moderately coarse-grained, grey iron.

No. 1536—PIG IRON. "*No. 2, Foundry iron; from Hunnewell (formerly Greenup) Furnace. Collected by P. N. Moore.*"

A moderately coarse-grained, grey iron; very hard, but yields to the file. Extends considerably under the hammer.

COMPOSITION OF THESE GREENUP COUNTY PIG IRONS.

	No. 1531.	No. 1532.	No. 1533.	No. 1534.	No. 1535.	No. 1536.
Specific gravity . . .	6.825	6.944	6.872	6.897	7.117	7.041
Iron	91.656	94.739	88.106	92.724	91.668	92.368
Graphite	2.790	3.620	1.950	3.320	2.950	3.690
Combined carbon . .	a trace.	.780	.570	.660		
Manganese	.084	.056	.014	.612	.332	.020
Silicon	4.106	.877	7.317	2.090	3.817	2.515
Slag	.600	.120	.900	.300	1.200	1.130
Aluminum	.399	.060	.165	.442	.128	.582
Calcium	.168	.104	.128	.184	.075	.048
Magnesium	.095	.082	.125	.190	.122	a trace.
Potassium	.086	.048	.048	.104	not est.	.056
Sodium	.016	.041	.002	.004	not est.	a trace.
Phosphorus	.695	.609	.768	.622	.334	.684
Sulphur	.150	.037	.019	.046	.041	.026
Total	100.845	101.173	100.112	101.298	100.667	101.119
Total carbon	2.790	4.400	2.520	3.980	2.950	3.690

[See Appendix for other pig irons of this county.]

No. 1537—SOIL. *"Surface soil, from near the top of Pea Ridge; two hundred and fifty feet above the railroad at Hunnewell, one and a half miles southwest of hill to east. 'Coaled land.' Has a second growth of oak, with a few maples, hickories, pines, &c. Above the limestone of Pea Ridge. Collected by J. A. Monroe."*

Soil of a dark yellowish-grey color. The coarse sieve (289 meshes to inch) removed from it some fragments of ferruginous sandstone.

No. 1538—SOIL. *Labeled "Sub-soil of the preceding, to eighteen inches below the surface, &c."*

Of a brownish-buff color; containing nearly half its weight of irregular fragments of ferruginous sandstone, with ferruginous concretions.

No. 1539—SOIL. *Labeled "Under clay to the two preceding, taken to three feet below the surface."*

Clay of a brownish-buff color, with lighter colored portions intermixed. Contains a considerable proportion of fragments of ferruginous sandstone and ferruginous concretions, but not quite so much as the preceding.

COMPOSITION OF THESE GREENUP COUNTY SOILS, DRIED AT 212° F.

	No. 1537.	No. 1538.	No. 1539.
Organic and volatile matters	5.050	4.030	5.105
Alumina	6.831	9.595	9.223
Iron peroxide			
Manganese, brown oxide.			
Lime carbonate.	a trace.	.123	.091
Magnesia	.116	.223	.034
Phosphoric acid	.089	.115	.192
Sulphuric acid	.058	.017	.019
Potash	.217	.231	.312
Soda	.055	.097	.120
Soluble silica	Not estimated.		
Sand and insoluble silicates	86.505	84.565	84.695
Water expelled at 380° F.	1.000	.685	.615
Loss	.079	.319	
Total	100.000	100.000	100.406
Moisture expelled at 212° F.	1.650	1.775	2.150
Potash in insoluble silicates	Not estimated.		
Soda in insoluble silicates	Not estimated.		
Character of soil	Coaled land Surface soil	Sub-soil.	Under clay.

These soils are of medium good quality; they would be benefited by top-dressing with lime, and, if well drained, could be made quite productive by judicious management, the use of green crops, and other fertilizers. The surface soil is not as rich in the mineral fertilizers as the sub-soil and under clay.

HARDIN COUNTY.

No. 1540—SOIL. *"Forty-five years in cultivation. Taken to the depth of eight inches. Collected by C. S. Schenk."*

Farm of H. B. Helm; three thousand two hundred and fifty feet west from Elizabethtown, and sixteen hundred feet to the

right of the Elizabethtown and Paducah Railroad (facing Paducah), twenty feet above the rail. Slope 1:25. On limestone substratum. Timber: elm, sycamore, shell-bark hickory, hazelnut, sumach, sassafras, dogwood, &c. Rotation of crops: lately, two years in corn; one in oats, with three in clover, followed by two in wheat. Yield: of corn, thirty bushels; wheat, fifteen to twenty; of oats, twenty-five bushels to the acre. The land has been kept in good order and has had some straw manure.

Soil of a dark drab color. The coarse sieve (two hundred and eighty-nine meshes to inch) sifted out a little shot-iron ore and small fragments of ferruginous sandstone.

No. 1541—"SUB-SOIL of the preceding; one thousand feet to the right of the railroad, and three thousand four hundred feet from Elizabethtown, on the Elizabethtown and Paducah Railroad. Twenty feet above the rail. Taken to the depth of from eight to twelve inches. Collected by C. S. Schenk."

Of a lighter color than the preceding; greyish-buff. Contains some fragments of chert and small quartzose and ferruginous concretions.

No. 1542—"UNDER CLAY to the two preceding, taken at a depth of from twelve to thirty-six inches. Collected by C. S. Schenk."

Of a lighter color than the preceding, and more yellowish. Contains some small fragments of weathered chert and ferruginous sandstone, and small concretions of oxides of iron and manganese.

No. 1543—"VIRGIN SOIL, taken to the depth of eight inches. Farm of J. B. Bryan. Collected by C. S. Schenk."

Four thousand eight hundred feet west from Elizabethtown, on the Elizabethtown and Paducah Railroad, and twenty-eight hundred feet from the railroad. Thirty feet above the rail. Substratum, limestone. Timber: post oak, black and red oak, hickory, hazel, sumach, sassafras, and dogwood. The soil in

this neighborhood, cultivated carelessly, yields thirty-five bushels of corn to the acre.

Soil of a dark drab color. Contains a notable quantity of fragments of weathered chert and some of a fossil cyathophylum.

No. 1544—"SUB-SOIL of the preceding, from the depth of from eight to thirty-four inches. The limestone rock is thirty-six inches below the surface. Collected by C. S. Schenk."

Color lighter than that of preceding; of brownish-buff. Contains fragments of chert, more or less weathered, and of fossils.

No. 1545—"SOIL of an old field, over forty years in cultivation without manure. Collected by C. S. Schenk."

Seven thousand two hundred and sixty feet west of Elizabethtown, on the Elizabethtown and Paducah Railroad, one thousand one hundred and forty-three feet to the left of that road, and ten feet above the level of the rail. Slope = 1:70. Sample to the depth of eight inches. Timber: same as the preceding. Rotation of crops: wheat, oats, clover, &c. Yields, when well managed, thirty bushels of corn, fifteen to sixteen of wheat, and twenty of oats, to the acre.

Soil of a dark drab color. Contains only a few small fragments (chips) of flint.

No. 1546—"SUB-SOIL of the preceding, taken from eight to thirty-four inches from the surface. Collected by C. S. Schenk."

Sub-soil of a lighter and more yellowish color than the preceding; brownish-buff.

No. 1547—"VIRGIN SOIL, taken to the depth of eight inches. Collected by C. S. Schenk."

Field seven thousand two hundred and sixty feet west from Elizabethtown, eight hundred and thirty-seven feet to the left of Elizabethtown and Paducah Railroad, and ten feet above the level of the rail. Slope = 1:65. Has been cultivated one year in corn, producing forty bushels to the acre; has been

resting five years. Had no manure. Substratum limestone, at the depth of ten feet.

Soil of a dark drab color; contains no gravel, and very few small fragments of weathered chert and decayed vegetable roots.

No. 1548—"SUB-SOIL *of the preceding, taken at the depth of from ten to thirty-four inches. Collected by C. S. Schenk.*"

Sub-soil of a handsome brownish-salmon color.

No. 1549—"NEW SOIL, *to the depth of eight inches, farm of Daniel Klingelsmith's heirs. Collected by C. S. Schenk.*"

Eleven thousand three hundred and fifty feet west of Elizabethtown, on the Elizabethtown and Paducah Railroad, and two hundred and fifty feet to the north. Three feet above the level of the rail. Slope = 1:45. Substratum, limestone. Has been in cultivation five years. Rotation of crops: two years in corn; then one each in wheat, oats, and corn. Rented out land. No manure. Yields, of corn, thirty bushels; of wheat, twenty; and of oats, twenty-five bushels to the acre.

Soil of a brownish, dark-grey color. Contains no gravel.

No. 1550—"SUB-SOIL *to the preceding, taken at the depth of from eight to thirty-six inches from the surface. Collected by C. S. Schenk.*"

Sub-soil of a greyish-buff color. Contains some fragments of weathered chert.

No. 1551—"SOIL, *taken to the depth of eight inches, from an old field long in cultivation; rented out, and supposed to be worn out. Collected by C. S. Schenk.*"

Land of heirs of Daniel Klingelsmith, thirteen thousand eight hundred and eighty feet west from Elizabethtown, on Elizabethtown and Paducah Railroad; fifty feet to the right, on a level with the rail. Slope = 1:15. Rotation of crops: corn, wheat, oats, clover. Yields, of corn, seventeen bushels; of wheat, twelve; of oats, fifteen to sixteen bushels to the acre. No manure.

Soil of a brownish drab color. Contains some few small fragments of much weathered chert.

No. 1552—"SUB-SOIL *to the preceding, taken at from eight to thirty-nine inches from the surface. Collected by C. S. Schenk.*"

Color much like that of the preceding soil. No gravel or chert fragments sifted out.

No. 1553—"VIRGIN SOIL. *Woodland. Farm of Hayden English, sixty feet west of the four mile-post, on the Elizabethtown and Paducah Railroad; four feet above the level of the rail. Collected by C. S. Schenk.*"

Sample taken to the depth of twelve inches. Slope = 1:15. Timber: scrub oak, black oak, and black jack, generally of small size. Undergrowth: small sumach, sassafras, &c. Yield of such land is, of corn, eleven bushels; of wheat, six; of oats, eleven bushels to the acre.

Dry soil of a grey-buff color.

No. 1554—"SUB-SOIL *of the preceding, taken from twelve to twenty-six inches below the surface. Collected by C. S. Schenk.*"

Dry soil of a lighter color and more yellowish than the preceding.

No. 1555—"NEW SOIL, *five years in cultivation, from farm of J. English. Collected by C. S. Schenk.*"

Sample taken to depth of eight inches, at a point two hundred and seventy feet west of the six mile-post, on the Elizabethtown and Paducah Railroad; twenty-one hundred feet to the left of the railroad, and at a level of ten feet above the rail. Slope = 1:75. Timber: black, white, red, and post oak, hickory, chestnut, &c. Rotation of crops: two years in corn, one each in oats, wheat, and corn. No manure. Yield of corn, thirty; of wheat, twelve; and of oats, twenty bushels to the acre.

Dried soil of a drab color.

No. 1556—"SUB-SOIL of the preceding, taken at a depth of from eight to thirty-six inches. Collected by C. S. Schenk."

Dry sub-soil of a grey-buff color; lighter and more yellowish than preceding.

No. 1557—"SOIL from an old field, forty-five years in cultivation. Snider's farm. Collected by C. S. Schenk."

Sample taken to the depth of eight inches, at a point thirteen hundred feet west of the six mile-post, on the Elizabethtown and Paducah Railroad, and twelve hundred and seventy feet to the left, at a level of ten feet above the rail. Slope 1:35. Section of the hole where the soil was taken: soil, eight inches; yellow clay, twenty-two inches; red clay, six inches. (The red clay land is considered best in this part of the State.) Roots penetrate to depth of eight feet, where the rock is found. Rotation of crops: corn, wheat, oats. Has been four years in pasture, and the last two years in grass. Yield: corn, twenty-two; oats, fifteen to sixteen; wheat, eight; potatoes, fifty-five; rye, ten bushels, and tobacco, eight hundred pounds to the acre.

Dried soil of a drab color.

No. 1558—"SUB-SOIL of the preceding, taken at a depth of from eight to thirty-six inches. Collected by C. S. Schenk."

Dried sub-soil of a brownish-orange color.

No. 1559—"SOIL of an old field, forty years or more in cultivation." Collected by C. S. Schenk."

Sample taken to the depth of six inches, at a point two hundred and fifty feet west of the nine mile-post (Long Grove Station). Three hundred and fifty feet to the right of the Elizabethtown and Paducah Railroad, at a level of twelve feet above the rail. Slope = 1:19. Timber, much like that in preceding soils of this county. Rotation of crops, for the last nine years: four in corn, one in wheat, with three in clover and one in wheat. No manure. Yield: corn, twenty-two; wheat, eight; oats, fifteen bushels to the acre.

Dried soil of a yellowish umber-grey color.

No. 1560—"SUB-SOIL of the preceding, taken at from six to thirty-six inches from the surface. Collected by C. S. Schenk."

Dried sub-soil of a dark grey-buff color.

No. 1561—"SOIL of an old field, farm of E. Hansborough. Collected by C. S. Schenk."

Sample taken to the depth of five inches, at a point one thousand three hundred and twenty-seven feet west of the three mile-post; eight and a quarter miles from Elizabethtown, on the Elizabethtown and Paducah Railroad; one thousand three hundred and fifty feet to the left of that road, and level with the rail. Slope = 1:24. Timber much like that on the preceding soils. Substratum limestone, at depth of forty-five inches. Rotation of crops: corn, wheat, oats, clover. No manure. Yield: corn, thirty; wheat, eighteen; oats, thirty; potatoes, forty bushels; tobacco, eight hundred to one thousand two hundred pounds to the acre. One of the best farms in this locality. Land kept in good order.

Dried soil darker than the next preceding, of a brownish-umber dark grey color.

No. 1562—SUB-SOIL of the preceding. Sample taken from five to forty-five inches below the surface. Collected by C. S. Schenk."

Dried sub-soil of a light brick-red color. Somewhat adhesive.

No. 1563—"SOIL of an old field, forty years in cultivation, without manure. Collected by C. S. Schenk."

Sample taken to the depth of ten inches, at a point two hundred feet to the right of the seven mile-post, Elizabethtown and Paducah Railroad; level five feet above the rail. Substratum limestone. Slope = 1:50. Rotation of crops: corn, wheat, oats, clover. Land kept in good order. Yield of corn, twenty-five; of wheat, twelve; of oats, twenty bushels to the acre.

Dried soil of a yellowish-umber color.

No. 1564—"SUB-SOIL of the preceding, taken at a depth of from ten to thirty-eight inches. Collected by C. S. Schenk."

Dried sub-soil of a light yellowish-brick color. Somewhat adhesive.

No. 1565—"VIRGIN SOIL, Woodland, on Hanson Duncan's farm. Collected by C. S. Schenk."

Sample taken to ten inches in depth, at a point seven hundred and sixty feet east of his house; about eighty feet below the Elizabethtown and Paducah Railroad at East View. Rock substratum—limestone.

Dried soil of a yellowish light-umber color.

No. 1566—"SUB-SOIL of the preceding, taken at a depth of from ten to forty-six inches. Collected by C. S. Schenk."

Dried sub-soil of a light yellowish-brick color.

No. 1567—SOIL from an old field, twenty-four years in cultivation. Collected by C. S. Schenk."

Sample taken to the depth of eight inches, at a point twelve hundred feet, north 50° east from Hanson Duncan's house; one hundred and seventeen feet below the railroad at East View Station. Slope = 1:26. Substratum limestone. Rotation of crops: 1. corn, 1. rye, 3. clover, 1. wheat. No manure. Yield: corn, thirty-five; wheat, seventeen; rye, six to seven bushels to the acre.

Dried soil of a yellowish light-umber color.

No. 1568—"SUB-SOIL of the preceding, taken at a depth of from eight to forty inches. Collected by C. S. Schenk."

Dried sub-soil of a light yellowish-brick color.

No. 1569—"VIRGIN SOIL, one year in cultivation, from sand land on Hanson Duncan's farm, near East View. Collected by C. S. Schenk."

Sample taken to the depth of four inches, at a point four hundred and twenty feet west of his house. Height level with

the roof of his house. Slope = 1:7. Substratum limestone. Timber about the same as described above. Land not much cultivated; considered too poor except for peaches, apples, &c.; but tobacco yields six hundred pounds to the acre.

Dried soil of a yellowish umber-grey; lighter colored than the preceding sample.

No. 1570—SUB-SOIL of the preceding, taken at a depth of from four to thirty-six inches. Collected by C. S. Schenk."

Sub-soil of a light yellowish-brick color.

No. 1571—SOIL from an old field, sixteen years in cultivation, on Hanson Duncan's farm, near East View. Collected by C. S. Schenk."

Sample taken to depth of six inches, at a point seven hundred and fifty feet, north 20° east from his house. Height, six feet above his house. Slope = 1:7. Substratum sandstone. In some years it has yielded eleven bushels of corn to the acre. Is now in orchard. Produces good peaches.

Dried soil of a yellowish light umber-grey color.

No. 1572—SUB-SOIL of the preceding, taken at a depth of from six to thirty-four inches. Collected by C. S. Schenk."

Sub-soil of a light brick-color, varying in intensity. Contains many angular fragments of soft, friable, ferruginous sandstone.

NOTE.—For a continuation of this serial collection of soils, made on or near the line of the Elizabethtown and Paducah Railroad, by Mr. C. S. Schenk, see Grayson and Ohio counties.

COMPOSITION OF THESE HARDIN COUNTY SOILS, &c., DRIED AT 212° F.

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CHEMICAL REPORT.

	No. 1540.	No. 1541.	No. 1542.	No. 1543.	No. 1544.	No. 1545.	No. 1546.	No. 1547.	No. 1548.	No. 1549.	No. 1550.	No. 1551.	No. 1552.
Organic and vol. matters	3.675	2.600	2.650	2.950	2.500	3.100	2.025	3.300	3.035	4.150	2.750	3.535	3.150
Alumina, and iron and manganese oxides.	5.790	8.617	10.775	5.786	9.705	6.905	9.190	7.705	11.624	6.865	8.870	8.784	11.900
Lime carbonate	.160	.195	.110	.195	.145	.245	.195	.295	.110	.495	.245	.230	.175
Magnesia	.250	.431	.158	.375	.240	.258	.140	.339	.267	.501	.284	.152	.321
Phosphoric acid	.160	.123	.115	.119	.125	.204	.125	.156	.216	.108	.134	.156	.108
Sulphuric acid	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.
Potash (ext'd by acid)	.154	.188	.265	.404	.462	.308	.327	.193	.256	.209	.399	.159	.150
Soda (extracted by acid)	.109	.002	.030	.030	.035	.033	.037	.027	.160	.079	.054	.026	.140
Sand and insol. silicates	88.590	86.975	84.740	89.555	85.925	87.465	86.840	86.815	83.925	86.590	86.640	86.215	83.315
Water expelled at 380° F.	1.235	.925	.750	.900	.850	1.100	.725	1.050	.600	1.250	.850	.800	.700
Loss	.....	.....	.407	.186	.013	.382	.396	.120	.....	.....	.....	.....	.041
Total	100.123	100.056	100.000	100.000	100.000	100.000	100.000	100.000	100.193	100.247	100.226	100.057	100.000
Hygroscopic moisture	1.510	1.575	2.140	1.125	1.650	1.325	1.700	1.500	1.800	1.650	1.875	1.650	2.200
Potash in insol. silicates	0.803	not est.	not est.	0.617	0.798	0.977	not est.	not est.	not est.	not est.	not est.	0.864	not est.
Soda in insol. silicates	.467	not est.	not est.	0.188	0.406	0.280	not est.	not est.	not est.	not est.	not est.	.444	not est.
Character of soil	Old field soil.	Sub-soil.	Under clay.	Virgin soil.	Sub-soil.	Old field.	Sub-soil.	Virgin soil.	Sub-soil.	New soil.	Sub-soil.	Old field.	Sub-soil.

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COMPOSITION OF THESE HARDIN COUNTY SOILS, &c., DRIED AT 212° F.—(Continued.)

	No. 1553	No. 1554	No. 1555	No. 1556	No. 1557	No. 1558	No. 1559	No. 1560	No. 1561	No. 1562	No. 1563	No. 1564
Organic and volatile matters	1.950	1.990	2.185	2.135	2.100	2.935	2.625	2.525	3.215	3.785	3.080	2.785
Alumina, and iron and manganese oxides	5.926	8.344	5.692	9.476	6.359	12.798	7.388	10.445	6.790	15.763	6.564	10.763
Lime carbonate	.130	.080	.270	.220	.220	.220	.190	.120	.370	.620	.445	.495
Magnesia	.167	.204	.213	.208	.050	.194	.095	.362	.189	.095	.213	.282
Phosphoric acid	.076	.093	.070	.134	.093	.124	.124	.120	.172	.124	.123	.124
Sulphuric acid	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.
Potash (extracted by acid)	.163	.298	.250	.313	.223	.342	.221	.339	.202	.421	.293	.212
Soda (extracted by acid)	.005	.120	.037	.045	.023	.033	.026	.260	.049	.101	.050	.219
Sand and insoluble silicates	90.465	88.115	89.965	86.240	89.790	82.165	88.090	85.140	87.765	77.375	87.975	84.290
Water expelled at 380° F.	.935	.775	1.425	.900	.950	.975	1.150	.950	1.400	1.515	1.235	1.135
Loss	.183	.....	.....	.329	.192	.214	.091	.....	.....	.201	.022	.....
Total	100.000	100.019	100.107	100.000	100.000	100.000	100.000	100.261	100.152	100.000	100.000	100.305
Hygroscopic moisture	1.585	2.200	1.400	2.400	1.485	2.650	1.385	2.450	1.600	3.860	1.300	1.375
Potash in the insoluble silicates	1.140	not est.	not est.	not est.	0.560	not est.	0.675	not est.	1.148	.974	not est.	not est.
Soda in the insoluble silicates	.641	not est.	not est.	not est.	.373	not est.	.339	not est.	.731	.420	not est.	not est.
Character of the soil	Virgin soil.	Sub-soil.	New soil.	Sub-soil.	Old field.	Sub-soil.	Old field.	Sub-soil.	Old field.	Sub-soil.	Old field.	Sub-soil.

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COMPOSITION OF THESE HARDIN COUNTY SOILS, &c., DRIED AT 212° F.—(Continued.)

	No. 1565.	No. 1566.	No. 1567.	No. 1568.	No. 1569.	No. 1570.	No. 1571.	No. 1572.
Organic and volatile matters	3.215	4.400	3.050	2.575	2.600	2.225	2.165	2.575
Alumina, and iron and manganese oxides	5.365	6.395	5.550	5.828	4.465	7.015	2.740	6.900
Lime carbonate	.445	.270	.305	.236	.170	.086	.180	.045
Magnesia	.168	.205	.240	.078	.176	.104	.087	.068
Phosphoric acid	.172	.045	.102	.112	.147	.134	.067	.102
Sulphuric acid	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.
Potash (extracted by acid)	.188	.202	.173	.183	.212	.202	.135	.183
Soda (extracted by acid)	.041	.050	a trace.	.053	.055	.076	.072	.045
Sand and insoluble silicates	87.940	88.425	89.290	90.470	91.790	89.855	94.290	89.940
Water expelled at 380° F.	1.525	.650	1.100	.475	.775	.450	.550	.225
Loss	.841		.190					
Total	100.000	100.742	100.000	100.010	100.390	100.141	100.286	100.083
Hygroscopic moisture	1.890	1.800	1.690	2.360	1.225	1.900	0.800	2.075
Potash in the insoluble silicates	1.550	not est.	not est.	not est.	1.332		0.869	0.485
Soda in the insoluble silicates	.350	not est.	not est.	not est.	.444		.236	.165
Character of the soil	Virgin soil.	Sub-soil.	Old field.	Sub-soil.	Virgin soil.	Sub-soil.	Old field.	Sub-soil.

For the other soils of this series, collected along the line of the Elizabethtown and Paducah Railroad by Mr. C. Schenk, see Grayson and Ohio counties. The remarks appended to the Grayson county soils will apply to these with some obvious local variations.

HENRY COUNTY.

No. 1575—GALENA. "*From Roberts' lode, north opening. Carefully averaged, by Prof. N. S. Shaler.*"

Cubical and granular galena, disseminated in white, compact, baryta sulphate; with some zinc blende (zinc sulphide).

The galena was selected from the mixed lumps, simply for assaying to determine the presence or proportion of silver.

No. 1576—GALENA "*From Roberts' lode, south opening, &c.*"

Like the preceding; but containing a larger proportion of galena. The galena was selected from the lumps for analysis.

Fused with the usual flux of carbonate of soda, nitrate of potash and salt; the former, No. 1575, gave 72.70 to 76.585 per cent. of lead; the latter, No. 1576, gave about seventy-one and a half per cent. This does not of course represent all the lead existing in the selected galena, but is supposed to contain all the silver.

The well washed lead buttons were dissolved, severally, in dilute nitric acid; and to the very much diluted solutions a solution of lead chloride was added.

The former, No. 1575, gave a faint precipitate of silver chloride on standing—not enough to justify its extraction; the latter gave no sensible precipitate of the silver chloride. These ores seem, therefore, to be too poor in silver to pay for its extraction.

Another specimen of lead ore, from an unopened lode, on Mill branch of Six Mile Creek, contained so small a proportion of galena to the baryta sulphate that it was not thought proper to analyze it.

No. 1577—MARLY SHALE or indurated marl. "*Cut of the Cumberland and Ohio Railroad, Eminence, Henry county. Collected by Prof. N. S. Shaler.*"

An olive-grey, indurated marl; containing nodules of chætetes, and portions of other Silurian fossils.

COMPOSITION, DRIED AT 212° F.

Silica	23.700
Alumina	7.146
Iron and manganese oxides	11.040
Lime carbonate	44.560
Magnesia	.310
Phosphoric acid	1.164
Sulphuric acid	.961
Potash	2.100
Soda	.623
Water expelled at red heat, and loss	8.396
Total	100.000

The large proportions of lime, potash, phosphoric acid, &c., in this marly shale, would doubtless make it valuable as a top-dressing on exhausted light soils; but it is not rich enough in the mineral fertilizers to justify much expenditure for transportation.

HOPKINS COUNTY.

No. 1578—COAL. "*Mr. Wm. Mills' coal, just partially opened. Nortonsville, Hopkins county. Collected by C. J. Norwood. (Probably not a fair average sample.)*"

Generally a jet-black, glossy coal; breaks in part in thin layers, with some compressed fibrous coal between. Some thin laminæ of pyrites apparent. (Specimen seems to contain an inordinate proportion of pyrites.)

No. 1579—COAL. "*St. Charles Mines. Average sample, by C. J. Norwood.*" (Coal D.)

A jet-black, glossy coal; iridescent in parts. Some fibrous coal between the laminæ, and but little appearance of pyrites.

COMPOSITION OF THESE HOPKINS COUNTY COALS, AIR-DRIED.

	No. 1578.	No. 1579.
Specific gravity	1.448	1.322
Hygroscopic moisture	3.40	3.20
Volatile combustible matters	30.00	35.90
Coke	66.60	60.90
Total	100.00	100.00
Total volatile matters	33.40	39.10
Carbon in the coke	51.10	54.00
Ashes	15.50	6.90
Total	100.00	100.00
Character of the coke	Spongy.	Light spongy.
Color of the ash	Dark grey-purple.	Light lilac-grey.
Per centage of sulphur	7.280	2.759

No. 1579 is a very good coal, containing but little earthy matter and a moderate proportion of sulphur. The other exceeds the average proportions of these; but is not probably a fair sample. It is well known that coal beds vary greatly in their different layers; and this may prove to be a good coal when the bed is fairly opened.

No. 1580—"LIMONITE, ochreous, from near St. Charles Mines, Mr. Norton's land. On the working coal. Collected by C J. Norwood."

Flat kidney-form concretions, of a handsome brownish-yellow color, of different shades. Easily scratched with the nail; adheres to the tongue.

COMPOSITION, DRIED AT 212° F.

Iron peroxide	50.850
Alumina	5.462
Manganese oxide	a trace.
Lime carbonate	3.129
Magnesia	1.546
Phosphoric acid	.198
Sulphuric acid	.189
Water expelled at red heat	10.530
Silica and insoluble silicates	27.680
Loss	.416
Total	100.000
Per centage of iron	35.595
Per centage of sulphur	.075
Per centage of silica	22.220
Per centage of phosphorus	.086

This is rich enough to be smelted for iron, and might make a good ochre pigment on grinding.

KENTON COUNTY.

No. 1581—“SILICIOUS GRIT *at first toll-gate, two miles from Covington, on Lexington Turnpike. Collected by Prof. N. S. Shaler.*”

A brownish-grey, ferruginous impure sandy mass.

No. 1582—“SILICIOUS GRIT *from same locality as preceding. Used for moulding sand. Collected by Prof. N. S. Shaler.*”

An impure, reddish-brown friable sandy mass; infiltrated with iron oxide; varying in tint from grey to deep brown. The sand grains are rounded.

COMPOSITION OF THESE KENTON COUNTY GRITS, DRIED AT 212° F.

	No. 1581.	No. 1582.
Silica	77.460	75.700
Alumina, and iron and manganese oxides	16.500	15.793
Lime carbonate	.480	.660
Magnesia	.121	.214
Potash	.828	.847
Soda	.580	.762
Phosphoric acid	not est.	.639
Sulphuric acid	not est.	not est.
Water expelled at red heat	4.500	5.100
Total	100.469	99.716

The amount of alkalies contained in these impure sands is somewhat remarkable. They exist in them, however, mostly in the silicates which are insoluble in acids; and were separated in the analyses, by the process of fusion with the mixture of lime carbonate and ammonium chloride, &c., according to the method of J. Lawrence Smith. Notwithstanding the unavailable condition of these alkalies, these sands might prove useful additions to heavy clay soils, more especially because of their notable proportion of phosphoric acid. For this purpose, however, they could only be employed in the close vicinity of their beds, as they would not pay for long transportation.

No. 1583—“CLAY, *supposed to be in the Cincinnati Group of the Lower Silurian formation. Lexington Turnpike, two miles south of Covington. Top section just below that of the preceding grits. Collected by Prof. N. S. Shaler.*”

A laminated or shaly clay of handsome light-buff and bluish-grey colors, alternating.

No. 1584—CLAY. “*Clay-pit at brick-yard. Head of Russel street, Covington. Average of the nine-feet section. Collected by Prof. N. S. Shaler.*”

A yellowish ferruginous clay; mottled with light bluish-grey; containing fine silicious grains.

No. 1585—MARLY SHALE. "*Junction of the Ohio and Licking rivers, twelve feet above low water mark. Cincinnati (Hudson River) Group. Collected by Prof. N. S. Shaler.*"

A fine-grained, dark-grey shale; dull; adhering somewhat to the tongue.

No. 1586—MARLY SHALE. Labeled "*Fine shales, between impure limestone; five feet above low water mark. Whitehall. No fossils. Collected by Prof. N. S. Shaler.*"

A soft friable shale; dark-grey in the fresh fracture; adhering to the tongue.

COMPOSITION OF THESE KENTON COUNTY MARLY CLAYS AND SHALES
DRIED AT 212° F.

	No. 1583.	No. 1584.	No. 1585.	No. 1586.
Silica	56.400	68.360	43.461	47.160
Alumina, and iron and manganese oxides . .	29.971	22.256	21.000	22.850
Lime carbonate	.760	1.000	27.040	20.140
Magnesia	1.514	1.181	.680	.840
Phosphoric acid	.166	.258	.607	.128
Sulphuric acid	not est.	not est.	not est.	not est.
Potash	3.538	2.139	2.447	2.301
Soda	.551	.906	.915	1.590
Water expelled at red heat	7.100	3.650	3.850	5.200
Total	100.000	99.750	100.000	100.209

These marly shales would undoubtedly be valuable for top-dressing poor light soils in their vicinity, notwithstanding most of their alkaline ingredients are in a state of combination which renders them, for the present, unavailable for plant nourishment. The gradual action of the atmospheric agencies and of humus, as well as that of the lime, will eventually bring them into a soluble state. The latter two may be considered the best for this purpose.

No. 1587—LIMESTONE. Labeled "*Blue argillaceous limestone. Low water mark. Whitehall, near Covington. Collected by Prof. N. S. Shaler.*"

A fine-grained, dark-grey limestone. Not adhering to the tongue.

COMPOSITION, DRIED AT 212° F.—SPECIFIC GRAVITY = 2.720.

Lime carbonate	64.240	= 35.974 per cent. of lime.
Magnesia carbonate	6.152	
Alumina, and iron and manganese oxides	4.960	
Phosphoric acid	.191	
Sulphuric acid	not est.	
Potash	.643	
Soda	.260	
Silic and insoluble silicates	23.860	
	100.306	

This limestone, like most of the layers of the Lower Silurian limestone (or blue limestone, so-called), is, in consequence of its large proportions of alkalies and phosphoric acid, peculiarly suited to agricultural purposes. The use of this lime, in the calcined state, upon our old fields, if properly managed and applied just before the clover crop, in a rotation, would doubtless be quite beneficial in restoring fertility.

LAWRENCE COUNTY.

No. 1588—COAL. No. 3, "*From McHenry's coal bank, six miles south of Louisa. Average sample, by A. R. Crandall.*"

A jet-black coal, with very little fibrous coal and no appearance of pyrites.

No. 1589—COAL. No. 1, "*from F. Swetman's bank, Brushy Creek. Collected by A. R. Crandall.*"

A jet-black coal, with some little external earthy or ferruginous staining, and but little fibrous coal or pyrites.

No. 1590—COAL. No. 1, "*From near Henderson, Boggs' Mill, Cane's Creek. Collected by A. R. Crandall.*"

Rather a dull-black coal, breaking into thin laminæ, with fibrous coal between, but with little appearance of pyrites. Some external ferruginous stain.

No. 1591—COAL. No. 3. "*Holbrook's coal, Brushy Creek. Collected by A. R. Crandall.*"

Rather a dull-black coal, breaking into thin laminæ, with fibrous coal between, but with little appearance of pyrites.

No. 1592—COAL. No. 3. "Mr. Boggs' bank, one mile from mouth of Cane's Creek. Upper portion of the coal. Collected by A. R. Crandall."

A jet-black coal, with some fibrous coal between the laminae, but with little appearance of pyrites.

No. 1593—COAL. No. 3. "Mr. Boggs' bank, &c., &c. Lower portion of the coal. Collected by A. R. Crandall."

Breaking into thin laminae, with fibrous coal between. Some external ferruginous incrustation.

COMPOSITION OF THESE LAWRENCE COUNTY COALS, AIR-DRIED.

	No. 1588	No. 1589	No. 1590	No. 1591	No. 1592	No. 1593
Specific gravity	1.316	1.281	1.376	1.349	1.350	1.284
Hygroscopic moisture	4.60	5.10	3.30	2.10	2.50	2.50
Volatile combustible matters	35.70	35.30	35.16	33.90	38.56	39.00
Coke	59.70	59.60	61.54	64.00	58.94	58.50
Total	100.00	100.00	100.00	100.00	100.00	100.00
Total volatile matters	40.30	40.40	38.46	36.00	41.06	41.50
Carbon in the coke	53.28	57.80	47.84	56.00	51.44	54.76
Ashes	6.42	1.80	13.70	8.00	7.50	3.74
Total	100.00	100.00	100.00	100.00	100.00	100.00
Character of the coke	Spongy.	Light spongy.	Dense spongy.	Friable.	Light spongy.	Spongy.
Color of the ash	Light lilac-grey	Light grey-buff.	Dark lilac-grey	Yellowish-white	Grey-purple.	Brownish grey.
Per centage of sulphur	1.080	0.736	2.109	0.736	3.785	1.066

With one or two exceptions, as is readily to be seen, these are remarkably good and pure coals, which will compare favorably with the best Ohio and Indiana coals.

It is interesting to notice in the above table the nearly constant relation of the specific gravity to the relative proportion of ash, to-wit:

In No. 1589 the specific gravity is 1.281; per centage of ash = 1.80.
 " 1593 " " 1.284; " " 3.74.
 " 1588 " " 1.316; " " 6.42.
 " 1592 " " 1.350; " " 7.50.
 " 1591 " " 1.349; " " 8.00.
 " 1590 " " 1.376; " " 13.70.

This relation of the specific gravity to the proportion of the ash is not constant in coals generally.

No. 1594—RED HEMATITE "Found on top of hill near Louisa, Lawrence county. By A. R. Crandall."

Nodular lumps, of various sizes, of very hard, dense, dark colored ore, with hardly any soft ochreous material. Powder of a brownish-red or maroon color.

COMPOSITION, DRIED AT 212° F.—SPECIFIC GRAVITY = 4.184.

Iron peroxide	80.004 = 56.028 per cent. of iron.
Alumina	3.474
Manganese, brown oxide	.250
Lime	.360
Magnesia	.396
Phosphoric acid	.172 = 0.075 per cent. of phosphorus.
Sulphuric acid	.055 = .020 per cent. of sulphur.
Silica and insoluble silicates	14.200 = 13.500 per cent. of silica.
Water and loss	1.089
	100.000

The red hematite is an exceptional ore in the coal measures, but is found in abundance in the Clinton Group.

LIVINGSTON COUNTY.

No. 1595—GALENA. "From Royall Mines, Mineral Point, Cumberland river. Taken one hundred and twenty-five feet from the surface; sloping away from the river. Collected by Prof. N. S. Shaler."

The galena is mingled with colorless and violet-colored fluor-spar.

No. 1596—GALENA. "From same mines, taken forty-five feet from the surface, &c., &c."

The galena, separated from the gangue, of both these samples, was reduced by the usual flux and tested for silver.

No. 1595 gave a button of lead weighing 79.34 per cent. of the weight of the galena, and No. 1596 one which weighed 79.052 per cent.

These were severally dissolved in diluted nitric acid and tested for silver by the addition of the watery solution of lead chloride to the diluted nitrate of lead solution; and in neither case was more than a minute trace of silver chloride obtained. So that these galenas cannot be profitably worked for the extraction of silver.

LYON COUNTY.

No. 1597—"LIMONITE *iron ore from old Suwannee Furnace, Big Showing. Sub-carboniferous. Collected by P. N. Moore.*"

A dense, dark-brown limonite, in irregular laminæ, with a small amount of investing soft ochreous ore.

No. 1598—LIMONITE. "*Old Suwannee Furnace. Bank close to the furnace. Sub-carboniferous. Collected by P. N. Moore.*"

A dense, dark-brown ore, in irregular laminæ, with some brown hematite and soft ochreous ore. Some cherty nodules.

No. 1599—"LIMONITE, *with occasional thin layers of brown hematite. Old Suwannee Furnace property. Railroad cut. Sub-carboniferous formation. Average sample of the ore in the railroad cut. Collected by P. N. Moore.*"

A dense, dark-brown limonite, with thin incrustations of brown hematite and some soft ochreous ore.

No. 1600—LIMONITE. "*Old Suwannee Furnace property. Iron Mountain bank. Sub-carboniferous. Average sample, by P. N. Moore.*"

Generally in dark-brown irregular laminæ, with some yellowish and brownish ochreous ore, and occasional small nodules of chert.

COMPOSITION OF THESE LYON COUNTY LIMONITES, DRIED AT 212° F.

	No. 1597.	No. 1598.	No. 1599.	No. 1600.
Iron peroxide	59.370	70.518	66.117	69.392
Alumina	1.622	.045	1.064	a trace.
Manganese, brown oxide	.090	.190	.170	.170
Lime carbonate	.170	.090	.090	.140
Magnesia	.100	a trace.	a trace.	a trace.
Phosphoric acid	.179	.275	.434	.303
Sulphuric acid	.508	.113	.213	a trace.
Water expelled at red heat	8.400	9.850	9.800	9.550
Silica and insoluble silicates	30.000	18.910	22.330	20.500
Moisture and loss		.009		
Total	100.439	100.000	100.218	100.055
Per centage of iron	41.559	49.363	46.819	48.574
Per centage of phosphorus	.077	.120	.189	.144
Per centage of sulphur	.212	.045	.083	
Per centage of silica	26.800	18.160	21.160	19.660

In volume 4 of *Reports of Kentucky Geological Survey*, old series, may be found the amount of the analyses of other materials from this old furnace, beginning at page 209.

Quite rich ores, and very good, except those which show a large proportion of sulphur or phosphorus.

For an account of the analysis of the water contained in the interior of a geode of "pot ore," see the Appendix.

MENIFEE COUNTY.

No. 1601—COAL. "*Sub-conglomerate, forty feet above the sub-carboniferous limestone. Hawkins' Creek, near the line of Powell county. Meniffee county. Average sample, collected by A. R. Crandall.*"

No. 1602—COAL. "*Sub-conglomerate, forty to forty-five feet above the sub-carboniferous limestone, near the mouth of Gladly Creek, on Ledford's land. A thin bed. Collected by A. R. Crandall.*"

No. 1603—BITUMINOUS SHALE. "*Sub-conglomerate (mistaken for coal). Twenty to twenty-two feet thick; immediately above the sub-carboniferous limestone. Average sample, by A. R. Crandall.*"

A friable shale, resembling some kinds of cannel coal, of a dull brownish-black, with some thin ferruginous incrustation. Fracture irregular; sub-conchoidal.

COMPOSITION OF THESE COALS AND THE SHALE, AIR-DRIED.

	No. 1601.	No. 1602.	No. 1603.
Specific gravity	1.319	not est.	not est.
Hygroscopic moisture	2.94	2.66	2.80
Volatile combustible matters	33.06	34.04	15.20
Coke (or fixed residue)	64.00	63.30	82.00
Total	100.00	100.00	100.00
Total volatile matters	36.00	36.70	18.00
Carbon in the coke, &c.	56.60	50.24	24.30
Ashes	7.40	13.06	57.70
Total	100.00	100.00	100.00
Character of the coke, &c.	Dense.	Dense.	Pulverulent
Color of the ash	Light brownish-grey.	Dark lilac-grey.	White.
Per centage of sulphur	0.997	4.092	not est.

Some of the sub-conglomerate coals are found to be quite good. The bituminous shale described above, however, hardly contains enough combustible matters (having only eighteen per cent.) to make it available for fuel.

Samples of various rocks and minerals were brought to the laboratory by Mr. J. M. Vanarsdall, from this county, from the vicinity of Gladys Creek; consisting of iron ores, pyrites, marly clay, zinc sulphide, &c., with some small globules of a white metal which he obtained from the ashes of the furnace of the

so-called "James Kirk's silver mine." The metal contained tin and copper, and the furnace was probably used by counterfeits, who, selecting out-of-the-way regions for their operations, seem frequently to conceal the character of them by the pretense of working a silver mine.

This county has not as yet been thoroughly examined by the Geological corps; and doubtless contains much more mineral wealth than is indicated by these few analyses here reported.

MONTGOMERY COUNTY.

No. 1604—"QUICKLIME. *Star Lime Company's lime. Burnt at (or near) Mt. Sterling. Obtained from Williamson & Bro., Lexington.*"

Not remarkably white, presenting an oölitic structure in some of the pieces.

COMPOSITION.

Lime	98.301
Magnesia	.092
Alumina, and iron and manganese oxides	.747
Phosphoric acid	.023
Sulphuric acid	not est.
Potash	.012
Soda	.011
Silica and insoluble silicates	.814
Total	100.000

This analysis, made by the youngest son of the writer (Alfred M. Peter) under his inspection, indicates a degree of purity which fits this lime for all purposes of construction, except, perhaps, for the whitest finishing coats in plastering.

MUHLENBURG COUNTY.

No. 1605—LIMONITE. *Labeled "Iron ore from near No. 4 entry. Airdrie Furnace. Averaged by P. N. Moore."*
A porous, yellowish, and deep brown ore.

No. 1606—LIMONITE. *"Iron ore from Jerry M. Hope's land, near Muddy river. Average sample, by P. N. Moore, of the surface limonite from the upper part of the bed."*

A cellular limonite (fossiliferous), of a bright yellowish-brown color externally, with darker, hard, curved laminae included.

No. 1607—LIMONITE. "*Ore from the lower and middle parts of the bed. Jerry Hope's land, &c., &c. Average sample, by P. N. Moore.*"

A porous, brownish-yellow, fossiliferous ore.

No. 1608 — LIMONITE. "*Martin ore from near Greenville. Average sample, by P. N. Moore.*"

A cellular limonite, with ochreous incrustation, &c.

No. 1609—"ROASTED ORE *from the Airdrie Furnace stock pile. Has been weathered seventeen years since roasting. Collected by P. N. Moore.*"

Apparently a "Black-band ore," so-called, originally. The roasted ore is of a dark, reddish-brown color, varying to lighter tints. Some portions are cellular, as though they had been fused.

COMPOSITION OF THESE MUHLENBURG COUNTY LIMONITE IRON ORES, &c., DRIED AT 212° F.

	No. 1605.	No. 1606.	No. 1607.	No. 1608.	No. 1609.
Specific gravity	3.246	.....	.....	.....	3.652
Iron peroxide	63.048	60.492	46.866	69.546	59.810
Alumina	5.290	7.075	5.930	3.914	2.972
Brown oxide of manganese . . .	.090	.360	.103	.230	.720
Lime carbonate	.680	1.980	2.535	.480	*2.263
Magnesia	.930	1.550	1.073	.921	4.270
Phosphoric acid	.147	.083	.179	.115	.223
Sulphuric acid	.112	.185	.059	.216	.065
Water expelled at red heat . . .	12.430	12.530	9.550	11.250	.200
Silex and insoluble silicates . . .	17.250	15.560	33.530	12.730	29.880
Moisture and loss . . . . .	.....	.185	.175	.598	.....
Total	100.077	100.000	100.000	100.000	100.403
Per centage of iron	44.133	42.344	32.806	48.822	41.867
Per centage of phosphorus . . .	.064	.035	.078	.050	.097
Per centage of sulphur	.044	.074	.024	.086	.026
Per centage of silica	16.500	13.660	32.860	11.300	25.260

* Lime.

These Airdrie Furnace limonites are all good and profitable ores, which would yield a good quality of iron if properly smelted, as they contain but a moderate proportion of the injurious ingredients, phosphorus and sulphur. Although it is probable that the "roasted ore" was from the so-called "Black-band ore" (bituminous clay iron-stone), it is properly tabulated with these limonites. The analyses of other similar iron ores from this region are detailed in the previous volumes of Kentucky Geological Reports. (See volume 1, pages 345 and 346, and volume 4, page 229.)

No. 1610—CLAY IRON-STONE. *Bituminous. So-called "Black-band" ore. From the Airdrie Furnace stock pile; weathered seventeen years. Not roasted. Collected by P. N. Moore.*"

A shaly ore, varying in color, in layers, from nearly black to dark grey-brown.

No. 1611 — CLAY IRON-STONE. *Bituminous. Labeled "Slate iron ore, from Buckner Furnace. Weathered thirty years. Average sample, by P. N. Moore."*

A Black-band ore, of a dark umber-brown color, varying in tint. Shaly, and containing carbonaceous matter.

No. 1612—CLAY IRON-STONE "*From the lower part of the bed at Jerry Hope's bank, near Muddy river. Collected by P. N. Moore.*"

A rough, greenish and brownish, fossiliferous and silicious carbonate ore.

COMPOSITION OF THESE CLAY IRON-STONES, DRIED AT 212° F.

	No. 1610.	No. 1611.	No. 1612.
Specific gravity	3.376	not deter'd.	not deter'd.
Iron carbonate	47.810	42.950	26.643
Iron peroxide	9.054	29.618	18.374
Alumina	5.205	2.454	6.548
Lime carbonate	3.740	2.490	13.430
Magnesia carbonate	7.180	4.828	5.698
Manganese carbonate	.797	1.083	a trace.
Phosphoric acid	.179	.083	.211
Sulphuric acid	.237	1.596	.185
Silica and insoluble silicates	17.010	9.030	22.230
Water, bituminous matter, and loss	8.788	5.868	6.681
Total	100.000	100.000	100.000
Per centage of iron	29.418	36.916	27.136
Per centage of phosphorus	.078	.035	.092
Per centage of sulphur	.094	.638	.074
Per centage of silica	12.900	6.220	20.660

These clay iron-stones are not very rich in iron, except the one (No. 1611) from Buckner Furnace, and this has a large proportion of sulphur. The others are probably too poor in iron to be separately smelted with profit; but they might be mixed with richer ores with advantage. Other analyses of the so-called Black-band ores of this region are to be found in volume 1, Kentucky Geological Reports, pages 346 to 350. It will be seen, by reference, that these vary in their proportion of iron from 31.17 to 36.80 per cent. of the ore.

[No. 1314—"LIMESTONE from Barren river, near the mouth of Jasper Creek. Used formerly as a flux at Airdrie Furnace." (See Butler county.)]

No. 1613—CLAY "From Ross coal mines, Owensboro Junction. (Fire-clay below the coal in the lower drift.) Collected by C. J. Norwood."

A dark-grey, soft, shaly clay.

COMPOSITION, DRIED AT 212° F.

Silica	63.180
Alumina, and iron and manganese oxides	26.281
Lime	.203
Magnesia	.255
Phosphoric acid	.179
Sulphuric acid	3.282 = 1.312 per cent. of sulphur.
Potash	2.000
Soda	.425
Water expelled at red heat, and loss	4.195
	100.000

Much of the sulphur and iron doubtless exist in the clay, not as sulphuric acid and iron oxide, but in combination, as iron sulphide. The considerable proportions of potash, lime, magnesia, and iron oxide may prevent this from being a *very* refractory clay; although it may very well answer for the manufacture of stone-ware and ordinary fire-bricks.

No. 1614—PIG IRON. (*Silver-grey.*) "An old sample, from a former smelting at Airdrie Furnace. Collected by P. N. Moore."

No. 1615—PIG IRON. (*Silver-grey.*) "From a former smelting, Airdrie Furnace, &c."

No. 1616—"PIG IRON (*silver-grey,*) &c., &c., as above.

No. 707—(See volume 3 Kentucky Geological Reports (old series), page 340, for an analysis of a somewhat similar pig iron from this furnace, made when the furnace was in blast.)

COMPOSITION OF THESE AIRDRIE FURNACE PIG IRONS.

	No. 1614.	No. 1615.	No. 1616.	* No. 707.
Specific gravity	6.826	6.826	7.782	7.007
Iron	86.636	85.455	86.842	88.426
Graphite	.900	.480	.740	1.360
Combined carbon	2.080	1.560	1.460	.190
Manganese	.202	.696	.355	.980
Silicon	7.704	7.747	8.614	6.216
Slag	2.260	3.460	2.360	3.090
Aluminum	.123	.098	.054	.099
Calcium	.045	.089	.112	not est.
Magnesium	.035	.017	.056	.309
Potassium	not est.	not est.	not est.	.059
Sodium	not est.	not est.	not est.	.091
Phosphorus	.235	.443	.123	.209
Sulphur	.104	.122	.122	.219
Total	100.334	100.167	100.836	101.250
Total carbon	2.980	2.040	2.200	1.550

* Of old series of Reports.

The analyses of these samples of the pig iron of old Airdrie Furnace show inordinate proportions, in all of them, of silicon, slag, phosphorus, and sulphur; which caused the very bad quality of the iron, as they all tend to make it brittle, whether hot or cold. But the examination of the ores, limestone, and coals of the neighborhood of this furnace, shows that, with due care in the selection of these materials, and a proper management of the furnace, as good iron could be produced by it as by any using pit coal or coke for fuel.

It appears that, in its early working, the limestone used for flux was very sulphurous, containing much pyrites; that the manager had too strong a preference for the so-called "Black-band" over the limonite ores, which former frequently contain much sulphur and phosphorus; and that, moreover, the blast was too slow and too hot—conditions which all tended to the production of impure iron.

An account of the examination of some of the coke used formerly in this furnace is appended, as follows:

No. 1617 — COKE. "*Airdrie Furnace coke, weathered sixteen years; made from the No. 12 coal. Collected by P. N. Moore.*"

COMPOSITION, AIR-DRIED.

Hygroscopic moisture (expelled at 212° F.)	7.50
Moisture, &c., expelled at red heat	4.20
Dry coke	88.30
Total	100.00
Total moisture and volatile matter	11.70
Fixed carbon	82.90
Ashes, of a light yellowish-grey color	5.40
Total	100.00
Per centage of sulphur	0.64

The ash of this coke was also analyzed.

COMPOSITION OF THE ASH.

	Per cent. of the coke.
Alumina, and iron and manganese oxides	0.40
Lime	.34
Magnesia	.18
Phosphoric acid	.08
Sand and insoluble silicates	4.32
Loss	.08
Total	5.40

The analysis of the coal of which this coke was made is given in the following (Nos. 1618 and 1619):

No. 1618—COAL. "*No. 12 of Owen. Airdrie Furnace, near No. 4 entry. Average sample, by P. N. Moore.*"

A deep-black coal, with some thin shaly laminæ.

No. 1619—COAL. "*No. 12 of Owen. From the old stock pile, at the entrance of the drift; where it has been weathered for sixteen years. Average sample, by P. N. Moore.*"

Like the preceding, but altered somewhat by weathering.

No. 1620—COAL. "*Average sample of the lowest division of the bed at Paradise mines. Airdrie Furnace. (No. 11 of Owen.) By P. N. Moore.*"

A bright, deep-black coal; with but little fibrous coal between the layers, but containing small bright crystals and incrusting scales of iron pyrites.

No. 1621—COAL. "*Average sample of the middle stratum of same beds of Paradise mine. By P. N. Moore.*"

A pure looking, deep-black coal, with shining fracture; showing less fibrous coal and iron bi-sulphide than the preceding.

No. 1622—COAL. "*Average sample of the upper stratum of Paradise mine, &c. By P. N. Moore.*"

Like the two preceding; having a shining fracture, like that of asphaltum. Very little fibrous coal or pyrites to be seen in it.

No. 1623—COAL. "*From Muddy river coal mine. Averaged by P. N. Moore.*"

A deep-black, glossy coal, with but little fibrous coal or pyrites apparent in it. Like the Paradise mine coal.

COMPOSITION OF THESE AIRDRIE FURNACE COALS, AIR-DRIED.

	No. 1618.	No. 1619.	No. 1620.	No. 1621.	No. 1622.	No. 1623.
Specific gravity	1.278	1.332	1.331	1.326	1.274	1.221
Hygroscopic moisture	3.60	4.70	4.20	4.10	3.60	3.80
Volatile combustible matters	31.40	30.60	36.10	35.90	38.70	32.70
Coke	65.00	64.70	59.70	60.00	57.70	63.50
Total	100.00	100.00	100.00	100.00	100.00	100.00
Total volatile matters	35.00	35.30	40.30	40.00	42.30	36.50
Carbon in the coke	58.50	58.80	50.50	53.60	53.70	58.60
Ashes	6.50	5.90	9.20	6.40	4.00	4.90
Total	100.00	100.00	100.00	100.00	100.00	100.00
Character of coke	Dense spongy.	Dense spongy.	Spongy.	Spongy.	Spongy.	Dense spongy.
Color of ash	Lilac-grey.	Light lilac-grey	Dark lilac-grey	Dark lilac-grey	Light lilac-grey	Brownish salmon-grey.
Per centage of sulphur	1.438	1.455	4.573	4.394	3.158	1.923

It appears that the No. 12 coal contains the least sulphur, while the No. 11 coal of the Paradise mine is quite sulphurous, the upper stratum being the least objectionable in this respect. They are all very good coals for ordinary uses, and might be measurably purified from sulphur by careful coking, and thus probably made available in the iron manufacture. The coal of the No. 12 bed of Owen is, however, preferable for this purpose.

No. 1624—COAL. "*Ross coal mine. Owensboro Junction. Top bench; above the clay parting. From the upper drift. Average sample, by C. J. Norwood.*" (Coal A.)

A jet-black coal, with fibrous coal between its thin laminae, and but little apparent pyrites.

No. 1625—COAL. "*Mercer coal mines. Louisville and Paducah and Southwestern Railroad. Collected by C. J. Norwood.*" (Coal D.)

A jet-black coal, with shining pyrites, and some fibrous coal between the laminae.

No. 1626—COAL. "*Upper seam of the old drift. Muhlenburg coal mines. Collected by C. J. Norwood.*" (Coal A.)

A glossy, pure-looking, pitch-black coal; with very little fibrous coal or pyrites apparent. Some little incrustation of lime sulphate in the seams.

No. 1627—COAL. "*Muhlenburg mines. Main working bed, near Mercer Station, Louisville and Paducah and Southwestern Railroad. Collected by C. J. Norwood.*" (Coal B.)

Like the next preceding, but has a little more fibrous coal than that, and some thin pyritous and lime sulphate incrustations.

No. 1628—COAL. "*Muhlenburg mines (John Pollock, Superintendent), near Mercer Station, &c., &c. Taken from head of main entry. Average sample, by C. J. Norwood.*"

A pure pitch-black looking coal; beautifully iridescent on some of the seam faces. But little fibrous coal or pyrites apparent, but some slight lime sulphate incrustation.

No. 1629—"FIBROUS COAL OR MINERAL CHARCOAL. "*From above the main working. Thickness from one half to one inch. Muhlenburg mines, &c. Collected by C. J. Norwood.*"

A very soft, friable mass of carbonaceous matter. Some in light powder, but much in the form of charred, fibrous, reedy stems, &c.

No. 1630 — CARBONACEOUS MUD OR CLAY. "*Filling cavities occurring in the bituminous shale overlying the coal. Muhlenburg mines. Collected by C. J. Norwood.*"

A brownish greyish-black indurated mud, or carbonaceous clay.

COMPOSITION OF THESE MUHLENBURG COUNTY COALS, &c., AIR-DRIED.

	No. 1624	No. 1625	No. 1626	No. 1627	No. 1628	No. 1629	No. 1630
Specific gravity	1.407	1.358	1.297	1.332	1.280	1.503	
Hygroscopic moisture . .	4.16	3.60	3.10	1.52	2.98	1.20	3.56
Volatile combustible matters	37.44	34.00	40.68	40.00	43.08	7.50	13.68
Coke	58.40	62.40	56.22	58.48	53.94	91.30	82.76
Total	100.00	100.00	100.000	100.00	100.00	100.00	100.00
Total volatile matters . .	41.60	37.60	43.78	41.52	46.06	8.70	17.24
Carbon in the coke . . .	49.80	50.60	50.66	50.92	50.22	86.48	6.82
Ashes	8.60	11.80	5.56	7.56	3.72	4.82	75.94
Total	100.00	100.00	100.000	100.00	100.00	100.00	100.00
Character of the coke . .	Light spongy.	Light spongy.	Spongy.	Spongy.	Spongy.	Powdery.	Powdery.
Color of the ash	Light lilac-grey	Lilac- grey.	Lilac- grey.	Lilac- grey.	Lavendar grey.	Dark- brown.	Brownish grey.
Per cent. of sulphur . .	2.727	4.032	2.779	2.840	3.125	3.431	1.983

These coals are generally of very good quality, although some of them contain a little more than the usual proportion of sulphur. Some of this, however, is in combination, in the form of *lime sulphate*. To ascertain how much was in this state, coals Nos. 1626 and 1629 were boiled in solution of soda carbonate, &c., &c., and the proportions of lime sulphate ascertained. The quantity in No. 1626 was only 0.168 per cent., while No. 1629 was found to contain 3.632 per cent. of this substance. In addition, No. 1629 was treated with bisulphide of carbon, by the method of displacement, and was thus found to contain a certain amount of uncombined sulphur. It is probable that in other coals free sulphur may be found, especially in those which have much fibrous coal between their laminae.

The fibrous coal above described is remarkable for the large proportion of carbon it contains. The carbonaceous mud, on the contrary, contains but little combustible matter. It would be a bituminous shale if indurated.

OHIO COUNTY.

No. 1631—COAL. "*Rockport mines, one and three quarter mile east of Rockport. Average sample, from along the entry. Collected by C. J. Norwood.*" (Coal D.)

Rather friable. Pitch-black, with some incrustations of shining pyrites in the seams, and some fibrous coal between the laminae.

No. 1632—COAL. "*Same locality, &c. Average sample, by C. J. Norwood.*" General average of the mine. (Coal D.)

A pitch-black coal, with fibrous coal between the layers; some infiltration of lime sulphate in the seams, and but little pyrites.

No. 1633—COAL. "*Same locality, &c. Averaged by C. J. Norwood.*" (Coal D.)

Much like the preceding.

COMPOSITION OF THESE OHIO COUNTY COALS, AIR-DRIED.

	No. 1631.	No. 1632.	No. 1633.
Specific gravity	1.421	1.332	1.334
Hygroscopic moisture	3.50	3.00	3.00
Volatile combustible matters	35.00	36.20	33.50
Coke	61.50	60.80	63.50
Total	100.00	100.00	100.00
Total volatile matters	38.50	39.20	36.50
Carbon in the coke	52.50	53.70	55.10
Ashes	9.00	7.10	8.40
Total	100.00	100.00	100.00
Character of the coke	Light spongy.	Light spongy.	Light spongy.
Color of the ash	Light brownish- grey.	Light lilac-grey.	Lilac-grey.
Per centage of sulphur	3.139	2.837	3.332

These coals are all of very good quality.

[See Appendix for other Ohio county coals.]

No. 1634—"VIRGIN SOIL from woodland, on Mr. Miller's land, fifteen hundred and twenty feet north to east from Horse Branch Station (Louisville and Paducah Railroad). Collected by C. S. Schenk."

Slope 1:16. Depth of sample six inches. Substratum sandstone. Timber: white and black oak, some chestnut, hickory, and poplar. Undergrowth: sassafras, dogwood, and small trees of above named kinds. The new land is said to produce of corn, forty to fifty bushels; wheat, twenty to thirty; oats, forty to fifty; and of tobacco, one thousand pounds to the acre.

Dried soil of a dark brownish-grey color. No gravel.

No. 1635—"SUB-SOIL of the preceding, taken at depth of from six to thirty-six inches. By C. S. Schenk."

Sub-soil of a light grey-buff color. No gravel.

No. 1636—"SOIL of an old field, forty years in cultivation. Level table land, owned by Mr. Miller, sixteen hundred feet north 20° east, from Horse Branch Station, &c. Collected by C. S. Schenk."

Sample taken to the depth of seven and a half inches. Substratum sandstone. Rotation of crops: tobacco two years, corn three years (in some cases corn until it fails to produce it), then wheat and clover, or oats and clover or grass. Yield of corn, twenty to thirty bushels; oats, twenty to thirty-five bushels; tobacco, six hundred pounds per acre. Never plowed over six or seven inches deep. Good quality of table-land; nearly as good as the valley land.

Dried soil of a greyish light-brown color. Contains a few small fragments of ferruginous sandstone.

No. 1637—"SUB-SOIL of the next preceding, taken to the depth of from seven and a half to thirty-six inches. Collected by C. S. Schenk."

Dried sub-soil of a yellowish-grey color. Contains no gravel.

COMPOSITION OF THESE OHIO COUNTY SOILS, DRIED AT 212° F.

	No. 1634.	No. 1635.	No. 1636.	No. 1637.
Organic and volatile matters	4.100	3.500	3.550	3.350
Alumina, and iron and manganese oxides . .	3.032	7.047	4.066	6.475
Lime carbonate	.170	.095	.095	.095
Magnesia	.131	.258	.104	.171
Phosphoric acid	.093	.093	.124	.140
Sulphuric acid	Not estimated.			
Potash	.125	.273	.333	.269
Soda	a trace.	.144	.012	.230
Sand and insoluble silicates	92.455	88.841	91.990	89.515
Water expelled at 380° F.	.900	.915	.775	.775
Total	101.066	101.165	101.049	101.020
Hygroscopic moisture	1.175	2.400	1.450	2.575
Potash in the insoluble silicates	1.273	1.470	.939	1.107
Soda in the insoluble silicates	.814	.617	.511	.290
Character of the soil	Virgin soil.	Sub-soil.	Old field soil.	Sub-soil.

The old field soil seems to have been naturally richer than the woodland soil, if no mistake has been made in the labels. The considerable proportions of potash and soda in the sandy portion (insoluble silicates) tend to give durability to the soils. With proper culture and the due application of fertilizers, this land may be made quite productive, if well drained.

For the analyses of other soils of this serial collection, made by Mr. C. S. Schenk along the line of the Elizabethtown and Paducah Railroad, see Grayson and Hardin counties.

APPENDIX.

BOURBON COUNTY.

No. 1638—"LIMESTONE (*magnesian*). From Cane Ridge; five miles east of Paris. Used for the foundation of the Bourbon county Court-house at Paris. Sent by Mr. James Stevenson."

A somewhat porous, fossiliferous, ferruginous, magnesian limestone, of a light grey-buff color, containing small specks of hydrated oxide of iron. Specific gravity = 2.58 to 2.60 (in the lump).

COMPOSITION, DRIED AT 212° F.

Lime carbonate	79.140 = 44.318 per cent. of lime.
Magnesia carbonate	11.826 = 5.371 per cent. of magnesia.
Alumina	.380
Iron peroxide	5.510
Phosphoric acid	.511
Sulphuric acid	.240
Potash	.231
Soda	.252
Soluble silica	.110
Insoluble silica	1.160
Loss	.640

100.000

The magnesian limestones are believed to withstand the atmospheric agencies generally better than the pure limestones. The iron in this rock is all in the state of peroxide, which is also favorable to its durability.

Whether its small cavities or pores may retain enough water to cause disintegration by freezing was not ascertained. It would calcine into lime good for ordinary building purposes or for use on the soil as a fertilizer.

COALS FROM THE STATE OF OHIO.

For the purpose of comparing our Kentucky coals with some of the best of those of our neighboring States, some of these, collected by Messrs. P. N. Moore and A. R. Crandall, were submitted to analysis, as follow:

No. A. 1—"COAL from Jackson county, Ohio. *Star Furnace coal. Averaged by A. R. Crandall.*"

A glossy, jet-black splint coal; breaking into thin laminae, with fibrous coal between.

No. A. 2—"COAL. *Hocking valley, Athens county, Ohio. Average sample from the whole thickness of the bed. Taken from the pillar, three hundred yards. By A. R. Crandall.*"

A pitch-black, glossy coal, iridescent on some of the faces; having very little fibrous coal, and no pyrites apparent.

No. A. 3—"COAL. *Hocking valley, &c., &c. Average sample from the stock pile, from the whole thickness of the bed. By A. R. Crandall.*"

Like the preceding, but brighter, and showing less fibrous coal.

No. A. 4—COAL. *Hocking valley, &c., &c. Average sample from the upper twenty-eight inches. Taken from two rooms. By A. R. Crandall.*"

Breaks into thinner laminae than the two preceding, with more fibrous coal between. Some little shining pyrites in thin crusts.

No. A. 5—"COAL. *Hocking valley, &c., &c. Average sample from the middle part (twenty-six inches), taken from two rooms. By A. R. Crandall.*"

In thicker laminae than preceding, with much less fibrous coal, and no appearance of pyrites between them. Handsomely iridescent on many of the seam faces.

No. A. 6—"COAL. *Hocking valley, &c., &c. Average sample, from the lower part (eighteen inches) of the bed. Taken from two rooms. By A. R. Crandall.*"

Resembles the preceding, but shows some bright pyrites in places.

No. A. 12—"COAL. *Sheridan coal mines, Lawrence county, Ohio. Collected by P. N. Moore.*"

A pure, pitch-black coal; with very little fibrous coal and some fine-granular pyrites, between the laminae.

COMPOSITION OF THESE SELECTED OHIO COALS, AIR-DRIED.

	A. 1.	A. 2.	A. 3.	A. 4.	A. 5.	A. 6.	A. 12.
Specific gravity	1.361	1.322	not det'd.	1.346	1.303	1.312	1.322
Hygroscopic moisture . .	4.54	3.60	4.20	3.26	3.74	4.40	3.46
Volatile combustible matters	29.68	33.42	36.68	33.76	36.32	35.08	36.64
Coke	65.78	62.98	59.12	62.98	59.94	60.52	59.90
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Total volatile matters . .	34.22	37.02	40.88	37.02	40.06	39.48	40.10
Carbon in the coke . . .	57.06	55.82	54.16	54.42	55.74	55.20	53.80
Ashes	8.72	7.16	4.96	8.56	4.20	5.32	6.10
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Character of the coke . .	Pulverulent.	Dense.	Spongy.	Dense.	Dense spongy.	Dense spongy.	Light spongy.
Color of the ash	Nearly white.	Brownish grey.	Light lilac-grey	Light lilac-grey	Light lilac-grey	Light lilac-grey	Light lilac-grey
Per centage of sulphur . .	0.756	0.862	1.692	2.247	1.299	1.659	1.947

These are remarkably good coals, and are acknowledged to be amongst the best of the country.

The sample A. 2, taken from the pillar, seems to show the effect of exposure to the atmosphere, which is generally believed to cause a diminution of the proportion of sulphur.

A correspondence may be observed between the proportion of ash and the specific gravity, as follows:

A. 5	has	specific gravity =	1.303,	and ash per cent. =	4.20
A. 6	has	"	1.312,	"	5.32
A. 2 and A. 13	have	"	1.322,	"	6.10 and 7.16
A. 4	has	"	1.346,	"	8.50
A. 1	has	"	1.361,	"	8.72

COALS FROM THE STATE OF ILLINOIS.

No. A. 7—COAL. "*Mine near Murphrysboro, Jackson county, Illinois. Block coal. Big Muddy coal. Average sample, by P. N. Moore.*"

A glossy, jet-black splint coal. It has some fibrous coal between the laminæ; with occasional scales of bright pyrites, and some slight lime sulphate incrustation in the seams.

No. A. 8—"COAL. *Big Muddy coal. Mine near Murphrysboro, Illinois. Average sample, by P. N. Moore.*"

Like the preceding. Some fine-granular pyrites with the fibrous coal between the laminæ, and occasional lime sulphate incrustation in the seams.

COMPOSITION OF THESE ILLINOIS COALS, AIR-DRIED.

	No. A. 7.	No. A. 8.
Specific gravity	1.310	1.310
Hygroscopic moisture	2.62	3.44
Volatile combustible matters	32.04	31.86
Coke	65.34	64.70
Total	100.00	100.00
Total volatile matters	34.66	35.30
Carbon in the coke	58.58	59.54
Ashes	6.76	5.16
Total	100.00	100.00
Character of the coke	Light spongy.	Spongy.
Color of the ash	Lilac-grey.	Lilac-grey.
Per centage of sulphur	2.472	1.376

These are also remarkably good coals, containing only a moderate proportion of sulphur, which is partly in the form of iron sulphide and partly in that of lime sulphate.

COALS FROM THE STATE OF INDIANA.

No. A. 9—"INDIANA BLOCK COAL. *From near Brazil, Clay county. Upper seam. Average sample, by P. N. Moore.*"

A pitch-black splint coal, breaking easily into thin laminæ, with fibrous coal (mineral charcoal) and some fine granular

pyrites between them. A few bright scales of iron pyrites and some slight lime sulphate incrustation in the seams.

No. A. 10—"INDIANA BLOCK COAL. *Mine near Brazil, Clay county. Lower seam. Average sample, by P. N. Moore.*"

Like preceding, but little appearance of pyrites or lime sulphate.

No. A. 11—"INDIANA BLOCK COAL. *From mine near Brazil, &c. Lower seam. Average sample, by P. N. Moore.*"

Resembles the others. Shows occasional bright scales of pyrites and lime sulphate incrustation.

COMPOSITION OF THESE INDIANA COALS, AIR-DRIED.

	No. A. 9.	No. A. 10.	No. A. 11.	No. A. 11 (repeated).
Specific gravity	1.313	not est.	not est.	.....
Hygroscopic moisture	2.70	2.68	2.40	2.52
Volatile combustible matters	36.38	36.32	35.10	35.48
Coke	60.92	61.00	62.50	62.00
Total	100.00	100.00	100.00	100.00
Total volatile matters	39.08	39.00	37.50	38.00
Carbon in the coke	55.64	53.58	53.50	53.06
Ashes	5.28	7.42	9.00	8.94
Total	100.00	100.00	100.00	100.00
Character of the coke	Spongy.	Dense spongy.	Dense.	.....
Color of the ash	Lilac-grey.	Light lilac-grey.	Lilac-grey.	.....
Per centage of sulphur	1.664	1.802	2.373	.....

These are remarkably good coals, as is well known by experience, especially in their use in the smelting of iron. Their high reputation and successful application to this industry make the comparison of their composition, with that of our Kentucky coal, an object of interest; and as we could find in

the excellent reports of the Chief Geologist of Indiana, Prof. E. T. Cox, no statement as to the amount of *sulphur* which they contain, an ingredient of great and evil influence in iron smelting, these block coals were examined especially for this determination.

It will be seen on reference to the preceding table that this ingredient exists in them in average proportion. Doubtless to the existence of the sulphur in this fuel may we attribute the fact, given by Prof. Cox, on page 70 of his First Annual Report, 1869, that "the general character of the iron made in Clay county is *red-short*, &c." This, however, may be measurably corrected, and indeed does not prevent the iron from being very good and profitable for many industrial purposes.

It is very probable that all the sulphur which exists in these coals in the free, or uncombined, condition, will be volatilized and burnt out at the upper part of the furnace, long before it encounters the heat necessary to cause its combination with the iron of the ore with which it is mixed. This would be the case also with the second atom of sulphur of the bright pyrites of the coal, the bi-sulphide of iron; so that only that portion of the sulphur which would remain in the resulting iron proto-sulphide could vitiate the cast iron product. Hence we can understand, how a coal which gives a considerable per centage of sulphur in its ultimate analysis, may yet be quite available for the smelting of tough iron.

CALIFORNIA ADOBÉ SOIL.

An opportunity having occurred for procuring a specimen of this remarkably fertile soil, it was analyzed for comparison with our Kentucky soils, with the following results.

No. A. 12—"ADOBÉ SOIL taken at three inches below the surface. Valley of the Sacramento river. Solano county, California." Collected by Robert Peter, jr.

Dried soil of a light-umber color; adhering in clods, which are easily crushed in the mortar. The powder (unground) passed wholly through fine bolting-cloth, leaving only a few vegetable fragments.

COMPOSITION OF THE AIR-DRIED SOIL.

	No. A. 12.	No. 1329.
Organic and volatile matters	7.740	7.615
Alumina, and iron and manganese oxides	11.117	12.085
Lime carbonate	.790	.990
Magnesia	1.596	.520
Phosphoric acid	.093	.483
Sulphuric acid	.082	a trace.
Potash	.727	.726
Soda	.983	a trace.
Sand and insoluble silicates	74.070	75.590
Water and loss	2.802	1.891
Total	100.00	100.000
Potash in the insoluble silicates	0.814	2.731
Soda in the insoluble silicates	0.903	.929

It will be seen above that this adobé soil resembles in composition the peculiar rich soil found locally in Campbell county, Kentucky, No. 1329, which is also like the adobé in being a sticky clay when wet, and hard and cloddy when dry. The California soil exceeds our Kentucky soils in soda, the latter has more phosphoric acid.

LYON COUNTY.—(Continued.)

No. 1639—"Water taken from the interior of a geode of iron ore—*pot iron ore*. Suwannee, Lyon county. Summit Cut ore bank. Sent by A. L. Anderson, Esq."

The water had a strong astringent taste; and had deposited much ferruginous sediment in the bottle. It was analyzed by my youngest son, Alfred M. Peter, in my laboratory.

COMPOSITION IN 100 PARTS OF THE WATER, APART FROM THE SEDIMENT.

Iron protosulphate	0.2435
Alumina sulphate	.4981
Manganese sulphate	.1004
Lime sulphate	.1209
Magnesia sulphate	.0609
Potash sulphate	.0257
Soda sulphate	.0651
Sodium chloride	.0053
Phosphoric acid	.0028
Total	1.1227

The analyses of some other samples of water, from the pot ore of Trigg county, are given in volume 4, page 260-1, of Kentucky Geological Reports.

EDMONSON COUNTY.—(Continued.)

No. 1640—LIMONITE. "*Old Nolin Furnace bank, near the furnace ore. Bank about a quarter of a mile north of the furnace. Davis' branch of Nolin river. Average sample, by P. N. Moore.*"

Generally of a brownish-red color. A porous ore, with some whitish portions.

COMPOSITION, DRIED AT 212° F.

Iron peroxide	27.340	= 19.138 per cent. of iron.
Alumina	5.930	
Manganese oxide	not det'd.	
Lime carbonate	1.090	
Magnesia	.447	
Phosphoric acid	1.068	= .497 per cent. of phosphorus.
Sulphuric acid	not det'd.	
Water expelled at red heat	12.380	
Silica and insoluble silicates	51.230	
Manganese oxide, alkalies, sulphuric acid, &c.	.515	
	100.000	

This ore is too poor in iron to be valuable. It is probable that its phosphorus is somewhat over-estimated.

No. 1643—PIG IRON. "*From old Nolin Furnace. Cold blast. Furnace long since out of blast.*"

A fine-grained grey iron, which yields easily to the file, and extends considerably under the hammer. Seems to be tougher than usual cast iron.

COMPOSITION.—SPECIFIC GRAVITY = 7.113.

Iron	94.287	
Graphite	3.100	} = 3.800 total carbon.
Combined carbon	.700	
Silicon	.493	} including that in the slag.
Phosphorus	1.029	
Sulphur	.012	
Undetermined ingredients and loss	.379	
	100.000	

This appears to be a remarkable instance of cast iron remaining tough although it contains a considerable proportion of phosphorus, which is believed to render it "cold-short," or

brittle at the ordinary temperature, in quantities even less than one per cent. Possibly the quite small per centage of silicon, which also renders iron brittle, may have something to do with this apparent anomaly.

The phosphorus in the above analysis was first determined as phosphate of bismuth, by the process of Chancel; but not satisfied with this determination, this phosphate, after solution in chlorohydric acid, was decomposed by sulphydric acid, and the separated phosphoric acid re-determined by means of the magnesia mixture, in the usual way; and this without any material alteration in the result obtained.

GRAYSON COUNTY.—(Continued.)

No. 1641 — "LIMONITE. "*Nolin Furnace ore bank, on the Brownsville road. Average sample, by P. N. Moore.*"

In irregular layers, varying in color and density.

No. 1642—LIMONITE. "*From Meredith Ray's farm, Taylor's Fork of Bear Creek, opposite the Chalybeate Spring. Average sample, by P. N. Moore.*"

A pretty dense ore, generally of a dark-brown color, with some lighter colored portions.

COMPOSITION OF THESE GRAYSON COUNTY LIMONITE ORES, DRIED AT 212° F.

	No. 1641.	No. 1642.
Iron peroxide	57.830	44.528
Alumina	6.719	1.368
Manganese oxide	Not determined.	
Lime carbonate	.290	5.590
Magnesia	.122	.609
Phosphoric acid	.921	1.074
Sulphuric acid	not deter'd.	.151
Water expelled at red heat	12.180	8.940
Silica and insoluble silicates	21.040	37.380
Undetermined and loss	.898	.360
Total	100.000	100.000
Iron, per centage	40.481	31.169
Phosphorus, per centage	.412	.468
Sulphur, per centage	not deter'd.	.060
Silica, per centage	14.360	not deter'd.

It is probable the phosphorus is somewhat over-estimated in these ores.

No. 1644 — CLAY IRON-STONE. *"The glady ore, on the old Brownsville and Litchfield road, west of Bear Creek, Grayson county."*

A dark-grey, fine-granular clay iron-stone, with much investing limonite ore.

COMPOSITION, DRIED AT 212° F.

Iron carbonate	16.598	} = 37.945 per cent. of iron.
Iron peroxide	42.761	
Alumina	4.994	
Lime carbonate	2.840	
Magnesia carbonate	not det'd.	
Phosphoric acid	1.017	} = .444 per cent. of phosphorus.
Sulphuric acid	a trace.	
Silica and insoluble silicates	20.830	
Water and loss	8.054	
	100.000	

BOYD COUNTY.—(Continued.)

No. 1645—COAL. No. 7. *Used at Ashland Furnace.*

A bright pure-looking coal, having but little fibrous coal between its laminae; has some little bright pyrites and thin scales of lime sulphate in the seams.

COMPOSITION, AIR-DRIED.—SPECIFIC GRAVITY = 1.291.

Hygroscopic moisture	4.80	} Total volatile matters = 39.00
Volatile combustible matters	34.20	
Spongy coke	61.00	} Carbon in the coke = 54.90
	100.00	Light brownish-grey ash = 6.10
		100.00

Per centage of sulphur = 1.312.

A very good and pure coal, which favorably compares with the best so-called "Block coal" of Indiana, and is well adapted to the purpose for which it is used.

CARTER COUNTY.—(Continued.)

No. 1646—COAL. No. 1. *"From Graham bank. Little Fork of Little Sandy river. Collected by P. N. Moore."*

A pure-looking coal, which has some fibrous coal between its laminae; but shows very little pyrites.

No. 1647—COAL. No. 1. *"From Graham bank, &c. Sample from all parts of the mine."*

COMPOSITION OF THESE CARTER COUNTY COALS, AIR-DRIED.

	No. 1646.	No. 1647.
Specific gravity	1.269	not deter'd.
Hygroscopic moisture	3.50	3.60
Volatile combustible matters	36.30	35.40
Coke	60.20	61.00
Total	100.00	100.00
Total volatile matters	39.80	39.00
Fixed carbon in the coke	57.30	57.60
Ashes	2.90	3.40
Total	100.00	100.00
Character of the coke	Spongy.	Spongy.
Color of the ash	Brownish-grey.	Brownish-grey.
Per centage of sulphur	1.148	1.107

Remarkably good and pure coals.

GREENUP COUNTY.—(Continued.)

No. 1648—COAL. No. 1. "*Raccoon Creek. Raccoon Furnace. Collected by P. N. Moore.*"

A splint coal, with quite thin laminæ and considerable fibrous coal between. Some little iron stain, but little appearance of pyrites.

No. 1649—COAL. "*Hunnewell cannel coal. Hunnewell mines.*"

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	No. 1648.	No. 1649.
Specific gravity	1.409	1.306
Hygroscopic moisture	4.10	1.50
Volatile combustible matters	28.90	52.20
Coke	67.00	46.30
Total	100.00	100.00
Total volatile matters	33.00	53.70
Fixed carbon in the coke	49.60	40.60
Ashes	17.40	5.70
Total	100.00	100.00
Character of the coke	Pulverulent	Very friable
Color of the ash	Light-grey, nearly white	Light yellowish-grey.
Per centage of sulphur	0.655	0.782

This cannel coal is remarkably pure and good. Its proportion of volatile combustible matters (52.20 per cent.) is remarkably great.

OHIO COUNTY.—(Continued.)

No. 1650—COAL (D.) "*From Taylor coal mines, near Beaver Dam, Ohio county. Collected by C. J. Norwood. (Rather better than a fair average.)*"

A bright-looking coal, with but little fibrous coal between the laminæ, but with some scales of bright pyrites.

No. 1651—COAL (D.) "*Stevens' coal mine, near Beaver Dam, &c. Collected by C. J. Norwood.*"

Has more fibrous coal than the preceding, but shows less pyrites. Iridescent in parts.

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COMPOSITION, AIR-DRIED.

	No. 1650.	No. 1651.
Specific gravity	1.315	1.316
Hygroscopic moisture	3.30	3.30
Volatile combustible matters	35.84	36.76
Coke	60.86	59.94
Total	100.00	100.00
Total volatile matters	39.14	40.06
Fixed carbon in the coke	54.36	52.60
Ashes	6.50	7.34
Total	100.00	100.00
Character of the coke	Spongy.	Spongy.
Color of the ash	Chocolate-grey.	Brownish-grey.
Per centage of sulphur	3.874	2.608

These are both very good coals; ranking amongst the best.

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TABLE I. SOILS, SUB-SOILS, &c., DRIED AT 212° F.

Number in Report.	County.	Organic and volatile matters.	Alumina.	Iron oxide.	Manganese oxide.	Lime carbonate.	Magnesia.	Phosphoric acid.	Sulphuric acid.	Potash.	Soda.	Sand and silicates.	Water lost at 380°.	Hygroscopic moisture.	Potash in the silicates.	Soda in the silicates.	Extracted from 1000 parts by carbonic acid water.	Remarks.
1298	Boyd.	3.140	5.837	5.091	0.214	0.034	0.134	0.076	0.099	0.317	0.076	00.490	0.650	1.375	not est	not est	not est.	Virgin soil (valley).
1299	Boyd.	3.085	5.837	5.091	0.178	0.034	0.083	0.076	0.099	0.307	0.099	88.420	0.525	1.735	not est	not est	not est.	Sub-soil of same.
1300	Boyd.	3.085	5.837	5.091	0.352	0.034	0.208	0.076	0.099	0.435	0.140	81.410	0.915	2.225	not est	not est	not est.	Virgin soil (slope of hill).
1301	Boyd.	3.085	5.837	5.091	0.281	0.034	0.201	0.076	0.099	0.205	0.050	81.230	0.590	1.700	not est	not est	not est.	Sub-soil of same.
1302	Boyd.	3.085	5.837	5.091	0.289	0.034	0.156	0.076	0.099	0.344	0.098	81.765	1.235	2.335	not est	not est	not est.	Old field soil.
1303	Boyd.	3.085	5.837	5.091	0.283	0.034	0.160	0.076	0.099	0.282	0.176	83.385	1.315	2.840	not est	not est	not est.	Sub-soil of same.
1304	Boyd.	3.085	5.837	5.091	0.276	0.034	0.223	0.076	0.099	0.110	0.194	82.140	1.015	2.200	not est	not est	1.316	Old field.
1305	Bracken.	3.085	5.837	5.091	0.228	0.034	0.223	0.076	0.099	0.110	0.194	82.140	1.015	2.200	not est	not est	0.960	Sub-soil.
1306	Bracken.	3.085	5.837	5.091	0.170	0.034	0.202	0.076	0.099	0.174	0.170	87.815	1.000	2.300	not est	not est	0.666	Old field, worn spot.
1307	Campbell.	3.085	5.837	5.091	0.268	0.034	0.145	0.076	0.099	0.135	0.047	87.545	1.160	1.765	not est	not est	2.322	Virgin soil.
1308	Campbell.	3.085	5.837	5.091	0.330	0.034	0.145	0.076	0.099	0.130	0.047	87.545	1.160	1.765	not est	not est	1.876	Old field soil.
1309	Campbell.	3.085	5.837	5.091	0.359	0.034	0.100	0.076	0.099	0.062	0.130	80.335	1.110	1.550	1.311	0.700	1.220	Old field soil.
1310	Campbell.	3.085	5.837	5.091	0.392	0.034	0.068	0.076	0.099	0.062	0.130	80.335	1.110	1.550	1.311	0.700	1.220	Old field soil.
1311	Campbell.	3.085	5.837	5.091	0.392	0.034	0.068	0.076	0.099	0.062	0.130	80.335	1.110	1.550	1.311	0.700	1.220	Old field soil.
1312	Campbell.	3.085	5.837	5.091	0.392	0.034	0.068	0.076	0.099	0.062	0.130	80.335	1.110	1.550	1.311	0.700	1.220	Old field soil.
1313	Campbell.	3.085	5.837	5.091	0.392	0.034	0.068	0.076	0.099	0.062	0.130	80.335	1.110	1.550	1.311	0.700	1.220	Old field soil.
1314	Campbell.	3.085	5.837	5.091	0.392	0.034	0.068	0.076	0.099	0.062	0.130	80.335	1.110	1.550	1.311	0.700	1.220	Old field soil.
1315	Campbell.	3.085	5.837	5.091	0.392	0.034	0.068	0.076	0.099	0.062	0.130	80.335	1.110	1.550	1.311	0.700	1.220	Old field soil.
1316	Campbell.	3.085	5.837	5.091	0.392	0.034	0.068	0.076	0.099	0.062	0.130	80.335	1.110	1.550	1.311	0.700	1.220	Old field soil.
1317	Campbell.	3.085	5.837	5.091	0.392	0.034	0.068	0.076	0.099	0.062	0.130	80.335	1.110	1.550	1.311	0.700	1.220	Old field soil.
1318	Campbell.	3.085	5.837	5.091	0.392	0.034	0.068	0.076	0.099	0.062	0.130	80.335	1.110	1.550	1.311	0.700	1.220	Old field soil.
1319	Campbell.	3.085	5.837	5.091	0.392	0.034	0.068	0.076	0.099	0.062	0.130	80.335	1.110	1.550	1.311	0.700	1.220	Old field soil.
1320	Campbell.	3.085	5.837	5.091	0.392	0.034	0.068	0.076	0.099	0.062	0.130	80.335	1.110	1.550	1.311	0.700	1.220	Old field soil.
1321	Campbell.	3.085	5.837	5.091	0.392	0.034	0.068	0.076	0.099	0.062	0.130	80.335	1.110	1.550	1.311	0.700	1.220	Old field soil.
1322	Campbell.	3.085	5.837	5.091	0.392	0.034	0.068	0.076	0.099	0.062	0.130	80.335	1.110	1.550	1.311	0.700	1.220	Old field soil.
1323	Campbell.	3.085	5.837	5.091	0.392	0.034	0.068	0.076	0.099	0.062	0.130	80.335	1.110	1.550	1.311	0.700	1.220	Old field soil.
1324	Campbell.	3.085	5.837	5.091	0.392	0.034	0.068	0.076	0.099	0.062	0.130	80.335	1.110	1.550	1.311	0.700	1.220	Old field soil.
1325	Campbell.	3.085	5.837	5.091	0.392	0.034	0.068	0.076	0.099	0.062	0.130	80.335	1.110	1.550	1.311	0.700	1.220	Old field soil.
1326	Campbell.	3.085	5.837	5.091	0.392	0.034	0.068	0.076	0.099	0.062	0.130	80.335	1.110	1.550	1.311	0.700	1.220	Old field soil.
1327	Campbell.	3.085	5.837	5.091	0.392	0.034	0.068	0.076	0.099	0.062	0.130	80.335	1.110	1.550	1.311	0.700	1.220	Old field soil.
1328	Campbell.	3.085	5.837	5.091	0.392	0.034	0.068	0.076	0.099	0.062	0.130	80.335	1.110	1.550	1.311	0.700	1.220	Old field soil.
1329	Campbell.	3.085	5.837	5.091	0.392	0.034	0.068	0.076	0.099	0.062	0.130	80.335	1.110	1.550	1.311	0.700	1.220	Old field soil.
1330	Campbell.	3.085	5.837	5.091	0.392	0.034	0.068	0.076	0.099	0.062	0.130	80.335	1.110	1.550	1.311	0.700	1.220	Old field soil.
1331	Campbell.	3.085	5.837	5.091	0.392	0.034	0.068	0.076	0.099	0.062	0.130	80.335	1.110	1.550	1.311	0.700	1.220	Old field soil.
1332	Campbell.	3.085	5.837	5.091	0.392	0.034	0.068	0.076	0.099	0.062	0.130	80.335	1.110	1.550	1.311	0.700	1.220	Old field soil.
1333	Campbell.	3.085	5.837	5.091	0.392	0.034	0.068	0.076	0.099	0.062	0.130	80.335	1.110	1.550	1.311	0.700	1.220	Old field soil.
1334	Campbell.	3.085	5.837	5.091	0.392	0.034	0.068	0.076	0.099	0.062	0.130	80.335	1.110	1.550	1.311	0.700	1.220	Old field soil.
1335	Campbell.	3.085	5.837	5.091	0.392	0.034	0.068	0.076	0.099	0.062	0.130	80.335	1.110	1.550	1.311	0.700	1.220	Old field soil.
1336	Campbell.	3.085	5.837	5.091	0.392	0.034	0.068	0.076	0.099	0.062	0.130	80.335	1.110	1.550	1.311	0.700	1.220	Old field soil.
1337	Campbell.	3.085	5.837	5.091	0.392	0.034	0.068	0.076	0.099	0.062	0.130	80.335	1.110	1.550	1.311	0.700	1.220	Old field soil.
1338	Campbell.	3.085	5.837	5.091	0.392	0.034	0.068	0.076	0.099	0.062	0.130	80.335	1.110	1.550	1.311	0.700	1.220	Old field soil.
1339	Campbell.	3.085	5.837	5.091	0.392	0.034	0.068	0.076	0.099	0.062	0.130	80.335	1.110	1.550	1.311	0.700	1.220	Old field soil.
1340	Campbell.	3.085	5.837	5.091	0.392	0.034	0.068	0.076	0.099	0.062	0.130	80.335	1.110	1.550	1.311	0.700	1.220	Old field soil.
1401	Carter.	3.085	5.837	5.091	0.392	0.034	0.068	0.076	0.099	0.062	0.130	80.335	1.110	1.550	1.311	0.700	1.220	Old field, near Iron Hill.
1402	Carter.	3.085	5.837	5.091	0.392	0.034	0.068	0.076	0.099	0.062	0.130	80.335	1.110	1.550	1.311	0.700	1.220	Old field, near Iron Hill.
1403	Carter.	3.085	5.837	5.091	0.392	0.034	0.068	0.076	0.099	0.062	0.130	80.335	1.110	1.550	1.311	0.700	1.220	Old field, near Iron Hill.
1404	Carter.	3.085	5.837	5.091	0.392	0.034	0.068	0.076	0.099	0.062	0.130	80.335	1.110	1.550	1.311	0.700	1.220	Old field, near Iron Hill.
1405	Carter.	3.085	5.837	5.091	0.392	0.034	0.068	0.076	0.099	0.062	0.130	80.335	1.110	1.550	1.311	0.700	1.220	Old field, near Iron Hill.
1406	Carter.	3.085	5.837	5.091	0.392	0.034	0.068	0.076	0.099	0.062	0.130	80.335	1.110	1.550	1.311	0.700	1.220	Old field, near Iron Hill.
1407	Carter.	3.085	5.837	5.091	0.392	0.034	0.068	0.076	0.099	0.062	0.130	80.335	1.110	1.550	1.311	0.700	1.220	Old field, near Iron Hill.
1408	Carter.	3.085	5.837	5.091	0.392	0.034	0.068	0.076	0.099	0.062	0.130	80.335	1.110	1.550	1.311	0.700	1.220	Old field, near Iron Hill.
1409	Carter.	3.085	5.837	5.091	0.392	0.034	0.068	0.076	0.099	0.062	0.130	80.335	1.110	1.550	1.311	0.700	1.220	Old field, near Iron Hill.
1410	Carter.	3.085	5.837	5.091	0.392	0.034	0.068	0.076	0.099	0.062	0.130	80.335	1.110	1.550	1.311	0.700	1.220	Old field, near Iron Hill.
1411	Carter.	3.085	5.837	5.091	0.392	0.034	0.068	0.076	0.099	0.062	0.130	80.335	1.110	1.550	1.311	0.700	1.220	Old field, near Iron Hill.
1412	Carter.	3.085	5.837	5.091	0.392	0.034	0.068	0.076	0.099	0.062	0.130	80.335	1.110	1.550	1.311	0.700	1.220	Old field, near Iron Hill.
1413	Carter.	3.085	5.837	5.091	0.392	0.034	0.068	0.076	0.099	0.062	0.130	80.335	1.110	1.550	1.311	0.700	1.220	Old field, near Iron Hill.
1414	Carter.	3.085	5.837	5.091	0.392	0.034	0.068	0.076	0.099	0.062	0.130	80.335	1.110	1.550	1.311	0.700	1.220	Old field, near Iron Hill.
1415	Carter.	3.085	5.837	5.091	0.392	0.034	0.068	0.076	0.099	0.062	0.130	80.335	1.110	1.550	1.311	0.700	1.220	Old field, near Iron Hill.
1416	Carter.	3.085	5.837	5.091	0.392	0.034	0.068	0.076	0.099	0.062	0.130	80.335	1.110	1.550	1.311	0.700	1.220	Old field, near Iron Hill.
1417	Carter.	3.085	5.837	5.091	0.392	0.034	0.068	0.076	0.099	0.062	0.130	80.335	1.110	1.550	1.311	0.700	1.220	Old field, near Iron Hill.
1418	Carter.	3.085	5.837	5.091	0.392	0.034	0.068	0.076	0.099	0.062	0.130	80.335	1.110	1.550	1.311	0.700	1.220	Old field, near Iron Hill.
1419	Carter.	3.085	5.837	5.091	0.392	0.034	0.068	0.076	0.099	0.062	0.130							

TABLE I. SOILS, SUB-SOILS, &c.—(Continued.)

Number in Report.	County.	Organic and volatile matters.	Alumina.	Iron oxide.	Manganese oxide.	Lime carbonate.	Magnesia.	Phosphoric acid.	Sulphuric acid.	Potash.	Soda.	Sand and silicates.	Water lost at 380°.	Hygroskop. moisture.	Potash in the silicates.	Soda in the silicates.	Extracted from 1000 parts by carbonic acid water.	Remarks.
1472	Grayson.	3.200	7.497	0.45	.145	.145	.145	.093	not est.	.105	.044	87.565	.875	2.700	.000	.000	.000	Virgin soil sub-soil (on sandstone).
1473	Grayson.	4.050	6.195	.020	.020	.020	.020	.093	not est.	.327	.023	86.783	1.075	1.950	.000	.000	.000	Virgin soil (on limestone).
1474	Grayson.	3.350	6.647	.020	.020	.020	.020	.093	not est.	.105	.070	88.995	1.000	1.051	.000	.000	.000	Virgin soil sub-soil (on limestone).
1475	Grayson.	4.170	4.172	.020	.020	.020	.020	.093	not est.	.120	.045	90.640	1.000	1.775	.000	.000	.000	Old field (on limestone).
1476	Grayson.	3.275	6.022	.020	.020	.020	.020	.093	not est.	.405	.055	86.595	.350	3.500	.000	.000	.000	Old field sub-soil (on limestone).
1537	Greenup.	5.050	6.831	.020	.020	.020	.020	.093	not est.	.217	.055	86.595	.085	1.775	.000	.000	.000	New soil (coaled land), Pea Ridge.
1538	Greenup.	4.030	9.223	.020	.020	.020	.020	.093	not est.	.312	.120	84.695	.615	1.775	.000	.000	.000	Sub-soil of same.
1539	Greenup.	5.105	9.223	.020	.020	.020	.020	.093	not est.	.154	.109	88.595	.615	1.775	.000	.000	.000	Under clay of same.
1540	Hardin.	3.675	5.790	.020	.020	.020	.020	.093	not est.	.188	.002	86.975	.925	1.510	.000	.000	.000	Old field (on limestone).
1541	Hardin.	2.600	8.617	.020	.020	.020	.020	.093	not est.	.205	.030	84.740	.750	1.215	.000	.000	.000	Sub-soil of same (on limestone).
1542	Hardin.	2.950	10.775	.020	.020	.020	.020	.093	not est.	.404	.030	89.555	.900	1.215	.000	.000	.000	Under clay of same (on limestone).
1543	Hardin.	2.950	5.786	.020	.020	.020	.020	.093	not est.	.404	.030	89.555	.900	1.215	.000	.000	.000	Sub-soil of same (on limestone).
1544	Hardin.	3.100	9.705	.020	.020	.020	.020	.093	not est.	.327	.033	87.465	.725	1.325	.000	.000	.000	Old field (on limestone).
1545	Hardin.	3.025	9.190	.020	.020	.020	.020	.093	not est.	.327	.033	87.465	.725	1.325	.000	.000	.000	Sub-soil of same (on limestone).
1546	Hardin.	3.035	11.625	.020	.020	.020	.020	.093	not est.	.256	.160	83.925	.600	1.800	.000	.000	.000	Virgin soil (on limestone).
1547	Hardin.	3.035	8.870	.020	.020	.020	.020	.093	not est.	.209	.054	86.595	.250	1.650	.000	.000	.000	Sub-soil of same (on limestone).
1549	Hardin.	4.150	8.870	.020	.020	.020	.020	.093	not est.	.399	.054	86.595	.250	1.650	.000	.000	.000	New soil (on limestone).
1550	Hardin.	3.535	11.900	.020	.020	.020	.020	.093	not est.	.209	.054	86.595	.250	1.650	.000	.000	.000	Sub-soil of same (on limestone).
1551	Hardin.	3.150	8.784	.020	.020	.020	.020	.093	not est.	.150	.140	83.315	.700	1.200	.000	.000	.000	Old field.
1552	Hardin.	1.950	5.926	.020	.020	.020	.020	.093	not est.	.150	.140	83.315	.700	1.200	.000	.000	.000	Sub-soil of same.
1553	Hardin.	1.950	8.344	.020	.020	.020	.020	.093	not est.	.150	.140	83.315	.700	1.200	.000	.000	.000	Virgin soil.
1554	Hardin.	2.185	5.692	.020	.020	.020	.020	.093	not est.	.150	.140	83.315	.700	1.200	.000	.000	.000	New soil.
1555	Hardin.	2.185	9.476	.020	.020	.020	.020	.093	not est.	.250	.054	86.595	.250	1.650	.000	.000	.000	Sub-soil of same.
1556	Hardin.	2.100	6.359	.020	.020	.020	.020	.093	not est.	.250	.054	86.595	.250	1.650	.000	.000	.000	Old field.
1557	Hardin.	2.100	7.388	.020	.020	.020	.020	.093	not est.	.250	.054	86.595	.250	1.650	.000	.000	.000	Sub-soil of same.
1558	Hardin.	2.695	10.445	.020	.020	.020	.020	.093	not est.	.250	.054	86.595	.250	1.650	.000	.000	.000	Sub-soil of same.
1559	Hardin.	3.215	6.790	.020	.020	.020	.020	.093	not est.	.250	.054	86.595	.250	1.650	.000	.000	.000	Old field (on limestone).
1560	Hardin.	3.215	15.763	.020	.020	.020	.020	.093	not est.	.250	.054	86.595	.250	1.650	.000	.000	.000	Sub-soil of same (on limestone).
1561	Hardin.	3.215	6.564	.020	.020	.020	.020	.093	not est.	.250	.054	86.595	.250	1.650	.000	.000	.000	Old field (on limestone).
1562	Hardin.	3.785	10.763	.020	.020	.020	.020	.093	not est.	.250	.054	86.595	.250	1.650	.000	.000	.000	Sub-soil of same (on limestone).
1563	Hardin.	3.080	10.763	.020	.020	.020	.020	.093	not est.	.250	.054	86.595	.250	1.650	.000	.000	.000	Old field (on limestone).
1564	Hardin.	3.215	5.395	.020	.020	.020	.020	.093	not est.	.250	.054	86.595	.250	1.650	.000	.000	.000	Sub-soil of same (on limestone).
1565	Hardin.	4.400	5.395	.020	.020	.020	.020	.093	not est.	.250	.054	86.595	.250	1.650	.000	.000	.000	Sub-soil of same (on limestone).
1566	Hardin.	3.050	5.395	.020	.020	.020	.020	.093	not est.	.250	.054	86.595	.250	1.650	.000	.000	.000	Sub-soil of same (on limestone).
1567	Hardin.	3.525	4.468	.020	.020	.020	.020	.093	not est.	.250	.054	86.595	.250	1.650	.000	.000	.000	Sub-soil of same (on limestone).
1568	Hardin.	2.525	4.468	.020	.020	.020	.020	.093	not est.	.250	.054	86.595	.250	1.650	.000	.000	.000	Sub-soil of same (on limestone).
1569	Hardin.	2.225	7.045	.020	.020	.020	.020	.093	not est.	.250	.054	86.595	.250	1.650	.000	.000	.000	Sub-soil of same (on limestone).
1570	Hardin.	2.165	7.045	.020	.020	.020	.020	.093	not est.	.250	.054	86.595	.250	1.650	.000	.000	.000	Sub-soil of same (on limestone).
1571	Hardin.	2.165	7.045	.020	.020	.020	.020	.093	not est.	.250	.054	86.595	.250	1.650	.000	.000	.000	Sub-soil of same (on limestone).
1572	Hardin.	2.575	6.900	.020	.020	.020	.020	.093	not est.	.250	.054	86.595	.250	1.650	.000	.000	.000	Sub-soil of same (on limestone).

TABLE II. LIMESTONES, &c., DRIED AT 212° F.

Number in report.	County.	Specific gravity.	Lime carbonate.	Magnesia carbonate.	Alumina.	Iron oxide.	Phosphoric acid.	Sulphuric acid.	Potash.	Soda.	Silica and silicates.	Per centage of lime.	Per centage of phosphorus.	Per centage of sulphur.	Remarks.
1313	Butler.	not det.	93.090	2.088	0.917	0.243	0.604	not est.	not est.	not est.	2.760	52.091	0.100	0.242	S. C., Barren river, Airdrie Furnace.
1334	Campbell.	not det.	93.200	not est.	1.700	.076	.535	not est.	0.173	0.384	2.360	52.192	.033	.214	Lower Silurian.
1388	Carter.	2.624	97.700	2.201	0.300	.083	not est.	.115	.107	1.560	54.723	54.723	.036	not est.	Boone Furnace (flux).
1389	Carter.	2.700	95.150	.245	1.390	.130	a trace.	not est.	not est.	not est.	53.284	53.284	.056	a trace.	Iron Hills Furnace (flux).
1390	Carter.	not det.	75.750	.575	6.413	.057	.775	not est.	not est.	not est.	14.700	42.420	.032	.310	Mt. Savage Furnace (flux).
1421	Edmonson.	2.678	90.050	.303	0.411	.081	.260	not est.	not est.	not est.	14.700	42.420	.022	.104	Oolitic, sub-carboniferous.
1422	Edmonson.	2.721	77.530	.303	2.680	.081	.192	not est.	not est.	not est.	14.700	42.420	.022	.077	Sub-carboniferous, upper part.
1423	Edmonson.	2.689	82.960	.241	4.505	.115	.260	not est.	not est.	not est.	14.700	42.420	.050	.104	Sub-carboniferous, lithographic.
1426	Fayette.	not det.	96.610	.401	4.505	.415	.446	not est.	not est.	not est.	14.700	42.420	.050	.104	Quicklime (Lower Silurian).
1498	Fayette.	not det.	88.140	.797	3.760	.057	.044	not est.	not est.	not est.	14.700	42.420	.050	.104	Pea Ridge (ferruginous).
1499	Greenup.	2.686	88.150	.385	1.52	.078	.044	not est.	not est.	not est.	14.700	42.420	.050	.104	Used as flux, Raccoon Furnace.
1500	Greenup.	2.700	92.050	.220	1.490	.128	.092	not est.	not est.	not est.	14.700	42.420	.050	.104	Used as flux, Kenton Furnace.
1501	Greenup.	2.770	60.750	25.656	4.167	.013	.192	not est.	not est.	not est.	14.700	42.420	.050	.104	Buffalo Creek (ferruginous).
1587	Kenton.	2.720	64.240	6.152	4.960	.191	not est.	not est.	not est.	not est.	23.860	35.074	.005	.126	Blue argillaceous (Lower Silurian).
1604	Montgomery.	not det.	79.140	11.826	0.380	.023	not est.	not est.	not est.	not est.	23.860	35.074	.005	.126	Quicklime (Star Lime Company).
1638	Bourbon.	2.600	79.140	11.826	0.380	.023	not est.	not est.	not est.	not est.	23.860	35.074	.005	.126	Cane Ridge limestone.

* Magnesia.

† Iron carbonate.

* Total alkalis separated by fusion.

† Silica separated by fusion with alkaline carbonates, &c.

TABLE III (A). IRON ORES (LIMONITES), DRIED AT 212° F.

Number in report.	County.	Iron peroxide.	Iron carbonate.	Alumina.	Manganese brown oxide.	Lime carbonate.	Magnesia.	Phosphoric acid.	Sulphuric acid.	Water (combined).	Silica and silicates.	Moisture and loss.	Per cent. of iron.	Per cent. of phosphorus.	Per cent. of sulphur.	Per cent. of silica.	Remarks.
1269	Bath	76.977	...	2.592	0.430	0.130	0.281	0.731	0.030	12.300	8.180	...	53.254	0.319	0.011	6.160	Old Slate Furnace.
1271	Boyd	58.653	...	4.324	3.680	trace	1.101	3.113	.220	10.150	30.940	...	37.551	.137	.086	29.560	Slate ore, Cane Creek.
1272	Boyd	7.284	...	7.284	3.80	4.30	.227	.376	.089	10.800	21.210	...	41.272	.164	.082	19.980	Star Furnace yellow limestone ore.
1275	Boyd	31.800	10.569	4.523	trace	7.480	.440	.795	.089	8.772	15.730	...	41.357	.231	.035	13.160	Bellefont Furnace limestone ore.
1276	Boyd	61.344	...	4.236	trace	7.50	.208	.795	.089	11.200	21.480	...	42.941	.347	.016	18.560	Buena Vista Furnace yellow kidney.
1277	Boyd	56.022	8.821	7.104	trace	2.520	1.271	.526	.090	10.150	13.430	...	43.473	.233	.036	11.660	Buena Vista Furnace, Straight Creek.
1278	Boyd	51.055	...	4.019	420	0.800	1.271	.076	.096	10.450	30.080	...	37.838	.033	.038	24.260	Star Furnace black kidney.
1309	Builer	48.049	...	8.171	140	.540	.105	.345	.473	9.750	31.900	...	43.733	.135	.189	29.460	J. E. Taylor's (L. Reedy).
1310	Builer	31.040	...	3.10	trace	.643	.234	.535	.158	7.020	44.180	...	31.482	.233	.063	42.200	Stevens' coal mine.
1371	Carter	52.460	...	7.504	trace	1.180	.910	.060	not est.	11.280	2.600	...	57.148	.026	...	...	Horsley bank, Boone Furnace.
1372	Carter	65.657	...	4.921	trace	trace	.040	.893	.604	10.740	17.780	...	66.930	.534	.107	23.980	Main Block, Lambert.
1373	Carter	57.090	...	4.438	trace	trace	.086	.370	.391	11.100	26.760	...	39.963	.161	.241	15.960	Potato Knob ore.
1375	Carter	38.285	...	5.455	120	.460	.005	1.000	.071	9.500	44.760	...	28.479	.436	.156	22.230	Main Block, Stewart bank.
1376	Carter	57.557	...	2.727	trace	trace	.005	1.746	.185	11.700	36.180	...	40.294	.762	.030	40.960	Royster Hill (Lambert).
1377	Carter	52.736	...	3.531	trace	trace	.005	.800	.171	10.700	31.840	...	36.815	.349	.074	...	Smith Hill (German).
1378	Carter	40.130	5.731	8.030	.380	.380	.234	.038	.177	7.715	37.220	...	29.816	.013	.071	...	Smith Hill crown ore.
1379	Carter	56.670	8.538	4.405	1.800	trace	.883	.337	.130	9.447	19.480	...	44.736	.147	.060	...	Lower Block ore.
1380	Carter	59.950	...	5.23	...	4.580	.343	.842	.845	11.800	16.860	...	41.905	.367	.335	16.860	Garvin's Hill Block.
1381	Carter	71.500	...	8.557	trace	trace	.054	.466	.800	9.500	9.030	...	48.585	.072	.320	7.64	Old Mount Tom Main Block.
1382	Carter	61.316	19.435	1.671	trace	trace	.483	.081	.408	9.230	36.830	...	36.136	.035	.163	11.560	Kibby Diggings Main Block.
1383	Carter	51.623	...	1.671	trace	trace	.483	.081	.408	9.230	36.830	...	36.136	.035	.163	11.560	Means & Russell's.
1384	Carter	66.200	...	4.155	0.380	0.380	.050	.084	.270	10.800	12.650	...	50.176	.036	.108	11.560	Graham Bank.
1385	Carter	59.347	9.599	1.957	.030	.830	.207	.153	.302	5.945	19.810	...	45.347	.066	.072	13.860	Mr. Savage yellow kidney.
1386	Carter	52.238	...	4.512	.130	.650	.641	.195	.230	10.650	30.580	...	36.566	.740	.091	14.260	Stinson Creek Main Block.
1387	Carter	55.028	...	1.066	.040	trace	.108	.312	.133	8.300	35.180	...	35.519	.135	.053	33.700	Clark's branch Tygett Creek.
1410	Edmonson	76.284	...	2.361	.030	.180	.068	.105	.151	12.000	7.951	...	53.399	.460	.059	7.660	By the Meredith farm.
1411	Edmonson	52.926	...	4.792	.210	.180	.475	.355	.143	10.400	30.580	...	37.048	.154	.047	29.160	Proctor ore bank.
1445	Grayson	80.040	...	6.634	...	trace	.425	.115	.264	10.000	6.560	...	56.280	.050	.051	25.500	Frederick's bank.
1509	Greenup	60.576	15.723	2.865	...	trace	.619	.632	.103	10.000	16.160	...	49.089	.358	.107	...	Limestone ore, Tygett Creek.
1511	Greenup	54.703	17.758	1.160	.980	.120	.499	.128	.680	7.104	15.958	...	46.895	.055	.272	12.960	Lower Block, Tygett Creek.
1512	Greenup	54.703	17.758	1.160	.980	.120	.499	.128	.680	7.104	15.958	...	46.895	.055	.272	12.960	Limestone ore, Hood's Branch.
1513	Greenup	54.703	17.758	1.160	.980	.120	.499	.128	.680	7.104	15.958	...	46.895	.055	.272	12.960	Poynter Bank, Raccoon Furnace.
1514	Greenup	54.703	17.758	1.160	.980	.120	.499	.128	.680	7.104	15.958	...	46.895	.055	.272	12.960	Limestone ore, Two Lick.
1515	Greenup	54.703	17.758	1.160	.980	.120	.499	.128	.680	7.104	15.958	...	46.895	.055	.272	12.960	Lower Block, Louden bank.
1516	Greenup	54.703	17.758	1.160	.980	.120	.499	.128	.680	7.104	15.958	...	46.895	.055	.272	12.960	Limestone ore, Boone bank.
1517	Greenup	54.703	17.758	1.160	.980	.120	.499	.128	.680	7.104	15.958	...	46.895	.055	.272	12.960	Limestone ore, Star drift.
1518	Greenup	54.703	17.758	1.160	.980	.120	.499	.128	.680	7.104	15.958	...	46.895	.055	.272	12.960	Limestone ore, Powder-mill Hollow.
1519	Greenup	54.703	17.758	1.160	.980	.120	.499	.128	.680	7.104	15.958	...	46.895	.055	.272	12.960	Lower Block, J. Thompson's.

1520	Greenup	23.396	14.972	4.077	33.775	0.68	.537	.537	.157	5.457	16.240	...	23.597	.224	.070	13.530	Main Block (calcareous).
1521	Greenup	68.928	...	2.768	180	1.80	.476	.601	.728	11.100	15.240	...	48.249	.098	.299	13.600	Main Block, L. Morton bank.
1522	Greenup	56.279	11.392	4.709	trace	trace	.476	.601	.728	11.100	15.240	...	48.249	.098	.299	13.600	Kidney ore, Buffalo bank.
1523	Greenup	67.084	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.	...	39.788	not est.	not est.	...	Main Block, Boone Knob bank.
1524	Greenup	42.560	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.	...	47.589	not est.	not est.	...	Kidney ore, Clay Lick Creek.
1525	Greenup	64.577	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.	...	29.722	not est.	not est.	...	Kidney ore, McAllister Point.
1526	Greenup	36.985	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.	...	45.204	.075	.070	18.600	Rough Block, below Main Block.
1527	Greenup	44.876	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.	...	40.285	.061	.049	18.860	Lower Block, Old Town Creek.
1528	Greenup	57.551	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.	...	40.285	.061	.049	18.860	Limestone ore (slate ore).
1529	Greenup	60.206	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.	...	40.285	.061	.049	18.860	Limestone ore, Brush Creek.
1530	Hopkins	50.850	...	5.485	trace	.285	.381	.161	.852	9.500	25.930	...	41.802	.070	.341	22.220	Ohreous near St. Charles' mine.
1597	Lyon	59.370	...	1.622	.690	1.700	.100	.179	.508	8.400	30.000	...	41.559	.077	.212	26.800	Suwannee Furnace (Big Showing).
1598	Lyon	70.518	...	.045	.090	trace	.275	.213	.113	9.850	18.910	...	40.819	.189	.045	18.100	Suwannee Furnace, bank near furnace.
1599	Lyon	66.117	...	1.064	.170	.090	trace	.434	.213	9.800	22.230	...	48.574	.144	.083	21.100	Suwannee Furnace, railroad cut.
1600	Lyon	69.392	...	5.290	.090	trace	.930	.147	.112	12.430	17.250	...	44.133	.064	.044	16.500	Aldrie Furnace (near No. 4 entry).
1605	Muhlenburg	63.048	...	7.075	.360	1.980	.155	.083	.185	12.530	15.560	...	42.344	.035	.074	13.600	From J. M. Hope's land, upper part.
1606	Muhlenburg	60.492	...	3.930	.103	2.535	.103	.179	.059	9.550	33.530	...	17.532	.078	.024	32.800	From J. M. Hope's land, upper part.
1607	Muhlenburg	66.866	...	3.914	.230	4.480	.921	.223	.065	200	29.880	...	41.867	.097	.026	25.200	Martin ore.
1608	Muhlenburg	59.546	...	2.972	.720	2.263	.470	.168	not est.	12.380	51.230	...	19.138	.497	.060	not est.	Roasted ore, Aldrie Furnace.
1609	Edmonson	57.340	...	6.719	not est.	1.090	.447	.168	not est.	12.380	51.230	...	19.138	.497	.060	not est.	Near Nolin Furnace.
1610	Edmonson	57.340	...	6.719	not est.	1.090	.447	.168	not est.	12.380	51.230	...	19.138	.497	.060	not est.	Near Nolin Furnace.
1611	Grayson	57.830	...	1.368	not est.	5.590	.609	.074	.151	8.940	37.380	...	360	.31	.060	not est.	Taylor's Fork, Bear Creek.
1645	Grayson	44.528	...	1.368	not est.	5.590	.609	.074	.151	8.940	37.380	...	360	.31	.060	not est.	Taylor's Fork, Bear Creek.

*Carbonates.

† Lime.

‡ And carbonic acid.

TABLE III (B). IRON ORES (CLAY IRON-STONES), DRIED AT 212° F.

Number in Report.	County.	Specific gravity.	Iron carbonate.	Iron peroxide.	Alumina.	Lime carbonate.	Magnesia carbonate.	Manganese carbonate.	Phosphoric acid.	Sulphuric acid.	Silica and silicates.	Water and loss.	Per cent. of iron.	Per cent. of phosphorus.	Per cent. of sulphur.	Per cent. of silica.	Remarks.
1270	Boyd	3.362	12.784	11.668	21.125	0.691	0.459	0.377	0.267	19.730	0.368	24.591	0.169	0.107	0.107	15.50	I. P. Jones' drift.
1271	Boyd	3.362	12.784	11.668	21.125	0.691	0.459	0.377	0.267	19.730	0.368	24.591	0.169	0.107	0.107	15.50	Wilson Creek Blue Block, Star Furnace.
1272	Boyd	3.362	12.784	11.668	21.125	0.691	0.459	0.377	0.267	19.730	0.368	24.591	0.169	0.107	0.107	15.50	Williams' Creek limestone ore, Star Furnace.
1273	Boyd	3.362	12.784	11.668	21.125	0.691	0.459	0.377	0.267	19.730	0.368	24.591	0.169	0.107	0.107	15.50	John Hudson's.
1274	Boyd	3.362	12.784	11.668	21.125	0.691	0.459	0.377	0.267	19.730	0.368	24.591	0.169	0.107	0.107	15.50	Knob Lick.
1275	Boyd	3.362	12.784	11.668	21.125	0.691	0.459	0.377	0.267	19.730	0.368	24.591	0.169	0.107	0.107	15.50	Ferruginous limestone.
1276	Boyd	3.362	12.784	11.668	21.125	0.691	0.459	0.377	0.267	19.730	0.368	24.591	0.169	0.107	0.107	15.50	Old Orchard diggings.
1277	Boyd	3.362	12.784	11.668	21.125	0.691	0.459	0.377	0.267	19.730	0.368	24.591	0.169	0.107	0.107	15.50	Horsley bank.
1278	Boyd	3.362	12.784	11.668	21.125	0.691	0.459	0.377	0.267	19.730	0.368	24.591	0.169	0.107	0.107	15.50	Tygart Creek.
1279	Boyd	3.362	12.784	11.668	21.125	0.691	0.459	0.377	0.267	19.730	0.368	24.591	0.169	0.107	0.107	15.50	Sinking Creek.
1280	Boyd	3.362	12.784	11.668	21.125	0.691	0.459	0.377	0.267	19.730	0.368	24.591	0.169	0.107	0.107	15.50	Foxden ore.
1281	Boyd	3.362	12.784	11.668	21.125	0.691	0.459	0.377	0.267	19.730	0.368	24.591	0.169	0.107	0.107	15.50	Mt. Savage Furnace.
1282	Boyd	3.362	12.784	11.668	21.125	0.691	0.459	0.377	0.267	19.730	0.368	24.591	0.169	0.107	0.107	15.50	Barrett's Creek.
1283	Boyd	3.362	12.784	11.668	21.125	0.691	0.459	0.377	0.267	19.730	0.368	24.591	0.169	0.107	0.107	15.50	J. H. Higdon's.
1284	Boyd	3.362	12.784	11.668	21.125	0.691	0.459	0.377	0.267	19.730	0.368	24.591	0.169	0.107	0.107	15.50	Lower Block, Alcorn Creek.
1285	Boyd	3.362	12.784	11.668	21.125	0.691	0.459	0.377	0.267	19.730	0.368	24.591	0.169	0.107	0.107	15.50	Blue Kidney, Kenton Furnace.
1286	Boyd	3.362	12.784	11.668	21.125	0.691	0.459	0.377	0.267	19.730	0.368	24.591	0.169	0.107	0.107	15.50	Main Block, Amanda Furnace.
1287	Boyd	3.362	12.784	11.668	21.125	0.691	0.459	0.377	0.267	19.730	0.368	24.591	0.169	0.107	0.107	15.50	Conglomerate ore, Buffalo Furnace.
1288	Boyd	3.362	12.784	11.668	21.125	0.691	0.459	0.377	0.267	19.730	0.368	24.591	0.169	0.107	0.107	15.50	Lower Block ore, Womack's bank.
1289	Boyd	3.362	12.784	11.668	21.125	0.691	0.459	0.377	0.267	19.730	0.368	24.591	0.169	0.107	0.107	15.50	Main Block or grey ore, Laurel Furnace.
1290	Boyd	3.362	12.784	11.668	21.125	0.691	0.459	0.377	0.267	19.730	0.368	24.591	0.169	0.107	0.107	15.50	Grey ore, Raccoon Furnace.
1291	Boyd	3.362	12.784	11.668	21.125	0.691	0.459	0.377	0.267	19.730	0.368	24.591	0.169	0.107	0.107	15.50	"Black-band ore," Alrdie Furnace.
1292	Boyd	3.362	12.784	11.668	21.125	0.691	0.459	0.377	0.267	19.730	0.368	24.591	0.169	0.107	0.107	15.50	"Slate Iron ore," Buckner Furnace.
1293	Boyd	3.362	12.784	11.668	21.125	0.691	0.459	0.377	0.267	19.730	0.368	24.591	0.169	0.107	0.107	15.50	Jerry Hope's bank (lower part).
1294	Boyd	3.362	12.784	11.668	21.125	0.691	0.459	0.377	0.267	19.730	0.368	24.591	0.169	0.107	0.107	15.50	"Glady ore," west of Bear Creek.

* See 1644.

TABLE IV. COALS, AIR-DRIED.

Number in Report.	County.	Specific gravity.	Hygroscopic moisture.	Volatiles combustible matters.	Coke.	Total volatile matters.	Carbon in the coke.	Ashes.	Character of the coke.	Color of the ash.	Per cent. of sulphur.	Remarks.
1279	Boyd	1.358	33.90	33.90	59.09	40.40	52.78	6.82	Dense.	Light lilac-grey.	3.765	Buena Vista Furnace (coal 7), Straight Creek.
1280	Boyd	1.358	33.90	33.90	59.09	40.40	52.78	6.82	Dense.	Light purple-grey.	1.230	Bellefont Furnace (coal 6), Turkey-pen Hollow.
1281	Boyd	1.358	33.90	33.90	59.09	40.40	52.78	6.82	Dense.	Purple-grey.	0.982	Bellefont Furnace (coal 6). Selected sample.
1282	Boyd	1.358	33.90	33.90	59.09	40.40	52.78	6.82	Dense.	Lilac-grey.	2.370	Chadwick Creek (coal, No. 7).
1283	Boyd	1.358	33.90	33.90	59.09	40.40	52.78	6.82	Dense.	Lilac-grey.	1.990	Buena Vista Furnace, Straight Creek (coal 5).
1284	Boyd	1.358	33.90	33.90	59.09	40.40	52.78	6.82	Dense.	Lilac-grey.	1.972	Key's Creek coal.
1285	Boyd	1.358	33.90	33.90	59.09	40.40	52.78	6.82	Dense.	Lilac-grey.	1.703	Bellefont Furnace, Hood's Creek (coal 3).
1286	Boyd	1.358	33.90	33.90	59.09	40.40	52.78	6.82	Dense.	Lilac-grey.	1.711	Horse Run coal (No. 6).
1287	Boyd	1.358	33.90	33.90	59.09	40.40	52.78	6.82	Dense.	Lilac-grey.	1.854	Ashland Company, mine 4, Coalton (No. 7).
1288	Boyd	1.358	33.90	33.90	59.09	40.40	52.78	6.82	Dense.	Lilac-grey.	2.698	Ashland Company, Dry Branch (No. 7).
1289	Boyd	1.358	33.90	33.90	59.09	40.40	52.78	6.82	Dense.	Lilac-grey.	1.854	Ashland Company, Trace Creek (No. 7).
1290	Boyd	1.358	33.90	33.90	59.09	40.40	52.78	6.82	Dense.	Lilac-grey.	1.854	Ashland Company, Coalton (No. 7).
1291	Boyd	1.358	33.90	33.90	59.09	40.40	52.78	6.82	Dense.	Lilac-grey.	1.854	Mr. Bryan's bank, Four-mile Creek (No. 7).
1292	Boyd	1.358	33.90	33.90	59.09	40.40	52.78	6.82	Dense.	Lilac-grey.	1.854	W. A. Bolt's coal, Little Sandy (No. 11).
1293	Boyd	1.358	33.90	33.90	59.09	40.40	52.78	6.82	Dense.	Lilac-grey.	1.854	Stevens' coal, Bear Creek.
1294	Boyd	1.358	33.90	33.90	59.09	40.40	52.78	6.82	Dense.	Lilac-grey.	1.854	Old Orchard diggings (sub-conglomerate?).
1295	Boyd	1.358	33.90	33.90	59.09	40.40	52.78	6.82	Dense.	Lilac-grey.	1.854	Star Furnace (coal, No. 7, upper layer).
1296	Boyd	1.358	33.90	33.90	59.09	40.40	52.78	6.82	Dense.	Lilac-grey.	1.854	Star Furnace (bottom layer).
1297	Boyd	1.358	33.90	33.90	59.09	40.40	52.78	6.82	Dense.	Lilac-grey.	1.854	Star Furnace (middle layer).
1298	Boyd	1.358	33.90	33.90	59.09	40.40	52.78	6.82	Dense.	Lilac-grey.	1.854	Star Furnace (bank, No. 7 coal).
1299	Boyd	1.358	33.90	33.90	59.09	40.40	52.78	6.82	Dense.	Lilac-grey.	1.854	Star Furnace (bank, No. 7 coal).
1300	Boyd	1.358	33.90	33.90	59.09	40.40	52.78	6.82	Dense.	Lilac-grey.	1.854	Star Furnace (bank, No. 7 coal).
1301	Boyd	1.358	33.90	33.90	59.09	40.40	52.78	6.82	Dense.	Lilac-grey.	1.854	Star Furnace (bank, No. 7 coal).
1302	Boyd	1.358	33.90	33.90	59.09	40.40	52.78	6.82	Dense.	Lilac-grey.	1.854	Star Furnace (bank, No. 7 coal).
1303	Boyd	1.358	33.90	33.90	59.09	40.40	52.78	6.82	Dense.	Lilac-grey.	1.854	Star Furnace (bank, No. 7 coal).
1304	Boyd	1.358	33.90	33.90	59.09	40.40	52.78	6.82	Dense.	Lilac-grey.	1.854	Star Furnace (bank, No. 7 coal).
1305	Boyd	1.358	33.90	33.90	59.09	40.40	52.78	6.82	Dense.	Lilac-grey.	1.854	Star Furnace (bank, No. 7 coal).
1306	Boyd	1.358	33.90	33.90	59.09	40.40	52.78	6.82	Dense.	Lilac-grey.	1.854	Star Furnace (bank, No. 7 coal).
1307	Boyd	1.358	33.90	33.90	59.09	40.40	52.78	6.82	Dense.	Lilac-grey.	1.854	Star Furnace (bank, No. 7 coal).
1308	Boyd	1.358	33.90	33.90	59.09	40.40	52.78	6.82	Dense.	Lilac-grey.	1.854	Star Furnace (bank, No. 7 coal).
1309	Boyd	1.358	33.90	33.90	59.09	40.40	52.78	6.82	Dense.	Lilac-grey.	1.854	Star Furnace (bank, No. 7 coal).
1310	Boyd	1.358	33.90	33.90	59.09	40.40	52.78	6.82	Dense.	Lilac-grey.	1.854	Star Furnace (bank, No. 7 coal).
1311	Boyd	1.358	33.90	33.90	59.09	40.40	52.78	6.82	Dense.	Lilac-grey.	1.854	Star Furnace (bank, No. 7 coal).
1312	Boyd	1.358	33.90	33.90	59.09	40.40	52.78	6.82	Dense.	Lilac-grey.	1.854	Star Furnace (bank, No. 7 coal).
1313	Boyd	1.358	33.90	33.90	59.09	40.40	52.78	6.82	Dense.	Lilac-grey.	1.854	Star Furnace (bank, No. 7 coal).
1314	Boyd	1.358	33.90	33.90	59.09	40.40	52.78	6.82	Dense.	Lilac-grey.	1.854	Star Furnace (bank, No. 7 coal).
1315	Boyd	1.358	33.90	33.90	59.09	40.40	52.78	6.82	Dense.	Lilac-grey.	1.854	Star Furnace (bank, No. 7 coal).
1316	Boyd	1.358	33.90	33.90	59.09	40.40	52.78	6.82	Dense.	Lilac-grey.	1.854	Star Furnace (bank, No. 7 coal).
1317	Boyd	1.358	33.90	33.90	59.09	40.40	52.78	6.82	Dense.	Lilac-grey.	1.854	Star Furnace (bank, No. 7 coal).
1318	Boyd	1.358	33.90	33.90	59.09	40.40	52.78	6.82	Dense.	Lilac-grey.	1.854	Star Furnace (bank, No. 7 coal).
1319	Boyd	1.358	33.90	33.90	59.09	40.40	52.78	6.82	Dense.	Lilac-grey.	1.854	Star Furnace (bank, No. 7 coal).
1320	Boyd	1.358	33.90	33.90	59.09	40.40	52.78	6.82	Dense.	Lilac-grey.	1.854	Star Furnace (bank, No. 7 coal).

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TABLE IV. COALS, AIR-DRIED.—(Continued.)

Number in Report.	County.	Specific gravity.	Hygroscopic moisture.	Volatile combustibles.	Coke.	Total volatile matters.	Carbon in the coke.	Character of the coke.	Color of the ash.	Per centage of sulphur.	Remarks.
1448	Grayson.	1.395	4.70	31.40	63.90	36.10	52.20	Spongy.	Light brownish-grey.	1.945	Tar Lick Coal, Dismal Creek.
1449	Grayson.	1.395	4.14	30.52	65.34	34.66	50.08	Dense spongy.	Brownish-grey.	3.568	Gravelly Lick, Miller's Fork of Bear Creek.
1450	Grayson.	1.346	6.26	32.44	61.30	38.70	53.80	Light friable.	Greyish-salmon.	2.476	Brushy branch of Calloway Creek.
1451	Grayson.	1.378	3.50	33.40	63.10	36.90	47.50	Light spongy.	Light chocolate.	2.711	Copperas bank, branch of Hunting Fork of Rock Creek.
1452	Grayson.	1.364	3.60	35.80	60.60	39.40	49.40	Light spongy.	Light chocolate.	3.158	L. Higdon's, sub-conglomerate.
1453	Grayson.	1.446	6.50	29.10	64.40	35.60	49.60	Friable.	Light brownish.	3.818	Gum Spring Fork of Cane Camp Creek.
1454	Grayson.	1.512	4.40	25.86	69.74	30.26	40.14	Friable.	Nearly white.	2.777	Gum Spring Fork (below slate parting).
1455	Grayson.	1.338	4.24	30.82	64.94	35.06	55.52	Light friable.	Brownish salmon-grey.	2.862	In the sub-carboniferous limestone.
1484	Greenup.	1.316	4.82	32.90	62.28	37.72	55.18	Friable.	Chocolate.	1.409	Coal, No. 1, Kenton Furnace.
1485	Greenup.	1.345	4.96	32.68	62.06	37.94	55.46	Light spongy.	Lilac-grey.	1.474	J. Thompson's bank, Kenton Furnace (sixteen inches).
1486	Greenup.	1.250	4.80	34.64	60.56	39.44	52.58	Dense.	Lilac-grey.	1.331	Coal, No. 3, Main coal, average sample, Raccoon Furn.
1487	Greenup.	1.420	4.28	36.52	59.20	40.80	47.00	Dense.	Lilac-grey.	5.934	Coal, No. 3 (upper part), Raccoon Furnace.
1488	Greenup.	1.374	3.20	30.56	65.54	39.46	47.54	Spongy.	Dark lilac-grey.	3.647	Coal, No. 3 (lower part), Raccoon Furnace.
1489	Greenup.	1.389	2.90	33.76	63.34	36.66	51.34	Dense.	Dark lilac-grey.	4.911	Coal, No. 3 (above shale parting), Raccoon Furnace.
1490	Greenup.	1.374	3.30	31.94	64.80	35.20	52.20	Friable.	Dark lilac-grey.	2.907	Alcorn Creek, probably sub-conglomerate.
1491	Greenup.	1.389	4.00	31.66	64.34	35.66	53.44	Spongy.	Dark lilac-grey.	0.746	Hanna bank (average of upper portion).
1492	Greenup.	1.289	3.20	33.90	60.94	39.06	55.54	Spongy.	Dark brick.	1.599	Coal (No. 3?), Laurel Furnace.
1493	Greenup.	1.335	4.04	33.62	62.34	37.66	53.34	Dense.	Grey-purple.	1.318	Coal, No. 6, Amanda Furnace.
1494	Greenup.	1.300	3.20	36.66	62.20	39.80	53.14	Spongy.	Lilac-grey.	2.264	Coal, No. 6, Pennsylvanian Furnace.
1495	Greenup.	1.355	3.80	37.70	58.50	41.50	47.20	Spongy.	Dark brownish-purple.	4.213	Coal, No. 6, Hummel Furnace (new bed).
1496	Greenup.	1.448	3.40	30.00	66.60	33.40	51.10	Spongy.	Light grey-purple.	2.789	Wm. Miller's coal, Nortonville.
1497	Hopkins.	1.332	3.20	35.90	60.90	39.10	54.00	Spongy.	Light lilac-grey.	1.780	St. Charles' mines.
1573	Hopkins.	1.316	4.60	35.70	59.60	40.40	52.28	Spongy.	Light grey-buff.	2.730	McHenry's coal bank (No. 3), near Louisa.
1588	Lawrence.	1.281	5.10	35.16	61.54	38.46	47.84	Light spongy.	Light grey-buff.	3.785	F. Sweetman's bank (Coal, No. 1), Brushy Creek.
1590	Lawrence.	1.376	3.30	35.16	61.54	38.46	47.84	Friable.	Yellowish-white.	1.066	Coal, No. 1, Boggs' Mill, Cane's Creek.
1591	Lawrence.	1.349	2.10	33.90	64.00	36.00	56.00	Spongy.	Grey-purple.	2.730	Coal, No. 3, Holbrook's coal, Brushy Creek.
1592	Lawrence.	1.350	2.50	38.56	58.94	41.06	51.44	Light spongy.	Brownish-grey.	1.997	Coal, No. 3, Mr. Boggs' bank, upper part.
1601	Menifee.	1.284	2.90	39.00	58.50	41.50	54.70	Spongy.	Light brownish-grey.	4.092	Sub-conglomerate, Hawkins' Creek.
1602	Menifee.	not est.	2.66	34.04	61.30	36.70	50.60	Dense.	Light brownish-grey.	4.092	Bituminous shale above S. C. limestone.
1603	Menifee.	not est.	2.80	35.20	82.00	18.00	24.30	Pulverulent.	White lilac-grey.	1.438	Coal, No. 12, Airtide Furnace.
1617	Menifee.	not est.	7.50	4.20	88.30	11.70	82.90	Dense spongy.	Light yellowish-grey.	4.523	Coal, No. 12, Airtide Furnace.
1618	Muhlenburg.	1.278	3.60	31.40	65.00	35.00	58.50	Dense spongy.	Lilac-grey.	1.438	Coal, No. 12, Airtide Furnace.
1619	Muhlenburg.	1.332	4.70	30.60	64.70	35.30	58.50	Spongy.	Dark lilac-grey.	4.523	Paradise mine (Airtide), coal 14, lower division.
1620	Muhlenburg.	1.331	4.20	36.10	59.70	40.30	50.50	Spongy.	Dark lilac-grey.	3.158	Paradise mine (Airtide), middle layer.
1621	Muhlenburg.	1.274	3.60	38.70	56.70	42.30	53.70	Spongy.	Light lilac-grey.	1.923	Muddy river coal mine.
1622	Muhlenburg.	1.274	3.60	38.70	56.70	42.30	53.70	Spongy.	Brownish salmon-grey.	2.727	Koss' coal mine, upper portion.
1623	Muhlenburg.	1.274	3.60	38.70	56.70	42.30	53.70	Spongy.	Light lilac-grey.	2.727	Koss' coal mine, upper portion.
1624	Muhlenburg.	1.407	4.10	37.44	58.40	41.60	49.80	Light spongy.	Light lilac-grey.	2.727	Koss' coal mine, upper portion.

1625	Muhlenburg.	1.358	3.60	34.00	62.40	37.60	50.60	Light spongy.	Lilac-grey.	4.092	Mercer coal mines.
1626	Muhlenburg.	1.279	3.10	40.08	56.22	43.78	50.66	Spongy.	Lilac-grey.	2.727	Muhlenburg coal mines, upper seam.
1627	Muhlenburg.	1.332	1.52	40.00	58.48	41.52	50.92	Spongy.	Lilac-grey.	2.840	Muhlenburg coal mines, main working bed.
1628	Muhlenburg.	1.286	2.98	43.08	53.94	46.06	50.92	Spongy.	Dark brown.	3.125	Muhlenburg coal mines, average head of main entry.
1629	Muhlenburg.	1.593	1.20	7.88	82.76	17.24	86.48	Powdery.	Brownish-grey.	3.431	Fibrous coal or mineral charcoal.
1630	Ohio.	not est.	3.50	35.00	61.80	38.20	52.50	Light spongy.	Light brownish-grey.	1.983	Carbonaceous mud.
1631	Ohio.	1.421	3.00	35.00	61.80	38.20	52.50	Light spongy.	Light lilac-grey.	3.139	Rockport coal mines, average sample along entry.
1632	Ohio.	1.334	3.00	35.00	61.80	38.20	52.50	Light spongy.	Light lilac-grey.	3.332	Rockport coal mines, general average of mine.
1633	Ohio.	1.361	4.54	32.42	63.68	37.02	55.82	Pulverulent.	Nearly white.	7.56	Star Furnace coal, Jackson county, Ohio.
A. 1	State of Ohio.	not est.	4.20	36.68	59.10	40.88	54.16	Dense.	Light lilac-grey.	1.802	Hocking Valley coal, average sample whole bed.
A. 2	State of Ohio.	not est.	4.20	36.68	59.10	40.88	54.16	Dense.	Light lilac-grey.	1.802	Hocking Valley (stock pile), average sample.
A. 3	State of Ohio.	1.340	3.26	33.76	62.98	37.02	54.42	Dense.	Light lilac-grey.	2.247	Hocking Valley, average of upper twenty-eight inches.
A. 4	State of Ohio.	1.303	3.74	36.32	59.94	40.06	55.70	Dense spongy.	Light lilac-grey.	1.209	Hocking Valley, average of middle twenty-six inches.
A. 5	State of Ohio.	1.312	4.40	35.08	60.54	39.46	53.86	Dense spongy.	Light lilac-grey.	1.947	Hocking Valley, average of lower eighteen inches.
A. 6	State of Ohio.	1.312	3.46	36.64	59.90	40.10	53.86	Light spongy.	Light lilac-grey.	1.659	Sheridan coal mines, Lawrence county, Ohio.
A. 7	State of Illinois.	1.310	2.62	32.64	65.34	34.66	58.58	Light spongy.	Lilac-grey.	2.472	Big Muddy coal, Jackson county, Illinois.
A. 8	State of Illinois.	1.310	3.44	31.86	64.70	35.30	59.54	Spongy.	Lilac-grey.	1.376	Big Muddy coal, Jackson county, Illinois.
A. 9	State of Indiana.	1.313	2.70	36.38	60.94	39.06	55.04	Spongy.	Lilac-grey.	1.664	Indiana Block coal, near Brazil, Clay county.
A. 10	State of Indiana.	not est.	2.68	36.32	61.00	39.00	53.50	Dense.	Lilac-grey.	1.802	Indiana Block coal, lower seam.
A. 11	State of Indiana.	not est.	2.40	35.10	62.50	37.50	53.50	Dense.	Lilac-grey.	2.373	Coal, No. 7, used at Ashland Furnace.
1645	Boyd.	1.291	4.80	34.20	61.00	37.80	54.90	Spongy.	Light brownish-grey.	1.312	Coal, No. 1, Graham bank.
1646	Carter.	1.269	3.50	36.30	60.20	39.80	57.30	Spongy.	Brownish-grey.	1.107	Coal, No. 1, Raccoon bank.
1647	Carter.	not est.	3.50	36.30	60.20	39.80	57.30	Pulverulent.	Nearly white, lit-grey.	655	Coal, No. 1, Raccoon Creek.
1648	Greenup.	1.409	4.10	28.90	67.00	33.00	49.60	Very friable.	Light yellowish-grey.	782	Cannel coal, Hummelwell mine.
1649	Greenup.	1.306	1.50	52.20	46.30	53.70	40.60	Spongy.	Chocolate-grey.	3.874	Coal D. Taylor's coal mines.
1650	Ohio.	1.315	3.30	35.84	60.80	39.14	54.36	Spongy.	Brownish-grey.	2.668	Coal D. Stevens' coal mines.
1651	Ohio.	1.316	3.30	36.76	59.94	40.06	52.60	Spongy.	Brownish-grey.	2.668	Coal D. Stevens' coal mines.

* See 1645.

† See 1646.

‡ See 1648.

§ See 1650.

TABLE V (A). MARLY SHALES, MARLES, SILICIOUS CONCRETIONS, &c., DRIED AT 212° F.

Number in Re-	County.	Silica and sili- cates.	Silica.	Alumina.	Iron oxide.	Lime.	Magnesia car- bonate.	Magnesia.	Phosphoric acid.	Sulphuric acid.	Potash.*	Soda.*	Total potash.	Total soda.	Water, &c.	Remarks.
1202	Boyd	77.560	66.660	12.643	0.480	...	...	...	.217	.079	1.387	.080	3.989	.639	5.830	Marly shale, near Clinton Furnace.
1307	Bracken	66.660	66.660	14.950	.500	...	...	...	.486	a trace.	...	...	2.735	1.515	3.400	Silicious mudstone.
1308	Campbell	66.660	66.660	20.860	1.060	...	...	...	.230	.061	...	...	.982	.301	...	Red under clay (ferruginous).
1315	Campbell	66.660	66.660	28.050	1.335	...	...	...	.223	not est.	...	...	3.254	.940	4.800	Marly shale, Cincinnati Group.
1316	Campbell	66.660	66.660	12.050	9.860	...	...	...	.235	not est.	...	...	3.045	.970	2.200	Marl (mudstone).
1317	Campbell	66.660	66.660	31.490	6.660	...	...	...	.122	not est.	...	...	3.045	.986	4.700	Clay shale, Newport Reservoir.
1318	Campbell	66.660	66.660	29.450	6.850	...	...	...	.102	not est.	...	...	1.243	.567	4.400	Clay shale, Newport Reservoir.
1319	Campbell	66.660	66.660	20.500	a trace	...	...	...	.102	not est.	...	...	1.243	.567	4.400	Clay, brick clay.
1320	Campbell	66.660	66.660	12.223	.100	...	...	...	not est	not est.	...	...	.675	.282	4.200	Sandy, ferruginous clay.
1321	Campbell	66.660	66.660	33.540	.860	...	...	...	a trace	not est.	...	...	2.668	.555	4.111	Ferruginous clay.
1322	Campbell	66.660	66.660	12.700	a trace	...	...	...	a trace	not est.	...	...	.756	.637	4.400	Sand, moulding sand.
1323	Campbell	66.660	66.660	3.500	7.400	...	...	...	not est.	not est.	...	...	not est.	not est.	2.200	Sand, beneath brick clay.
1335	Campbell	66.660	66.660	12.260	7.800	...	...	...	.281	.659	...	...	3.298	.926	4.892	Marly shale, Cincinnati Group.
1336	Campbell	66.660	66.660	16.782	4.560	...	...	...	.008	.233	...	...	4.471	1.072	3.336	Marly shale, Cincinnati Group.
1409	Carter	66.660	66.660	11.500	.560	...	...	...	.223	not est.	...	...	.366	.587	2.500	Sandy sub-soil, Little Sandy river.
1431	Franklin	66.660	66.660	10.415	1.440	...	...	...	.435	.738	3.488	.042	8.479	.690	2.500	Green marly shale.
1432	Franklin	66.660	66.660	15.305	...	...	...	...	.460	.570	3.565	.318	7.130	.748	5.350	Olive marly shale.
1433	Franklin	66.660	66.660	16.816	6.997	...	...	...	.217	.286	...	...	3.623	.731	6.400	Marly shale (mineral paint).
1434	Franklin	66.660	66.660	18.831	9.200	...	...	...	.319	.920	...	...	5.402	.720	8.304	Marly shale (mineral paint).
1439	Fulton	66.660	66.660	18.350	.560	...	...	...	.051	.501	...	...	.230	.124	5.800	Silicious clay (indurated).
1440	Fulton	66.660	66.660	13.609	.560	...	...	...	.139	.844	...	...	.231	.021	3.600	Soft sandstone or silicious concretion.
1441	Fulton	66.660	66.660	7.869	.380	...	...	...	.086	.051	.797	...	.115	.080	2.400	Soft sandstone or silicious concretion.
1442	Fulton	66.660	66.660	3.129	.380	...	...	...	.173	.051	.981	...	.230	.124	1.600	Soft sandstone or silicious concretion.
1443	Illinois	66.660	66.660	20.309	.960	...	...	...	.307	.051	1.188	...	.819	.487	5.219	Post Tertiary clay, Grand Chain.
1446	Grayson	66.660	66.660	19.133	...	...	...	...	.353	.267	.027	.052	4.115	.602	6.230	Marly shale, Sunset Lick.
1446	Grayson	66.660	66.660	14.130	13.480	...	...	...	1.158	.280	.204	...	4.625	.783	6.000	Same, analyzed by fusion.
1447	Grayson	66.660	66.660	7.040	.100	...	...	...	.245	.370	.049	.975	.401	...	3.000	Soft sandstone, Horse Branch.
1577	Henry	66.660	66.660	7.146	11.040	...	...	...	.310	1.164	.961	...	2.100	.623	8.396	Marl (cut of Cumberland & Ohio Railr'd, Eminence).
1581	Kenton	66.660	66.660	16.500	.480	...	...	...	.121	not est.	...	...	.828	.580	4.500	Silicious grit.
1582	Kenton	66.660	66.660	15.793	.660	...	...	...	.214	.639	not est.	...	.847	.760	5.100	Silicious grit.
1583	Kenton	66.660	66.660	29.971	1.760	...	...	...	1.514	.166	not est.	...	2.538	.551	7.100	Marly clay, Cincinnati Group, Lower Silurian.
1584	Kenton	66.660	66.660	22.256	1.000	...	...	...	1.181	.258	not est.	...	2.139	.906	3.550	Brick clay, Cincinnati Group.
1585	Kenton	66.660	66.660	21.000	.680	...	...	...	.607	not est.	...	...	2.447	.915	3.550	Marly shale, Cincinnati Group.
1586	Kenton	66.660	66.660	22.850	.840	...	...	...	.128	not est.	...	...	2.301	1.590	3.200	Marly shale, Cincinnati Group.

* Extracted by digestion in acids.

TABLE V (B). CLAYS, &c., DRIED AT 212° F.

Number in Report.	County.	Silica.	Alumina.	Iron oxide.	Lime.	Magnesia.	Phosphoric acid.	Sulphuric acid.	Potash.	Soda.	Water expelled at red heat.	Remarks.
1337	Carter	48.560	37.471	a trace.	.112	a trace.	.255	not est.	.289	.283	13.030	Fire-clay, Boone Furnace property.
1338	Carter	45.000	38.531	a trace.	.145	a trace.	.503	not est.	.250	.341	14.210	Fire-clay, Boone Furnace property.
1339	Carter	54.600	39.466	a trace.	a trace.	a trace.	.243	not est.	.12	.670	11.780	Fire-clay, Boone Furnace property.
1340	Carter	50.400	27.203	a trace.	a trace.	a trace.	.147	not est.	1.850	.584	7.756	Fire-clay, under coal, Old Orchard diggings, Boone Furn. property.
1341	Carter	45.560	43.775	a trace.	.145	a trace.	.307	not est.	.993	.758	8.522	Fire-clay, Boone Furnace property.
1342	Carter	42.260	24.604	not est.	.538	a trace.	.946	not est.	.751	.515	8.300	Fire-clay, under twelve inch coal, Geo. Ossenton's.
1343	Carter	66.660	36.020	not est.	*.300	not est.	.127	not est.	2.093	2.273	5.300	Clay shale, Grayson.
(a.)	France	48.680	36.020	not est.	not est.	*.520	not est.	not est.	not est.	not est.	2.130	Porcelain clay, of St. Yrieux.
(b.)	China	55.300	30.300	2.000	not est.	.400	not est.	not est.	1.100	not est.	8.200	Porcelain clay, of China.
(c.)	England	63.400	31.700	3.000	not est.	not est.	not est.	not est.	not est.	not est.	not est.	Stourbridge fire-clay.
(d.)	Germany(?)	47.500	34.370	1.240	.500	1.000	not est.	not est.	not est.	not est.	1.000	Cruelle clay, of Almerode.
1443	Illinois	70.660	20.309	...	*.960	.307	.501	1.188	.819	.487	5.219	Post Tertiary clay, foot of Grand Chain.
1477	Greenup	49.680	35.281	traces.	.213	.136	.626	not est.	.103	.211	13.660	Fire-clay, Kenton Furnace, Louder's land.
1478	Greenup	62.020	20.735	3.820	.213	2.281	.371	not est.	2.601	.659	6.400	Fire-clay, Kenton Furnace, Powder-mill Hollow.
1479	Greenup	66.560	22.679	traces.	.157	.605	.503	not est.	1.946	.690	6.800	Clay, Pea Ridge.
1480	Greenup	47.060	36.620	traces.	.015	.382	.408	not est.	1.156	.234	13.300	Clay, Pea Ridge, near Hunnwell.
1481	Greenup	67.700	22.092	traces.	.101	.383	.498	not est.	1.156	.268	7.900	Clay, Pea Ridge, two and a half feet bed.
1482	Greenup	55.560	31.027	traces.	.385	.403	.358	not est.	1.167	.560	10.600	Clay, Pea Ridge, fourteen inch, third bed.
1483	Greenup	47.560	40.661	a trace.	.280	.497	.249	a trace.	.308	.409	10.036	Fire-clay, Thomas' bank, Shultz's Creek.
1613	Muhlenburg	63.180	26.281	...	.203	.955	.179	3.282	2.000	.425	4.195	Ross' coal mines, fire-clay, below the coal.

* Carbonate.

TABLE VI. PIG IRONS.

Number in Report.	County.	Specific gravity.	Iron.	Graphite.	Combined carbon.	Manganese.	Silicon.	Slag.	Aluminum	Calcium.	Magnesium.	Potassium.	Sodium.	Phosphorus.	Sulphur.	Total carbon.	Remarks.
1293	Boyd	7.132	93.308	3.350	.220	.054	2.386	1.109	.193	.144	.095	.047	.032	.104	.000	3.570	Hot blast, No. 1, Bellefont Furnace.
1294	Boyd	7.127	93.712	2.990	.210	.056	1.908	.600	.644	.104	.095	.063	.010	.380	.066	3.200	Hot blast, No. 1, Buena Vista Furnace.
1295	Boyd	6.410	91.420	2.460	.240	.195	3.709	.540	not est	.176	.233	not est	not est	.385	.082	2.700	Stone-coal, No. 1 mill, Ashland Furnace.
1296	Boyd	6.503	90.899	2.560	.160	.236	5.121	.760	not est	.072	.106	not est	not est	.394	.045	2.720	Stone-coal, No. 2 mill, Ashland Furnace.
1297	Boyd	6.406	89.731	1.660	.700	.471	6.308	1.120	not est	.152	.060	not est	not est	.461	.015	2.450	Stone-coal, foundry iron, Ashland Furnace.
1301	Carter	6.423	90.958	2.104	.116	.115	2.682	4.180	.479	not est	not est	not est	not est	.304	not est	2.280	Foundry iron, No. 2, Boone Furnace.
1302	Carter	6.905	93.212	2.940	.060	.083	1.624	2.460	.320	not est	not est	not est	not est	.486	.079	3.000	Foundry iron, No. 1, Boone Furnace.
1303	Carter	7.021	92.387	3.340	.760	.066	2.240	.690	.120	.120	.056	.080	.023	.836	.057	4.100	Hot blast, No. 1, Iron Hills Furnace.
1304	Carter	6.880	91.656	2.670	.030	.123	4.470	1.160	.128	.114	.112	.076	.023	.203	.041	2.700	Hot blast, No. 1, Mt. Savage Furnace.
1331	Greenup	6.825	91.656	2.790	.030	.123	4.470	1.160	.128	.114	.112	.076	.023	.203	.041	2.700	Hot blast, No. 1, Buffalo Furnace.
1332	Greenup	6.944	94.739	3.620	.780	.084	4.100	.600	.399	.168	.085	.086	.016	.605	.150	2.790	Cold blast, No. 1, Buffalo Furnace.
1333	Greenup	6.872	88.160	1.950	.570	.014	7.317	.900	.105	.128	.125	.048	.041	.609	.037	4.400	Hot blast, silver-grey, Buffalo Furnace.
1334	Greenup	6.897	92.724	3.320	.660	.612	2.090	.300	.442	.184	.190	.104	.004	.622	.046	3.980	Hot blast, No. 1 foundry, Kenton Furnace.
1335	Greenup	7.117	91.668	2.950	. . .	.332	3.817	1.200	.128	.075	.122	not est	not est	.334	.041	2.950	Hot blast, No. 1, Raccoon Furnace.
1336	Greenup	7.041	92.398	3.690	. . .	.020	2.515	1.130	.582	.048	trace	.056	trace	.684	.026	3.690	Hot blast, No. 2, Hunnewell Furnace.
1364	Muhlenburg	6.826	86.636	.900	2.080	.202	7.704	2.260	.123	.045	.035	not est	not est	.235	.104	2.980	Silver-grey, Airdrie Furnace.
1365	Muhlenburg	6.826	85.455	.480	1.560	.696	7.747	3.460	.068	.089	.017	not est	not est	.445	.122	2.040	Silver-grey, Airdrie Furnace.
1366	Muhlenburg	7.782	86.842	.740	1.460	.355	8.614	2.360	.054	.112	.056	not est	not est	.123	.122	2.200	Silver-grey, Airdrie Furnace.
1367	Edmonson	7.113	94.287	3.100	.700	not est	.492	not est	not est	not est	not est	not est	not est	1.029	.012	3.800	Cold blast, old Nolin Furnace.

GEOLOGICAL SURVEY OF KENTUCKY.

N. S. SHALER, DIRECTOR.

THE IRON MANUFACTURE

OF THE KENTUCKY DIVISION OF THE

HANGING ROCK IRON REGION,

BY P. N. MOORE.

PART V. VOL. I. SECOND SERIES.

SOME NOTES UPON THE IRON MANUFACTURE IN THE KENTUCKY DIVISION OF THE HANGING ROCK IRON DISTRICT.

The Hanging Rock Iron District takes its name from a peculiarly shaped rock exposure upon the Ohio river, near which is now the village of the same name. Some of the early furnaces were located near and had here their landing place. The name Hanging Rock pig iron was applied to the product of these furnaces, and as the number of furnaces increased the name was still retained, until now it is applied to all the iron produced in a number of adjoining counties, in both Ohio and Kentucky. The region now embraces in Ohio the whole or parts of Scioto, Lawrence, Gallia, Jackson, Vinton, and Hocking counties, and in Kentucky, the counties of Greenup, Boyd, and Carter, and it will, without doubt, eventually extend still further to the southward.

In this region the native ores of the coal measures are those in most general use. They are used exclusively by the charcoal, and very largely by the stone-coal, furnaces.

The Hanging Rock iron has an excellent reputation throughout the West. It is used for a variety of purposes; but perhaps more generally for foundry purposes than any other. For general foundry use, combining strength with fluidity and small shrinkage in cooling, it is probably unsurpassed in this country, if anywhere. It can also be used with a considerable proportion of scrap without injury to the resulting castings.

Certain brands of the cold blast charcoal iron have a national reputation for the manufacture of car-wheels, for which purpose they are unsurpassed.

The iron from the stone-coal furnaces of this region is used for both foundry and mill purposes, but most largely in the mills, for conversion into wrought iron. The fuel in use at a majority of the furnaces is charcoal. It was upon charcoal iron

that the reputation of this region was established. It was not until within the past ten years that the use of stone-coal for the manufacture of iron was introduced. It has grown rapidly since that time, and is destined to become the prevailing industry; but as yet the charcoal largely outnumber the stone-coal furnaces. There are in this region sixty-one furnaces, either in active operation or in a condition to be put in operation in a short time. Of the whole number, forty-four are charcoal and seventeen stone-coal. Of these, thirteen are situated in Kentucky, of which eleven are charcoal and two stone-coal furnaces.

The following is a list of these furnaces:

CHARCOAL FURNACES.

Name.	When built.	County.	Owners.
Bellefont . .	1826	Boyd . .	Means, Russell & Means.
Boone . . .	1856	Greenup .	Nathaniel Sands & Co.
Buena Vista .	1847	Boyd . .	Means & Co.
Buffalo . . .	1851	Greenup .	Culbertson, Earheart & Co.
Hunnewell . .	1845	Greenup .	Eastern Kentucky Railway Company.
Iron Hills . .	1873	Carter . .	Iron Hills Railway, Mining, and Manufacturing Company.
Laurel . . .	1849	Greenup .	Robert Scott & Co.
Kenton . . .	1849	Greenup .	Kenton Furnace Railway and Manufacturing Company.
Mt. Savage . .	1848	Carter . .	Lexington and Carter County Mining Company.
Pennsylvania .	1845	Greenup .	Eastern Kentucky Railway Company.
Raccoon . . .	1833	Greenup .	Raccoon Mining and Manufacturing Company.

STONE-COAL FURNACES.

Ashland . . .	1869	Boyd . .	Lexington and Big Sandy Railroad Company, East'n Div.
Norton . . .	1873	Boyd . .	Norton Iron Works Company.

In addition to these, there were quite a number of furnaces formerly in operation in this region, which have been discontinued from various causes, usually either poor original location, exhaustion of timber supply for charcoal, or unsuccessful management. They were all charcoal furnaces, although one of them, Star Furnace, used stone-coal during the last few years it was in operation.

The following is a list of these:

Name.	When built.	County.	Builders.
Argillite	1822	Greenup	Trimble Brothers & Deering.
Pactolus	1822	Carter	McMurtril & Ward.
Steam	1824	Greenup	Shreve Brothers.
Enterprise	1826	Greenup	Deering, McCoy, Clingman & Co.
Amanda	1829	Greenup	Pogue Brothers, Culvert & McDowell.
Clinton	1830	Boyd	Pogue Brothers.
Globe	1830	Greenup	Darlington & McGee.
Hopewell	1833	Greenup	Wm. Ward.
Caroline	1833	Greenup	Henry Blake & Co.
Oakland	1834	Boyd	Kouns Brothers.
New Hampshire . . .	1846	Greenup	
Star	1848	Carter	
Sandy	1853	Boyd	

The most of the above given dates and names of builders were kindly furnished the Survey for publication by Col. J. Bell, of Ashland. Mr. J. Russell, of Bellefont Furnace, also furnished information which aided the completion of the list.

From the above list it will be seen that the first furnaces of this region were Argillite and Pactolus, built in 1822. It has been stated by Mr. Andrews, in the Ohio Geological Report for 1870, page 217, that the first furnace in the Hanging Rock region was the Union Furnace, built in 1826, by Sparks, Means & Fair. From the above list it will be seen that three Kentucky furnaces in this region were built before Union Furnace, viz: Argillite, Pactolus, and Steam, while two others, Bellefont and Enterprise, were built the same year. To Kentucky, then, properly belongs the credit of having first started the manufacture of iron in this now important region. Although not relating immediately to this region, the fact is worth stating at this place, that in Kentucky was built the first iron furnace in the West, and one of the earliest in the country. This was called Slate Furnace, and was situated in Bath county, upon Slate Creek, a branch of Licking river. It was built as early as 1791, and went out of blast after about thirty years operation. Of the Hanging Rock furnaces given in the above list, Argillite, Hopewell, Pactolus, Enterprise, and Globe were built adjacent to water-power, which was used for driving

the blowing machinery. Argillite, Hopewell, and Pactolus were upon Little Sandy river, Globe and Enterprise upon Tygert Creek. The water-power was not sufficient at all times of the year, and in one case at least a furnace was chilled by the failure of the water requisite to drive her blast engines. The result was that they were all soon abandoned, and others erected using steam-power. The first furnaces were of small size compared with those of the present time, and their production was correspondingly small. Steam Furnace, for instance, was first erected twenty-eight feet high by eight and a half feet bosh, and is said to have produced only three tons of iron per day. It is reported that Argillite Furnace was still smaller, being only twenty-five feet high by six feet bosh, and made only two tons per day. The site for this furnace was excavated out of the shale near the end of the dam, and it was so low that in time of floods the water could only be kept from the furnace by means of coffer-dams.

The present charcoal furnaces are much larger, and produce from ten to sixteen and even twenty tons per day. They are nearly all built after the old model, with a massive stone stack in the form of a truncated pyramid. With one exception, Iron Hills Furnace, the model of all the charcoal furnaces, is the same. They are built against a hillside, at the base of which the rock is excavated to give room to place the stack. The ore and charcoal are hauled in wagons to the stock bank at the level of the furnace throat, and thus the necessity for an elevator is obviated. The boilers are placed over the furnace throat, and the hot blast ovens at the end of the boilers, so that the waste gases are utilized effectually. The engine in common use is horizontal, with one steam cylinder working two blast cylinders, which are geared in such a manner that when the piston of one is at its least velocity the other is at its greatest, and thus a comparatively constant pressure of blast is obtained without the use of a reservoir to regulate it. The engines are usually geared to make one stroke of each blast cylinder to two of the steam cylinder, which is equivalent to stroke for stroke, as there are two of the blast

cylinders. The furnaces are usually worked with open hearth, and most of them use but one tuyere, entering at the side. The hearths are generally constructed of sandstone, of which there is an abundance of good quality on most of the furnace estates. Formerly the inwall or lining was also generally of sandstone, but of late years the use of fire-brick for that purpose has become more common.

Most of the furnaces are without either pressure gauge or pyrometer, so that the pressure and temperature of the blast are not known with any accuracy, the general rule being to heat the blast as high as possible with the ovens at command, and to keep the pressure as great as the steam will allow, varying it, of course, according to the necessities of the furnace working. It is probable that the general pressure of blast does not vary much from two and a half to three pounds.

The following table gives the principal dimensions and other details of the charcoal furnaces in this portion of Kentucky:

CHARCOAL FURNACES IN THE KENTUCKY DIVISION OF THE HANGING ROCK IRON DISTRICT.

	Bellefont	Boone	Buena Vista	Buffalo	Hunnewell	Iron Hills	Kenton	Laurel	Mount Savage	Pennsylvania	Raccoon
Height	34'	44'	40'	36'	47'	49'	37'	39'	39'	36'	35'
Diameter of bosh	10'	10'	10'	10'	12'	12'	10'	10'	11'	10'	10'
Batter or slope of bosh	53°	53°	53°	55°	53°	53°	55°	55°	53°	50°	53°
Diameter of throat	3'	2'	3'	3'	3'	7'	2'	3'	3'	2'	2'
Height of hearth	6'	6'	4'	6'	6'	6'	6'	6'	6'	6'	6'
Diameter at top	8"	8"	7"	10"	4"	6"	8"	9"	8"	6"	4"
Diameter at bottom	8"	3'	3'	5"	2'	6"	3'	3'	6"	2'	2'
Number of tuyeres	2'	1	1	2	1	3	1	1	1	1	1
Diameter of tuyeres	4"	4"	4"	2"	4 1/2"	2"	4"	4"	4"	4"	4"
Height of tuyere above bottom of hearth	3'	2'	2'	6"	2'	2'	1"	2'	2'	2'	2'
Number of boilers	2	2	2	2	3	3	2	3	3	2	2
Diameter of boilers	2'	3'	3'	2'	3'	3'	2'	3'	2'	2'	2'
Length of boilers	8"	48'	52'	9"	30'	3'	37'	9"	38'	30'	3'
Number of blast cylinders	2	2	2	2	2	1	2	2	2	2	2
Diameter of blast cylinders	4'	4'	3'	4"	4'	5'	6"	3'	3'	3'	4'
Stroke of blast cylinders	6"	6"	5'	6"	4'	4'	5'	4'	5'	4'	4'
Diameter of steam cylinder	1'	1'	1'	3"	1'	2'	1'	1'	1'	1'	1'
Stroke of steam cylinder	6"	6' 10"	5'	6"	6"	4'	5'	3"	5'	5'	5'
Kind of hot blast ovens	Davis	None, cold blast	Davis	Davis	Hoop	Hoop	Hoop	Davis	Davis	Hoop	Hoop
Usual pressure of blast	3 lbs.	3 1/2 to 4 lbs	3 1/2 to 4 lbs	3 lbs.	2 1/2 to 3 1/2 lbs.	2 1/2 to 3 1/2 lbs.	3 lbs.	3 lbs.	3 lbs.	3 lbs.	3 lbs.

It will be seen from the above table that, with the exception of two furnaces, Hunnewell and Iron Hills, there is no very great difference in the size or general details of construction. Hunnewell Furnace is also built on the same model, but is larger than usual.

Iron Hills Furnace is, however, constructed on an altogether different and more modern pattern, and one sufficiently novel for this region to deserve a special description.

The furnace has an iron shell stack resting upon iron pillars, fire-brick hearth and lining or inwall, closed top with bell and hopper charging apparatus, and a gas flue for carrying the waste gases to the boilers, which are situated on a bank about twenty-five feet below the top of the furnace. The boilers are situated upon the same level as the stock bank, and an inclined plane elevator is used to hoist the charges to the furnace throat from this level. The hot blast, which is of the Hoop patent, is situated at the end of the boilers. The furnace was built to run upon the Lambert ore, which has been already described. It started at a very inauspicious time for a new enterprise of the kind, the winter of 1873-'74, and was compelled, through financial troubles, to cease operation in the following spring, after having made only nine hundred and sixty-two tons of iron. Since that time it has been idle, but it is to be hoped that it will not long remain so.

It has been freely charged that the lack of success of the furnace was due to the novelties introduced in its construction: notably the substitution of gas flues for taking the gases down to the boilers instead of placing the boilers over the throat of the furnace, in accordance with the time-honored custom. There is certainly no reason why this plan, which has been successful at other places, and which is being introduced in the latest and most improved charcoal furnaces in other regions, should not be successful here also. If it has not been, it may possibly be due to defective construction, improper size of flues, insufficient draft, or some other similar cause; but there certainly is no reason why the gases from a charcoal furnace cannot be taken down through flues and then consumed

in heating boilers and hot blast as well as those from a coke furnace. There is no material difference in the composition of the gases.

In working the furnace it was found that the hot blast apparatus never was heated sufficiently to give a temperature to the blast of more than three hundred degrees to four hundred degrees, and it usually was about two hundred degrees, hardly warm enough to be called hot blast. It is not unlikely that the situation of the hot blast apparatus at the end of the boilers is too far from the place of combustion, which principally takes place where the air is first admitted under the boilers at the end nearest the furnace and farthest from the hot blast stove, so that in reality it receives little more than the waste heat from the boilers, all the combustible portion of the gases being consumed before reaching it. It is probable that if the hot blast apparatus were placed nearer the furnace, with a separate flue to conduct a portion of the gases directly to it, there to be consumed, it would be found as effective as desired, and, with the furnace working properly, there would be abundance of gas for both blast and boilers.

Of the charcoal furnaces in this region, Boone, Buffalo, and Laurel run a large portion of the time, or altogether, with cold blast, for the manufacture of car-wheel pig iron. The remainder use hot blast all the time. The average yield of the ores is generally stated by the furnace managers to be thirty-three and a third per cent. of iron, thus requiring three tons of raw ore for the production of one ton of iron. The figures, however, taken from the stock books at seven furnaces, for periods ranging from one to five years, give an average yield of 31.94 per cent., thus showing that it has been slightly over-estimated.

It will be noticed that the averages for the different furnaces do not vary greatly, three per cent. being about the limit. This shows the general uniformity in quality among the different ores. Those furnaces situated west of Little Sandy, and which use more or less of the lower block ores, show the least average per centage of iron, while those using the

limestone and kidney ores show the highest yield. It will also be observed that the average yield shown by the furnaces is a considerably less per centage than indicated in the analyses of the ores which have been given heretofore. This is due to no fault of the analyses; they show accurately the composition of the specimens submitted to the chemist. The discrepancy is due to the following causes: 1st. To the loss of iron, which often attends the working of the furnace, through the combination of iron with the slag. This loss is not constant, but is greater as the furnace is working more irregularly and producing more mill iron. In such case there is usually an appreciable amount of iron in the slag. As the amount of slag is often greater than the iron produced, a very small per centage of iron in the slag involves a considerable loss, and materially reduces the yield of iron. This loss amounts to little or nothing when the furnace is working well and producing a foundry iron; for as the pig iron is not pure iron, but contains from five to eight per cent. of foreign matter, carbon, silicon, phosphorus, &c., the gain by these impurities will more than counterbalance the loss by the iron in the slag. In fact the furnace working should show a gain over the analysis when everything works properly. 2d. To the inaccuracy in selecting samples for analysis. The difficulty of selecting perfectly average samples of ores has been already referred to. The method adopted has been to take a great many small pieces of ore, each broken from a different place in the pile or outcrop to be sampled from, until the whole should amount to four or five pounds. The endeavor has been in every case to obtain as near a representative average sample of the whole as possible; but it is probable that, in the majority of cases, it has been actually taken better than the average. The personal equation in the matter of sampling an ore or coal is of great importance, and it almost invariably works in favor of selecting the best specimens, in spite of the fair intentions of the sampler. However careful he may be, he will be apt to think that it is unfair to take a sandy or cherty lump of ore or a piece of pyrites in coal, lest it be more than the general average of the

bed. It is a singular feature of human nature, but it exists in every one, whether personally interested in having the ore or coal well represented or not. In addition to this personal bias, it is usually the case that the ore sampled is cleaner and freer from adhering dirt and clay than the average as it is weighed at the furnace scales. This is caused by the sampler usually selecting a clean corner on each lump to chip or break his sample piece from, as he naturally thinks it would misrepresent the ore to take a piece covered with dirt or clay. There is no doubt that the per centage of iron is materially reduced from this cause below what it would yield if the ore could be purchased clean.

Notwithstanding all this, it is believed that the samples of both ores and coals which have been selected for analysis by the different members of the present Survey, approach more nearly to the character of true representative samples than any which have ever before been collected in this State or by the Geological Surveys of many other States. The character of the sample is of as much importance as the accuracy of the analysis, if a true estimate is to be formed of the quality of an ore or coal; and it should be held as requisite for the sampler to be conscientious and unbiased, as for the chemist to be skillful and accurate; and the name of the sampler should be given as well as the chemist. It is because analyses are so often made from small picked specimens representing the very best of the ore or coal, that so many practical men consider an analysis of no value, and charge upon the chemist the fault of misrepresentation which belongs to the sampler. This matter is more important, if possible, in coal than in ore analyses.

The difference which there is between an analysis made from a single lump taken from the center of a bed of coal or from that part of it which is freest from sulphur, and one made from a sample taken by making a number of cuttings through the whole thickness of the bed representing the coal exactly as it occurs, is very great. In the majority of cases heretofore, the former is the kind of sample which has been subjected to analysis.

The average consumption of charcoal per ton of iron in this region ranges from one hundred and forty-five bushels, at some of the best hot blast furnaces, to two hundred and thirty at some of those working cold blast.

The figures from the books at nine furnaces, for periods of time from one to five years, give an average for the whole of one hundred and seventy-nine bushels per ton of pig iron. This requires for its production about four and a half cords of wood, estimating the usual yield at forty bushels of charcoal to the cord of wood. The original forest of this region yields from thirty to fifty cords of wood per acre, with an average of perhaps thirty-five. Each furnace consumes from five thousand to fifteen thousand cords of wood per annum, varying with the length of the blast, thus clearing from one hundred and forty to four hundred and thirty acres of land each year. In 1872, as shown by the tables of production, there were made in this region twenty-four thousand three hundred and twelve tons of charcoal iron, which would require for its production the wood from over three thousand acres of land.

It will thus be seen how rapidly the forests are being destroyed, and how it is that only those charcoal furnaces which are situated on the very largest estates, those of from twelve thousand to fifteen thousand acres and upwards, can be permanent, as they alone afford time for the second growth to attain a size sufficient for charcoal-making before the original forest is exhausted. It is evident, therefore, that in course of time the charcoal iron industry of this region must be supplanted by the manufacture of iron with stone-coal, while the charcoal furnaces will be built further back from the river, where the forests are as yet comparatively unbroken, and from whence the more valuable charcoal iron will bear the higher cost of transportation.

The following table shows the average yield of ore, and the consumption of charcoal, at most of the furnaces of this region. The returns are not as complete as could be desired from all the furnaces, but the number of years from which the averages

are made is given in each case, so that the proper weight can be given to the comparative returns by the reader.

In many cases the figures from which this table was constructed were taken directly from the furnace books, which were kindly placed at the disposal of the Survey. The returns of charcoal consumption are not absolutely accurate for comparison, as there is some variation in measurement at the different furnaces. The charcoal receipts are given in loads of two hundred bushels each, but the size of the wagon-beds, which are counted as holding two hundred bushels, varies somewhat at different furnaces. The consumption of charcoal was of course taken at the furnace measurement in each case. It is believed that this error will not amount to more than a few bushels in the general average. The returns of ore are probably accurate.

Furnace.	Number of years.	Ave'ge per cent- age of iron in the ore.	Number of years.	Average bushels charcoal to ton of iron.
Bellefont	4	32.23	5	185
Buena Vista	2	33.5	5	141
Buffalo	1	30.6	3	*229
Hunnewell	5	32.38	5	161
Kenton	4	32.8	4	197
Laurel	4	32.8	4	175
Mt. Savage	4	32.8	4	164
Pennsylvania	5	31.7	5	194
Raccoon	4	30.4	1	163
Average	4	31.94	4	179

*Furnace working cold blast much of the time.

The ores of this region usually contain such a mixture of ingredients that comparatively little lime is required to flux them. This is usually obtained from either the sub-carboniferous or the ferriferous limestones. At Mount Savage Furnace some limestone is used from the fossiliferous beds of the middle coal measures. The amount used varies from two to twenty-two per cent. of the roasted ore charged, as will be seen by the following table showing the ordinary charges, or so-called half charges, in use at the different furnaces. These are given as they were reported, without any guarantee as to

the accuracy of the weights or measurements. It is probable that the weight of ore is usually pretty correct. The weight of limestone is, in many cases, estimated; and in the measurement of the charge of charcoal, considerable differences exist among the various furnaces; to reconcile which, in tabulating, no attempt has been made. The following table is, therefore, most valuable as showing the proportion of limestone used at the different furnaces, as the ores vary:

AVERAGE "HALF CHARGES" USED AT THE DIFFERENT CHARCOAL FURNACES.

Name of Furnace.	Roasted ore. Pounds.	Limestone. Pounds.	Charcoal. Bushels.	Average number of half charges in 12 hours.
Bellefont	1000	20	33 $\frac{1}{3}$	...
Buena Vista	1700	20	33 $\frac{1}{3}$	...
Buffalo { C. B.	750	100	30	26
{ H. B.	950	125	30	28
Hunnewell	1500	60	40	30
Iron Hills	1200	225	33 $\frac{1}{3}$	...
Kenton	1100	240	22	36
Laurel { C. B.	650	100	22	38
{ H. B.	900	60	22	45
Mt. Savage	1050	40	25	30
Pennsylvania	1250	60	35	...
Raccoon	1000	200	28	26

It will be noticed from the above table, that those furnaces situated west of Little Sandy river, working considerable quantities of the silicious lower block ores, use the largest percentage of limestone. Kenton Furnace, which is compelled to use more of these ores than any other, also consumes correspondingly increased amount of lime. Iron Hills Furnace, working the Lambert ore, shows its silicious nature by the amount of lime which it was obliged to use. The furnaces, on the other hand, which work the upper limestone and kidney ores, consume a very small amount of lime, only ranging from two to five per cent. of the amount of roasted ore.

The ore is prepared for the furnace by a preliminary roasting or calcination. This is, as yet, done altogether in open heaps or piles, so-called kilns. The fuel used is charcoal

braze, fine charcoal, which is pulverized in the manufacture and handling. The ore is piled in pyramidal heaps upon a framework of logs, in alternate layers of ore and fine charcoal. The pile is then ignited at the bottom, and allowed to burn until the charcoal is all consumed, which usually occupies several weeks, when the ore is screened from the ashes and dust, and charged in the furnace. None of the furnaces as yet have roasting ovens or furnaces. This process, as usually conducted, probably offers more room for improvement than any other feature of the iron metallurgy of this region. It is open to serious objections, not the least of which is, that there is no control over the operation after the fire is once started; the whole success is dependent on the judgment of the man who "sets" the pile; if he properly arranges it and distributes the necessary amount of fuel, the operation will go on successfully; if not, there is no help for it, until the pile is all burned out. It is extremely difficult, if not impossible, to roast all portions of the ore alike. The interior of a heap is apt to become too highly heated, while the exterior may be scarcely warmed. There is great danger also of looping or melting the ore before it is roasted. This is quite a serious injury to the ore, rendering it more difficult to smelt, and materially increasing the liability to loss of iron in the furnace, through its entering into combination with the silicious matter present, forming silicates of iron, which are apt to go into the slag. Looped or melted ore is more difficult to smelt, as it is so dense and compact that it is impermeable to the reducing gases of the furnace.

These features are inherent to the system, and no care can entirely remove them; but the custom of roasting many different kinds of ore together, putting in one pile hard carbonate block ores and shelly limonite kidneys, without regard to the fact that they require very different treatment, as is often done, adds another and probably the strongest objection of all. It is a question whether roasting in open heaps is a method suitable for carbonate ores under the best circumstances; but nothing can be more injudicious than to pile indiscriminately,

into one heap, a mixture of carbonate and limonite ores, and then expect to roast them all suitably at one operation. The result is, that if fuel enough be used to properly roast the hard carbonates, the limonites are looped; and if the heat is regulated for the limonites the carbonates will be scarcely affected, and require another treatment. Moreover, the carbonate ores usually contain more sulphur than the limonites, and for this reason they should not be roasted together, as the sulphur escaping from the carbonates is apt to impregnate, more or less, the other ores. This method of roasting is not an effectual one for the removal of sulphur. This can be much more thoroughly accomplished by the use of permanent roasting ovens or furnaces, in which the process can be under complete control, and the heat easily regulated according to the character or requirements of the ore under treatment.

The present inability of the charcoal furnaces to use the hard blue carbonate ores, and continue the regular production of a coarse-grained foundry iron, has been already referred to.

We thus see that by far the greater proportion of all the ore in this region is practically unavailable. If this is ever to be used by the charcoal furnaces, it must be after an improved method of roasting is introduced, by which the sulphur can be effectually removed, and the ore, instead of being looped or melted together, as at present, can be roasted with the admission of air enough to convert it into a porous, easily reducible peroxide.

At present it is regarded as a finality by many furnace managers that the blue ores cannot be worked to produce a hot blast foundry iron, and they are therefore abandoning large quantities of excellent ore of this kind, or else using it in the production of cold blast iron, in which a light color or fine grain is no objection. Where this kind of ore is used and roasted in the ordinary manner, it is sometimes found necessary to roast it two and even three times, before it is all converted into peroxide and ready for the furnace. The bad economy of this operation is readily seen. Any improvement, therefore, which will enable this vast amount of now useless material to

be utilized, will add materially to the wealth of this portion of the State.

The introduction of roasting furnaces and an improved and more intelligent conduct of the process, might not, it is true, completely accomplish this result; but it is an experiment which can be easily tried, is not expensive, and if it did not succeed in making the blue ores available, would certainly show an economy and improvement in the process over the old method which would amply compensate for the slight expense.

Roasting in furnaces or ovens consumes less fuel and costs considerably less per ton than the old method, as well as requires less time. In the roasting kilns used in the Cleveland iron region in England, the ore, a hard, impure carbonate, is roasted in about two days, and about one ton of coal slack is used to roast twenty-five or thirty tons of ore. These kilns are shaft furnaces working on a similar plan to the continuously operated lime-kilns.

The quality of the charcoal pig iron of this region has been before alluded to. Its chemical composition is shown by the following table of analyses by Dr. Peter and Mr. Talbutt:

	Bellefont Mill.	Bellefont No. 1 Foundry.	Bellefont Silver Grey.
Iron	92.962	93.208	89.902
Graphitic carbon	2.100	3.350	2.900
Combined carbon	1.310	.220	.070
Manganese	.054	.054	.054
Silicon	2.525	2.389	5.082
Slag	.220	1.160	.280
Aluminum		.193	
Calcium		.144	
Magnesium		.095	
Potassium		.047	
Sodium		.032	
Phosphorus	.568	.194	.417
Sulphur	.114	.005	.114
Total	99.799	101.091	98.763

	Pennsylva- nia Mill.	Pennsylva- nia No. 2 Foundry.	Pennsylva- nia No. 1 Foundry.	Pennsylva- nia Silver Grey.
Iron	94.764	92.856	92.060	90.630
Graphitic carbon	2.900	3.230	2.700	2.500
Combined carbon	.780		.630	.830
Silicon	1.193	2.545	3.104	4.969
Slag	.200	.360	.300	
Phosphorus	.860	.817	.740	.741
Sulphur	.033	.046	.033	.040
Total	100.730	99.854	99.567	99.710

	Mt. Savage Mill.	Mt. Savage No. 2 Foundry.	Mt. Savage No. 1 Foundry.	Mt. Savage Silver Grey.
Iron	93.268	91.584	91.502	89.687
Graphitic carbon	3.950	2.600	2.670	2.300
Combined carbon	.770	1.070	.030	.500
Manganese			.123	
Silicon	1.799	3.058	4.470	5.575
Slag	.160	.620	1.160	.660
Aluminum			.128	
Calcium			.144	
Magnesium			.112	
Potassium			.076	
Sodium			.023	
Phosphorus	.680	.609	.203	.609
Sulphur	.081	.152	.041	.136
Total	100.708	99.493	100.682	99.467

	Hunnewell No. 2 Foundry.	Hunnewell No. 1 Foundry.	Buena Vista No. 1 Foundry.
Iron	92.368	92.284	93.712
Graphitic carbon	3.690	2.960	2.990
Combined carbon		.690	.210
Manganese	.020		.056
Silicon	2.515	3.011	1.908
Slag	1.130	.880	.600
Aluminum	.582		.644
Calcium	.048		.104
Magnesium	a trace.		.095
Potassium	.056		.063
Sodium	a trace.		.010
Phosphorus	.684	.474	.380
Sulphur	.026	a trace.	.066
Total	101.119	100.299	100.838

The above analyses are all from furnaces east of Little Sandy river, which use the upper limestone and kidney ores almost exclusively. The analyses are all of hot blast iron. The grades of iron are known as Mill, No. 2 Foundry, No. 1 Foundry, and "Silver Grey" or glazed pig. Mill iron is made when the furnace is working "cold," No. 2 Foundry when working between "cold" and "hot," No. 1 Foundry when the furnace is working "hot," and "Silver Grey" when working too hot. No. 1 Foundry is the most valuable, and is the grade which the furnaces endeavor to produce all the time. It is a free flowing, non-shrinking iron, which is used for castings of all kinds. "Silver Grey" or glazed pig is of the least value. It is so brittle that it can be used for no purpose where strength is required.

It will be noticed that there is a regular gradation in the amount of silicon present in the different grades of pig iron, directly proportional to the relative heat required in the furnace to produce them. Mill iron, which is made with the least expenditure of heat, contains least silicon, while "Silver Grey" contains the most. The poor quality of this iron is undoubtedly owing to the excess of silicon, which renders the iron brittle or "cold-short," and unfit for the puddling furnace, as in puddling the silicon oxidizes to silica, and combines with a large proportion of the iron, causing a great waste of iron, and rendering the process slow and difficult.

These irons are all somewhat phosphatic, but not enough to injure them for foundry purposes; on the contrary, it is probable that the free flowing, small shrinking qualities in this iron are largely due to the phosphorus present. Sulphur is low—0.15 per cent. being the highest in any samples analyzed.

The above statements apply equally well to the iron made at the furnaces west of Little Sandy river, which use the block and lower limestone ores exclusively.

	Boone No. 1 F., hot blast.	Boone No. 2 F., hot blast.	Kenton No. 1 F., hot blast.	Raccoon No. 1 F., hot blast.	Iron Hills No. 1 F., hot blast.	Laurel No. 2, cold blast.	Buffalo No. 1 F., hot blast.	Buffalo Silv. Grey, hot blast.	Buffalo No. 1, cold blast.
Iron	93.212	90.958	92.724	91.668	92.387	92.697	91.656	88.106	94.739
Graph. carbon	2.940	2.164	3.320	2.950	3.340	2.100	2.790	1.950	3.620
Comb. carbon	.060	.116	.660		.760	1.000		.570	.780
Manganese . .	.083	.115	.612	.332	.056		.084	.014	.056
Silicon	1.634	2.682	2.090	3.817	2.240	1.813	4.106	7.317	.877
Slag	2.460	4.180	.300	1.200	.620		.600	.900	.120
Aluminum . .	.330	.479	.442	.128	.120		.399	.165	.060
Calcium			.184	.075	.120		.168	.128	.104
Magnesium . .			.190	.122	.056		.095	.125	.082
Potassium . .			.104		.080		.086	.048	.048
Sodium			.004				.016	.002	.041
Phosphorus . .	.486	.304	.622	.334	.836	.454	.695	.768	.609
Sulphur . . .	.079	not det.	.046	.041	.057	.218	.150	.019	.037
Total . . .	101.284	100.998	101.298	100.667	100.672		100.845	100.112	101.773

These irons show a very slight excess in the average amount of phosphorus over those from furnaces east of Little Sandy, but it is small. The superiority of cold blast iron seems, from these analyses, to be due more to its comparative freedom from silicon than any other cause. It is made when the furnace is not working so hot as with hot blast, and those metals, such as silicon, aluminum, &c., which require for their reduction an intense heat, are not reduced to alloy with the iron, but pass into the slag.

THE STONE-COAL IRON MANUFACTURE.

This branch of the iron manufacture, as yet in this region comparatively in its infancy, is destined to become ere long by far the most important industry. The great majority of charcoal furnaces are of necessity, as already shown, short lived through the exhaustion of their timber supply, which happens usually long before the ore supply becomes precarious. The permanent manufacture must then be based upon a supply of fuel which shall be neither precarious nor expensive. Fortunately this portion of Kentucky is richly blessed with an ample supply of a most excellent coal, a coal which the experience of the past six years has proved to stand in the front rank of the iron-making coals of the country. It is a dry-burning non-coking coal, which is used most successfully in a raw state for the manufacture of pig iron. It is known variously as the Coalton or Ashland coal, and is classed as No. 7. Its geological position and equivalency have already been described in

Mr. Crandall's report. It is the Kilgore coal of the old Geological Reports. It is known as the Coalton or Ashland coal, from the fact that it is most extensively mined by the Ashland Coal Company, at Coalton, on the Lexington and Big Sandy Railroad, Eastern Division, about twelve miles back from Ashland, in Boyd county. From the mines of this company the greater portion of this coal for furnace use has been obtained.

In addition, it is mined on the Star Furnace estate, now the property of the Norton Iron Works, of Ashland, and at Willard, Carter county, the present terminus of the Eastern Kentucky Railway, by the Bellefont and Ætna Coal and Iron Company. It is used in this State by the Ashland Furnace, belonging to the Lexington and Big Sandy Railroad, Eastern Division, and by the furnace of the Norton Iron Works Company, both situated in Ashland. It is also used by the Bellefont Furnace, of Ironton, Ohio, and will be used in the large furnaces now being erected by the Ætna Iron Company, near the same place.

As yet the No. 7 is the only coal which has been successfully used as a furnace fuel in this region. An attempt was made several years since to use the No. 3 coal at Hunnewell Furnace, but it was not sufficiently successful to justify a repetition of the trial. A blast of about four months was made, using this coal, but the production did not average over six tons per day, and the iron was of very poor quality, as could have been expected from the character of the coal, which is very sulphurous. It is probable that the working of the furnace when using this coal would have been more successful had the furnace and machinery been adapted to that fuel. They were constructed for charcoal and used for stone-coal without any material alteration. The coal is so sulphurous, however, that it is probable it would always make a poor iron, unless it could be first washed and coked.

The No. 1 coal, which is probably the equivalent of the well-known Jackson coal, of Ohio, which has proved so successful a furnace coal, is found of workable thickness at a number of places in this region, and will probably, on trial, be found to be

well adapted to furnace use. It shows, in some places, of very good quality; but it is, unfortunately, somewhat irregular in its thickness. The following are analyses, by Dr. Peter and Mr. Talbutt, of this coal from the Graham bank, near Willard, Carter county:

	I.	II.	III.
Moisture	3.80	3.50	3.60
Volatile combustible matters	34.50	36.30	35.40
Fixed carbon	58.50	57.30	57.60
Ash	3.20	2.90	3.40
Total	100.00	100.00	100.00
Coke	61.70	60.20	61.00
Specific gravity	1.274	1.269	...
Sulphur	2.164	1.148	1.065
Sampler	P. N. Moore	P. N. Moore	Geo. Gibbs.

No. I is a sample taken from the whole thickness of the coal, including a pyritous band, which can be rejected in mining. Nos. II and III are taken from the whole thickness of the bed, rejecting this band.

From the above analyses it is evident that the coal is of most excellent quality. The ash and sulphur are both low, and the fixed carbon is high. There can be little doubt that it will make an excellent furnace fuel, equal to or superior to any in this region.

The quality of the Coalton or No. 7 coal varies greatly, and it is at some places irregular in its thickness. The difference in quality is due to the greater or less proportion of sulphur present in the coal. This varies greatly in very short distances. The same mine will show coal in different parts of it of greatly different quality. The per centage of ash is quite uniform, as is the general structure of the coal, which retains its dry burning character throughout; but the sulphur is sub-

ject to rapid variation. The analyses that have been made by Dr. Peter and Mr. Talbutt, of this coal, usually show more sulphur than the coal was supposed to contain, and more than former analyses had indicated. This is due to the different methods of sampling employed. Heretofore the analyses had been made from single lumps, or from several lumps, which were usually taken by interested parties, and probably represented the coal at its best. This has been too often the plan pursued by members of Geological Surveys in other States, and the result has been to generally represent the coals as better than they actually are. The plan pursued by the members of the present Survey has been to take carefully averaged samples. These were made by cutting a large number of small pieces of coal from the whole thickness of the bed, taking them in regular succession from top to bottom, thus representing the coal exactly as it occurs at the place of sampling. Slate partings, or pyritous bands, large enough to be rejected in mining, were not of course represented in the sample, but otherwise impurities were taken if they occurred at the place of the cutting. Wherever possible the sample was taken from a number of rooms in each mine, or, where the coal was not opened, from as many outcrops as possible. The constant endeavor has been to secure samples representing the coal as it actually occurs in the mine. The personal bias already referred to in the matter of ore sampling, probably does not have as much influence in favor of the coals, when they are sampled in the mine in the way just described, for the reason that the cutting is made right through the coal where it is once started, and in the darkness of the mine it is difficult to see what is the exact quality of each piece taken. In sampling coal from a stock pile it is a different and more difficult matter to select a fair average sample; for the personal bias of the sampler then works in favor of the coal. It requires a strong effort of the will to break off a piece of pyritous coal and drop it into the sample bag when the sampler sees it before him in broad daylight. However conscientious he may be, he will be apt to think that perhaps if he takes that iden-

tical fragment of pyritous coal it will be more than the average, and so he will reason in regard to the next piece and the next, until in the end his sample will be much better than the average of the coal.

The following analyses of the No. 7 coal were all made from samples taken in the manner above described. The analyses are by Dr. Peter and Mr. Talbutt. The name of the sample is given with analysis:

	1.	2.	3.	4.	5.	6. Star.
Specific gravity	1.291	1.320	1.336	1.340	1.308	1.377
Water	4.80	5.00	4.06	4.40	3.30	7.70
Volatile combustible matter	34.20	34.50	34.24	31.10	33.30	28.16
Fixed carbon	54.90	55.40	54.70	57.90	57.60	53.04
Ash	6.10	5.10	7.00	6.60	5.80	11.10
Total	100.00	100.00	100.00	100.00	100.00	100.00
Coke	61.00	60.50	61.70	64.50	63.40	64.14
Sulphur	1.312	1.285	1.854	2.095	2.480	1.055
Sampled by	Moore.	Moore.	Moore.	Moore.	Moore.	Crandall.

	7. Star.	8. Star.	9.	10.	11.	12.
Specific gravity	1.290	1.288	1.320	1.340	1.320	1.350
Water	6.40	6.60	6.06	6.40	4.40	3.20
Volatile combustible matter	27.22	34.36	32.94	31.40	38.00	35.06
Fixed carbon	58.88	54.64	54.80	57.66	52.86	54.40
Ash	7.50	4.40	6.20	4.54	9.14	7.34
Total	100.00	100.00	100.00	100.00	100.00	100.00
Coke	66.38	59.04	61.00	62.20	62.00	61.74
Sulphur	.973	.724	1.867	1.670	2.200	2.631
Sampled by	Crandall.	Crandall.	Moore.	Moore.	Moore.	Moore.

No. 1 is an average sample of the coal from the stock-house at Ashland Furnace, taken to represent as nearly as possible the coal as actually used in the furnace.

Numbers 2 to 5, inclusive, are samples, each one taken from several rooms in mine No. 4 of the Ashland Coal Company, above Coalton, in Boyd county.

No. 2 is from several rooms about two hundred and fifty yards from the west end of entry No. 4.

No. 3 from rooms about three hundred yards from east end of entry No. 4.

No. 4 from rooms about eight hundred yards from west end of same entry.

No. 5 from rooms opening into the Dry branch cross-entry.

Nos. 6 to 8 are samples taken from the upper, middle, and lower members of the coal bed at the old Star Furnace mines above the furnace. The samples were taken from the pillars, which had been exposed for some time, and probably contained less sulphur than the freshly broken coal.

No. 6 is the upper, No. 7 the middle, and No. 8 the lower stratum of the coal.

Nos. 9 and 10 are samples from the upper and lower layers of the coal, here consisting of but two members, at an opening on Gum branch of Straight Creek, Mt. Savage Furnace property, Carter county. These samples were selected from coal on the bank, and hence are probably not as accurate averages as those taken in the mines.

No. 11 is a sample from the old Watson drift, on Lost Creek, near Willard, Carter county.

No. 12 is from several rooms in the mine west of Dry Fork, at Willard, Carter county, main entry.

These analyses show the great variation that exists in the amount of sulphur in this coal. In other respects, as will be seen above, the uniformity is remarkable. The per centage of ash is quite uniform. The sample that shows 11.10 per cent. is from the upper member of the coal at Star Furnace, a layer that is not taken down in mining, as it is usually quite sulphurous and slaty.

These analyses were all made from carefully taken samples, and they showed the coal to be more sulphurous than generally supposed, and more than analyses heretofore published had shown. They also indicate a coal poorer than similar coals from other States, judging by the published analyses of them, which, however, had probably been made from picked specimens, or at least there was no description given of the character of the samples from which the analyses were made.

Actual experience with the working of this coal in the furnace, for the past eight years, as will be shown more in detail further on, proves that it is a most excellent iron-making fuel, and that it ranks among the best of the country, although the analyses did not show as well as those of similar coals from other States.

With the view of making a trustworthy comparison with other successful iron-making coals of the country, based upon analyses from samples which were taken in the same way, and were known to be honestly and carefully selected to fairly represent the coal as it actually occurs, not picked to make as good a showing as possible, the Indiana Block, the Big Muddy, Illinois, the Hocking Valley or Nelsonville, and the Jackson, Ohio, coal regions were visited by members of the Survey, and samples selected in the same manner as in all the Kentucky coals.

The following are the analyses by Dr. Peter and Mr. Talbutt:

	1.	2.	3.	4.	5.
Specific gravity	1.313			1.310	1.310
Water	2.40	2.70	2.68	2.62	3.44
Volatile combustible matter	35.10	36.38	36.32	32.04	31.86
Fixed carbon	55.50	55.64	53.58	58.58	59.54
Ash	9.00	5.28	7.42	6.76	5.16
Total	100.00	100.00	100.00	100.00	100.00
Coke	62.50	60.92	61.00	65.34	64.70
Sulphur	2.373	1.664	1.803	2.472	01.370
Sampled by	Moore.	Moore.	Moore.	Moore.	Moore.

	6.	7.	8.	9.	10.
Specific gravity	1.346	1.303	1.312	1.361	1.322
Water	3.26	3.74	4.40	4.54	3.46
Volatile combustible matter	33.76	36.32	35.08	29.68	36.64
Fixed carbon	54.42	55.74	55.20	57.06	53.80
Ash	8.56	4.20	5.32	8.72	6.10
Total	100.00	100.00	100.00	100.00	100.00
Coke	62.98	59.94	60.52	65.78	59.90
Sulphur	2.247	1.299	1.659	0.758	1.848
Sampled by	Crandall.	Crandall.	Crandall.	Crandall.	Moore.

Nos. 1, 2, and 3 Indiana Block coal, from near Brazil, Indiana. Samples representing the coal from three different mines. Each sample was taken from several rooms in the same mine, so as to represent it as fairly as possible. These mines rank among the best of that region, and coal from all of them has been, or is now, successfully used in the furnace for making iron. The difference between these analyses and those here-

tofore generally published, strongly points to the probability that they have been made from picked samples.

Nos. 4 and 5 are from two of the best mines in the Big Muddy coal region, near Murphysboro, Illinois. Large quantities of coal from both of these mines have been used in the furnaces at South St. Louis.

Nos. 6, 7, and 8 are samples of the Hocking Valley or Nelsonville coal, from mine near Nelsonville, Ohio. No. 6 from the upper, No. 7 from the middle, and No. 8 from the lower division of the coal.

No. 9 is from the well-known Jackson coal, of Ohio. This analysis compares very favorably with those heretofore published, except that the per centage of ash is much greater.

No. 10 is from the Sheridan mines, Lawrence county, Ohio.

All of the above are excellent fuels, and, with one exception, the Sheridan coal, which has not as yet been tried for iron-making, they rank as the best, or among the best, furnace fuels of the West. The analyses of them heretofore published show much more favorable results; but they have not unlikely been made from picked specimens.

Long trial has proved that these coals work well in the furnace, and that the per centage of sulphur is not sufficient to seriously injure the iron made with them. The conclusion, then, that these analyses point to, is, that a larger proportion of sulphur than heretofore generally supposed, can be present in a coal without destroying its availability for iron-making.

The No. 7 coal, as shown by the analyses already given, compares very favorably with the other iron-making coals, and is superior to most of them. When properly selected for the furnace use, as must be done with all coals, no matter where they are from, it is among the best of the furnace coals in the West.

There is no coal which is of uniform quality throughout its whole range; there is variation in all of them, and the No. 7 coal is no exception. It holds the same general character throughout, but is more or less sulphurous, according to locality.

The first attempt to use this coal for furnace purposes was in 1866, when a considerable quantity of it was sent up the Ohio river to Martinsville, Ohio, and tried in the furnace there. This trial resulted so successfully that in 1867 the Bellefont Furnace was erected at Ironton, Ohio, relying upon this coal for its main supply of fuel, although a considerable proportion of coke is generally used. This was followed, in 1869, by the erection of the Ashland Furnace, at Ashland, and in 1873, by the Norton Iron Works at the same place. These two furnaces are, therefore, as yet, the only ones in this portion of Kentucky which manufacture iron from stone-coal. They are among the most successful and complete furnaces in the West.

The following are the principal dimensions of the two:

	Ashland.	Norton.
Height	60'	67'
Diameter of bosh	15'	18'
Slope of bosh	72°	73°
Diameter of throat	10'	9'
Height of hearth	6'	7'
Diameter of hearth at bottom	6'	6'
Diameter of hearth at top	6'	6'
Number of tuyeres	6	7
Diameter of tuyere	4"	4"
Height of tuyere above hearth	3' 6"	3' 4"
Vertical blowing engines	1	2
Diameter of blowing cylinder	7'	7'
Stroke of blowing cylinder	6'	4' 6"
Diameter of steam cylinder	3'	2' 8"
Stroke of steam cylinder	6'	4' 6"
Number of hot blast ovens	5	5
Hot blast ovens—pattern	Player.	Player.
Usual temperature of blast	900°	850° to 1000°
Usual pressure of blast—pounds	8	6 to 7

The Ashland Furnace has an iron-shell stack, resting upon four masonry pillars at the base, between which are the tuyere and casting embrasures. The furnace produces mill iron only. It averages a production of from thirty-seven to forty tons per day. In addition to the native ore, which it receives by the railroad, it uses Iron Mountain ore from Missouri, mill cinder, and sometimes ores from other localities.

For fuel it uses the Coalton (No. 7) coal alone, not consuming a pound of coke after the furnace is filled with that material at starting into blast. This fact is of great interest and importance, as showing the high rank of the Coalton coal as an iron-making fuel. It is of especial interest for comparison with other dry-burning furnace coals of the West. The far-famed Indiana Block coal has never been successfully worked in the furnace for any length of time without the use of a considerable amount of coke to mix with it, which coke has heretofore been brought all the way from Pittsburg by rail; but lately coking ovens have been erected at some of the furnaces in the Indiana Block coal region, to coke the coal from their own mines.

The Big Muddy coal of Illinois, which is the fuel upon which the iron manufacture of St. Louis is based, and which is an excellent coal, has never been used successfully alone for any length of time. The furnaces of St. Louis have also been compelled to bring coke all the way from Pittsburg to use with the coal.

The Hocking Valley or Nelsonville coal, of Ohio, which is also regarded as an excellent furnace fuel, has not been used alone without some admixture of coke. Only the Briar Hill and the Massillon coal of northern, the Jackson coal of southern Ohio, and the Coalton coal of Kentucky, have been used for any length of time alone, of all the furnace coals of the West.

The Ashland Furnace, in which this coal has proved to be so excellent a fuel, is one of the most successfully managed in the West. On the 20th of June, 1874, it finished a blast of three years and four months duration, during which it made, on a hearth of Mt. Savage fire-brick, forty thousand five hundred and twenty-seven tons of iron; during which time, as already stated, not a pound of coke was consumed after the first filling of the furnace. This is a record such as few furnaces can equal. This furnace stops on Sunday, from twelve to twenty-four hours, so that this production represents a less number of days blowing than the total time of the blast.

The following is the record of this furnace consumption and production for the past five years:

	1870.	1871.	1872.	1873.	1874.
Native ore (roasted) used, tons of 2240 lbs. .	6425	7439	8852	10216	6407
Iron Mountain ore " " "	5630	7533	9463	8095	4758
Other ores " " "	4841	41	1077	868	568
Mill cinder " " "	2250	2731	3675	4941	2723
Limestone " " 2268	5990	5184	6820	7655	4800
Coal (tons of 2000 lbs.) used	23466	25166	33923	34499	*19160
Iron made, tons of 2240 lbs.	9316	9509	12105	12741	6710
Tons coal (2000 lbs.) to ton iron, 2240 lbs. .	2.51	2.62	2.80	2.70	2.85
Average per centage of iron in the ore mixture	48.6	53.5	52.4	52.8	46.4
Tons of limestone to ton of ore	0.30	0.29	0.29	0.31	0.33

* Including 230 tons coke used in starting the furnace.

There is an error in the amount of coal consumed in 1870. It is probably under-estimated about one fourth ton to the ton of iron made. Leaving the consumption for this year out of consideration, as being uncertain, the table gives us for the four years, from 1871 to 1874, inclusive, an average consumption of 2.74 tons (of 2000 pounds each) to the ton of iron from an ore mixture averaging a little over fifty per cent. This corresponds to about 2.44 tons of coal of 2240 pounds each. This consumption is less than that required for a ton of iron, in the majority of the furnaces of the West using other coals of similar character. At Jackson, Ohio, where, however, the furnaces are mostly of small size, the consumption of coal is stated at one hundred bushels per ton of iron, or between three and four tons. At Massillon, Ohio, where the No. 1 coal is used, the equivalent of the Jackson and Briar Hill coals, nearly four tons of coal are consumed to the ton of iron. In Indiana the consumption of the "Block coal" is about three tons, and the ores used are usually of high grade, from Missouri or Lake Superior. All of these are higher than is desirable, and much

more than theoretically required to produce a ton of iron. The volatile matter of the raw coal is considered as having little or no influence in the reduction of the iron, which is effected by the carbonic oxide produced by the combustion of the carbon in the coke, which is therefore the valuable element.

The average per centage of coke in the No. 7 coal, as shown by four analyses from the Ashland Company's mines, is 62.5. The consumption of 2.44 tons of raw coal to the ton of iron is therefore equivalent to 1.52 tons of coke, or about 30 cwt.

When it is remembered that at many of the furnaces of the Cleveland district of England a ton of iron is now made with 18 or 19 cwt. of coke, or less than a ton of coke to the ton of iron, the ores at the same time not yielding more than forty per cent. of iron, the improvement yet to be made in this region will readily be seen.

The average consumption of coal per ton of iron at the Norton Furnace, as will be shown further along, was 2.69 tons of 2000 pounds each, equivalent to 2.4 tons of 2240 pounds. Of this, however, about 8 per cent. was coke used in the early part of the blast. The mixture of ores did not differ greatly from that used at the Ashland Furnace. The consumption of coal is very nearly the same in both furnaces, showing that the quality of the coal is very similar, and that 2.4 to 2.5 gross tons is the amount which as yet the best practice has required in making a ton of iron.

The Norton Iron Works comprise three separate establishments—a blast furnace, a rolling mill, and a nail mill. The works were erected in 1873, but did not go into operation until the spring of 1874. They are among the most extensive and perfect of the kind in the country. The dimensions of the furnace have been already given. It is an iron-shell stack resting upon iron pillars. The hoisting apparatus is an Otis elevator, working in a substantial brick building. Everything about the furnace is constructed in the most thorough and substantial manner. There are five hot blast ovens of the Player pattern, and twelve boilers, each 42" diameter by 60'

long, which furnish steam for both mills and the furnace. The boilers and hot blast are heated by the waste gases from the furnace. The iron produced at this furnace is mostly mill iron, which is made into nails. There are in the rolling-mill sixteen puddling, and two reheating furnaces. This mill works only for the preparation of plate for the nail machines, of which there are eighty in the nail mill, producing four thousand kegs of nails per week.

For fuel this furnace uses the Coalton (No. 7) coal, from the mines of the company, on the old Star Furnace estate. Some Pittsburg coke was used in starting the furnace into blast, but it was not long continued. The total amount used was not quite 2,000 tons. The No. 7 coal is also used in the rolling-mill, where it proves a very satisfactory fuel in the puddling furnaces. Ore, mostly kidney, is obtained from the Star Furnace lands, and also limestone ore from the old Kentucky Steam and Caroline Furnace estates, which are now owned by the Norton Iron Works Company. In addition to the native ore, a considerable amount of Iron Mountain ore is also used. The following are the statistics of the working of this furnace for 1874. It did not go into operation until the latter part of February, so that these figures represent only about ten months' operations:

Native ore used	tons of 2268 pounds	8592
Iron Mountain ore,	" 2240 "	8228
Mill cinder	" 2240 "	2417
Limestone	" 2268 "	7810
Coal	" 2000 "	26334
Coke	" 2000 "	1930
Iron made, tons of 2240 pounds		10502
Per centage of iron in the ore mixture		54.5
Tons coal and coke (2000 pounds) to ton iron (2240 pounds).		2.69
Tons limestone to ton of ore		0.40

As yet only the No. 7 coal, from the mines of the Ashland and Norton Companies, in the valley of Williams' Creek, has been successfully used for iron-making. The coal has a far wider field than this valley, where it has been so extensively mined, and it is certainly highly improbable that it should only be found of quality requisite for smelting purposes in that narrow basin. It is finely developed to the south and southwest, showing at places as full a thickness and apparently as good quality as where first mined. It has been opened at Willard, in Carter county, on the land of the Bellefont and Ætna Company, and the coal unsuccessfully tried in the Bellefont Furnace, at Ironton, Ohio. The opening was made on the west side of Dry Fork, in a spur of the main ridge, where the coal was thin and quite sulphurous; so much so that it showed readily to the eye that it was impure. The analysis shows 2.63 per cent. of sulphur. It is no wonder that the attempt was unsuccessful. There is a large field north and northeast of this, on Lost Creek, Davy Run, Straight Creek, and on the Mt. Savage Furnace property, where the coal is well developed in thickness, and at many places is of very good quality. It is probable, or almost certain, that it will at many places be found of quality suitable for iron-making. It may not be such at every opening or outcrop, as it is not, where most successfully mined; but there is every probability that abundance will be found of the best quality. It should be remembered that not every room nor every entry of the mines on Williams' Creek, where this coal is best developed, furnishes a suitable coal for furnace uses. It has to be selected for that purpose from different parts of the mine, and the locality of the best coal changes frequently.

With careful prospecting and selection, it is certainly probable that furnace coal will be found at many places where the coal is now either unknown or unopened.

There can be little doubt that eventually the immense stores of this excellent fuel, with which this region is so richly endowed, will be made servicable. There is also little doubt that eventually much poorer fuel will be successfully used in

the manufacture of iron than is now supposed to be possible; and great quantities of this coal, as well as others which have not as yet been tried, will become sources of wealth.

The tendency of modern improvements in metallurgy is to the invention and introduction of appliances whereby more impure fuels than formerly supposed available can be used in metallurgical operations without detriment to the resulting product. Whether this desirable result will be attained through peculiar construction of furnaces, or by the purification of the coals by some cheap process of washing and coking before they go into the furnace, is impossible to say. It is not unlikely that both methods will be successfully introduced.

The quality of the iron made with the No. 7 coal is shown by the following analyses, by Dr. Peter and Mr. Talbutt:

	No. 1.	No. 2.	No. 3.
Iron	91.420	90.899	89.731
Graphitic carbon	2.460	2.560	1.660
Combined carbon	.240	.160	.790
Manganese	.195	.236	.471
Silicon	3.709	5.121	6.308
Slag	.540	.760	1.120
Calcium	.176	.072	.152
Magnesium	.233	.106	.060
Phosphorus	.385	.394	.461
Sulphur	.082	.045	.015
Total	99.440	100.353	100.768

No. 1 is the No. 1 mill iron, from the Ashland Furnace.

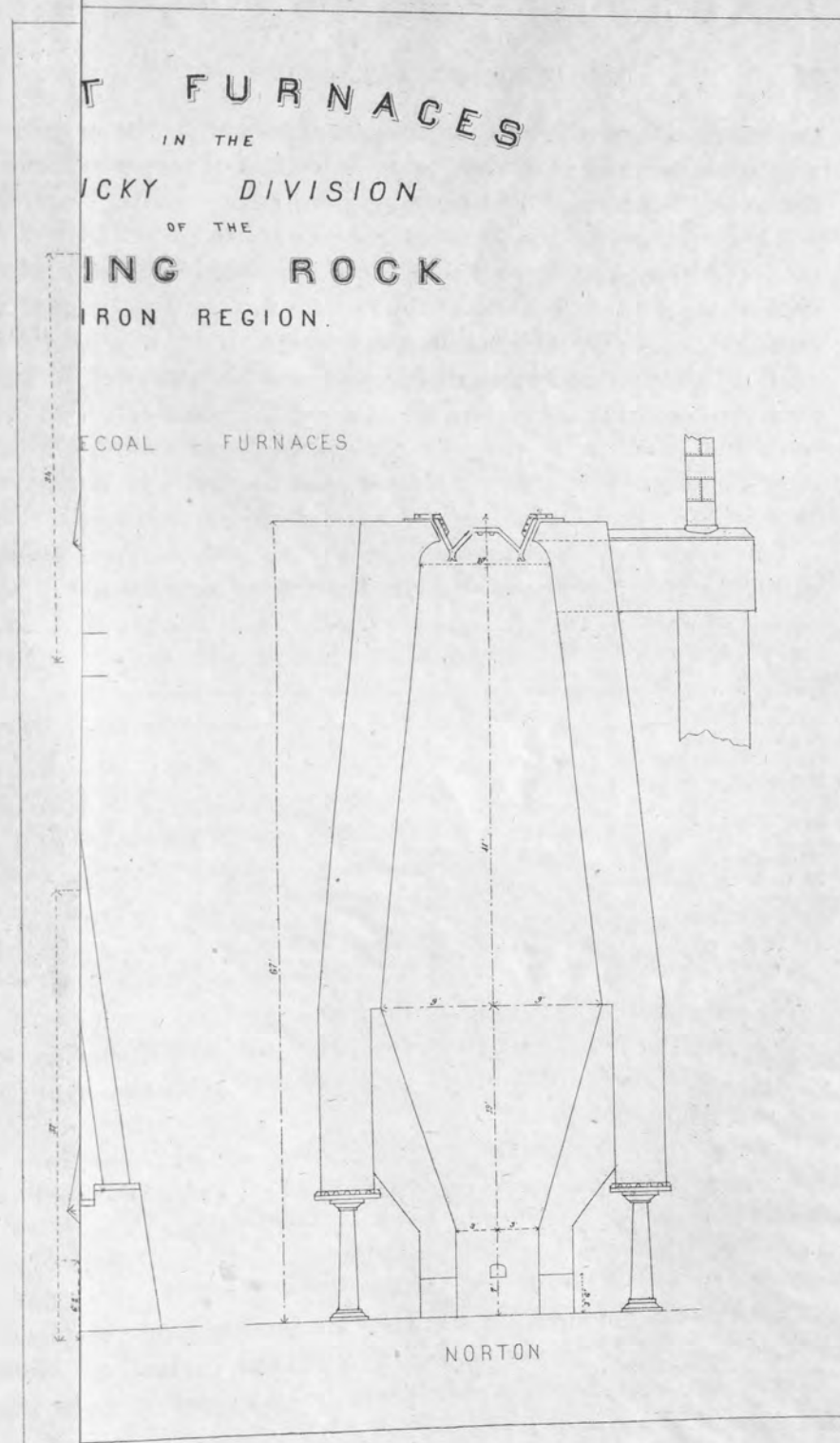
No. 2 is the No. 2 mill iron, from the Ashland Furnace.

No. 3 is a grade of foundry iron, only occasionally made at the same furnace.

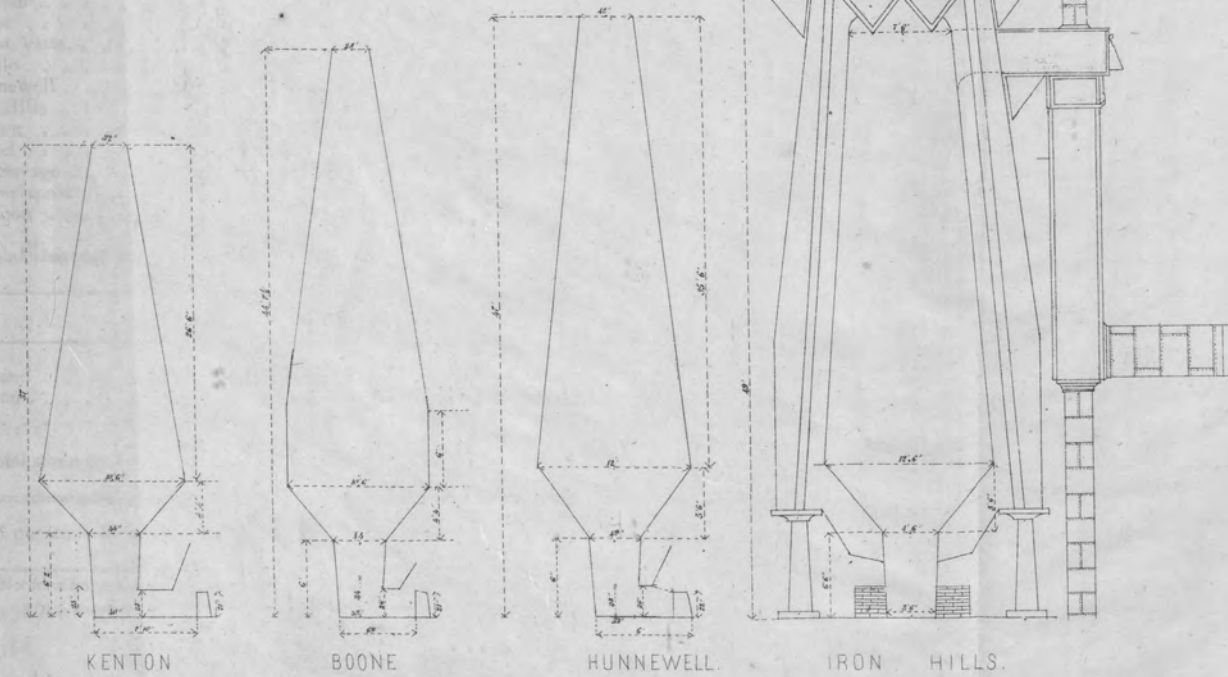
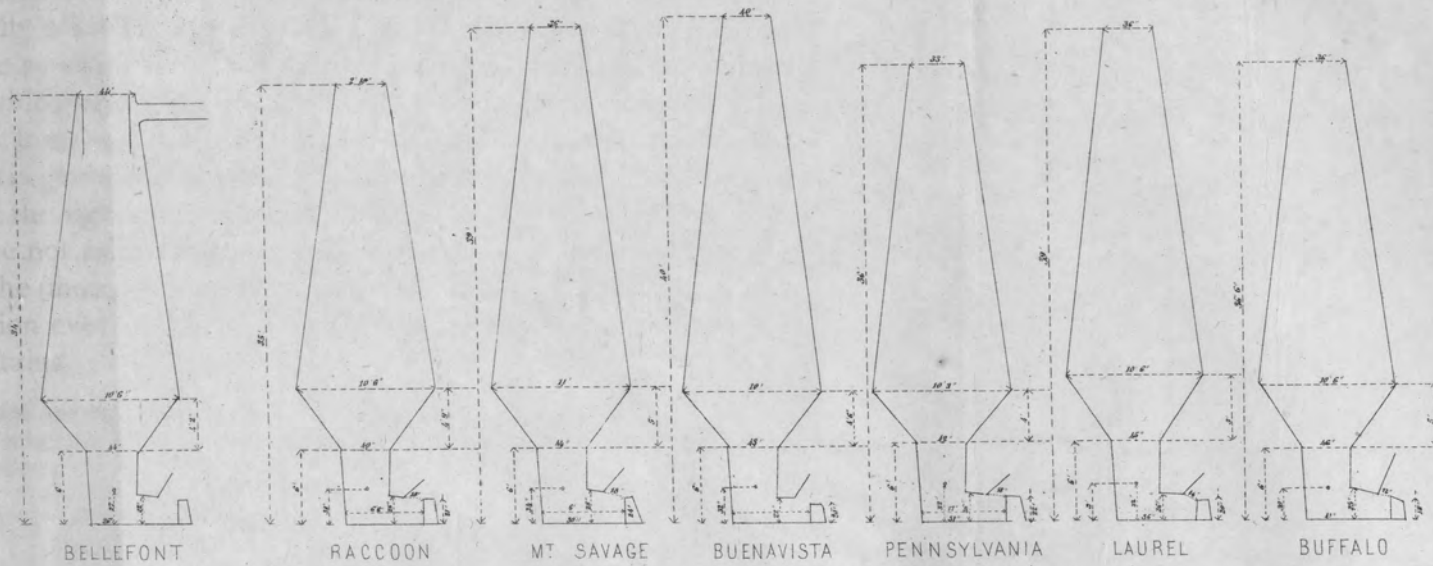
All the above were made with the No. 7 coal alone, from a mixture of sixty per cent. native ore, twenty-two per cent. of Iron Mountain ore, eighteen per cent. mill cinder.

STATISTICS OF IRON PRODUCTION.

Below will be found the statistics of the pig iron production of this region for the five years, 1870 to 1874, inclusive. These figures have, in nearly every case, been obtained by a per-

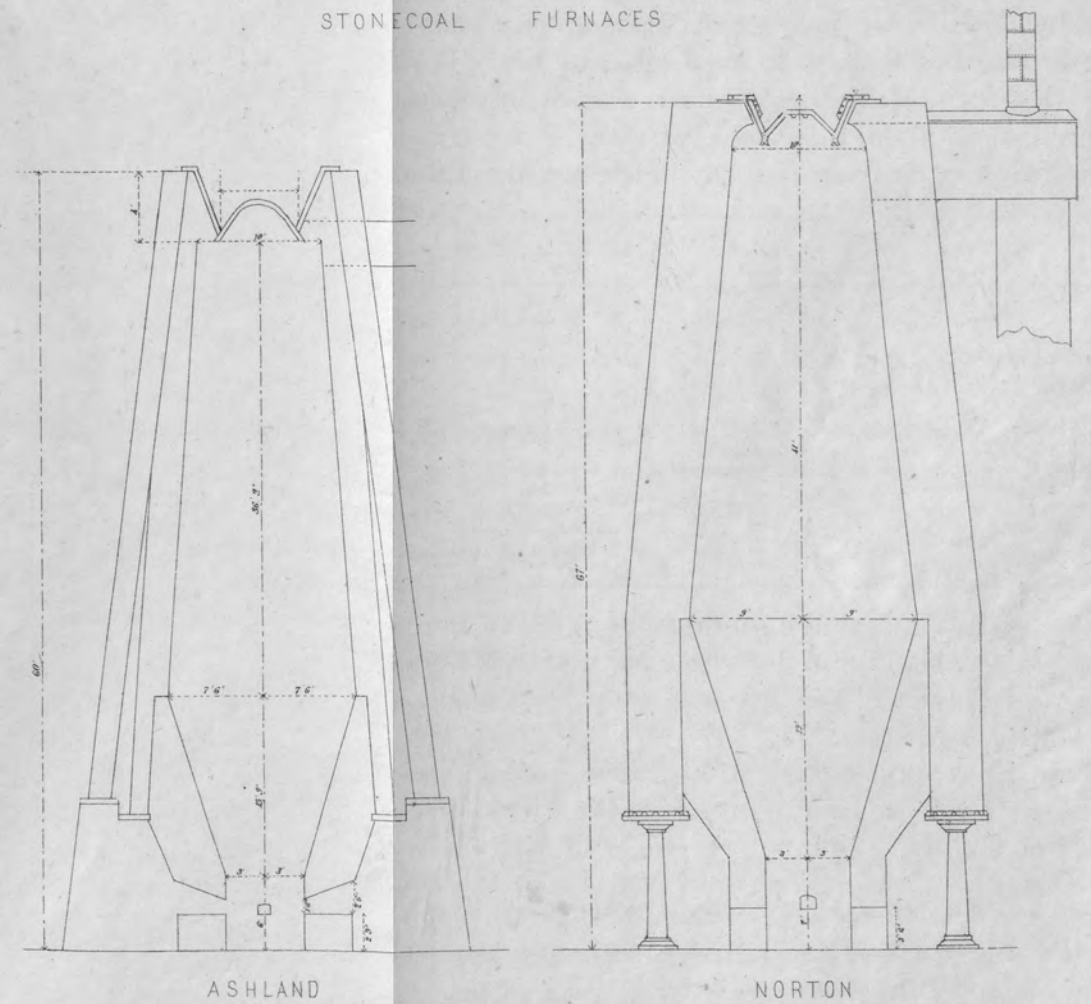


CHARCOAL FURNACES.



BLAST FURNACES IN THE KENTUCKY DIVISION OF THE HANGING ROCK IRON REGION.

STONECOAL FURNACES



sonal inspection of the furnace books, which have always been kindly placed at our disposal. In a few cases it was impossible to obtain the exact figures, owing to the careless manner in which accounts were kept, or to transfers of furnace property from one owner to another. In these cases the production is given as estimated from the best data that could be had, and the figures are marked with a star (*), showing that they were not as trustworthy as the others. It is believed that this is the most complete and accurate table of statistics of this region ever published, notwithstanding the few errors which it contains.

TABLE SHOWING THE PRODUCTION OF PIG IRON (GROSS TONS) IN THE KENTUCKY DIVISION OF THE HANGING ROCK IRON REGION, FROM 1870 TO 1874.

CHARCOAL IRON.					
Furnace.	1870.	1871.	1872.	1873.	1874.
Bellefont	3217	2790	3304	2850	3600
Boone	*1200	*1400	not in blast.	not in blast.	not in blast.
Buena Vista	3448	2808	3800	3600	4113
Buffalo	1407	1258	2262	1756	*1042
Hunnewell	3059	2265	4322	3812	4371
Iron Hills	not in blast.	not in blast.	not in blast.	141	822
Kenton	1250	1334	2865	2300	3525
Laurel	775	1890	1850	1748	1300*
Mt. Savage	not in blast.	2293	2707	3000	2017
Pennsylvania	2110	1592	1847	2213	1751
Raccoon	*750	882	1247	1467	1320
Total charcoal iron	17216	18512	25204	22887	23861
STONE-COAL IRON.					
Ashland	9316	9509	12150	12741	6710
Norton	not in blast.	not in blast.	not in blast.	not in blast.	10502
Star	1302	1958	1643	959	not in blast.
Total stone-coal	10618	11467	13748	13700	17212
Total pig irons of all kinds . . .	27834	29979	38952	36587	41073

*Not from furnace books. Estimated from the most reliable data at command.

GEOLOGICAL SURVEY OF KENTUCKY.

N. S. SHALER, DIRECTOR.

REPORT ON THE GEOLOGY OF THE REGION

ADJACENT TO THE

LOUISVILLE, PADUCAH & SOUTHWESTERN RAILROAD,

WITH A SECTION,

BY CHAS. J. NORWOOD.

PART VI. VOL. I. SECOND SERIES.

INTRODUCTORY LETTER.

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

DEAR SIR: I present herewith a report on the region adjacent the line of the Louisville, Paducah and Southwestern Railroad, accompanied by a horizontal section, exhibiting the geological structure of the country examined, under instructions received from you.

Thanks are due to many for kind attention given and interest exhibited in promoting the work of the Survey.

Thanks are especially due to Mr. D. Brock, the former General Superintendent, and to Mr. D. F. Whitcomb, the present General Superintendent of the road, for favors received.

Respectfully,

CHAS. J. NORWOOD.

LEXINGTON, KENTUCKY, May 5th, 1875.

INTRODUCTORY.

The work of constructing a horizontal section of the rocks, in the region traversed by the line of the Louisville, Paducah, and Southwestern Railroad (the Elizabethtown and Paducah, as it was then called), was commenced in January, 1874, and continued till the first of April of the same year. At that time circumstances required that the work be suspended for a time. In September, 1874, the work was resumed and carried to completion.

Mr. Carl Schenk was detailed as Topographer, but circumstances were such that little could be done in that direction.

It has been the aim not only to obtain a section of the rocks along the road, but also to acquire an insight into the general mineral wealth of the region adjacent.

The very nature of the work in hand, however, precludes detailed discussion, to any large extent, of *particular* districts.

The distance to be traversed could not possibly have been gone over in the allotted time, had detailed examinations been extended any considerable distance on either side of the road. Every effort having been made to make the report so, it is hoped, that it may be found of present economic value, as well as an assistant in future investigations.

In regard to the horizontal section accompanying the report, it is proper to state that in a number of localities the hills are quite distant from the railroad, and frequently without exposures. In some instances, also, the rocks dip towards the road. In such cases, although the rocks were referred to the road, which was used as a datum, they are not represented exactly in their true position towards it. The dip is always so irregular that no reliable calculation could be made to correct that evil. When it is known, however, that where no exposures

are to be found immediately on the road, the section refers to those on the nearest hills, the matter will be understood.

That everything might be as correct as possible, the hills on the north were used, whenever within convenient reach. Sometimes, however, when the hills on the north were not available, those on the south were used.

In some instances the road passes along the trough of a fault for a few miles. In such instances it is not unlikely for slight mistakes to be made, in *referring* the rocks to the road, for very evident reasons. It is believed, however, that, as a whole, the section is a fairly accurate representation of the geological structure of the region across which it is taken; and where a mistake may have been made it is easily rectified.

No pretense to accuracy is made in the delineation of the topographical features of the country traversed: the hills are merely sketched in; they may be too low in some instances, or too high, and again they may be too regular in outline.

Particular attention was given to the question regarding the number of coals in the region traversed by the road, and their persistency. It was desired that this report be a scaffolding upon which to build some general system, for the entire western coal field of Kentucky. Every effort was made to obtain the material for that purpose.

As large a number of coal analyses as might properly be expected are not presented, because of two reasons: the first is, that some of the samples were miscarried, and the other, that it is intended, at a future time, to give a general review of the Kentucky coal, in its character as a fuel for manufacturing and other purposes; when it is proposed to give a complete list of analyses of the coal at many points.

CHAPTER I.

GENERAL GEOLOGY.

The geological formations exposed along the road from Elizabethtown to Tennessee river, include the LOWER CARBONIFEROUS and COAL MEASURES.

The lower carboniferous rocks are exposed, both at the eastern and western extremities of the road, while the coal measures occupy a basin between.

At the eastern extension of the road there is a gradual descent of the rocks towards the west, with but few undulations. As the coal measures are approached, however, flexures are frequent and faults occasionally occur. In the coal measures the rocks are frequently faulted, but most of the irregularities in the strata may be referred to waves.

Dip and Strike.—The dip of the rocks is quite variable. With the few observations at hand it is a difficult matter to arrive at any correct estimate for the general dip, as there are so many local modifications.

Towards the east, from Green river to Elizabethtown, the dip may be considered as being *about* west, the strike being alternately east of north and west of north, occasionally due north.

Beyond Green river the dip is eastward, with a greater number of local changes than on the east. Towards the western limits of the coal field the rocks are frequently so faulted as to cause them to dip northwardly or southwardly, as the case may be, at various degrees.

This is illustrated between St. Charles and Tradewater river. Between those points the road runs along the trough of a fault. On the north side of the road, rocks occupying a high position in the series, are seen dipping rapidly in a southerly course, while on the opposite hills lower ones are exposed, dipping in a northerly direction, creating the false impression that the rocks on each side are equivalents.

The following is a tabulated list of the local dip and strike of the rocks at a number of points along the road:

Locality.*	Dip.	Course.	Strike.
2d cut west of East View	2°	W.	N.
3d cut west of Stephensburg	2°	S. 54° W.	N. 36° W.
3d cut west of Stephensburg	2°	N. 40° E.	N. 50° W.
At East View	1°	N. 69° W.	N. 21° E.
Big Clifty bridge	2°	N. 87° W.	N. 3° E.
1st cut west of the 62d mile-post	2°	S. 20° W.	N. 70° W.
2d cut west of the 65th mile-post	3°	N. 55° E.	N. 35° W.
1st cut east of the 68th mile-post	2°	N. 65° E.	N. 25° W.
1st cut west of Litchfield	2°	N. 42° E.	N. 48° W.
4th cut west of the 71st mile-post	4°	E.	N.
1st cut east of the 72d mile-post	4°	W.	N.
At the 76th mile-post	5°	S. 80° W.	N. 10° E.
1st large cut west of Millwood	9°	E.	N.
At the 39th mile-post	20°	N. 50° W.	N. 40° E.
1st cut east of the 80th mile-post	15°	S. 75° E.	N. 15° E.
Ridge south of the 80th mile-post	2°	S. 23° E.	N. 67° E.
Renfrow's, at Spring Lick	8°	S. 30° E.	N. 60° E.
Wm. Miller's coal bank, Horse Branch	9°	S. 60° W.	N. 30° W.
Hill north of 1st bridge east of the 91st mile-post	..	N. 70° E.	N. 20° W.
Hill north of the 92d mile-post	4°	N. 48° E.	N. 42° W.
Near foregoing place	4°	N. 54° W.	N. 36° E.
Horse Branch tunnel	..	N. 25° E.	N. 65° W.
4th cut east of Horse Branch tunnel	..	N. 80° W.	N. 10° E.
3d cut east of the 97th mile-post	2°	E.	N.
South of the 1st large fill west of the 96th mile-post	4°	N. 75° E.	N. 15° W.
South of the 1st large fill west of the 96th mile-post	9°	S. 19° W.	N. 71° W.
1100 feet south of the 1st cut east of the 97th mile-post	..	S. 81° W.	N. 90° W.
Opposite the 2d cut east of the 97th mile-post	..	N. 75° W.	N. 15° E.
3d cut east of the 100th mile-post	2°	N. 82° E.	N. 8° W.
1st cut west of Elm Lick	..	S. 30° E.	N. 60° E.
1st cut east of the 104th mile-post	2°	S. 35° W.	N. 55° W.
North of Rockport	10°	S. 35° W.	N. 55° W.
North of Rockport	10°	N. 35° E.	N. 55° W.
Paine's coal mine, near Green River Station	..	N. 60° E.	N. 30° W.
Collier & Woodcock's mines, near Green River Station	..	N. 5° E.	N. 85° W.
Richmond coal mines	..	W.	N.
1st cut west of the 121st mile-post	3°	S. 45° W.	N. 45° W.
Mercer's mines	2°	S. 45° W.	N. 45° E.
Cut at the crossing of the Owensboro and Russellville Railroad, Owensboro Junction	..	N. 40° W.	N. 50° E.
Ross mine, Owensboro Junction	2°	N. 45° W.	N. 45° E.
1st cut west of the 135th mile-post	..	N. 75° E.	N. 15° W.
In the Russellville road, near Greenville	6°	N. 30° W.	N. 60° E.
½ mile southwest of the depot at Greenville	1°	N. 20° W.	N. 70° E.
Föbel & Krauth's coal, on Pond river	1°	N. 30° E.	N. 60° W.
Gibson's, at Woodruff	2°	N. 55° E.	N. 35° W.
Jos. Ray's, near Woodruff	2°	S. 55° W.	N. 35° E.
350 yards east of 152d mile-post, on a ridge south of the railroad	13°	N. 50° E.	N. 40° W.
Ashmore's land, 2½ miles south 60° west of Woodruff	3°	S. 34° E.	N. 56° E.
Coal Ford, on Tradewater	2°	N. 20° W.	N. 70° E.

* Where no angle of dip is given the angle is less than a degree and not calculated.

It should be noticed in the table that in twenty-five cases the strike is about north 42° west; in twenty instances, north 42° east, and in six due north.

I am inclined to believe that, when the subject is more fully studied, and some system arrived at, the strike will be found to be nearly north and south, perhaps bearing a little to the east.

It seems to be the fact that the coal measures, in their western extension, terminate in a heavy fault.

Before reaching Tradewater, which is near the western limit of the coal formation, faults are numerous, some of them quite perplexing and on a large scale for that region.

Indeed months of incessant labor might be devoted to the study of the disturbances in the region lying along the borders of Christian, Hopkins, and Union counties, to unravel them and reduce the whole to a system. There seem to be faults and cross-faults, as well as waves in the strata. Beyond the limits of the coal measures, however, the rocks are comparatively horizontal, and end at the Tennessee river in an abrupt vertical escarpment.

LOWER CARBONIFEROUS.

Two divisions of the lower carboniferous rocks may be distinguished in the series along the road; these are the Chester and St. Louis Groups. The base of the formation was seen at no point along the road,* so that its precise thickness cannot be given at present.

THE ST. LOUIS GROUP.

This group includes the lowest rocks seen at either end of the road. The beds vary in their description somewhat, but still have certain characteristic features which serve to identify them from the rocks of the overlying Chester Group.

The group may be divided into two divisions, according to the lithological characters of the strata.

Towards the top of the group beds of beautifully oölitic limestone occur, alternating with beds that are drab to cream-colored, fine-grained, and compact, resembling lithographic

*The line running from Elizabethtown to Paducah is the one under consideration. No examinations were made along the Louisville Extension.

limestone in texture. Unfortunately, however, they are usually marred for lithographic purposes by thin seams and small specks of calcite, quartz grains, or pyrites. In some instances beds are found which may answer for work not requiring great nicety.*

Below the "lithographic beds" (so-called for convenience), beds of coarse grey, often semi-oölitic limestone, occur. These are quite variable in texture and color, passing from a dirty grey, coarse-grained rock, frequently quite argillaceous, to a blue or white, close-textured and fine-grained limestone. This forms the base of the upper division. Chert beds are of frequent occurrence in this part of the upper division, frequently abounding in organic remains.

Below the above described division and extending to the base of the group, so far as known at present, are beds of dark-blue, frequently fetid limestone, with numerous small drusy cavities studded with quartz or calcite crystals.

Patches of calcite are also distributed through the mass, and fluor-spar is of no unfrequent occurrence.

Chert is also abundant in the lower part of the group, occurring either in irregular bands or concretions.

This division is so well marked by the deep blue color and its geodiferous character, that it is easily identified wherever seen. The St. Louis Group is mentioned in the former Geological Reports on Kentucky as the "barren" or the "cavernous limestone," no attempt being made to identify it with the grouped rocks of the other States.

It is possible that the name, "cavernous limestone," as applied by Dr. Owen, may also include a series of limestones below the ones in question. It is a fact to be remarked that in its entire extent in western Kentucky, this group retains its cavernous character, and may even be identified, in great measure, by the topography.† In a region underlaid by rocks of the St. Louis Group, "sink-holes" and semicircular valleys,

*The lithographical limestone quarries at Glasgow Junction, Barren county, are probably in the upper division of this group.

†This cavernous character is also one of the features of the group as represented in Missouri.

caused by the roofs of caverns giving way, are marked features in the topography.

At the eastern extension of the railroad in Hardin and Grayson counties, between Cecilia Junction and East View, inclusive, the group, so far as exposed, is made up of a mass of coarse-grey limestones, very fine-grained dove-colored limestones, oölitic and arenaceous limestones, and shales.

A blue limestone is exposed at Elizabethtown, which is probably a member of the group, occupying a place towards the lower part.

The following is a descriptive section of the rocks from Cecilia Junction to East View, and includes all of the rocks so far as exposed between those points:

No.	Thickness.
A. "Big Clifty" sandstone, at the base of the Chester Group.	
1. Limestone; heavy-bedded, lumpy, color dark-grey, coarse-grained. Abounds in <i>Productis mesialis</i> and <i>Athyris subquadrata</i> , with great numbers of <i>Spirifer</i> in the upper part.	7 feet.
2. Limestone, abounding in <i>Bellerophons</i> .	1 "
3. Fine-grained, dove-colored limestone, abounding in <i>Hemipronites Keokuk</i> .	3 "
4. Limestone; grey to dove in color.	10 "
5. Oölitic limestone, with great numbers of gasteropods.	18 "
6. Arenaceous and calcareous shale.	10 "
7. Thin-bedded sandstone.	17 "
8. Limestone; grey and drab, containing <i>Pentremites</i> .	8 "
9. Heavy-bedded, grey limestone.	25 "
10. Compact, dove-colored limestone.	7 "
11. Grey, compact limestone, containing <i>Productus elegans</i> .	12 "
12. Arenaceous cellular limestone.	3 "
13. Calcareous sandstone.	6 "
14. Arenaceous limestone.	8 "
15. Limestone, abounding in <i>Pentremites</i> .	8 "
16. Limestone, abounding in <i>Rhynchonella</i> .	2 "
17. Oölitic limestone.	3 "
18. Silicious limestone; "Fire Rock".	6 "
19. "Lithographic limestone".	4 "
20. Oölitic limestone.	5 "
21. "Lithographic limestone".	4 "
22. Oölitic limestone.	5 "
23. Fawn-colored, calcareous sandstone, or arenaceous oölitic limestone.	7 "
24. Compact, oölitic limestone.	3 "
25. Fawn-colored, calcareous sandstone, and oölitic limestones.	16 "
26. Blue, somewhat fetid, cherty, geodiferous limestone.	20 "

No. 26 is the lowest rock at Long Grove, on the railroad, and at "White Mills," on Nolin river, south of East View.

It corresponds to the blue limestones in Caldwell and Lyon counties; it is at about the top of that division. On the Louisville extension of the road, the geodiferous limestone, containing *Lithostrotion proliferum* and *Syringopora ramulosa* (?) is

exposed. It occupies a position below No. 26; unfortunately no opportunity presented itself for connecting the beds.

The origin of the oölitic limestones is clearly demonstrated in the foregoing section. The passage from coarse sandstone, made up of rounded grains of sand cemented by a calcareous paste, into a coarse and then fine oölite, is beautifully exhibited.*

In the western extension of this group, beyond Tradewater, oölitic limestones are not so frequent, and the individual beds are not so easily identified by their organic remains. There seems to be a blending of forms in the various beds. The two grand divisions, previously mentioned, are easily distinguished, however.

The drab-colored limestones predominate towards the top, there, and beautiful oölitic limestone occupies the place of the poorer sandy beds of the eastern margin, as is to be seen at Princeton and vicinity. Chert beds are also more frequent.

Plate 2 represents a general section of the group.†

Paleontology.—As much information as is desirable, concerning the paleontology of the St. Louis Group as it exists in southwest Kentucky, cannot be given for want of the proper means and adequate time for studying the organic remains. It is hoped, however, that at some future time the matter will receive more extended attention, as there certainly are interesting questions to be decided, and a clear exposition of the subject to be given. Save in the upper members of the group, fossils are rather scarce, at the eastern margin of the formation. This, however, is not so remarkable, as there is such a preponderance of arenaceous beds in the lower part. In its western extension organic remains are more numerous.

The fossils identified so far are:

Productus cora, *Prod. mesialis*, *Prod. Altonensis*? *Prod. muricatus*, *Prod. elegans*, *Hemipronites Keokuk*, *Athyris subquadrata*, *Athyris Royssii*, *Spirifer Forbesi*, *Spr. lineatus*, *Spr. tenuicosta-*

* They do not seem to have been formed by infiltration of silica, causing a replacement, in the manner that some oölitic limestones are accounted for.

† The thickness of No. 26 is given as it is seen beyond Princeton. It does not represent the total thickness, however, as that was not determined.

tus, *Spr. Keokuk*, *Terebratula trinuclea*, *Rhynconella subcuneata*, *Rhynconella mutata*, *Orthis dubia*, *Orthis Michellini*? *Pleurotomaria*, *Loxonema*, *Polyphemopsis*, *Nautilus*—? *Myalina*—? *Macrocheilus*—? *Pentremites Koninckiana*, *Pentremites pyri-formis*, *Pentremites Godonii*, *Pentremites Norwoodii*? *Agassizocrinus*—? *Dichocrinus*—? *Lithostrotion proliferum*, *Lithostrotion canadense*, *Zaphrentis spinuliferum*, *Syringopora ramulosa*? and *Archimedes*.

Cyathophylloid corals are quite abundant in some of the geodiferous beds.

THE CHESTER GROUP.

Above the St. Louis Group, and below the coal measures, a series of limestones, sandstones, and shales are included.

These constitute beds of passage, as it were, from the massive limestones of the lower carboniferous to the coal measures; marking an era of rapid deposition and changeful currents existing during the period preceding the epoch of the coal measures. As will be noticed hereafter, they mark the first appearance of the coal-making plants in this part of the western carboniferous area.

The organic remains and general features of the series at once identify the group with that collection of limestones, shales, and sandstones, constituting the upper division of the lower carboniferous rocks in Illinois, and denominated the "*Chester Group*" in the geological reports on that State.

It corresponds *in part* to the "millstone grit series" of Lyon, a group, however, which included members of the coal measures as well as the underlying rocks extending to the St. Louis Group.

The members of this group are met with at intervals from East View, Hardin county, to Litchfield, Grayson county, and beyond; and also at points between Scottsburg, Caldwell county, and Tradewater river.

The group is in the best condition for study on the eastern margin of the lower carboniferous area, as its divisions are

more distinctly defined. On the western margin it is not so well exposed.

The group is mostly made up of a suite of limestones and sandstones alternating with beds of marly shales. The limestones are usually thin-bedded, frequently mere plates of limestone in shale.

A general statement of the arrangement of the series, as they occur in Hardin and Grayson counties, is the following:*

No.	Thickness.
1. Shale, with thin beds of limestone	15 feet.
2. Heavy-bedded, cherty limestone	13 "
3. Red and green shale	5 "
4. Rhomboidally jointed sandstone	0 to 10 "
5. Limestone	2 "
6. Shale	10 "
7. Limestone and shale; the upper ten feet usually heavy-bedded limestone, the lower ten feet thin-bedded limestone and shale; great numbers of organic remains	20 "
8. Green, purple, red, and blue marly shales, "Litchfield marls"	25 to 60 "
9. Shale and thin-bedded limestone	5 "
10. Shaly sandstone	0 to 20 "
11. Heavy-bedded, dark-grey, and blue limestone	15 to 45 "
12. Heavy-bedded sandstone, the "Big Clifty sandstone"	60 to 130 "

The different strata making up the group are exceedingly variable in their lithological features and horizontal extent, and, consequently, furnish very unreliable data upon which to base observations. Indeed it is a question whether any one member of the entire series (unless it be the Big Clifty sandstone) can be traced continuously for a distance of five miles, unchanged in its thickness or its physical features.

At one locality a limestone may be compact, thick-bedded, possibly adapted for building purposes; at another it will be represented by a bed of marly shale with thin limestone layers. At other places the shales will attain great thickness, reaching as much as fifty feet or more, with but a few thin beds of limestone; these will be found at another locality greatly diminished in thickness; again they are entirely absent, limestone occupying their place. There is a continual wedging out and thickening of the strata throughout the entire series.

These local modifications, both in the thickness and lithological features of the rocks, are interesting as well as curious, affording a subject worthy of careful study.

*For reasons hereafter made evident, the section is not applicable to all localities, even in the counties named, and may be accepted merely as a typical one.

The limestone No. 2 varies in thickness from five to thirteen feet, and is the one usually found at from five to ten feet below coal K, in Grayson county. When in thin beds organic remains are rare, but when fully developed the upper part is charged with small *Bellerophons*. The sandstone No. 4 is very seldom present (it was found only in Grayson county), though fragments of it are frequently found strewn over the hills in the vicinity of Grayson Springs Station. It is peculiar in its character, being somewhat calcareous, thin-bedded, and breaking in rectangular blocks; it also contains *Brachiopoda*. It is easily recognized, as it always presents the appearance of a flag pavement, and, possessing the features above mentioned, differing essentially from the other sandstones.

Number 7 is remarkably variable in its lithological appearance, as well as thickness. At certain localities it is only three feet thick, and a good, compact limestone; at others, it is represented by ten feet of limestone, or by a mass of shale and thin limestone beds, twenty-five feet thick. It is in this number that the greatest quantity of organic remains are found.

Number 8 is also quite variable in its thickness. It alternately thins and thickens; it is entirely absent at some points, and at others is thirty feet thick. Some of the beds, especially the green, will answer admirably for fertilizing the worn out lands so common in the hilly regions.

It is exposed in the vicinity of Grayson Springs Station, at Litchfield, and at other points along the road in Grayson county. Analyses of it will be found in the Chemical Report.

Number 9 is also absent occasionally.

Number 10 is seldom present. It is a shaly sandstone, occasionally becoming compact, but usually merely a sandy shale. When continuous for any considerable distance its prevailing thickness is twelve feet; as a rare thing it is twenty feet thick.

Number 11 is as remarkable as any of the rocks in its lateral changes.

At "Grayson Springs," in Grayson county, near the Catholic Chapel, it is forty-five feet thick and a good compact rock.

From that point towards the railroad it seems to thin and change in character. It was quarried on the land of Mr. Patterson, near Grayson Springs Station, and used in the construction of the railroad bridge over Big Clifty Creek.

At Grayson Springs, and a few other localities, the rock contains beautiful crinoideæ.

Number 12, the Big Clifty sandstone, is at its best and fullest development at the Big Clifty bridge. It presents different features at either margin of the carboniferous area.

In its eastern extension the rock varies in thickness from sixty to one hundred and thirty feet, and from a soft, friable rock to a close-textured, heavy-bedded one. It is also of different colors, the prevailing ones being buff to cream, often ferruginous.

At East View, Hardin county, it is very soft and friable, color white or buff, beautifully mottled and banded with brilliant purple or dull brownish spots and stripes. The quartz grains are usually exceedingly small and loosely cemented. Cross lamination is a frequent feature in the mass.

At the western outcrop of the Chester Group, in Caldwell county, the sandstone is represented by a mass of sandstone and shales in an alternating series; the sandstone predominating in the upper part and at the bottom, with shales and thin sandstone beds at the middle.

This sandstone, forming the base of the Chester Group, is the equivalent of the "ferruginous sandstone" of Illinois. It is also equivalent to the "ferruginous sandstone" (*in part*) of Missouri.

In Swallow's Geological Report on Missouri, 1855, page 93, that sandstone is spoken of as "occupying the position of the *millstone grit* of the English geologists, the conglomerates of Ohio and Tennessee, and the 'conglomerates and ferruginous grits' of Iowa (Owen)."

There seems to have been some confusion existing in regard to the place of that sandstone, however. There is reason to believe that there are two distinct *ferruginous sandstones* in that State (Missouri); one resting on the St. Louis Group, the

equivalent of the ferruginous sandstone of Illinois, of Iowa,* and of the Big Clifty sandstone in this State; the other taking the place of the conglomerates, possibly (?) occupying a place similar to our *Bee Spring sandstone*. When comparing the Chester Group, as represented in Kentucky, with that of Illinois, the great similarity both in its lithological and paleontological features is at once apparent. In that State as in this one there are incessant lateral changes in the lithological aspects of the strata.

It is a marked fact that towards the southern and western borders of the coal measures, in the vicinity of the conglomerate, shales preponderate greatly, and that the Big Clifty sandstone in a great degree loses its character as a sandstone and passes into shales.

It seems that the conglomerate does thus gradually change, marking the ending of the turbulent waters, and ushers in the more quiet days of the coal measures.

Plate 1 is a general representation of the group.

Paleontology.—Great abundance of organic remains are found in this group; chiefly confined to the shaly beds, however.

Where the limestones are thick-bedded and compact they are not so numerous, but where alternating with shales hundreds of fossils may be collected in a short time.

Sufficient study has not been given to the collections made to enumerate all of the species found; the following list, however, embraces the principal and typical fossils of the group, as exposed along the road:

OF THE BRACHIOPODA: *Productus cora*, *Prod. elegans*, *Spirifer Leidyi*, *Spr. spinosus*, *Spr. increbescens*, *Spr. setigerus*, *Athyris Royssii*, *Retzia vera*.

LAMELLIBRANCHIATA: *Allorisma Chesterensis* and *Aviculopecten* —?

CRINOIDEA: *Scaphiocrinus (Zeacrinus) manniformis*, *Agassizocrinus dactyliformis*, *Pentremites obesus*, *Pentremites cervinus*,

* See Hall's Report, volume 1, part 1, page 109.

Pentremites pyriformis, *Pentremites Norwoodii?* *Pentremites Godonii*, *Pentremites Koninckiana*, *Pentremites globosus?*

CORALS: *Zaphrentis Spinulifera*, *Chaetetes*, etc.

BRYOZOA: *Archimedes Oweni* (?) and *Retepora lyra*.

COAL MEASURES.

As intimated on a preceding page, the coal measures occupy a basin extending from a point three or four miles west of Litchfield to a point about four miles beyond Tradewater, the lower carboniferous rocks forming the rim.

The basin proper, however, as generally understood, extends from Green river to Tradewater river, with the centre (as regards the railroad) near Owensboro Junction; the strata rise in waves both to the east and west of that place.

It is premature to discuss the history of this basin at present, therefore the subject will be deferred for future consideration.

It is suggested, however, that the basin, as it is at present, is in great measure due to uplifts at either margin of the field, and subsequent fractures.

In consequence of the numerous faults and flexures in the strata the lower rocks are seldom seen along the road, and the continuity is frequently abruptly broken. An absolutely correct vertical section of the rocks in the western coal field cannot, therefore, be constructed, relying altogether on observations made exclusively along the line of the Louisville, Paducah, and Southwestern Railroad.

It is deemed advisable, therefore, to number the coals from the top down, giving to each one a letter.

In the geological report on the State of Indiana for 1869, by Mr. E. T. Cox, a statement is made calculated to produce the impression that we have but four coals in this field.

It is stated that "the *Ice-house* coal, No. 3, is the equivalent of No. 1 B, having been mistaken for a higher coal. And the *Curlew* coal, No. 4, is the equivalent of No. 11."

Therefore the sandstone above No. 4 is regarded as being nothing more than the "*Anvil Rock*" sandstone.

The conclusions of Mr. Cox, however, must certainly have been hasty; or, based only on observations made in Indiana. If the latter is the case, there is no cause to wonder at his mistake; for it is now known that all the coal beds in a coal field are not co-extensive with its entire area. Consequently, although certain of the Kentucky coal beds may, and probably do, extend into Indiana, there is no reason to believe that they all do. As will be shown hereafter, they are not all co-extensive even with the entire area of the Kentucky coal field.

Therefore, as Mr. Cox says, the attempt to apply a section made of the coal measures in the Western Kentucky coal field to that of Indiana, would certainly create confusion. The same may be said of Illinois.

It must be admitted that when the matter of determining the true number of coals in the western coal field of this State was taken in hand, it was with a mind favorable to the conclusions given by Mr. Cox.

After a careful study of the coals, however, over an area of considerable east and west extent, the error was apparent. It is possible, and even probable, that coals at certain places were referred to the wrong number; but the existence of twelve beds of coal below the "Anvil Rock" seems to be true, beyond doubt.

Everything tends to prove Dr. Owen's numbering of the coals *between* the *Anvil Rock* and *conglomerate* to be correct.

He gives the number as twelve, giving to each bed, whether thick or thin, with a few exceptions, a distinctive number.

This certainly was not the best policy to pursue, as a number are so thin and poor, and so limited in their lateral extent, as to be of no value. Working after him, however, it is but justice to accept his system of nomenclature in discussing the number of the coals; and according to that plan at least twelve distinct beds are known to exist along the road.*

However, although Dr. Owen's section may be accepted as embracing the coal field in general, it is not applicable in its

* Letters are adopted at present instead of Dr. Owen's numbers, as it may be decided not to number the thin beds. The advisability of this, however, can only be determined when the entire coal field is studied.

entirety to any *particular* district. No matter how carefully made, no single section will answer for the entire coal field. It is a question, indeed, whether a single section will answer for any coal field.

It is deemed best, therefore, to insert vertical sections, as complete as could be obtained, for certain districts only.

Coals are found in certain regions that do not exist in others; so that all the coals as numbered will not be found in any one boring. Coals are found at about the centre of the field (following the railroad), that wedge out both to the east and the west. In fact, of the twelve beds enumerated by Dr. Owen, and recognized by the present Survey, not more than four or five are even tolerably persistent, and only one is unbroken in its entire extent.

Consequently the propriety of giving sections for certain districts only, and of lettering the coals at present, is evident.

Were a section desired applicable to the entire field, only the thick coals should be numbered, as the thin ones are certainly in some instances local beds, probably not existing outside of an area of a few square miles. Were the numbering to be done over again, such would be the plan. There would then be about eight beds to which numbers could be applied.

Upper Coal Measures.—Except in one doubtful case, to be cleared up hereafter, no coals were found above the Anvil Rock, although Dr. Owen represents a series of sandstones, shales, coals, etc., above that sandstone (in all some 2,000 feet thick), which are denominated "upper coal measures." Eight distinct beds are mentioned as existing in that series, making in all twenty beds of coal in the western coal field of this State.

Though not prepared to discard the upper part of his section in toto, there is reason to doubt the accuracy of the observations upon which the section was established.

As far as my observations extend (excepting the doubtful case already referred to, and which involves about sixty feet of rocks, including a coal stain), the Anvil Rock is the highest in

the coal measures. It certainly is the fact that the coal beds were duplicated, and extremely doubtful whether there are really any upper coal measures in this coal field; it seems almost a certainty that what were considered as such was simply a repetition of the series included between the Anvil Rock and conglomerate. There even appears to have been a reduplication of the supposed upper series; coals being repeated.

Therefore, though accepting the section as given for the series from the Anvil Rock to the conglomerate, the existence of the upper part, denominated *upper coal measures*, is extremely doubtful, and in all probability must eventually be discarded; this is certainly true for the region adjacent the railroad. The entire thickness of the coal measures may be included within one thousand feet.*

For reasons heretofore made evident, the coal field along the railroad has been separated into three divisions; the *first* extending from Green river to Spring Lick, and towards Litchfield; the *second* embracing the major part of the field lying between Green river and Pond river, possibly even beyond; the *third* from Pond river to Tradewater.

As certain coals are to be found in each division that are absent in the others (so far as the observations along the road extend), distinctive sections will be given for each.†

The following is a condensed section of the coals included between the Anvil Rock and conglomerate, according to Dr. Owen, with the lettering adopted in this report:‡

1. Anvil Rock sandstone	20	feet.
2. Coal, No. 12 (Coal A)	3	"
3. Space	21	"
4. Coal, No. 11 (Coal B)	5	"
5. Space	46	"
6. Coal, No. 10 (Coal C)	3	"
7. Space	68	"
8. Coal, No. 9 (Coal D)	5	"
9. Space	50	"

* In some instances it is not more than eight hundred or even seven hundred feet.

† It must be noted that these divisions refer only to the line of country adjacent the railroad, say for three to five miles on either side. Little is known at present concerning the geology beyond those limits.

‡ The thickness of the beds and their distances apart are according as given in Owen's section, in every particular.

10. Coal, No. 8 (Coal E)	2½	feet.
11. Space	43	"
12. Coal, No. 7 (Coal F)	2	"
13. Space	84	"
14. Coal, No. 6 (Coal G?)	3	"
15. Space	65	"
16. Coal, No. 5 (Coal H?)	4	"
17. Space	95	"
18. Coal, No. 4 (Coal I)	4	"
19. Space	154	"
20. Coal, No. 3 (Coal J)	2½	"
21. Space	71	"
22. Coal, No. 2 (Coal K?) No thickness given.		
23. Space	82	"
24. Coal, No. 1, B (Coal L)	5	"

Although the coals correspond in number, it must not be understood that the vertical distances between them, as represented in the foregoing section, are the same in the one constructed by the present Survey; nor is the thickness given to each coal the same. On the contrary, in some instances the distances are increased, in others diminished, and several of the coals are not represented as being so thick as given in Owen's section. The following section embraces the rocks and coals in the first division, extending from Green river eastward:

1. Anvil Rock sandstone	35	feet.
2. Shale with iron ore (carbonate)	0 to 30	"
3. Bituminous shale (not always present)	1	"
4. Coal A	5	"
5. Fire-clay	3	"
6. Sandy shale (not always present)	7	"
7. Sandstone (seldom present)	12	"
8. Limestone, fossiliferous	1½ to 8	"
9. Clay shale	½	"
10. Bituminous slate (seldom present)	1	"
11. Coal B, with one or two clay partings	5 to 7	"
12. Fire-clay	5 to 7	"
13. Sandstone and shale	15 to 35	"
14. Coal C	0 to 2½	"
15. Sandy shale	15	"
16. Sandstone	30	"
17. Shale with indurated pyritous concretions and iron-stones	25	"
18. Clay, fossiliferous	0 to ½	"
19. Bituminous slate	5	"
20. Coal D	5	"
21. Fire-clay	3	"
22. Shale and sandstone	50	"
23. Bituminous slate	3	"
24. Coal E	1½	"
25. Sandstone and shale	80 to 100	"
26. Coal	2	"
27. Shale and fire-clay } Coal H	8	"
28. Coal	1½	"
29. Sandstone and sandy shale	165	"
30. Blue shale with iron-stones	18	"
31. Coal	7	inches

32. "Bee Spring sandstone"	45	feet.
33. Coal	1/3	"
34. Sandy shale with occasional iron-stones	16	"
35. Coal K	1 to 2 1/2	"
36. Shale, locally containing iron-stones	15	"
37. Sandstone	15 to 25	"
38. Sandy shale, locally containing iron-stones	15	"
39. Bituminous slate containing <i>Lingula</i>	1/3	"
40. Coal L	2 1/4	"
41. Shale	10 to 25	"
42. Sandstone, base of the coal measures	10	"

It will be noticed in the foregoing section that although the rocks, from the base to the top of the coal measures, are represented (as they appear in the district under consideration), only eight of the twelve coal beds are present.

Coals F, G, I, and J are entirely absent, as are also their associate rocks.

In the vicinity of Greenville, however, the Coals F and G are present, as represented in the following section; the high coals indicated are found at Owensboro Junction and on the high hills near Greenville.

The section is intended to represent the arrangement of the rocks and coals in the second division, from Green river to Pond river.

1. Anvil Rock sandstone	25	to	60	feet.
2. Sandy shale with iron ore	25			"
3. Bituminous slate	1			"
4. Coal A	5			"
5. Fire-clay	3			"
6. Shale	7			"
7. Sandstone	0	to	12	"
8. Limestone	3	to	8	"
9. Clay shale	1/2			"
10. Bituminous slate	1			"
11. Coal B	5	to	7	"
12. Fire-clay	7			"
13. Sandstone and shale	25			"
14. Coal C	0	to	2 1/2	"
15. Sandy shale	15			"
16. Sandstone	30			"
17. Shale with pyritous concretions, sometimes ochreous, and occasionally with a thin ferruginous limestone bed	25			"
18. Pyritous clay	0	to	1/2	"
19. Bituminous slate	5			"
20. Coal D	5			"
21. Fire-clay	3			"
22. Sandstone	25			"
23. Covered; all sandstone?	15			"
24. Limestone	1/2	to	2	"
25. Sandstone	40			"
26. Shale with ochreous concretions	20			"
27. Bituminous slate	1 1/2	to	3	"
28. Clay	0	to	1	"

29. Coal E	0	to	1 1/2	feet.
30. Shale with thin layers of sandstone, and impure, sandy iron-stone concretions	5	to	10	"
31. Pink and white disintegrating sandstone	20			"
32. Bituminous slate	0	to	3	"
33. Coal F	0	to	1 1/2	"
34. Fire-clay	1			"
35. Sandstone and shale with concretions of ochre	0	to	5	"
36. Limestone; mottled; sometimes a breccia of limestone and sandstone, or even passing into clear gritty sandstone	3			"
37. Sandstone and shale	42	to	70	"
38. Bituminous slate	1			"
39. Coal G (said to attain a thickness of 14 inches)	1/2			"
40. Fire-clay	9			"
41. Sandstone	55			"
42. Bituminous slate	1			"
43. Coal	3 1/2			"
44. Fire-clay } Coal H	(?) 4			"
45. Coal	5			inches
46. Fire-clay and argillaceous shale	20			feet.

It should be stated that in the foregoing section, from number 37 in part to number 46 inclusive, is the record of a shaft sunk at Greenville, the coal No. 43 and 45 being at the bottom.

In the third division, that district west of Nortonville, it is necessary to give a section only of the lower coals. The higher ones are exposed and worked, but it will simply be a repetition of what has gone before to include them.*

It is as follows:

1. Sandstone underlying Coal H	15	to	20	feet.
2. Shale	5			"
3. Coal I†	1			"
4. Drab and dark-grey sandy shale	5			"
5. Sandstone	5			"
6. Limestone, fossiliferous	2	to	8	"
7. Sandstone and sandy shale	20	to	40	"
8. Coal J (sometimes with a 12-inch clay parting)	4 1/2	to	5	"
9. Covered	100			"
10. Sandstone, top of the conglomerate?				"

The data for the foregoing section was obtained on the hill south of the St. Charles mines, on the hills south of Hamby's Station, and at the tank on the St. Louis and Southeastern Railway, three miles south of Nortonville, Hopkins county.

For a better comparison of the coals as exposed along the railroad with the coals as represented in Dr. Owen's section, and to illustrate the lateral changes undergone by the

*It is probable that the coals F and G are absent.

†At one locality this is reported to be three feet thick. It was partially covered; therefore, the thickness only as seen is given.

rocks, the several sections have been grouped and presented as plate 3.

DISTRIBUTION OF THE COAL.

The observations upon which the following deductions are based were necessarily restricted to a limited north and south area; therefore, what may be true for the region adjacent the railroad may not stand for the entire coal field.

There seem to have been disturbances in the coal region at the time of the formation of the coal, as well as at a later period.

The disturbances, however, were slight, and there is every reason to believe that in the early history of the coal measures the rocks were rather horizontal; otherwise the measures, instead of conforming with the dip of the sub-carboniferous rocks, as they do, would rest unconformably on them.

At the time of the deposition of the coal the region seems to have been subject to repeated floods. The evidences of these overflows, however, are visible only in certain parts, occurring irregularly along the road. This leads to the conclusion that they must have been local, produced, perhaps, by an irregularly changing level in the surface. With the exception of one bed, Coal D, there is a continual change in the thickness of the coal seams. Coals which at one place are represented by merely an inch or so of carbonaceous matter, will in a short distance thicken to as much as thirty inches, or a coal of three and a half feet, or even five feet, may thin materially or disappear entirely. The upper and lower coals afford ample illustrations of these changes. Coals A and C are so exceedingly variable in their thickness that not the least confidence may be placed on them. Other coals will wedge out, terminating in a sandstone bed, or a bed of shale at one locality, apparently disappearing forever; then in a few miles they will be found again, presenting their usual thickness. This wedging out of the coals was caused, no doubt, by a number of temporary currents cutting away the vegetable matter in certain places before the coal bed was completely formed, depositing

mud or sand, as the case may be, in its stead, followed by a more extended overflow continuing the work of deposition above the coal. The frequent passage of sandstone into shale in the localities of this so-called wedging out of the coals, certainly lends force to the supposition.

There also seem to have been a series of subsidences and elevations going on during the entire period of the deposition of the coal.

This has also caused the coal to be very irregularly distributed, as the flooding waters had frequent access to it in certain parts, while on the high points it was untouched.

The low coals appear to be thicker towards the southern and western margins of the field, while the high coals thicken towards the north.

It is possible, therefore, that such thin beds as Coals C, E, F, and G, may assume a workable thickness towards the north, or at least be thicker than they are in the region traversed by the railroad, if they extend so far.

DESCRIPTION OF THE COALS AND THEIR ASSOCIATE ROCKS.

In these descriptions it is the aim to afford the explorer some satisfactory means of identifying the distinctive beds in the region he contemplates examining, as well as to discuss the relative merits of the coals.

In some instances the information concerning certain beds is very meagre, which necessarily renders the description of them incomplete. It is believed, however, that all knowledge requisite for the identification of the most reliable beds is given.

It is hoped that those coals necessarily inadequately described at this time may yet receive such attention as to render the means of their identification more definite. It has been considered best to take the coals in the order as they are numbered; the descriptions begin, therefore, with the highest and descend to the lowest.

The Anvil Rock (Mahoning Sandstone?)—Occupying a position at the top of the coal measures, is a massive sandstone,

known in the former Geological Reports on this State as the "Anvil Rock."

It is frequently compact and close-textured, with but few scales of mica.

Its character, however, is exceedingly variable. At Rockport, where it forms cliffs on the east bank of Green river, it presents its usual appearance.

When fully developed it is usually coarse-grained, micaceous, mediumly soft, color light buff to cream, and buff speckled with white and black. Occasionally hollow concretions of limonite occur towards the top. Large fragments of fossil trees, viz: *Sigillaria* and *Calamites tuberculosus* (?) with *Stigmaria ficoides*, associated with the markings of other trees and plants, are abundant in some parts of the rock.

These are usually very much contorted and broken. Often the plants and bark of the trees are changed into fibrous coal.

At certain parts the rock is literally a mass of vegetable remains; the markings of which, however, are, in nearly all cases, quite obscure.

The rock disintegrates at about the middle, so that, when the upper part is absent, it is frequently a mere bed of sand.

One very marked feature of the rock, though not a characteristic one by any means, is its tendency to weather with a honey-combed appearance. This is considered by some to be a reliable means of identification; but nothing is more likely to lead to error.

In fact it is a difficult matter to distinguish one sandstone from another over large areas in this region merely by their physical characters. They so often resemble each other, and change so frequently in appearance, that to be able to identify them respectively requires close attention to the accompanying strata and topography on the part of the observer.

I am very much inclined to regard this sandstone as the equivalent of the "Mahoning sandstone." Sufficient data have not been collected to justify a decided opinion in the matter, but certain facts elicited during the explorations suggest that such is the case.

In the vicinity of the McHenry mines, large and small tumbled fragments of very ferruginous conglomerate sandstone were found strewn over the hillside, lying above Coal B. The pebbles are of quartz, varying in size from that of a pea to that of a chestnut, sparsely though widely distributed throughout the mass. The sandstone has nowhere been found *in situ* containing such pebbles, but these must certainly have come from it.

The Anvil Rock is known to cap the neighboring hills, and is exposed near the top of the hill in question. It is very evident that the fragments were broken off from this sandstone. As it is known to contain pebbles at this locality, it is possible that the sandstone may be found possessing a conglomerate character in other parts of the coal field not yet examined. According to the investigations of Mr. Crandall, in eastern Kentucky, the Mahoning sandstone is not always a conglomerate. He also places it at from four hundred to five hundred feet above the conglomerate (not very much lower than the position of the Anvil Rock), with eight coal seams between.

The similarity between the rocks is apparent.

The Anvil Rock must have been deposited in turbulent waters, judging from the many and varied changes found in it.

In some regions it rests directly on the limestone over Coal B, with what are probably the crushed fragments of Coal A, distributed in patches and pockets through the lower part.

At Owensboro Junction the lower two feet of the sandstone is a conglomerate of yellow earthy limestone fragments. Whether these are from the limestone overlying Coal B, is a matter for speculation only.

Coal A.—The Coal.—Coal A, the first coal below the Anvil Rock, is perhaps the best workable coal, as far as regards *quality*, to be found in the region traversed by the railroad.

It is undoubtedly the best in the upper series, counting from Coal H upwards.

Unfortunately it is seldom found in a suitable condition for working. Its unreliability is such that those engaged in mining in the western coal field place no confidence in it.

When present at all, it varies in thickness from three to six feet.

The deposition of the coal seems to have been frequently interrupted. It appears as if at certain points there had been an eddy in the water bearing the sand which went towards forming the Anvil Rock, tearing the soft coaly material from its bedding and depositing it again in the same place mingled with the mud and sand.

When found in a workable condition, however, it is comparatively free from all irregularities, and is easily mined.

In texture it is somewhat variable, occurring as a firm, glossy black, dense coal at one locality, while at another it may be rather soft and apt to slack considerably upon much handling.

Compared with others, there is little sulphur present in the coal, little more, in fact, than in the celebrated Block coal of Indiana, as the following general average analysis will show:*

Specific gravity	1.339	
Moisture	4.15	
Volatile combustible matter	33.14	
Fixed carbon	55.71	} Coke 62.71.
Ash	7.00	
	100.00	
Sulphur	1.873	

In an analysis made by Dr. Peter, and published in the fourth volume Kentucky Geological Reports by Dr. D. D. Owen, the per centage of sulphur and ash is represented as being quite small. The analysis is numbered 1164, and is as follows:

Specific gravity	1.593	
Moisture	7.06	
Volatile combustible matter	30.84	
Fixed carbon	58.70	} Coke 62.10.
Ash	3.40	
	100.00	
Sulphur	0.879	

By whom the sample analyzed was taken is not known to me, as no name accompanies the label attached to the analysis. There is every probability that it was not an *average* sample

* Single analyses will of course differ from this somewhat, being better in some instances and poorer in others.

but a picked specimen; in no other way can the great difference between the two analyses be explained.

As far as regards the amount of sulphur present, however, the coal could be successfully used in the raw state for the manufacture of iron; but the fact of its being too *fat*, producing too much bitumen when heated, thus caking and agglutinating, choking the furnace, and obstructing the blast, precludes the possibility of making good iron with it when used raw. It was thus used at Airdrie, but the quality of iron produced was poor.

Excellent coke may be made of it, however, and when thus used there is no reason why a fair quality of iron may not be obtained.

An analysis of samples of coke procured by P. N. Moore from a large heap of the material prepared for use at the Airdrie Furnace seventeen years ago, is as follows:

Moisture expelled at 212°	7.50
Moisture expelled at red heat	4.20
Fixed carbon	82.90
Ash	5.40
	100.00
Sulphur	0.64

As remarked by Mr. Moore,* the sample "does not fairly represent the coke that can be made from the coal;" the pile (containing several thousand bushels) has been exposed to the action of the weather for seventeen years, and a large amount of water was naturally absorbed. Besides, it was prepared in open heaps, which method does not produce as good quality of coke as when closed ovens are used for the purpose.

When these facts are taken into consideration, it will be conceded that an excellent coke may be made from the coal.

The quality of Coal A is as good at Airdrie as at any point near the line of the railroad; but there is a bare possibility that in some part of the coal field it may be found with quite as little sulphur, and approaching more nearly to a dry free-burning coal, capable of being used in the furnace without coking. It is a fine domestic fuel and an excellent steam coal.

* See his published report on the Airdrie Furnace, in the Louisville *Courier-Journal*, January 11th, 1875.

The Slate.—As a rare case only is bituminous slate found capping the coal. It seems to have been pretty generally removed over the entire region covered by this report.

The Shale.—The coal is frequently immediately overlaid by a bed of argillo-sandy shale carrying thin beds of carbonate of iron (usually altered to limonite near the surface).

The shale varies in thickness from twenty to thirty-five feet. Towards the bottom, near the coal, it is generally quite hard, and forms a good roof; sufficiently strong, with judicious propping, to support the overlying strata whilst the coal is being mined.

When once seen and sufficiently studied, the shale is easily identified at other localities. Ferns of the genera *Neuropteris*, *Sphenophyllum*, *Asterophyllites*, and *Sphenopteris* are found in it.

Without paying due attention to the peculiarities of each, there is a great possibility of confounding this shale with that overlying Coal D. A sufficient examination of each, however, will reveal to the explorer characteristic features by which he may be guided and make no mistake. The iron ore formerly used at the Airdrie Furnace was taken from a bed of this shale overlying Coal A at that place.

Coal B.—*The Coal.*—This is the coal numbered 11 in Dr. Owen's report. It is very unreliable in the region under consideration. At Paradise, and the surrounding region, it is at its best development, so far as regards uniformity in thickness and quality.

It is always found with at least one clay parting, sometimes two.

It thins and thickens in a remarkable manner; occasionally it is represented by only twelve inches of soft smutty coal, and again will attain a thickness of seven feet.

It ranks next to Coal D in persistency, however.

When workable the coal is of fair quality, but is so subject to clay slips, rolls and undulations, that the mining of it is attended with more expense than in the case of the other coals. It is not intended to convey the impression that the coal is never without these evils, for such is not the case.

At Paradise, for instance, the coal lies in very good condition for working.

The coal is glossy black and compact, frequently with fibrous coal between the laminæ. Immediately at the top a layer of from one eighth to two inches of the fibrous coal occasionally occurs. An interesting analysis, by Dr. Peter and Mr. Talbutt, of a piece obtained at the Muhlenburg mines (Muhlenburg county), is presented:

Specific gravity	1.503	
Moisture	1.20	
Volatile combustible matter	7.50	
Fixed carbon	86.48	} Powdery residue 91.30.
Ash	4.82	
	100.00	
Sulphur	2.43	

This analysis is of much interest, as showing the per centage of sulphur, of fixed carbon, and volatile matters. It is shown to have great heating power; so that, though adding to the amount of sulphur in the coal, it augments its heating power greatly. It is in fact not much more than a *coke*, and the name *mineral charcoal*, usually given it, is peculiarly applicable. Its presence no doubt adds to the amount of ash as well as sulphur in the coal; and it is so poor in volatile matters that much of it detracts from the value of a coal for gas purposes. As a *heating* fuel, however, it is of peculiar worth.

The upper part of the coal is, on an average, the best, the quality deteriorating towards the bottom.

Wherever a clay slip occurs the quality of the coal is affected for yards. At such places the coal is usually slaty, with much iron pyrites mingled with it.

The clay cuts both the coal and the roof in many instances, and often there will be what may be termed a *main* slip extending entirely across the bed, so far as exposed to view, with several little leaders spreading out from it.

These "slips" may be accounted for in three ways, the explanation depending upon whether the clay simply cuts the coal or whether it cuts both the roof and the coal.

First, when the clay cuts only the coal. In this case the clay is to be considered as of later date than the coal bed.

As is apparent in the rolls and undulations of the under clay forming the floor for the coal, the vegetable matter was deposited on an uneven surface. There were, consequently, inequalities in the thickness of the vegetable matter. The coaly matter may also not have been of uniform hardness. As a consequence, the weight of the superincumbent strata pinched down the coal at certain points to a much less thickness than at others. A slight but uneven depression or elevation of the bed would cause a fracture or series of fractures in the stratum, and these fractures would naturally be at the weakest points. A subsequent flood removed the overlying strata, and when the work of redeposition began the muddy sediment held in the water found its way into the fractures of the coal, and there remained, being squeezed into compactness by the weight of the succeeding strata.

Second. In this instance the clay cuts the coal as before. Considering that the coal was deposited in the same manner as previously described, and that the bed was fractured in the same way, it is possible that when the succeeding strata were deposited the additional weight forced the plastic under-clay up in the fractures.

Third. When the clay cuts both the roof and coal it is accounted for in a somewhat different manner from the foregoing.

It would seem that the clay came from above the coal. Subsequent to the deposition of the roof shales a series of very slight disturbances produced small fractures in the strata, which were afterwards filled with clay. In some instances these cracks were widened by the erosive action of running water; in that case the width of the clay seam is greater. The evidences of fractures are presented in the smooth-worn sides of the coal, etc.

The explanation of the whole matter, however, resolves itself into that given in the first place. It is a noticeable fact, that where these clay slips are most frequent, part of the strata overlying the coal have been removed

The coal varies in its quality considerably, the greatest change being in the amount of sulphur present.

Unfortunately a sufficient number of samples could not be obtained to make it possible that a reliable average analysis might be given. The two following analyses are given, however, as being better than none.

The first is an *averaged* analysis of samples taken from the Muhlenburg mines; the second an average of the analyses made of samples, collected by P. N. Moore at Paradise.*

No. 1.			
Specific gravity		1.304	
Moisture			2.25
Volatile combustible matter			41.54
Fixed carbon } Coke			50.62
Ash	56.26		5.64
Sulphur		2.982	

No. 2.			
Specific gravity		1.310	
Moisture			3.96
Volatile combustible matter			36.90
Fixed carbon } Coke			52.60
Ash	59.13		6.53
Sulphur		4.41	

There is considerable difference between the two analyses in the per centage of sulphur indicated. Comparing analyses of the upper part of the bed at each locality, however, the difference is not so great.

No. 1.†			
Specific gravity		1.332	
Moisture			1.52
Volatile combustible matter			40.00
Fixed carbon			50.92
Ash			7.56
			100.00
Sulphur		2.840	

No. 2.			
Specific gravity		1.274	
Moisture			3.60
Volatile combustible matter			38.70
Fixed carbon			53.70
Ash			4.00
			100.00
Sulphur		3.158	

The Under-clay.—The clay below Coal B is, in some instances, suitable for the manufacture of fire-bricks. Its thickness is variable, ranging from two to seven feet.

* From his published report on the Airdrie Furnace.

† No 1 from Muhlenburg mines. No. 2 from Paradise.

The bricks made (so far as is yet known) are not of the best quality, but will answer the purpose when better ones may not be had.

An analysis, by Dr. Peter and Mr. Talbutt, of a fair sample obtained at the Ross mines, Owensboro Junction, exhibits an undue preponderance of silica and too little alumina. The presence of sulphur is also injurious.

The following is the analysis:

Silica	63.180
Alumina, &c.	26.281
Lime	.203
Magnesia	.255
Phosphoric acid	.179
Sulphur	1.312
Potash	2.000
Soda	.425
Water and loss	6.165
	100.000

The Slate.—The bituminous slate over Coal B was found in a few instances only; a bed of limestone or clay usually rests immediately above the coal. Where seen it is compact, brittle, close-textured, of rather a glossy black color, and jointed rhomboidally. Few fossils were found in it.

Cox gives a list, in volume three of Dr. Owen's reports, of shells found in the shale over Coal B. They, no doubt, came from the overlying limestone. With two or three exceptions the fossils enumerated by him were found in a much lower coal, *i. e.* Coal D.

The Limestone.—Occupying a true position above the slate, but usually resting immediately on the coal, or else separated from it by only a few inches of clay, a bed of limestone occurs.

This varies from a loose, friable or marly mass, to a hard, compact rock, and in thickness from six inches to eight feet; the usual thickness being eighteen inches.

It is easily identified by its organic remains; which are *Productus splendens*, *Athyris subtilita*, *Martinia perplexus*, *Martinia plano-convexus*, *Spirifer cumeratus*, *Spirifer Kentuckiensis*, *Retzia punctulifera*, *Rhynchonella Osagensis*, *Chonetes Smithii*, a large *Chonetes*, *Macrocheilus inhabilis*, *Bellerophon percarinatus*, *Pleurotomaria Grayvillensis*, *Murchisonia*? *Lophophyllum proliferum*.

Archæocidaris megastylus, *Chaetetes milleporaceus*, etc. *Martinia plano-convexus* is the most abundant and characteristic fossil.

The rock varies in color greatly, changing from drab to blue, grey or buff, or buff mottled with ashy white. It is always quite impure, very earthy, and often pyritiferous.

The Sandstone.—At Airdrie, the only place, perhaps, near the railroad where coals A and B are in their true position towards each other, a sandstone twelve feet in thickness overlies the limestone, separating it from the fire-clay of Coal A.

Farther west the sandstone is entirely absent, the two coals approaching very near to each other; in some instances, as at the Muhlenburg mines, separated by two feet of clay only.

The absence of the sandstone may be easily accounted for, but it is not necessary to do so here.

Coal C.—This coal is very erratic and quite seldom present. It is usually no more than a two-inch smut. At first it was proposed not to number it, but subsequently, determining to follow Dr. Owen's system of numbering (for the present), it was thought best to do so, especially as it was found at a few places exhibiting a thickness of two and a half feet. It is remarkable in its lateral changes. At Paine's, on Green river, it is a thin streak in sandy shale, scarcely noticeable. Proceeding west to the Richmond mines, a distance of about one mile, it is found presenting a thickness of two and a half feet. It retains that thickness for barely half a mile, and is then lost sight of. It will be seen by this that it has no economic worth.

Coal D.—*The Coal.*—This coal varies in its quality and physical features wherever seen. There is not much change in short distances; only at points widely separated are the differences very marked.

It is not strictly true that the *quality* changes frequently, but rather that the texture is variable.

The coal is usually hard and compact, made up of alternating dull and shiny black layers, with layers of fibrous coal between, giving it an appearance remotely resembling *splint coal*.

It is an excellent heating coal, but is too fat and sulphurous for a furnace fuel. The upper two and a half feet is usually the best, in that it is freer from pyrites than the bottom, though such is not always the case. It is never free from *iron pyrites*. This unwelcome mineral is always found in it, either as thin bands, or plates introduced between the vertical joints, or occurring irregularly throughout. The position occupied by the pyrites in the coal cannot, therefore, be used as a means of identifying the bed; a fact contrary to the supposition of many. As a general thing, however, most of the pyrites is found below the middle, increasing in quantity towards the bottom.

Fortunately the greater portion of the pyrites occurs as bands concentrated at one point in the bed, and may be removed when the coal is mined.

The coal is remarkably persistent and uniform in quality and thickness, and from this circumstance may be considered the most valuable of any of the coal beds in the southwestern portion of the State. Its thickness ranges from four to six feet, averaging about four feet nine inches.

At one locality only was it found troubled with clay slips; it is indeed singularly free from the evils attending the other coals. It is somewhat inferior in quality to Coals A and B, but this is balanced by its great persistency.

The following is an average of seven analyses made of the coal, by Dr. Peter and Mr. J. H. Talbutt:*

Specific gravity	1.371	
Moisture	3.27	
Volatile combustible matter	35.31	
Fixed carbon	53.12	} Coke 61.26.
Ash	8.14	
Sulphur	3.218	

The coal has been tried in a few instances for the manufacture of iron—once at least in the raw state. A glance at the analysis, however, shows that besides having an excess of sulphur, it is too apt to cake and choke up the furnace to be used raw.

*Single analyses will be found in a table given at the end of this chapter.

If well washed, however, so as to remove as much of the pyrites as possible, it will, no doubt, make a fair coke, and may thus be used.*

There is, no doubt, a certain amount of sulphur present in the coal in an uncombined state (as is probably the case with all bituminous coals); but it is likely that most of it is present as thin plates of pyrites introduced between the joints of the coal or in heavier masses, and may be partially removed.

It is always provided with a reliable roof, which renders the mining of it safe.

The Slate ranges in thickness from two to five feet. It is usually dense, smooth, and even-textured, cleaving readily in thin laminæ, varying in color from dark blue to bluish-black. Though usually dense its texture is variable. When the slate is more than ordinarily earthy, it is coarse-grained and inclined to soften under the influence of water.

In some localities many pyritous concretions of various fanciful shapes are found in it. Some are discoid or spherical, and others long and flattened.†

These concretions are occasionally entirely of yellow iron pyrites, but are often a dark blue, heavy, pyrito-bituminous limestone. In the latter case fossils are often found in them, including *Productus muricatus* *Solenomya*—? *Bellerophon carbonarius*—? a minute *Polyphemopsis*? etc. Vegetable remains are also occasionally found in the concretions.

What appear to be the remains of minute gasteropods are occasionally found in the slate.

Between the slate and the coal a mass of flattened remains of *Sigillaria* and *Cordaites*, with other plants, so interlaced as to form a matting, is nearly always present. The plants are always found converted into hard, brittle, brilliantly black coal.

The Clay over the Slate.—Immediately over the slate a bed

*It is believed that most of the sulphur is present in the plates of pyrites in the joints.

†Some of these concretions are of such curious shapes that they are frequently mistaken by miners and others for "petrified fish," "trees," "cabbages," etc. Such stories occasionally find their way to newspapers, and to one not conversant with the facts are subject to much interesting comment.

of dark or blue pyritous clay, varying from two to twelve inches in thickness, is usually found.

It is literally filled with fossils, including many species. The following are those identified at this time:

Productus muricatus, *Prod. Nebrascensis*, *Hemipronites crassus*, *Meekella striato-costata*, a *Lingula* (rare), *Rhynchonella Algerii*? (it may be *Rh. Osagensis* of Sw.), *Astartella vera*, *Nucula ventricosa*, *Chonetes mesoloba*, *Nuculana bellistriata*, *Aviculopecten rectalaterarea*, *Aviculopecten* —? a *Prothyris*, *Macrodon tenuistriata*, *Pleurotomaria carbonaria*, *Pl. speciosa*? *Pl. sphaerulata*, *Bellerophon carbonarius*, *B. percarinatus*, *B. Montfortianus*, *Macrocheilus inhabilis*, *Mac. fusiformis*, *Nautilus decoratus*, *Orthoceras cribosum*, and long slender univalves, probably belonging to the genus *Loxonema*.

Productus muricatus is about the most abundant fossil; next to that in abundance is *Pleurotomaria speciosa*? and then the slender univalves.

These fossils are seldom found grouped together; on the contrary, the clay may be charged with *Producti* at one point, while at another a *Pleurotomaria* may be the predominating fossil.

The clay is not always present, and may even be found in but a few places in a single mine. Wherever found, however, it absolutely identifies Coal D.

The Paleontology.—The fossil shells found connected with this coal, besides those already enumerated, are *Aviculopecten acosta*, *Pleurotomaria Grayvillensis*, *Productus Prattenianus*, *Athyris subtilita*, *Spirifer cameratus*. Plants: *Neuropteris hirsuta*, *Pecopteris Miltoni*, *Sigillaria*—? *Stigmara ficoides*, *Calamites tuberculosus*? etc.

The Blue Shale.—From ten to thirty feet of blue argillaceous sandy shale usually lies above the bituminous slate. In certain regions this is a very good index to the coal, but it is not always present; or rather it often passes into sandstone. The sandstone, however, is usually quite shaly and bluish-grey in color; so that, upon the whole, considerable confidence may be placed in the shale. Occasionally, though seldom, beds of

ochreous limonite (altered carbonate of iron) are found in the shale. In the western portion of the coal field this circumstance is apt to create confusion in identifying the coal bed.

The shales in certain localities in that region resemble those overlying Coal A, and, without exercising great care, there is danger of the explorer mistaking Coal D for Coal A. In the eastern portion of the coal field, however, the shales were nowhere found with any abundance of the ochre, and there is little danger of any mistake being made.

Occasionally a thin ferruginous limestone, almost an iron ore, containing very small univalves (*Bellerophons*?) is found in the shale, occupying a position about twenty-five feet above the coal. The limestone is very thin, scarcely ever greater than two and a half inches, more often one half an inch in thickness, and is not constant.

The Sandstone.—Overlying the blue shale is a mass of sandstone varying greatly in its thickness and physical characters. It is variably coarse and fine-grained, and passes from a hard, compact, heavy-bedded sandstone to a soft, loosely-cemented or shaly one, weathering into caverns or rock-houses. In some instances it is an excellent building stone; again it is a bed of sand.

A curious feature in the way this sandstone weathers is the honey-combed appearance of the cliffs formed by the massive variety.

This feature, however, is not peculiar to this rock alone, but is found in nearly all the sandstones from the Big Clifty to the Anvil Rock, inclusive. It varies in thickness from thirty-five to fifty feet.

Coal E.—This coal is regarded as the equivalent of No. 8, according as the coals were numbered by the old Survey. It is of fine quality, occurring as a glossy black, firm, even-textured coal. There are only two reasons why it is not the most valuable coal in the field, viz: its limited thickness (varying from one half an inch to thirty inches), and the manner of its distribution. It is sometimes entirely absent, represented only by a bed of bituminous slate underlaid by a thin bed of fire-clay,

with or without a coal streak. However, it is of such superior quality, that were a bed three or three and a half feet thick found, it would be considered as workable, even in the neighborhood of thicker coals.

Its associate rocks are not always the same. North of Greenville, Muhlenburg county, on the Madisonville road, it is represented by a mere streak of coal capped by bituminous slate and underlaid by shales holding thin beds of sandstone and nodules of sandy iron-stone.

Nearer the town, in a valley, about half a mile southwest of the Station, the coal is entirely absent; bituminous slate is present, however, resting immediately on sandstone, the shale with the iron-stones having disappeared. Near Gordon's Station, about three and a half miles west of Greenville, it is again found, presenting a thickness of eighteen inches, and capped by eighteen inches of dense slate.

Its unreliability is apparent

The Slate.—The slate is dense, glossy black, and even-textured, rhomboidally jointed, and cleaving readily in thin plates. At some localities it is literally filled with fish remains, generally the scales, with occasional spines. Teeth are rare; *Peripristis semi-circularis* is occasionally found.

The Shale.—Overlying the slate, ochreous shale, varying from ten to twenty feet in thickness, usually occurs. Occasionally it is absent, and the overlying sandstone rests immediately on the slate.

Coal F.—This seam is of no consequence either in an economic or commercial point of view. It was found at Greenville and vicinity, but only as an impure earthy coal, immediately underlying a disintegrating ferruginous sandstone, and resting on a brecciated limestone. Occasionally it is overlaid by bituminous slate.

The Limestone.—The limestone below the coal makes some curious changes in very short distances. It was seen only at Greenville, and is probably local.

At one locality near the town it is a rough blue limestone mottled with dove, drab, and buff, mediumly compact and hard.

At another place it is a breccia of limestone and sandstone, passing into a sandstone containing calcareous lumps, then suddenly shading into a micaceous sandstone, merely to resume its former character within a few yards. These peculiar changes take place without any break in the continuity of the bed. At other places it is a rough, nodular, calcareous mass, cemented by oxide of iron. A sandstone, accompanied by shale inclosing nodules of iron-stone, is occasionally interpolated between the limestone and coal.

Coal G.—This coal was not observed anywhere along the road, but is reported as occurring in the Greenville shaft. Every evidence tends to verify the report, although there are discrepancies in regard to its thickness.

It is a thin bed, of no economic value, so far as known to the Survey.

Coal H.—This coal was first noticed at Mr. Sandifur's, on the Hines Mill and Cromwell road, about one and a half miles south of Elm Lick, in Ohio county.

Only the outcrop was seen, and nothing very definite in regard to it could be obtained. It is divided by shale into two members. The shale varies from two to eight feet in thickness, which would lead to the supposition that there are really two distinct beds of coal, and that they may be more widely separated at other localities.

This coal is also reported as lying at the bottom of the Greenville shaft, where its upper member is said to be three feet two inches thick, and the lower one eighteen inches.*

Coal I.†—Little is known regarding this coal; an accurate description of it cannot, therefore, be given. It was observed on the hills south of the St. Charles mines, Hopkins county, measuring one foot in thickness.

It is immediately overlaid by argillaceous shale, which lies beneath a heavy-bedded, rather soft sandstone. The most

*One of the men who sunk the shaft places the thickness of the lower bed at five inches.

†On Col. Gano Henry's land, southwest of Hamby's Station, Hopkins county (on the old Breathitt place), there is a coal that may be referred to this; it is said to be three feet thick, and is of excellent quality.

accurate means of identifying it is the limestone lying at from ten to fifteen feet below it.

The limestone varies in thickness from two to eight feet. It is easily recognized by its fossil contents, which are, *Spirifer cameratus*, *Productus muricatus*, *Prod. Prattenianus*, *Prod. splendens*, *Martinia plano-convexus*, *Fenestella*, and *Crinoid* columns.

Productus splendens is especially abundant, and may be regarded as the typical fossil.

Coal J.—This coal occupies a position at from twenty to forty feet below the limestone. But little better opportunity was afforded to examine it than was the case with coal I. As seen in the bank, the coal is of admirable quality; glossy black and compact. It is occasionally separated into two members by a clay parting twelve inches thick. The most reliable and convenient means for its identification is presented by the limestone previously mentioned.

Coal K.—This was first observed in the first cut west of Millwood, Grayson county. It varies from nothing to two and a half feet, and is only of medium quality. It occupies a position about twenty feet below the Bee Spring sandstone.*

Coal L.—The Coal.—As demonstrated by investigations made in Livingston county, this is an inter-conglomerate coal.† In Grayson county it usually occupies a position at from five to ten feet above the Chester Group. Occasionally, however, a sandstone nearly ten feet thick is interpolated between the coal and limestone.

At the western border of the coal field the coal rests about fifteen feet above a heavy conglomerate, and is from three to four feet thick. In Grayson county, it occupies a position at from sixty-five to seventy-five feet below the Bee Spring sandstone, which corresponds to the "fifth sandstone" of Lyon.

At the Union coal mine in Livingston county it occurs at ten feet below a conglomerate twenty feet thick, with another con-

* This sandstone received its present name from a noted spring in Edmonson county. Further concerning it may be found in Mr. Moore's report on the iron ores of that county.

† This is true, provided the conclusions were correct in identifying the coal on the railroad with that in Livingston county, which is believed to be the case. The coal is undoubtedly that numbered No. 1 B by Dr. Owen, which number M. Lesquereux assigns to that at the Union coal mine, Livingston county. (See "Report on the Lead Region of Livingston, etc.")

glomerate, varying from forty to one hundred feet in thickness, below it.*

It is barely possible that the sandstone twenty feet thick which occupies a position twenty feet above the coal in Grayson county, and the one occasionally found below it in that county, correspond to the conglomerates found in Livingston county. Should this be true, the coal lying twenty feet below the Bee Spring sandstone is probably the one overlying the upper conglomerate in Livingston county.

This is regarded as the equivalent of Coal No. 1 B of the old Survey, and a hurried examination made in September, 1874, gave the impression that it is also the "Knob Lick" coal of Edmonson county. In the eastern part of the region embraced in this report the coal is seldom more than twenty-seven inches thick; but on Tradewater, in the conglomerate district, its thickness is from three to four feet.

The Slate.—Overlying the coal there is usually a bed of bituminous slate, from four inches to three feet thick. It is usually quite earthy, frequently almost imperceptibly shading above into dark drab, argillaceous shale. *Lingula mytiloides?* (*L. umbonata* Cox), associated with long slender leaflets of plants, *Pinnularia(?)*, often occurs in great profusion. When most abundant, however, the *Lingulae* are not widely distributed through the slate, but seem to have been gregarious. In other instances, although present, many slabs may be examined before any of the fossils will be found.

The *Lingula* seems to belong almost exclusively to the shale overlying Coal L. At one locality the clay over Coal D was found to contain an occasional individual; but in all the examinations of that shale for fossils, no more than three or four specimens of *Lingula* were obtained. These were quite small, and may not belong to the same species as those in connection with Coal L.

The Shale.—On Tradewater, interposed between the conglomerate and Coal L, is a bed of dark blue, somewhat argillaceous shale, with concretions of carbonate of iron.

* See report on the Lead region of Livingston, Crittenden, and Caldwell counties.

No good exposures were observed; therefore no opinion can be given respecting the value of the shale as an iron ore repository.

The Conglomerate.—The conglomerate, so far as known, extends only around the southern and western margins of the coal field. It is not seen near the road in the east, but towards the western margin is exposed as a great pebbly mass from fifty to one hundred and twenty-five feet thick (probably more in places), and lying at about twenty feet below Coal L.

It is not always conglomeratic in its entire vertical extent. The pebbles are more abundant towards the middle and the bottom, though frequently distributed irregularly throughout the mass.

There seems to be a gradual change from a coarse, pebbly rock at the bottom, to a loosely cemented, often disintegrating, exceedingly fine-grained sandstone at the top, marking the advent of the more quiet time preceding the deposition of Coal L. It is also frequently devoid of pebbles, and may extend for miles simply as a ferruginous, dirty, moderately fine-grained sandstone. Towards the top the lines of deposition are very irregular, as would naturally be expected from the nature of the rock.

There are evidently two conglomerates in the western coal field; a fact first brought to light by the examinations in the lead region of Livingston county.

The conglomerate on Tradewater is regarded as the lower one, and which skirts the southern borders of the coal field, while the upper one (so far as known) is not present so far east; this is true at least for the region under consideration.

Sub-Conglomerate Coal.—Immediately below the conglomerate, on Tradewater, near the railroad bridge, a coal is exposed at low water. Its thickness is variously reported as being eighteen inches and two and one half feet thick. It has never been opened, being in the bed of Tradewater river, and its precise thickness is not known. The outcrop was seen at the time of low water in the autumn of 1874.

DISTANCES BETWEEN COALS.

The following table exhibits the average distances between the coals, from A to H, inclusive, as they occur along the line of the railroad:

1. Coal A.	5	feet.
2. Space	5	"
3. Coal B.	6	"
4. Space	15	"
5. Coal C.		
6. Space	75	"
7. Coal D.	5	"
8. Space	75	"
9. Coal E.	1 1/2	"
10. Space	20	"
11. Coal F.	1 1/2	"
12. Space	50	"
13. Coal G.	1/2	"
14. Space	100	"
15. Coal H	4 1/2	"

COAL IN THE CHESTER GROUP.

In Grayson county, in the Chester Group, a thin coal seam occurs immediately below a thick limestone. It occupies a position at from seventy-five to one hundred and twenty feet below the top of the group, according as the strata are thick or thin.

The only personal knowledge I have of it is of its occurrence on Mr. Horn's place on Rock Creek. Mr. Moore, however, cites several localities where it is known to exist.

Its thickness is only about two inches, but it is remarkably persistent. The same coal seen on Rock Creek is reported to occur about three miles east of Mammoth Cave.

The limestone overlying the coal is regarded as being the lowest in the Chester Group, though this cannot be said with certainty, as there was little opportunity to study it. Mr. Moore's section at Manyan's, on Nolin river, near Wheeler's mill, which he has kindly placed at my disposal, shows the position of the coal very nicely. It is as follows:

1. Sandstone	10	feet.
2. Covered (all sandstone?)	15	"
3. Limestone	38	"
4. Shale	2	"
5. Coal	1 1/2	inch
6. Shale	5	feet
7. Shaly sandstone	15	"

The coal has a dull, dry, somewhat slaty appearance, and a foliated structure, susceptible of being divided in very thin leaves; approaching very much in appearance to bituminous slate. It breaks with ragged edges, the faces of the fracture having a banded, brilliant black appearance. Like bituminous slate ordinarily is, it is crossed by vertical joints, the bed separating into rhomboidal blocks quite easily.

The coal seems to be formed entirely of *Cordaites*, the markings of which are distinctly visible on each sheet, no matter how often the coal be split.

Notwithstanding the poor appearance of the coal, an analysis of it shows it to compare very favorably with most of the coals in the coal measures.

The analysis, by Dr. Peter and Mr. Talbutt, is as follows:

Specific gravity	1.338	
Moisture	4.24	
Volatile combustible matter	30.82	
Fixed carbon	55.52	} Coke 64.94.
Ash	9.42	
Sulphur	2.892	100.00

The only plants found, besides the *Cordaites* mentioned, belong to the genera *Sphenophyllum* and *Hymenophyllites*; others may occur. Ordinarily a thin bed of calcareous shale overlies the coal, intervening between it and the limestone, but no bituminous slate has been found connected with it, so far as I know. Coal occupying a similar position to the one under consideration is reported to occur in Livingston county.

The presence of this coal in the Chester Group indicates a growth of coal-making plants, notably *Cordaites*, and a feeble attempt at the formation of a coal bed at a period long anterior to the epoch of the coal measures, making the Chester Group a link between the massive limestones of the lower carboniferous and the coal measures.

Though of no economic value, and not militating in the least against the generally accepted opinion that no coal of importance will be found below the coal measures in this country, it antedates the time usually given for the first appearance of coal.

SAMPLING COALS FOR ANALYSIS.

It seems expedient in discussing the coals that a few notes on sampling them for analysis be given.

It is an impossibility to fairly sample coals without the adoption of some methodical plan. No one, be he ever so honest in his endeavors to obtain specimens showing a fair *average* quality of the bed, can do so trusting to his own power of discrimination, or relying on his impartiality. Take him to the stock pile and his collection will invariably represent the quality of the coal to be better than it really is, or, trying to avoid that evil, he will go to the other extreme, selecting samples with too much sulphur or other bad qualities.

The plan adopted in sampling the coals in the district embraced in this report was purely mechanical, otherwise the analyses appended to this chapter would have shown the coals either in a better or poorer light, and been of little value. The plan was as follows: Entering the mine, chips were taken from the bed, beginning at the top and descending to the bottom, at intervals along the main entries, selecting freshly fractured surfaces when available; then entering the rooms, chips were taken from them, sampling the entire bed, from the top to the bottom, in every case.

Everything was included, except in the case of clay partings or where a *thick* band of pyrites occurred, which it was *evident* could be and would be separated from the coal when mined.

These chips, usually a large collecting satchel full, were then taken out and so mingled together as not to have the chip-pings from one part of the mine distinct from those of another.

The pile was then halved, one half being thrown away, and the other undergoing another course of mixing. This pile was then halved, and the process continued as before till the desired bulk was obtained necessary for analysis.

In this way it is believed that a fair average was obtained of the quality of the coal *as it lies in the bank*.

Though the foregoing plan may be considered a good one for special applications, it is open to objections when the quality of the coal, as it is sent to the market, is to be obtained.

In passing over the screens, it is of course separated from some of the impurities found in the mine.

The analysis is sufficiently accurate, however, to approximately determine whether the coal is suitable for gas or an iron furnace fuel. A general plan for the sampling of the coals in a large mining district, the object being to obtain an accurate analysis of the coal in the entire region, is suggested as follows.

First, chippings from the mine should be taken in the manner previously described. Then samples, to the quantity of several shovel-fulls, should be taken from the stock pile of lump and nut, and averaged by *quartering*.*

Third, samples to be taken from the *lump* and *nut* coal piles separately and averaged as before; this represents the coal as it is sent to the market. And lastly, samples should be taken from the slack pile.

This would give a series of five analyses for each mine, showing the quality of the coal (as near as could be obtained) in the bank, its quality after exposure in the stock pile, the quality of the lump and nut separately as sent to market, and lastly, the amount of impurities removed as slack.

An average of the sum of the analyses made for a number of such collections would then be a fair one for the entire district. The only apparent hindrance to the successful operation of the plan in a general survey is the length of time required for its accomplishment.

On the following page a table of analyses of certain coals, by Dr. Peter and Mr. Talbutt, sampled according to the plan heretofore mentioned, is given.

* This is by dividing the pile into quarters; then taking the opposite quarters they are mixed together and that heap quartered, proceeding in this manner till the amount required for analysis is obtained.

ANALYSES OF COALS FROM CERTAIN COAL MINES IN THE WESTERN COAL FIELD OF KENTUCKY.

	Taylor coal mine (Beaver Dam)	Stevens' mine (Beaver Dam)	Rockport mine.	Rockport mine.	Rockport mine.	Mercer's mine.	St. Charles mine.	Ross mine, (Owensboro Junction).	Muhlenburg mines.	Muhlenburg mines.	Muhlenburg mines.
Specific gravity	1.315	1.316	1.421	1.332	1.534	1.358	1.322	1.470	1.297	1.332	1.280
Moisture	3.34	3.30	3.50	3.50	3.00	3.00	3.20	3.20	3.10	1.52	2.98
Moisture	35.84	36.76	35.00	35.00	33.50	34.00	35.90	37.44	40.68	40.00	43.08
Fixed carbon	54.36	52.60	53.70	53.70	63.50	50.00	54.00	49.80	50.66	50.92	50.22
Coke	60.86	59.94	61.50	60.80	63.50	62.40	60.90	58.40	56.22	58.48	53.94
Ash	6.50	7.34	9.00	7.10	8.40	11.80	6.90	8.60	5.50	7.56	3.72
Sulphur	3.826	2.604	3.390	2.837	3.332	4.032	2.759	2.727	2.779	2.840	3.125
Number of coal	D*	D*	D	D	D	D	D	A	A	B†	B†

* Somewhat better than an average sample. † Lower part of bed.

† Upper part of bed.

CHAPTER II.

DESCRIPTIVE GEOLOGY.

It is the purpose in this chapter to give an outline of the geological structure of the country in reference to the railroad, believing that it may be of assistance to the explorer, and considering it necessary as explaining the horizontal section accompanying the report. The endeavor has also been made to give it a present economic value by treating of the mineral resources of the district traversed by the road in as much detail as possible. Work was practically commenced at a point between Cecilia Junction and Long Grove. From Elizabethtown to Cecilia the country is quite flat for a considerable distance on each side of the railroad. From Cecilia to Long Grove occasional outcrops of the St. Louis Group are seen; but it is not till the latter place is reached that any important exposure of rock is found.

At that point the hills approach the road and lower carboniferous rocks come to view. The first place at which there is any considerable exposure is on Shiny Mountain, about two miles in a southerly course from Long Grove. A good section of the St. Louis beds was obtained there, beginning at the top of the hill and descending on the south side to the valley of Valley Creek. The rocks are included between numbers 12 and 24 of the general section of the St. Louis Group. The upper part of the lower division of the St. Louis Group is exposed in the field of Mr. Eskridge, about half a mile south of the road.

Legends are current in this region, as indeed they are in nearly every locality in southwest Kentucky, that lead or silver has been found in the hills, either by Indians or old settlers, and worked. These old-time stories are not to be believed, however; the relaters were too indiscriminate in the selection of their places. It is as frequent that the lead is said to have been found in sandstones belonging to the coal formation as that it was obtained in rocks where there is even a remote probability for it to occur.

The cause of the mistake is to be referred to the quantity of calcite (pure carbonate of lime) contained in the rocks, which is frequently thought to be silver or lead by those unfamiliar with either metal in its crude state.

From Long Grove to Stephensburg there is a gradual fall in the rocks, with occasional slight flexures in the series, as higher rocks come to view.

Around Stephensburg the rocks included between numbers 6 and 19, of the general section of the St. Louis Group, are exposed, with the sandstone No. 7 (?) capping the hills. In the vicinity of Stephensburg a limestone excellent as a "fire-rock" is exposed. It is grey, hard, and quite silicious and faintly oölitic. It is exposed in the old town and at the east end of the second cut west of the station, and is easily recognized in that vicinity by its peculiar banded appearance. It is universally used at Stephensburg in the construction of backs and jambs of fire-places, and is much esteemed.

At the first large cut west of the fifty-second mile-post the sandstone and shale, numbered 6 and 7 in the section previously referred to, are seen. At the base of the shale the limestone containing *Pentremites Godonii*, *Pent. pyrformis*, *Pent. Koninckiana* and *Pent. Norwoodii?* is exposed. The sandstone and shale are exposed at intervals from this point on to within a short distance of Nebo Tunnel, at which place the Big Clifty sandstone comes to view.

The Big Clifty sandstone is then the most prominent rock exposure on to Big Clifty Creek. At some points in the vicinity of East View it exhibits a thickness of sixty feet, thickening towards the west.

A short distance beyond Big Clifty Creek the sandstone disappears, and the first of the series of limestones and shales overlying it come to view.

At the first cut west of Big Clifty Creek the following section of the Chester beds was obtained:

1. Coarse, dark and bluish-grey, impure limestone, in several thick beds, with shale partings. The beds vary from two to five feet in thickness. The fossils are, *Agassizocrinus dactyliformis*, *Archimedes Oweni* (?), and *Zaphrentis spinulifera* 10 feet.
2. Mottled, dark and olive colored calcareo-argillaceous shale, with thin beds or layers of limestone at the top abounding in fossils 5 "
3. Hard, bluish-grey, sub-crystalline limestone, in several layers, with partings of calcareous shale. Organic remains are abundant, the list including *Spirifer Leidyi*, *Zaphrentis spinulifera*, *Retepora lyra*, *Archimedes*, *Dichocrinus*, *Agassizocrinus dactyliformis*, *Athyris Royssii*, *Straparollus*, *Spirifer increbescens*, etc. 3 "
4. Dark blue shale, with thin layers and plates of limestone, abounding in fossils, 8 "

The foregoing rocks are near the base of the series, lying a few feet above the Big Clifty sandstone. Towards Grayson Springs Station higher rocks come to view, the series having a general dip towards the west. At Mr. Patterson's, near the station, a quarry has been opened in the limestone at the base of the group. It is blue, hard, and compact. Large blocks thirty inches thick and six feet long are quarried from it. It is suitable for building abutments, foundations, &c., and can be used for such rough masonry as jails, etc. From Grayson Springs Station to the Springs the rocks descend by what may be termed a series of step-like faults, the Chapel limestone there being the one at Patterson's quarry near the station.

From Grayson Springs Station to Leitchfield the Chester rocks are exposed in an alternating series of limestones, shales, and sandstones; the higher rocks coming to view at the latter place.

A short distance beyond Leitchfield the rocks at the base of the coal measures make their appearance, the sandstone overlying Coal L coming to view.

At Keyser's Tunnel (at the seventy-fifth mile-post) the Bee Spring sandstone is exposed, displaying a thickness of forty feet. At the bottom a thin local bed of coal is seen.

The sandstone is exposed in the railroad cuts between the tunnel and Millwood. At the latter place Coal K (?) is reported at a few feet below the surface; it was not seen.

Beyond Millwood, at the seventy-ninth mile-post, Coals K and L are exposed in the sides of the cuts. The Bee Spring sandstone caps the hills, exhibiting a thickness of from fifteen to twenty-five feet.

The following section was made at the cut on which mile-post No. 79 stands:

1. Covered space from hill-top; probably sandstone	40 feet.
2. Sandstone	15 "
3. Drab argillaceous shale.	5 "
4. Concretionary bed of impure sandy iron-stone; too sandy to be of value as an iron ore.	1/2 "
5. Drab argillaceous shale, with small iron-stone concretions	4 1/2 "
6. Coal K. Not of very good quality.	0 to 2 1/2 "
7. Fire-clay	1/2 "
8. Bluish colored shale, with iron-stone concretions. (To railroad track).	10 "
9. Compact grey and buff sandstone	7 "

In the next cut west Coal L is exposed, but its precise thickness could not be determined. The bituminous slate overlying it, containing *Lingula mytiloides*, is only four inches thick.

In the second cut west, however, the coal was well exposed, displaying a thickness of twenty-one inches. The coal is about level with the railroad track, which descends rapidly towards the west. At seventeen feet below the coal a bed of limestone, one of the superior members of the Chester Group, is exposed. The Bee Spring sandstone caps the hill, occupying a position about fifty-five feet above the coal.

It also caps the hills from the seventy-ninth mile-post to Caneyville. About one quarter of a mile east of the latter place the rocks are faulted twice. At the first fault, opposite the bridge over Bennett's Fork, the Chester limestone is brought up to a level nearly with the sandstone capping the hill on the west side of Caneyville.

The limestone coming below Coal L is forty-four feet above the road, with a thin sandstone interposed between it and the coal. The section is as follows:

1. Twenty feet slope strewn with sandstone fragments.
2. Five feet soft buff sandstone.
3. Ten feet covered space; all sandstone?
4. Fifteen feet irregularly-bedded limestone, abounding in fossils pertaining to the Chester Group.
5. Forty-four feet covered space to the railroad.

Just before reaching Caneyville, and at the town, there is another fault, a down-throw. All the faults hade westward.

Caneyville lies in a valley coursing about north and south, the valley being apparently the sequence of a fault. Sand-

stone is exposed on the ridges both on the east and the west. The sandstone on the west seems to lie in its true position, but that on the east seems to be thrown down. On the hill at Mr. Stephen Bond's, at the north end of Caneyville, the sandstone has been quarried. It makes a handsome and endurable building stone.

From Caneyville to Spring Lick the rocks lie horizontally, the Bee Spring sandstone still acting as the capping of the hills. On Jas. S. Carroll's land, three eighths of a mile north of the "Wolf-pen Tank" on the railroad, Coal K has been opened. The coal is about twenty-six inches thick, covered by six inches of soft blue clay filled with plants, among which *Cordaites*, *Lepidodendron*, and *Sigillaria* were recognized. At sixteen feet above the coal the Bee Spring sandstone is exposed.

At Spring Lick, on Mr. Russell Renfrow's land, Coal L is seen, exhibiting a thickness of eleven inches or more.

The following section was made near Spring Lick, commencing on the hills about one mile and a quarter west of north of Mr. Renfrow's house, and proceeding south to the railroad:

1. Eleven feet sandstone weathering with a honey-combed appearance.
2. Twenty-five feet covered space; probably shale.
3. Fifteen feet soft sandstone.
4. Seventy-five feet covered space.
5. Five feet sandstone.
6. Twenty-two feet covered space.
7. Three feet ochreous clay.
8. Seven inches hard, brittle coal.
9. One foot fire-clay.
10. Twenty-six feet covered space.
11. Seven feet very thinly laminated, hard, sandy shale.
12. Twenty feet sandstone.
13. Twenty feet shale.
14. Four inches bituminous slate.
15. Eleven inches coal.
16. One foot fire-clay.
17. Five feet covered space.
18. Limestone of the Chester Group.

It is probable that the Coal No. 8 is Coal K. The rocks dip west from Mr. Renfrow's, the coal seen at his dwelling passing below the railroad. It was reached in a well dug at Spring Lick Station, which showed it to be ten feet below the railroad at that point.

On Mr. Evan Rodgers' land, one quarter of a mile north 35° east from the bridge over Spring Lick Run, two thin beds of coal are found, occupying a position above that at Spring Lick. The upper coal is regarded as a local bed, at least not having any very extended area; the lower one is probably Coal K.

The following section shows the position the two beds hold towards each other:

1. Three feet buff, brown, and drab sandstone.
2. Two feet ochreous and blue clay.
3. Four inches brashy coal.
4. One foot plastic fire-clay.
5. Fifteen feet ochreous and blue shale, with sandy concretions.
6. Four inches hard, sandy shale.
7. Fourteen inches coal.
8. Ten feet sandy and argillaceous shale.
9. Sandstone; the first above Coal L.

From Spring Lick to Ferguson's Station, which is at the ninety-third mile-post, the rocks are nearly horizontal, but undergo several local modifications.

The Bee Spring sandstone is pretty persistent; but the first sandstone above Coal L passes into shale, and Coal K thins to an inch or so, and finally disappears at some point between mile-posts ninety and ninety-one. On the hill opposite the ninety-first mile-post about forty-five feet of bluish-grey sandy shale is exposed, the bottom level with the railroad track, with about seventy-five feet of sandstone still above.

It does appear here as if the Bee Spring sandstone had disappeared or passed into shale, with the sandstone, which occupies a position above it, come to view.

At Ferguson's Station the shale is exposed in the railroad cut. On the hill back of the store a thin coal, about twelve inches thick, occurs at the top of a sandstone some ten or twelve feet thick.

I am rather doubtful respecting the place of the coal, being inclined to regard it as equivalent either to Coal K or to a thin seam only two inches thick seen running through the shales over the Bee Spring sandstone about half way between Spring Lick and Ferguson's. The top of the sandstone, immediately below the coal, is a mass of *Stigmara fcoides* with

the rootlets attached. On Mr. Jas. Ferguson's land, about one mile and three quarters northeast from the station, several openings in the coal have been made. Two horizons of coal are found as indicated in the following section:

1. Ten feet or more of blue, blue and chocolate colored argillaceous shale.
2. Three feet of coal. The upper three inches of the bed is dull black, with a fracture resembling that of cannel coal. The bottom four inches rash coal made up of the flattened bark of *Sigillaria* and *Stigmara ficoides*. The remainder of the coal is glossy black, close-textured, firm, and of excellent quality.
3. Twenty feet shale.
4. One foot coal.

This coal has been regarded as Coal H, though it is a question whether the conclusion is correct. For the present, however, it will be so considered; at least till more light may be thrown on the subject by future investigations in this region.

There is some confusion existing in regard to the rocks in the locality in question, the information concerning them not being as complete as desirable. This is, in great measure, due to the fact that the sandstones have a great tendency to pass into sandy shale, the change frequently being so abrupt that, without the aid of numerous exposures, the observer is apt to be led astray; also to the fact that at Ferguson's the rocks are dipping south, while towards the east they are horizontal.

Between Ferguson's and Horse Branch, a distance of two miles and a half, rock exposures are rare. The hills on the north recede from the railroad, while the rocks on the southern ridges are so disturbed that, with the limited outcrops, it is a quite difficult matter to connect them.

At the first cut west of the 49th mile-post, seventeen feet of blue sandy shale is exposed, which probably is a continuation of that seen at Ferguson's Station. It appears to be dipping east. There is reason to believe that the rocks on the southern hills make a wave between Ferguson's and Horse Branch, the crest of the wave occurring somewhere between mile-posts 94 and 95, the rocks falling off towards both Ferguson's and Horse Branch.

On Mr. Wm. M. Miller's land, about south of mile-post 95, a coal bank has been opened. The coal ranges from twenty-

seven inches to two and one half feet in thickness, and is of fair quality. Its bedding, however, is very irregular; slickensides and rolls being predominant features in it. The coal has much the appearance of the three feet bed north of Ferguson's, but there is reason to believe that it occupies a lower horizon. The coal, so far as opened, has a general dip of 9° , course south 60° west. This is a very strong dip, and, if constant, represents a fall of sixteen feet in every hundred, or, approximately, eight hundred and thirty-two feet in a mile. Of course, however, the angle is not constant; but it is undoubtedly persistent for a sufficient distance to bring the coal below the sandstones and shales at Horse Branch.

In the cuts just west of Horse Branch the thick series of sandstones and shales underlying Coal H come to view. The total thickness has been estimated as being from eighty to one hundred feet. The sandstones are very micaceous, loose-textured, quite friable, and curiously cross-laminated. They frequently and abruptly pass into shale, the transition often being so sudden as to escape notice. The series are exposed in the cuts from Horse Branch to Rosine and beyond, exhibiting an alternating system of shale beds and sandstones. The tunnel just east of Rosine is driven through the upper part of the series. From Rosine to mile-post one hundred and four, a distance of five miles, this sandstone is exposed at intervals in the hills and in the railroad cuts. It has a gradual dip to the west, allowing Coal H to come to view at Mr. J. M. Sandifur's house, about one mile and a half a little west of south of Elm Lick.

The coal is exposed in two places there, on the creek; at an old mill site, as a smutty coal of fourteen inches, and in the bank of the creek, about fifteen feet below that, as a good bed two feet thick. A better view of the coal was obtained there than was offered at any other point along the railroad.

A section made in the vicinity exhibits the following arrangement of the strata:

1. Brown and ferruginous shaly sandstone	10 feet.
2. Earthy coal	1 " 2 inches.
3. Sandy shale	4 "
4. Ferruginous shaly sandstone	7 "
5. Covered space, about	3 "
6. Brown disintegrating sandstone	2 "
7. Firm, glossy black, good coal	2 "
8. Blue sandy shale. This is very changeable; it is sometimes grey, soft sandstone, and again passes below into brown sandstone, containing markings resembling <i>Caulerpites</i>	5 "

In digging his well on a point higher than the mill-site, Mr. Sandifur pierced one coal bed of two feet thickness, at eight feet below the surface, and penetrated another, supposed to be the upper bed at the mill-site, at eight feet below that. These are included under the letter H, according to the numbering of the coals adopted in this report.

In the Hines' Mill and Cromwell road, just west of Sandifur's house, the coals found in his well are exposed, as exhibited in the following section:

1. Soft brown disintegrating sandstone	58 feet.
2. Buff and drab clay	1 foot.
3. Coal stain	9 inches.
4. White and ochreous fire-clay	5 feet.
5. Buff to brown micaceous sandy shale, in hard, thin laminæ	5 "
6. Ochreous argillaceous shale	3 "
7. Coal stain	4 "
8. Clay and shale	7 "
9. Covered to level of valley. Level of railroad nearly	10 "

About one quarter of a mile west of Mr. Sandifur's the sandstone No. 1 of the foregoing section is exposed, exhibiting a thickness of forty feet.

Ascending the hill, following the road towards Beaver Dam, additional sandstone is exposed, making the entire thickness in that locality to be about eighty feet. There is great similarity in the physical features of this sandstone and that seen on the railroad between Elm Lick and Rosine, but I scarcely think they are equivalent. It is more probable that the one in question overlies the Rosine sandstone, with Coal H between. Such was the conclusion when the vertical section for this district was constructed.

The sandstone caps the ridge on to Richard Stewart's house, which is about one mile or a little more west of Sandifur's, on the Beaver Dam road.

About one quarter of a mile east of Stewart's a thin coal stain of about two inches, sixty feet below the hill top and thirty feet above the level of the valley, is exposed. The valley at this place is about seven feet lower than the railroad track is at a point near the bridge over the South Fork of Big Muddy Creek. This coal is probably equivalent to the upper bed at Sandifur's. In Stewart's well, on the top of the ridge, eighteen feet below the surface, a thin coal is reported to have been found. Possibly it is an outlier of Coal E.

Sandstone equivalent to that at Sandifur's was found underlying the coal, and penetrated to the depth of twenty feet.

From Stewart's to Beaver Dam the sandstone crops out at intervals; occasionally seen in thin layers and again in massive beds; always soft and with a tendency to disintegrate.

Valleys, which are usually wider towards the railroad than towards the south, frequently cut the ridges, which in many instances recede far from the railroad. Rock exposures are few. In the Hartford and Morgantown road, opposite J. M. Peak's house, and a short distance from the railroad bridge over the South Fork of Big Muddy, the sandstone overlying Coal H is exposed for twenty-five feet, the base being about twenty feet above the bottoms. It seems that the rocks are dipping towards the road.

At the side of the road leading south from Beaver Dam, near Mr. Thomas Stevens' coal bank, Coal E is exposed. It is eighteen inches thick, covered with hard, polished, slabby, bituminous slate, and is of excellent quality. It is about fifty feet below the coal at Stevens' bank, and twenty-five feet above the railroad at Beaver Dam Station. The coal is also found on Mr. J. M. Peak's and on Mr. J. B. Poyner's land. At Mr. Poyner's, which is about one mile and a quarter south 25° east from Beaver Dam, the coal ranges from fourteen to twenty inches in thickness, and is of excellent quality. It is covered by three feet of hard, polished, bituminous slate, abounding in fish scales and spines.

At Mr. Peak's, three quarters of a mile north 25° east of Beaver Dam, the coal is thirteen inches thick, covered by one

foot or more of bituminous slate, with *Cordaïtes* and fish remains. The coal is only fifteen feet above the bottoms at this place; a consequence of the northward dip of the rocks.

The coal is also exposed in the east banks of Rough Creek, at Hartford. The coal there is rotten, varying from four to fourteen inches in thickness, and covered by two feet of smooth, slabby, bituminous slate, containing numerous fish scales of the same species as found at Poyner's and Peak's.

In the Hartford and Beaver Dam road, about one mile and a half from the latter place, a coal stain of fourteen inches is seen, occupying a position below Coal E. It is doubtfully referred to the highest coal at Sandifur's. It is overlaid by twenty-five feet of shale and sandstone, and underlaid by olive and drab sandy shale.

At Mr. Thomas Stevens' coal bank, about three quarters of a mile south of Beaver Dam, Coal D is worked. The coal averages four feet eight inches in thickness, and is of very fair quality. The thin pyritous shale usually accompanying the coal is found in the bank, filled with the typical fossils.

From Stevens' bank to the Taylor coal mine* there is a rapid fall in the rocks, the coal at that place occupying a lower level than the railroad track.

The distance is about one mile, the rocks making a descent of about seventy-five feet in that distance. On the hills back of the Taylor mine the limestone over Coal B makes its appearance, the coal being represented by a mere stain. The "Anvil Rock" sandstone caps the hill.

From the Taylor mine to the McHenry mine, a distance of about two miles and a half, the rocks lie tolerably horizontally, Coal D retaining its position towards the railroad. At McHenry Coals A and B are both found on the hills; neither is fully developed, however. From McHenry to the Lewis Creek tunnel the sandstone overlying Coal D thickens. At the cut immediately west of the Lewis Creek bridge, about half a mile west of the 113th mile-post, it is exposed, displaying a thickness of fifty-five feet.

*This coal mine, with others along the road, is noticed in another chapter.

At the Lewis Creek tunnel, which is but a short distance east of mile-post 115, two thin coals are seen, which are referable to Coal A.

The following section displays the arrangement of the strata:

1. Shale with thin beds of carbonate of iron	24	feet.
2. Bituminous slate.	3	"
3. Coal	1	"
4. Shale; black and bituminous, shading into slate	9	"
5. Coal	2	"
6. Clay with pyritous concretions.	1½	"
7. Clay and coal	½	"
8. Hard clayey shale with large pyritous concretions.	4½	"
9. Limestone; impure, ashy-blue mottled with white. Local?	2	"
10. Drab shale with nodules of sandy iron-stone.	3	"
11. Limestone; very nodular. To railroad	5	"

Between Lewis Creek tunnel and Rockport the rocks extend in a series of undulations, and are faulted several times, ending with a down-throw at Green river.

The first fault occurs a short distance east of mile-post 116, the Anvil Rock falling to a level with the railroad.

At the first cut east of Rockport the rocks are much disturbed, the strata being contorted and crushed in a singular manner. At the extreme eastern end of the cut, a six-inch coal smut, underlaid by fire-clay, is exposed level with the railroad track. Taking a wave-like dip to the west, it is lost to sight for a short distance, but makes its appearance once more at the west end of the cut. A slight fault, or rather fracture, occurs there, and the coal takes a sudden dip to the west, disappearing below the railroad.

Between the above mentioned cut and the one near the depot building at Rockport there is sufficient rise in the rocks to bring up Coal B, which is exposed as a thin bed at that place.

The following section exhibits the structure of the eastern end of the cut:

1. "Anvil Rock" sandstone.	10	feet.
2. Sandy shale	1	foot.
3. Clay and coal.		6 inches.
4. Blue clay.	2	feet.
5. Limestone, containing <i>Prod. Prattianus</i>	1	foot.
6. Shale and marlite	2	feet.

7. Limestone; rough, irregularly-bedded, abounding in fossils, viz: *Spirifer cameratus*, *Spr. plano-convexus*, *Chonetes Smithii*, *Archæocidaris megastylus*, etc. 6 inches to 3 feet.
8. Dark argillaceous shale 1 foot.
9. Coal 7 inches.
10. Blue and yellowish argillaceous shale, with ochreous concretions about the middle. Calcareous nodules are distributed through the lower part. 8 feet.
11. Earthy limestone 1 foot 6 inches.
12. Sandstone and shale to the railroad.

This section is of interest as showing the presence of limestone below coal B, which is represented by the thin coal No. 9.

Excepting No. 1, all the strata on the south side of the cut, down to No. 12, lie horizontally till they near the west end. On the north they dip slightly to the west. At the west end the sandstone is brought down by a fault, crushing down the underlying rocks, and resembling a wedge. At the river, a short distance beyond the cut, it is horizontal, standing out in a vertical escarpment, the mass presenting a thickness of forty feet.

Beyond Green river, in Muhlenburg county, the Anvil Rock and associate coals still continue to furnish exposures, extending in a series of waves to within a mile or two of Greenville.

At Paine's mines, about one quarter of a mile north of Green River Station, Coal A has been worked at a thickness of six feet, the coal being reached by drifting. The thickness is said, however, to be very variable, ranging from one to six feet. The drift having been deserted, was in such a bad condition that it could not be entered.

In the first cut west of Green River Station the sandstone underlying Coal B is exposed.

Coal C makes its appearance as a streak of three inches, included between the upper beds of the sandstone.

From Green river to within a short distance of the Richmond mines, a distance of nearly two miles, the rocks are regular and retain their horizontality.

Between the two points, at the old mines of Collier and Woodcox, opposite the 118th mile-post, Coals A and B have each been worked. Coal A is five feet thick, immediately overlaid by the Anvil Rock.

Coal B is also five feet thick, and occupies a position five feet below Coal A.

From these mines to the Richmond mines, a distance of not quite half a mile, gentle hills are seen on either side of the road, with occasional intervening valleys.

Near the Richmond mines the strata are found to have experienced peculiar changes. Coal A has dwindled to a few inches, Coal B has also thinned materially, while Coal C has thickened remarkably, displaying a thickness of two and a half feet at the mines; farther west, however, it commences to thin, and in a short distance finally disappears.

Coal D, the working coal at the mines, is reached at ninety-five feet below the bed of the railroad. In the three miles included between mile-posts 119 and 122, the rocks, though apparently horizontal, make a slight undulation, dipping first to the west and then rising, thus bringing the Anvil Rock sandstone on a level with the railroad between the points, but allowing the first underlying coals to come to view at either end.

At the first large cut west of the 119th mile-post the sandstone displays a thickness of from forty-five to fifty-five feet.

At Nelson Creek Station Coal A has been estimated to lie at from eighteen to thirty-five feet below the surface, depending altogether on the nature of the ground.

At the cut on which mile-post 122 stands the rocks rise, allowing the shale under the Anvil Rock to come to view.

The rocks here present some remarkable changes, both physically and in position. The major part of the cut is through sandstone. Towards the west end, however, this rises, or more truly seems to thin from below, and a medley of clay and shales comes to view.

Coal A is represented by a few patches and thin streaks of coal in the base of the sandstone. Towards the west these eventually split off from the sandstone, and traverse the shale for a short distance, gradually disappearing as mere threads. Then a sandy limestone makes its appearance, varying from twelve to eighteen inches in thickness, which, after a series

of irregular undulations, also disappears towards the west. Figure 1, plate 4, represents a hasty sketch of the cut.

The limestone is argillaceous, quite ferruginous, and somewhat sandy. It resembles the limestones at Lewis Creek tunnel, and is probably of local origin.

It is probable that the irregularities in the bedding of the strata at the cut are caused by a slight fault; the rocks beyond the cut west seem to make a drop of a few feet, and then fall gently to the west.

At Owensboro Junction the centre of the coal basin, as it is noted along the line of the railroad, is reached. Coals A and B occur about on a level with the railroad. A number of mines have been opened in either the one or the other bed at the town. These are mentioned in a succeeding chapter.

From Owensboro Junction the rocks and coals rise rapidly to the west, Coal B, which is level with the road at the Junction, being about thirty-five feet above the railroad at Mercer's mines, a distance of three miles. This is not all of the rise, however; the railroad ascends eight feet, making the total rise to be forty-three feet. From Mercer's to the Muhlenburg mines the rise is still more rapid. The distance is not quite a mile, the rocks taking a rise of fifty-four feet, still ascending towards the west till they disappear. The effect of this rapid ascent of the strata is seen at Greenville and vicinity, where the lower series, from Coal D to Coal F, come to view. It seems, in fact, that the explanation is to be found in a faulting of the rocks just east of Greenville.

In the town of Greenville Coal F is exposed in a ravine back of the "Reno House."

A section made to include the rocks in the immediate vicinity of the town is as follows:

1. Ten feet or more of soft, ferruginous, disintegrating sandstone capping the high points in the immediate vicinity of the town.
2. Fourteen inches of coal dirt. Coal F.
3. One foot of fire-clay.
4. Five feet of sandstone and shale, with ochreous concretions.
5. Three feet of mottled blue, dove and drab, somewhat nodular limestone.
6. Twenty-five feet or more of soft sandstone.

The limestone number 5 undergoes some remarkable and sudden changes. Where first seen, in the ravine back of the "Reno House," it was noted as a heavy-bedded, somewhat nodular limestone, coming immediately under the coal. On the road towards the depot, it is a breccia of sandstone and limestone, gradually shading into sandstone. Then on the Russellville road, at the south part of the town, it presents the appearance of a good, compact limestone. It is very probable that the rock is peculiar to the district around Greenville; certainly having a limited area as far as regards the region adjacent the railroad.

About half a mile southwest of the station, up a little ravine, the place for Coal E is found. It is only represented by the overlying bituminous slate.

On the Madisonville road, about one mile in an easterly course from "Rickett's Orchard," the same slate is exposed. The coal is represented by a mere stain.

The following section includes the rocks immediately associated with the slate at that place:

1. Three feet bituminous slate.
2. Eighteen inches clay, with a thin coal stain.
3. Three feet white sandstone, resulting from fire-clay.
4. Ten feet or more of shale, with occasional thin layers of sandstone, and large, heavy, dark blue ferruginous sandstone concretions.

In the cut just east of Greenville, a curious instance of cross-bedding in sandstone is to be seen. Figure 2, plate 4, represents a rough sketch of the sandstone. Besides the remarkable cross-lamination and bedding, there appears to be a fault there, the sandstone at the east end belonging above that at the west.

Beyond Greenville the rocks are horizontal, but with a higher series come to view. Coals D and E are both found in the hills.

At Gordon's Station Coal D is worked at the several mines located there. It is in the hills high above the railroad. On the old "Lucket farm," below the railroad, Coal E is exposed.

The following section exhibits the order in the strata at Gordon's Station and vicinity, commencing at Estill's coal

bank, and descending to the level of the valley south of the road:

1. Sandstone, about	25 feet.	
2. Sandy shale	25 "	
3. Heavy ferruginous limestone, containing small <i>gasteropods</i>	20 "	2 inches.
4. Sandy shale	20 "	
5. Black bituminous slate	1½ "	
6. Coal D	4 "	10 "
7. Mostly covered space; notably sandstone.	40 "	
8. Hard, blue, pyritiferous limestone	6 "	
9. Mostly covered space; sandstone outcroppings	25 "	
10. Sandstone	15 "	
11. Sandy shale	15 "	
12. Bituminous slate	10 "	
13. Coal E	1½ "	

Beyond Gordon's Station, at a point between mile-posts 137 and 138, there is apparently a fracture in the rocks, the coals dipping rapidly to the west so as to pass below Coal B at Pond river, where it is thirteen feet above the bed of the railroad at the bridge.

The distance is six miles, and the fall is one hundred and forty-five feet, a little more than twenty-four feet to the mile.

Down the river from Bakersport, about half a mile below the railroad bridge, Coals A and B are exposed on land belonging to Föbel and Krauth. Coal B has been worked to a limited extent, the mine being entered by a drift. Coal A displays a thickness of five feet, and Coal B a thickness of four feet ten inches.

The two beds are separated by sixteen inches of limestone. At Bakersport, on the west bank of Pond river, the limestone displays a thickness of six feet, showing a remarkable thickening (for that especial rock) in the short distance separating the two points.

From Bakersport to Nortonville the rocks are nearly horizontal, Coals A and B occasionally outcropping on the southern hills.

At Nortonville a heavy fault is met with. In fact, the town seems to stand on the eastern limits of a series of faults, some of them coursing in a northerly direction, and others coursing about south 55° west.

These latter faults, however, are not immediately in the vicinity of the road at Nortonville, but are some distance to the north and south of it.

The main fault, which seems to be a down-throw, crosses the road a short distance west of the town.

At Mr. Wm. Mills' coal bank, about one quarter of a mile north of Nortonville, on the east side of the St. Louis and Southeastern Railway, Coal B has been worked, and has been estimated as being about level with the Louisville, Paducah, and Southwestern track at the town.

West of the town, on the west side of the St. Louis and Southeastern Railway, the sandstone overlying Coal D is exposed.

The coal does not crop out, however, so far as known, at any place in the vicinity of the town.

The amount of down-throw is from sixty to eighty-five feet. From this main fault the rocks and coals seem to rise in a series of curious step like faults.

In representing these faults in the horizontal section there is a degree of uncertainty as to the exact location of the line of the fractures. The exposures are not continuous in the hills, and small valleys are frequent; consequently, the whereabouts of the fractures had to be estimated. As the horizontal section is not represented as being an *absolutely* correct one, however, but is to be subject to future corrections, acting as a preliminary basis for studying the geological structure of the region across which it is taken, any mistakes, if there be any, will be easily remedied.

The faults in question extend from a short distance beyond mile-post 152 to Rocky Gap. Beyond the Gap the rocks make a drop of about twenty-five feet, Coal D lying at about ten feet above the bed of the road. It then rises towards Underwood, lying about level with the road there, and then makes a slight bend to the west to Caney Fork of Tradewater.

Near Thos. G. Davis's house the sandstone overlying the coal is exposed on each side of the valley of Caney Fork, standing out in heavy cliffs.

At the centre of the valley it is brought down by a fault, crushing the coal up at that point.

The rocks rise from the middle of the valley, both to the east and west, assuming a comparatively horizontal position within a short distance of either side of it.

This fracture in the rocks at Davis's is no doubt an associate of the faults at the Caney Creek mines, discussed in a succeeding chapter.*

As intimated, the strata in the vicinity of the Caney Creek mines exhibit a series of disturbances; but in general the rocks from those mines to Woodruff lie horizontally east and west, *rising* towards the *north*, however. The rocks on the southern hills, however, *dip* towards the north, a lower series coming to view than is to be found in the northern hills. In fact, it appears that the railroad from Caney Creek to within three or four miles of Tradewater passes along the trough of a fault, the course of which is about north 55° east.

On the north side of the road, to within two miles (perhaps a little more) of Tradewater Station, the high coals cap the hills, dipping towards the road, while on the south coals as low as Coal J are exposed.

The hills on either side of the railroad are in many instances quite distant from each other, so that the coals on the south are apparently, so far as their topographical position would imply, identical with those on the north, while in reality they belong below. The coals on either side, as previously intimated, dip towards the road, those on the north having the greatest fall. The existence of the fault in question does not seem to have been noticed by the majority of those making investigations in the region, and, as a consequence, much confusion and perplexity has ensued. The attempt has been made to connect the beds as exposed on the north and south with each other; of course resulting in failure. An illustration of the topographical relation the coals in question bear to each other is to be found in the vicinity of the St. Charles

* The singular position of the rocks at Davis's suggests that they may have been faulted by the undermining by water of the lower strata.

mines. The coal worked at the mines is Coal D, occupying a position (as measured from the mines) about thirty-two feet above the railroad. On the hills south of the road, on Mr. Childer's land, opposite the mines, Coal I crops out with the limestone lying forty feet above Coal J, also exposed, both dipping northwardly.

These occupy a position about sixty feet above the road, measuring the distance from their place of outcropping to the railroad. Were they extended to the road, however, the distance would be diminished considerably.

The coal at the St. Charles mines dips south 30° east, at the rate of three feet in the hundred; this is sufficient to bring it about level with the road, did it extend so far.

Not perceiving the fault, these coals have been regarded by some as identical, who thus commit a serious mistake.

The coal on the south having been recognized as No. 4 of Dr. Owen, by those acquainted with the coals in Union county, they have considered that at the Caney Creek and St. Charles mines to be No. 4 also, when, in fact, it is his No. 9, or Coal D, according to the nomenclature adopted in this report.

In studying this district the two regions lying to the north and south of the road should be kept distinct.

Taking the limestone previously mentioned, which is probably equivalent to the "Curlew limestone" of Dr. Owen, as the starting point on the south, and allowing for the dip, there will be no difficulty in locating the different coal beds towards the south; but when the attempt is made to build conclusions for the country north of the road, based on what may be seen on the south, it will inevitably lead to error.

It has been previously stated that the railroad followed the trough of the fault. The statement was intended to be general in its character: the fault has a general course south 55° to 80° west, while the road runs nearly west; following the valley, however, which is probably a sequence of the fault.

Beyond the St. Charles mines the hills are, in the greatest number of instances, quite distant from each other, with the rocks still retaining their synclinal dip.

Consequent on the curves in the course of the road the rocks are sometimes level with, and again above it.

The rocks associated with Coal D extend a considerable distance beyond St. Charles, but finally disappear from view beyond Hamby's Station, and the connection between them and the lower ones is lost.

On the south side of the road, however, Coals I and J may be followed until the connection with Coal L is made. On the horizontal section, therefore, a gap of about three quarters of a mile was left to avoid producing confusion, and the geology then drawn in as it is presented on the southern hills.

In Dr. Woodruff's lane, about half a mile in a northwesterly direction from Woodruff, Coals A and B crop out, with two feet of limestone between them.

The coals are about three hundred yards north of the railroad, and ten feet above the track, brought down by the rapid dip mentioned heretofore.

The sandstone overlying Coal D is seen on Cane Run, a short distance away from Coals A and B. Starting at these Coals (A and B), and following up Cane Run to the old Pritchett farm, the sandstone is in view all the way, rising rapidly to the north.

At the Pritchett farm it constitutes the backbone of the ridge (one of the spurs of Wright's Mountain?) Pursuing an irregular westerly course from there, following the ridge, the sandstone is traced to Hamby's Station.

On Sandstone Branch (between Cane Run and Rocky Mt. Branch), half a mile east of Hamby's Station, it is exposed in heavy beds, some thirty feet thick.

On Rocky Mt. Branch, at the crossing of the Princeton and Greenville road, about half a mile north of Hamby's Station, it is seen presenting a thickness of from thirty to forty feet.

At Mr. John Day's, a short distance up the branch from the Greenville road, the same rock is seen with a coal bed about ten feet above it. The thickness of the coal was not known.

On Mr. Dixon Wright's land, about one mile and a half north 24° west of Hamby's Station, coal also occupying a

position above the sandstone (probably equivalent to that at Day's) is found. It is of excellent quality, so much as could be seen, which was only two feet, the base not being exposed.

Coal is exposed in a number of places on Mr. Wright's property. At one place, where measured, it was found to be five feet thick. It is reported to be seven feet thick near Mr. Wright's house. This coal and that on Mr. Thomas Crabtree's place, about two and a half miles north of the railroad bridge over Sugar Creek, is in all probability Coal A. It is of good quality, and underlies a large area of the country.

At Capt. John Hamby's house, which is about half a mile in a northeasterly direction from mile-post 160, sandstone is exposed, which is probably equivalent to that overlying Coal D. A bed of coal is reported to occur above the sandstone. It was penetrated two feet, but not passed through.

On Captain Hamby's land, about two hundred yards west of the 160th mile-post, north of the railroad, a well dug to the depth of twenty-two feet exposes sandy shale very like that overlying Coal D. It is quite probable that coal is to be found within a short depth. Beyond Captain Hamby's house, the sandstone traced from St. Charles mines is lost to view, the country merging into flat land.

Farther north, however, at Mr. Dutch Woodruff's coal bank, Coal D is exposed and has been worked.

Consequent on its rise to the north the coal is high in the hill, with another bed two feet thick and most excellent in quality at from fifty to sixty feet below it.

On the old Breathitt farm* on the south side of the road, about two hundred yards west of mile-post 160, the limestone above Coal J crops out. It is about fifteen feet above the level of the valley, indicating that the coal should be found at about twenty feet below the surface.

Half a mile south of the mile-post, also on the Breathitt place (south of the house), Coal I has been partially opened. Its entire thickness could not be seen; it is reported to be

* Now owned by Col. Gano Henry.

three feet. The coal is hard, glossy black, and at its exposure appeared to be most admirable in quality.

In a hill about four hundred yards south of the railroad, about three quarters of a mile east of Murray's switch, Coal J is found. Only the upper part was exposed, so that its precise thickness could not be ascertained by actual measurement. It is reported to be four and a half feet thick, which measurement agrees very well with other reports.

The limestone is seen on the hill at forty feet above the coal, the intervening space being taken up by sandstone and shale. The coal is one hundred feet above the valley of Caney Creek, on which stream an outcrop of sandstone is seen, which is probably the top of the conglomerate, or the first sandstone above it.

At Tradewater Station the conglomerate and associate coals make their appearance. The conglomerate is about eighty-five feet thick, and is exposed in the cuts at the station and in the hills. At Mr. Alexander's, about half a mile south 50° east from the station, Coal L has been worked, and is reported to be two and a half feet thick.

According to barometrical measurements, the coal should be found at from ten to twenty feet above the level of the railroad at the station.

At "Coal Ford," on Tradewater, the coal crops out in the west bank of the stream, showing a thickness of four feet (scant). The coal dips north 20° west, at an angle of about 2°; the situation of the bed is such that the angle of dip could not be accurately determined with the means at hand.

During time of low water in the river a coal lying below the conglomerate may be seen in the bed of the stream. Its thickness has never been ascertained.

Beyond Tradewater, the conglomerate forms the geological features along the road for several miles, disappearing at some point near the 171st mile-post. The exact limit of its western extension was not definitely ascertained, however, the time necessary for so doing not being convenient; nor was it considered necessary for the usefulness of the work in hand that it should be done at this time. When the question of the

mineral wealth of Caldwell and adjoining counties comes to be considered, it certainly will be very important that its exact limits should be defined, on account of the coals, and possibly iron ores, associated with it.

The first exposure of the rocks underlying the conglomerate, the Chester Group, is seen a short distance east of the 171st mile-post.

The limestones, alternating with shales, are exposed at intervals on to the first cut west of mile-post 172.

At that cut sandstones and shales occupying the position of the Big Clifty sandstone,* lying at the base of the Chester Group, come to view.†

They are exposed in the two succeeding cuts, dipping at a high angle, nearly 45°, north 60° east. The total thickness is about two hundred feet.

The upper members of the St. Louis Group appear at the cut where mile-post 173 stands. Here the rocks dip south 60° west, at an angle of 2°. It will be noticed that this is the reverse of the dip at the cut where the Big Clifty sandstone is exposed. The axis of the anticlinal is about six hundred feet east of the 173d mile-post.

From this point to Princeton the members of the upper division of the St. Louis Group are exposed, assuming comparative horizontality near Scottsburg, and retaining it, with slight variation, on to Princeton and beyond.

At Princeton and vicinity fine exposures of the group are obtained, nearly all the beds, from the top of the series to the blue limestone of the second division, appearing in the hills back of the town and in the railroad cuts.

The following section was constructed to include the rocks in the vicinity of the town:‡

- | | |
|---|---------|
| 1. Drab limestone in heavy beds; the upper members rather coarse-grained, bluish-drab in color, with shale partings; the lower members fine-grained, even-textured, and compact | 35 feet |
|---|---------|

*See general section of the Chester Group.

†To avoid a redundancy of names, the name "Big Clifty sandstone" will be retained for this series of sandstones, &c., though differing physically from the sandstone seen in Grayson county, where it received its name.

‡The "Big Clifty sandstone" is exposed in the hills north of Princeton, but was not included in the section.

2. Somewhat argillaceous, bluish-colored limestone, containing <i>Orthis dubia</i> ?	5 feet.
3. Moderately fine-grained, bluish-drab limestone, abounding in small <i>Bellerophons</i> and small <i>Pentremites</i>	5 "
4. Coarse-grained blue limestone; abounds in <i>Productus elegans</i> , <i>Prod. cora</i> , <i>Retzia vera</i> , etc.	15 "
5. Dark blue, fetid, impure limestone	2 "
6. Blue, coarse limestone	15 "
7. Greenish calcareous shale	3 "
8. Thin-bedded argillaceous limestone	2 "
9. Grey and oölitic limestone, with chert	20 "
10. Oölitic limestone	10 "

No. 10 is quarried by the Messrs. McElfatrick at Princeton.

The stone is a most admirable material for fine structures, being both beautiful in appearance and durable in quality.

In fact, for all structural purposes this oölite (not particularly at this quarry, but in the entire region) can scarcely be surpassed by any of the lower carboniferous limestones. Beyond Princeton the rocks are comparatively horizontal, extending to the Tennessee river.

The Geodiferous limestone is exposed in the first cut east of the 182d mile-post, and forms the surface structure of the country on to the western limit of the carboniferous formation. Beyond Eddyville it has been eroded in places, and the channels thus made filled by drift deposits.

These places are indicated in the horizontal section accompanying the report, and do not need special description here.

The cut at mile-post 196 is of peculiar interest, the drift deposits, through which it is made, bearing large masses of fine limonite.

This is on the land of Governor Charles Anderson, who has quarried considerable ore from the cut. There is, indeed, a belt of country between the Cumberland and Tennessee rivers, and also somewhat to the east of them, which affords an abundance of very fine limonite.*

From the 196th mile-post to the Tennessee river the limestone is exposed at intervals. At the cut at the eastern end of the Tennessee river trestle it exhibits a thickness of fifty feet, lying horizontally, suddenly terminating at the river.

Beyond Tennessee river, extending to Paducah, the country is flat and covered with post-tertiary deposits.

*As the study of the iron interests of the State is in charge of Mr. Moore, the subject will not be commented on here, more than to state that there appears to be a large area in this region, accessible to the railroad or rivers, productive of the ore.

CHAPTER III.

MINES AND MINING.

The present mode of mining in our western coal field is, in many instances, defective; or it would, perhaps, be nearer the mark to say that the application of the system adopted is not so uniform or thorough as it should be.

It is true the mines are yet comparatively new, and many improvements may yet be introduced; indeed they must necessarily be adopted, that Kentucky may assume the position among the coal-producing States that she deserves. For, with capital to develop it, there is no question that in her wealth of coal she ranks among the first.

Too little care has been had for the future prosperity of the mines. Had they been opened with skill, and properly equipped with machinery at the very start, much money would have been saved that otherwise has been expended in the way of repairs, etc.

Now that these facts are becoming evident to the operators, and skilled men are given charge of the mines, the importance of improvements is acknowledged, and efforts are made to remedy the evils perpetrated by former managers.

It must not be understood that *all* the mines are here referred to; on the contrary, some of them were opened with care, and one or two are handsomely equipped.

There are in all some fifteen or twenty mines in operation along the line of the railroad, in immediate connection with the track, from all of which coal is shipped. There are, besides, a number of mines worked on a modest scale, and outcroppings of coal in the region adjacent the road, which may be connected with it by tramways, or else by side-tracks.

Though considered of but little importance at present, no doubt they will increase in value, and the coal be mined for exportation, when the Kentucky coal has taken its proper place in the different markets.

The following list embraces the important mines along the route, with the distance between each:*

Name of mine.	Distance in miles and tenths.
Taylor Mine*	
Render	1.7
McHenry	.8
Rockport	4.5
Richmond	2.9
Louisville and Stroud City	7.5
Ross	
St. Louis Coal Company's	.5
Cypress	1.4
Coppage	1.1
Mercer's	.1
Muhlenburg	1.0
Gordon Coal and Mining Company	6.2
Quinn's	
Arbuckle's	
Caney Creek	18.4
St. Charles	1.8

*This mine is 108½ miles from Louisville.

Out of this number certain ones may be selected as being worked on a more extensive scale than the others. These are the Taylor, Render, McHenry, Richmond, Louisville and Stroud City, Coppage, Mercer's, Muhlenburg, Caney Creek, and St. Charles.†

System of Mining.—The mines are all operated on the same general plan, that known as the *pillar-and-chamber* or *post-and-stall* system, as it is variously termed.

The rooms are turned at every thirty feet along the entry, and are eighteen feet wide, leaving a *pillar* of twelve feet and a *stump* of twenty-two feet. They are usually driven through from entry to entry, cross-cuts being made at intervals to facilitate the passage of air and expedite the removal of the coal as it is mined. The *main entries* are usually eight feet wide, and the side-entries (cross-entries) six feet in width.

In turning the rooms the entry is kept at a uniform width, usually six to eight feet, for twelve feet in; the rooms are then

*The distances are taken from a list of stations kindly furnished by the engineer's office of the Louisville, Paducah and Southwestern Railroad.

†The "St. Louis Company" were sinking a shaft when their locality was examined, and so were not fairly under way. See notice in another chapter.

widened out, either on both sides or altogether on one side, to the full proportions intended. There are modifications to the dimensions as given, but these hold true in a general application.

Plate 5 is a fair representation of the plan as it is operated in this coal field.

There are, of course, changes made in the direction of the drifts, etc., to suit local requirements, depending on the drainage, means of ventilation, depth from surface, etc., at the various mines.

It has been the custom to *pull* the pillars at an early stage of the workings at some mines, while at others they are left standing a considerable time before being removed; the whole matter, so far as I am aware, depending on the fancy of the inside manager.

This leads to the question, why cannot the *long-wall* system be introduced with success? There certainly are localities where it may be adopted.

The great advantage to be derived from it is the simplicity of plan, ease of ventilation, and increased proportion of *lump* coal to *nut* and *slack*, an item of great importance in mining our soft coal.

Mr. Warington W. Smyth,* in his excellent work on "Coal and Coal Mining," speaks in commendatory terms of the application of the long-wall system to coals of six to nine feet thick; not considering it indispensable, however, that they should be of that thickness only.

In suggesting this plan heretofore to some of the superintendents of our mines, objections were raised in instances where the roof was not good.

Mr. Smyth, whose position and range of observation has enabled him to speak authoritatively on the subject, says: "Nor is it necessary that the roof be good, although the expense will be very different according to its general fragility; but if operations be carried with sufficient smartness to push the working-place daily under a fresh or 'green' roof, it may

*Chief Inspector of the Mines of the Crown (England) and of the Duchy of Cornwall.

be managed on this system, even when composed of *mere fire-clay with slippery joints*."

This is a strong recommendation, and as the roof is very seldom bad in any of our mines (excepting a few instances where Coal B is worked), there should be no objection on that score.

The economy of the system is manifest, both in the diminished cost of driving entries, in the increased yield of good coal, and in the additional safety to the miners.

It is a well known fact that when the pillars are *pulled*, after standing for any time, it is always accompanied with danger.

The long-wall system has, according to Mr. Smyth, been successfully applied even in the deepest Durham collieries.

It is hoped that the superintendents of our mines will yet give the matter their serious attention; they can yet change their present system into the *long workings*, and as a matter of economy it certainly seems advisable.

The majority of the mines are opened by drifting, the drift entering the hill either as a *slope* or a *level*. In some instances two good and distinct coals may be mined in a single locality; one by drifting and the other by shallow shafting.

In the majority of cases, where the coal is mined by drifting, the bed is sufficiently high in the hill for the coal to be drawn immediately from the mine to the tipple by the bank mules.

In a few instances, however, the bed and railroad are nearly on the same level, necessitating the use of steam power to elevate the coal to the tipple.

The *tipple* or *tip*, as it is usually termed, is built sufficiently high, about thirty-two feet, to allow a car to be run under the lump screen, and thus facilitate loading.

At the drifts where steam power is used in raising the coal to the tipple it is brought only to the mouth of the mine by mules. There the bank cars are attached to wire ropes passing around a *drum* operated by the engine in the tip-house, and over a series of rollers placed on an inclined plane, and are thus elevated to the tip; there they are taken charge of, and the coal dumped from the car down an inclined plane

through a chute, which carries it to the *coal flat* standing on the track below.

Where the mouth of the drift is level with the tip, or nearly so, the bank cars are carried directly to the tip by the mules.

Screens.—It is an undeniable fact that the coal from the mines in general in this coal field is not cleaned as thoroughly as it should be. The distance between the bars in the screens is not sufficient at many of the mines. In the large screen it should be at least one and three fourths inches, the maximum two inches, and in the smaller one, one half inch. The usual distances in the large screens, as now constructed, are one and one fourth and one and one half inches.

It is a mistake that the spaces between the bars are not enlarged; the increased sales of the coal consequent on its being cleaner would amply repay any additional expense attending the alteration.

The Kentucky coal is a soft coal, and under much handling makes considerable slack. We have a good coal to compete with in our home markets, and should, therefore, be especially careful to send ours away from the mines in as good condition as possible. This can be accomplished only by thorough screening.

The screens, inclined at an angle of from thirty-five to forty-five degrees, are placed in the tipple, thus loading and screening the coal at one and the same time. As the tips are constructed at present, two screens are used.

The first one (termed the *lump screen*) separates the *lump* from the *nut coal*, which, falling between the bars, drops on a second screen (the *nut screen*), and passing over it, is separated from the slack.

After passing over the lump screen the coal enters a *hopper* (in which the coal is weighed) provided with a gate raising vertically and an *apron* at the end. The apron, which is simply a gate swung horizontally, is for the purpose of running the coal over into the flat. When used, one end is fastened by means of clasps to the sides of the car; the other end being permanently attached to the hopper, it forms a gangway for

the coal to pass over. The hopper of course swings free, and is sustained by iron rods passing up into the weighing-house, and fastened to beams attached to the scales.

When the coal is to be weighed the gate is lowered into the hopper and the apron detached from the car. The coal is then dumped from above, and, after passing over the two screens, the lump enters the hopper, is weighed, and then passed over the apron into the car. The nut enters another car without being weighed.

Where the greatest care is taken to obtain clean coal a screen is placed in the apron, thus getting rid of much of the slack resulting from the bruising of the coal in its passage to the hopper. The plan of having a *third* screen is a good one, and should be adopted at all the mines.

The plan of weighing the coal in a hopper is not the best. An improvement is to have *track* scales, on the platform of which the flat to be loaded is placed.

The hopper is then stationary, or rather done away with, and the coal passes directly into the flat, to be weighed there.

When the coal strikes the gate in the hopper it is naturally broken into smaller lumps, and additional slack made; in its passage to the car it is again bruised, making still more slack; by being allowed to pass without obstruction into the car it suffers but one bruising, and is, therefore, comparatively free from fine coal, etc.

At some mines using track scales the gate is retained, but there is no need for it. Arrangements for keeping each miner's coal distinct could be made in other ways.

Shafts.—When the coal is procured by shafting, steam power is used in all cases.

The pits are usually fourteen and a half feet by six and a half feet in diameter, divided at about the middle by heavy planking into two apartments. Then by a simple arrangement of a revolving drum carrying a wire rope, and operated by the engine, a basket is raised and one lowered at the same time, with the same revolutions of the drum; the loaded bas-

ket passes up on one side while on the other the empty one descends.

The *bank cars* used at the mines are of various capacities. The large size hold thirty bushels; the small size about fourteen bushels.

SOME NOTES ON THE COAL TRADE.

The season of 1874 has been a very dull one in the coal trade of southwest Kentucky.

This was due to a variety of circumstances, the most prominent being the great scarcity of money, which brought down the price of coal everywhere, and also the depressed condition of the principal markets, in consequence of their being overstocked. Another cause acting greatly against the operators was the difficulty experienced in procuring a sufficient number of cars to transport the coal.

When certain mines were supplied with transportation, others were compelled to do without, and thus all the orders received could not be filled. This injured the trade materially, as orders which would have come to the Kentucky miners were of necessity filled by dealers in foreign coal.

It was not because of any partiality entertained by the officers of the Louisville, Paducah and Southwestern Railroad toward any particular mine, nor was it because they were regardless of the coal interests along their road, that affairs were thus. It was because the road was not sufficiently equipped with rolling stock to supply all the mines at one time.

The road was in pecuniary difficulty, and, applying to Louisville in vain for help, nothing could be done for the mines. There is no doubt that had Louisville helped the road when asked, thousands of dollars would have been saved to the State, or have been brought into it, that otherwise went to other coal markets.

The Louisville and Paducah Railroad is eminently a coal-road, running for nearly a hundred miles through a continuous coal field, with mines at intervals along its route for nearly that entire distance. It is the outlet for the Kentucky coal

field to the north and south, east and west, and as such should be sustained.

Connecting as it does with the St. Louis and Southeastern Railway at Nortonville, and the Memphis and Paducah road at Paducah, the greater portion of the South is within reach of our mines. A very fair southern trade was gradually coming within the control of our mines, but it unfortunately received a great check by the delayed action of Louisville in respect to the Louisville, Paducah and Southwestern Railroad. Besides the railroads as means of transportation, we have the Green, Cumberland, and Tennessee rivers.

The Tennessee river is already used as a means of transportation by the St. Bernard Coal Company. A fine tipple has been erected on the river, near the railroad bridge, by that company; from March, 1873, to October, 1874, that company had shipped about three hundred and fifty thousand bushels of coal South.

The principal points in the South to which the coal from the various mines is shipped are Jackson, Tennessee, Jackson, Mississippi, Holly Springs, Oxford, Canton, Water Valley, Mississippi, and Bolivar, Tennessee.

Much effort was made to obtain correct statistics of the amount of coal shipped from the mines, but the returns are quite imperfect. The operators of some of the mines failed to give even imperfect returns.

The following table shows only *approximately* the amount of coal shipped from the mines, dating from October, 1872, to October, 1874: *

COAL EXPORTED.

From the principal mines.		From other mines.		Total.		Value at 12 cents.	Cost at 5 cents.	Balance.
Tons.	Bushels.	Tons.	Bushels.	Tons.	Bushels.			
216,000	5,400,000	54,000	1,350,000	270,000	6,750,000	\$810,000	\$337,500	\$472,500

*A number of the largest mines were not opened until 1873, so that for some of them the table does not represent a two years' business.

Points to which coal was shipped.	Tons.	Bushels.	Value. †	Cost. ‡	Balance.
Louisville*	171,000	4,275,000	\$513,000	\$256,000	\$256,000
South and West	4,000	1,000,000	120,000	60,000	60,000

* This table is also a rough estimate. It is likely that much more coal went to Louisville than is estimated.

† Valued at 12 cents per bushel. The coal sells at from 10 to 14 cents per bushel, however.

‡ The cost is placed at 6 cents per bushel; this for mining, transporting, &c

It must be remembered that scarcely any of the mines had been opened longer than two years when the statistics were obtained, and a few were not more than a year old. The St. Charles mine, the largest one on the road, had been shipping coal for only nineteen months.

The coal interest is an immense one, representing far more capital than many have Estimated. A single mine working thirty miners will pay out about one hundred and twenty-five dollars daily, with a total for one year of about thirty-nine thousand dollars. Multiplying that by ten, which will include all mines working so many as thirty miners, and the total is three hundred and ninety thousand dollars. This, however, is scarcely even an approximately correct estimate, for some of the mines employ as many as one hundred miners, and nearly all are prepared to work sixty.

In fact, it would not be far from the truth to state that the coal mines of southwest Kentucky put as much as five hundred thousand dollars in actual circulation within the State yearly. This amount will, of course, increase as the mines assume more importance and increase in number.

The mines, as stated heretofore, are comparatively young, but it may be seen at a glance that they are a source of great wealth to all western Kentucky, and consequently to the entire State.

CHAPTER IV.

NOTES ON THE MINES.

In the description of coal mines, there is necessarily, where the system is alike in all, much repetition.

There is also a continual advance and change in the extent of the workings, so that a description given now of a mine examined several months ago will not represent its present condition.

It is determined, therefore, to avoid much detail in every case, except when a mine presents some peculiar or interesting feature not existing in others.

The Taylor Mine.—This is the first mine of importance west of Louisville. It is situated about two miles southwest of Beaver Dam, Ohio county, and is connected with the main stem of the railroad by a side-track. The mine is opened in Coal D, which averages five feet in thickness, and is worked by drifting, the drift entering a high hill capped by the Anvil Rock sandstone.

The coal is provided with an excellent roof of dense bituminous slate.

The coal is raised to the tippie by steam power in a manner heretofore described.

No returns were received from this mine for the amount of coal shipped up to October 1st, 1874. Mr. D. L. Sublett, the Superintendent, estimates the amount shipped up to January 1st, 1874, as being 15,832 tons (395,812 bushels). Since then, however, there has been considerable increase in the sales.

An analysis of the coal, made by Dr. Peter and Mr. Talbutt, is as follows:*

Specific gravity	1.315	
Moisture	3.34	
Volatile combustible matter	35.84	
Fixed carbon	54.36	} Coke 60.86.
Ash	6.50	
Sulphur	3.826	

The Render Mine.—This mine is opened at Hamilton Station, a few yards south of the railroad.

* This analysis is not of a fairly-averaged specimen.

The number of the coal is the same as that worked at the Taylor mine. The mine is opened by a drift, and the coal raised to the tippie by steam power.

The coal is firm, made up of alternating dull and glossy black layers, with a little fibrous coal between the laminæ. It is an excellent heating coal.*

No returns were received from this mine exhibiting the amount of coal shipped up to October, 1874. From January 1st, 1873, to December 1st, 1873, seven hundred and twelve thousand six hundred and seventy bushels were shipped.

The following section, taken in the mine, exhibits the order in the strata:

1. Hard, blue, pyritous, somewhat sandy shale, with small pyritous nodules . . .	10	feet.
2. Blue, argillo-slaty shale; fossiliferous	1/4	"
3. Bituminous slate	2	"
4. Coal D	4 3/4	"

Mr. Wm. Hamilton, sr., has charge of the mine, with Mr. Briggs as General Superintendent.

The mine is well ventilated, and kept in good order.

The McHenry Mine.—This mine is entered by a slope. The coal, as at the foregoing mines, is raised to the tip by an engine stationed in the tip-house.

The coal has a good reputation, and is gotten out in good order. It is, perhaps, in itself no better than that at the neighboring mines, the cause of its being so valued as a fuel depending on the care taken to get it out in good condition. Samples for analysis were taken from this mine, but were miscarried. Mr. Duncan is the Superintendent.

The Rockport Mine.—This is in the same coal (Coal D) as that worked at the McHenry mine. The bed is reached by a shaft sunk to the depth of eighty feet.

Coal B crops out at ten feet above the top of the shaft, and is said to be four feet thick.†

Above that Coal A is also exposed, said to be two feet in thickness.

At thirty-six feet below the top of the shaft Coal C was passed through—present as a mere streak, however. The

* Samples were collected for analysis, but were miscarried.

† It was not opened at the time the mine was examined.

company have three hundred acres, which, not taking into consideration the two upper beds, will produce one million five hundred and sixty-two thousand five hundred tons of marketable coal—estimating the waste in mining at one third. The three following analyses were made of the coal by Dr. Peter and Mr. Talbutt:

	No. 1.	No. 2.	No. 3.
Specific gravity	1.421	1.332	1.534
Moisture	3.50	3.00	3.00
Volatile combustible matter	35.00	36.20	33.50
Coke	61.50	60.80	63.50
Ash	9.00	7.10	8.40
Fixed carbon	52.50	53.70	55.10
Sulphur	3.39	2.837	3.332

The coal is raised by means of a twenty-five horse power engine, made by Shultz & Thurman, Evansville, Indiana.

The Richmond Mine.—This mine had been opened but a short time when visited, and comparatively little shipping had been done.

I am informed, however, that the managers have completed arrangements to work on a large scale, and will bring their mine up to assume an important position among others. Coal D is the one worked, and is reached by a shaft one hundred and ten feet deep.

The mine is provided with many of the modern appliances used in the West, including a fine engine, operating a drum seven feet in diameter, and every thing is kept in excellent order.

Mr. Aaron Evans is the Superintendent.

Louisville and Stroud City Mine.—This mine was opened December, 1872. Coal B is the bed worked at present, reached by shallow shafting. The company propose, however, to sink a shaft to Coal D.

A coal is reported in a boring at one hundred and sixty feet from the surface, below Coal D, said to be seven feet thick. There must be some mistake in this, however. It is probable that there was either an error in estimating the thickness of

the coal or that a bed of bituminous slate, with perhaps a bed of coal, was penetrated and supposed to be all coal. Coal E is very probably the one penetrated.

Mr. Maddox is the Superintendent.

The Ross Mines.—These are opposite the foregoing. Both Coal A and Coal B are worked by drifting. Coal A is of good quality, and in a good condition for working. Its thickness averages five feet. The following analysis of it was made by Dr. Peter and Mr. Talbutt:

Specific gravity	1.407	
Moisture	4.16	
Volatile combustible matter	37.44	
Fixed carbon	49.80	} Coke 58.40.
Ash	8.60	
Sulphur	2.727	100.00

Coal B is said not to be as badly cut by clay slips, etc., as is usual with that bed. The slips and rolls course north 50° west.

The St. Louis Coal Company's Mines.—This company owns the old "Finch Shafts" (working Coal B), just west of Owensboro Junction. No shipping was going on when the mines were visited. The work of sinking for Coal D was under way, and, according to information given by those at the mine, the old shafts were abandoned.

The Cypress Mine.—No mining was in operation when this mine was visited.

The Coppage Mine.—This mine is opened by a drift. Coal B is the one worked. No report as to the amount of coal shipped could be obtained.

Mercer's Mine.—This mine is worked by a shaft about sixty feet in depth. Coal D is the one mined.

The mine is fairly well ventilated, and much care taken for the health and safety of the miner. The coal is raised by one of John B. Davis's (Cincinnati, O.) forty horse-power engines, operating a drum five feet in diameter.

The arrangements for draining the mine are complete. The water is collected in a sump, six feet in depth, at one part of the mine, as represented in the diagram opposite page 77.

Then by means of a "Knowles A No. 1" steam pump, with a suction pipe three hundred and fifty feet long, in connection with the engine, and an "A No. 1" bucket-and-plunge pump, the mine is kept clear of water.

Attached to the steam pump is a column pipe seventy-five feet high, through which the water is discharged.

The bucket-and-plunge pump forces water upward seventy-five feet into a cistern in the engine-house, for boiler use.

The tip is placed at about thirty-five feet from the shaft. Three screens are attached to it, one for lump, one for nut, and one placed in the apron.

The lump coal consequently passes over three screens, and is as well cleaned as at any mine on the road.

The following is an analysis of the coal, made by Dr. Peter and Mr. Talbutt:

Specific gravity	1.358	
Moisture	3.60	
Volatile combustible matter	34.00	
Fixed carbon	50.60	} Coke 62.40.
Ash	11.80	
Sulphur	4.032	

An interesting feature in this mine is observable in the eastern part. There the bed of a former stream, which had cut a channel through the coal, is found, clay now filling up the gap.

Fragments of trees were found in the clay, when an entry was driven through it. No indication of this old water-course is to be seen on the surface.

Mr. Wm. Mercer is the Superintendent.

The Muhlenburg Mine.—Coal B is the bed worked at this mine, which is entered by a drift.

In some parts of the mine the coal is covered by five and a half feet of bituminous slate. Above that Coal A is found.

The limestone usually present over Coal B is wanting throughout the mine.

The coal is badly cut by clay slips, all having about the same general course, which is north 20° west.

From the condition of Coal B, it seems advisable that it be abandoned for the present, and Coal A be worked. The latter is a better coal, and more uniform in its bedding.

Coal B, however, is of good quality, as the following analyses, by the gentlemen above named, show:

No. 1.		
Specific gravity	1.332	
Moisture	1.52	
Volatile combustible matter	40.00	
Fixed carbon	50.92	} Coke 58.48.
Ash	7.56	
Sulphur	2.840	
	100.00	

No. 2.		
Specific gravity	1.280	
Moisture	2.98	
Volatile combustible matter	43.08	
Fixed carbon	50.22	} Coke 53.94.
Ash	3.72	
Sulphur	3.125	
	100.00	

No. 1 is the upper part of the bed; No. 2 the lower part. Up to October 1st, 1874, about 6,200 tons of coal had been shipped from the mine.

Mr. John Pollock is the Superintendent.

The Gordon Coal Mining Company's Mine.—Coal D is the one worked here. It is mined by drifting in a hill at a point about seventy-five feet above the railroad at Gordon's Station. The coal averages four feet ten inches in thickness. The mine is connected with the railroad, where the tippie is stationed, by a wooden tramway about five hundred feet long.

No returns for the amount of coal shipped were received.

Quinn's Mine.—This mine is near the former. The same coal is worked, and mined in the same manner as at that one.

Arbuckle's Mine.—This is also in Coal D, and is near Gordon's Station. The coal is reached by drifting.

In the vicinity of the above mentioned mines, on the old Luckett farm, now owned by the Louisville, Paducah and Southwestern Railroad, Coal E crops out in the bed of a branch. It is worked by stripping, by those living in the neighborhood.

The coal appears to be excellent in quality, but is only eighteen inches thick.

The Caney Creek Mine.—This mine is located on the line of the railroad about five miles west of Nortonville, in Hopkins county.

It was opened, ready for shipping, May, 1873. The coal worked is Coal D, which, contrary to its character at all other points, is cut by clay seams in a remarkable manner. These seams, however, differ in their character from those attending Coal B. They are evidently results of fractures in the coal, caused by the faulting of it and its associate rocks, and are, therefore, really faults and not clay slips in the ordinary sense of that term.

The course of the faults is north 80° east.

The region abounds in faults, and these at the mine seem to be related to them.

The mine is worked by drifting, the course of the main entry bearing about north.

A section of the strata in the immediate vicinity of the mine is as follows:

1. Sandstone	50 feet.
2. Blue and ochreous shale	10 "
3. Bituminous slate	5 "
4. Coal	5 "
5. Fire-clay	5 "
6. Clay, with masses of limestone	5 "

To facilitate the description of the mine plate 6 is inserted.

The drift is started in a little valley, about fifty feet wide, which seems to have originated in a fault. The shale No. 2 is brought down to the level of the bottom of the coal as now seen (the coal itself having been cut away, or else depressed), with the sandstone No. 1 resting above.

To reach the coal the entry was driven through the shale, as indicated in the figure.

Reaching the coal it was found to lie horizontally, and so it continued for a distance of seventy-five feet. At the end of that distance a second fault was met (fault No. 2), the coal suddenly assuming a position nine feet above the level of the tramway.

It continues in this position for thirty-nine feet; then it drops at an angle of about 45° , the coal being wedge-shaped, with the point of the wedge above. A shaly sandstone, about ten feet thick, accompanies the coal in its fall, lying immediately above it, as if there was an end of the bed (see faults 3

and 4). Driving through this sandstone wedge (so to call it), however, the coal was caught on the other side, *lying in a horizontal position*, and followed for one hundred and twenty-five yards. At the end of that distance another fault was met with, the coal dropping ten feet, and continuing in that position for sixteen yards.

It then rises and assumes its proper position once more. This is the last fault seen in the bank; but there seem to be indications of the existence of others still beyond. It will be noticed that the coal does not make these changes in position by rolls or undulations, but by sudden slips, the body of the coal dropping or rising for a certain distance, and then lying horizontally.

The ends of the broken parts are always connected by a thin streak of coal. The presence of the sandstone between faults three and four is, at first view, a problem difficult to solve. The solution, however, is presented by the coal itself outside of the mine.

At an old drift, north from the mouth of the mine, the coal is found to have overlapped itself, presenting a seeming thickness of eleven feet.

The bed having been fractured, was depressed or elevated; and the strata being subsequently moved by what was possibly a lateral motion of the earth, the two parts were, by the combined movements (the forward and backward), brought into the position they now occupy.

This explanation is applicable to the case of the sandstone. It is an overlap also, differing from the former, however, in that one of the parts is inclined at an angle of forty-five degrees, while the other retained its horizontality. The sandstone wedge is very probably a part of No. 1. It seems that the fracture of the coal bed was a clean, wide one, and that the sandstone was thrown down into the gap, either at a time preceding the action of the force which drew the sundered parts together, or during the operation of that action.

The absence of the shales over the coal at certain parts of the mine (near the fractures) may be accounted for by suppos-

ing the gaps to have endured some time before the sides were brought together.

The circumstance of the ends of the fractured coal being connected by thin streaks of the material tend to show, however, that the fractures were never very long exposed to outward agencies. It is more probable that the shales were partially removed before the faulting took place.

The connection of the broken parts in the manner referred to is of much interest, and suggests to the mind that the coal may have been partially dislocated when in a soft state. It is merely a suggestion, however, and does not bear with it conviction.

Mr. Wilverth, the Superintendent of the mine, deserves much credit for his energy and ability exhibited in driving the entry. When the sandstone wedge was reached it was calculated to discourage any one; but by wisely sinking a test shaft beyond, the coal was found and reached by driving the entry through.

As would be supposed, the number of these extraordinary "slips" retarded the work greatly, and, as a consequence, comparatively little coal has been exported. Up to October 1st, 1874, the shipments amounted to two hundred and seventy thousand bushels.

The St. Charles Mine.—This is the last mine on the road, going west. Coal D is the working vein. The coal is removed from the hill by drifting.

This is the largest mine on the road. Though only opened in March, 1873, 1,061,093 bushels of coal had been shipped up to October 1st, 1874. Quite a flourishing little village has sprung up around the works.

The greater portion of coal exported goes south by way of the Tennessee river.

There are a few unimportant slips in the coal; but though barely two miles west of the Caney Creek mine, this one is singularly free from them.

It is very possible that the slips encountered there extend as far as the St. Charles mine; but from the position the two

mines have in regard to each other, it is probable they pass to the southward of this one.

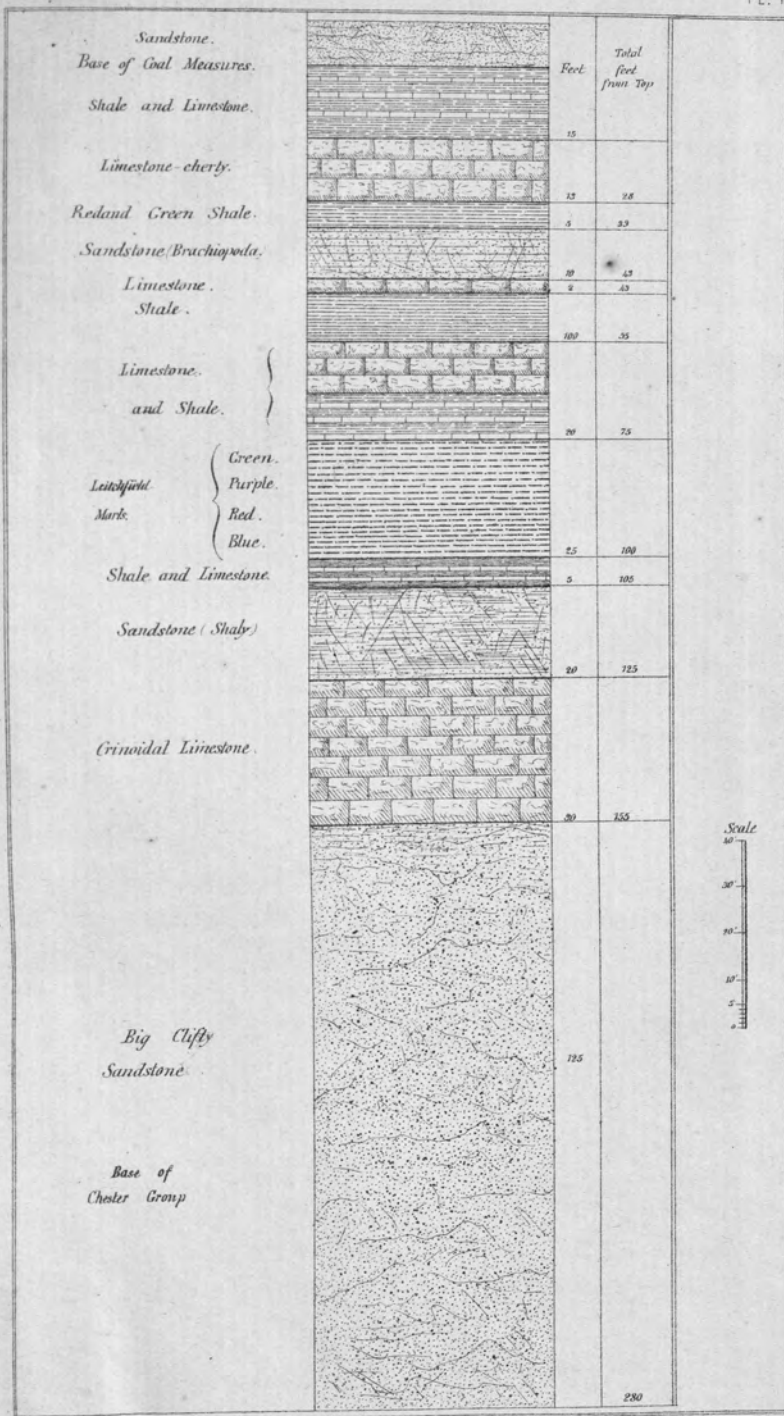
In the Dozier entry there is a slight slip, coursing northeast, which crushes the coal down to three feet. Large sandy, pyritous concretions frequently occur in the overlying slate in the Dozier entry. Some are of extraordinary size. They are apt to break down the slate when the coal is removed; otherwise the roof is excellent.

A section made at one of the air shafts of the Dozier entry is as follows:

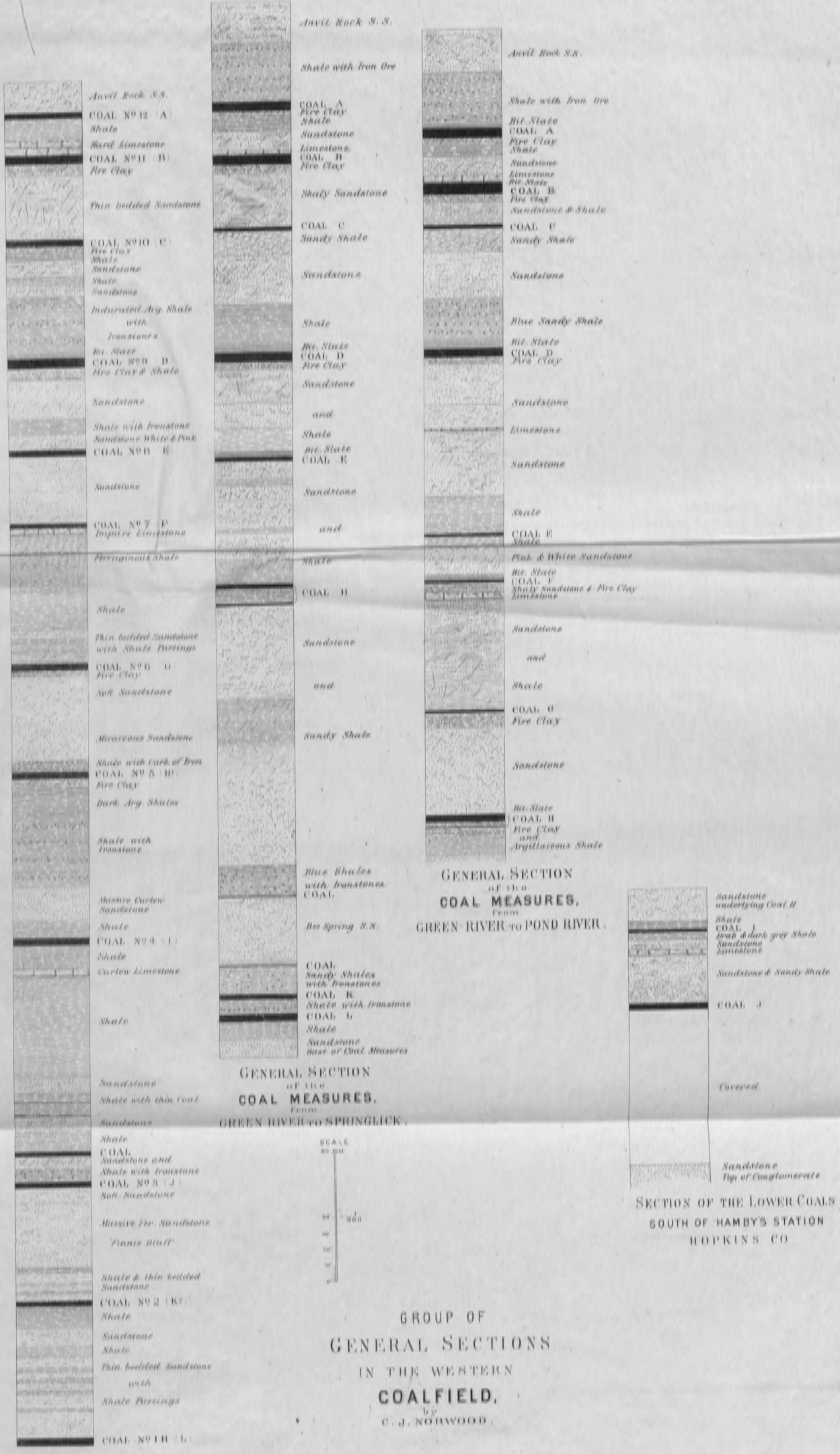
1. Earth, etc.	3 feet.
2. Buff sandstone	10 "
3. Dark blue shale, with pyritous concretions.	14 "
4. Black slate	4 "
5. Coal D.	

The coal rises rapidly north 30° east, the rise being about three feet in one hundred. Major M. M. Kimmel is the superintendent.

An analysis of the coal will be found on page 49.



GENERAL SECTION OF THE CHESTER GROUP



GENERAL SECTION
OF THE
COAL MEASURES,
as given by
DR. D. D. OWEN.

GENERAL SECTION
OF THE
COAL MEASURES,
FROM
GREEN RIVER TO POND RIVER.

SECTION OF THE LOWER COALS
SOUTH OF HAMBY'S STATION
HOPKINS CO

GROUP OF
GENERAL SECTIONS
IN THE WESTERN
COALFIELD,
by
C. J. NORWOOD.

Horizontal Scale
0 10 20 30 40 ft.

Vertical Scale
0 10 20 30 ft.



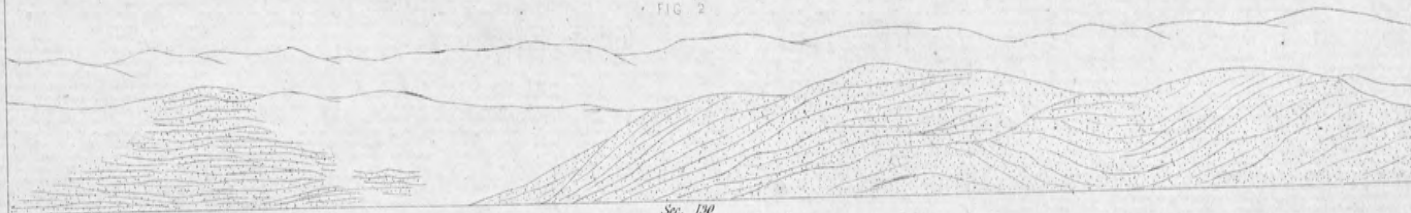
Sec. 133
At first Cut West of Owensboro Junction.

FIG. 3



Sec. 131
First Cut East of Milepost 131

FIG. 2



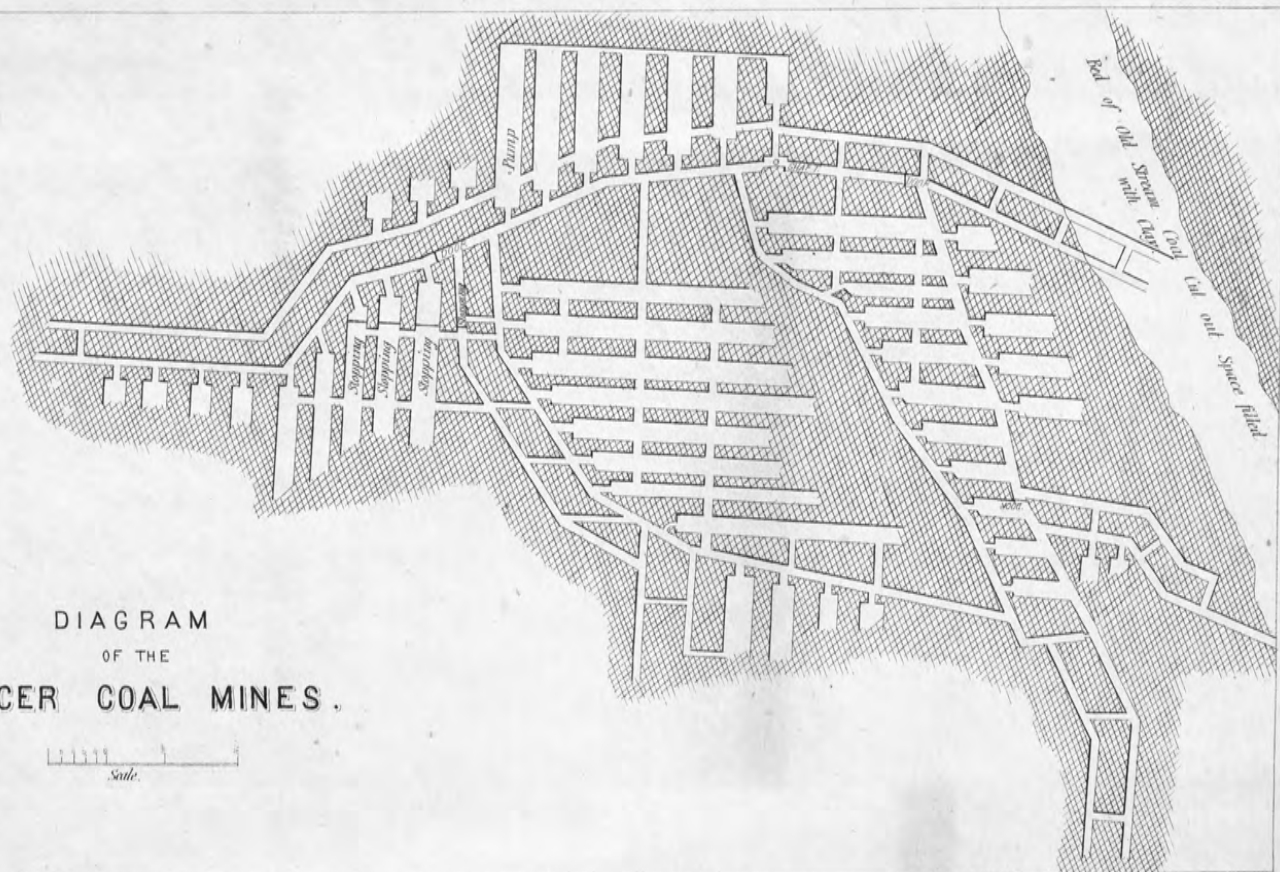
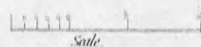
Sec. 130
First Cut East of Greenville Sta.

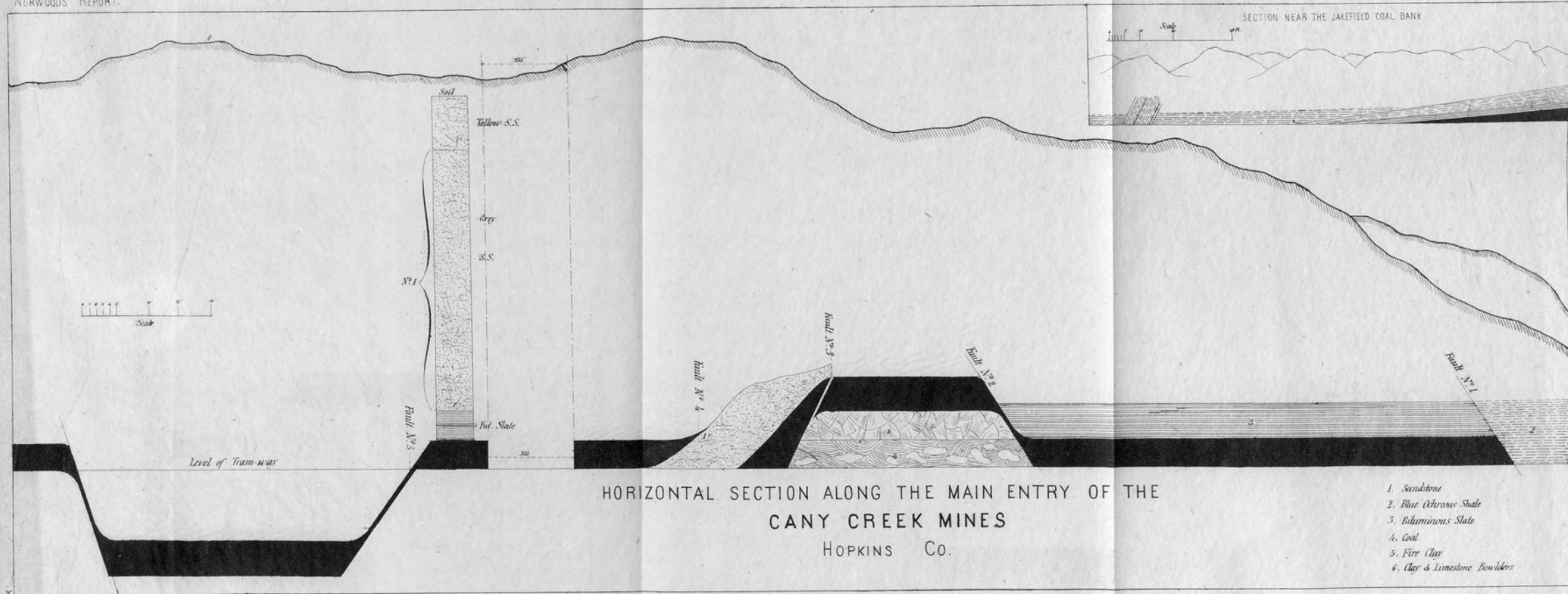
FIG. 1



Sec. 129
First full cut East of Milligans Sta.

DIAGRAM
OF THE
MERCER COAL MINES.





GEOLOGICAL SURVEY OF KENTUCKY.

N. S. SHALER, DIRECTOR.

REPORT OF A RECONNOISSANCE

IN THE

LEAD REGION OF LIVINGSTON, CRITTENDEN, AND
CALDWELL COUNTIES,

INCLUDING A

SKETCH OF THEIR GENERAL WEALTH.

BY CHAS. J. NORWOOD.

PART VII. VOL. I. SECOND SERIES.

INTRODUCTORY LETTER.

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

DEAR SIR: According to your instructions, I present you herewith a report of a reconnoissance of the lead region embraced in the counties of Livingston, Crittenden, and Caldwell. Accompanying it is a preliminary map, incorrect in many particulars as regards the geography, but better than none.

As there was much territory to be traversed in a short space of time, the report does not purport to be an exhaustive or elaborate one by any means.

The prime object of the reconnoissance was to obtain a knowledge of the character of the lead deposits and their probable worth. It is believed all the time requisite for such a result was devoted to the work.

I embrace this opportunity to express my gratitude to all those who rendered me kindly aid when in their region.

The Survey is under especial obligations to Mr. P. C. Barnett, Col. Callahan, the Messrs. Woods, Mr. Hodge, the Messrs. Hewlett, Hon. Chas. Webb, Mr. Lemen, Rev. Isaac McMurray, the Messrs. Glass, and Mr. Wm. Marble.

Respectfully,

CHAS. J. NORWOOD.

LEXINGTON, KY., April 15th, 1875.

REPORT OF A RECONNOISSANCE IN THE LEAD REGION OF LIVINGSTON, CRIT- TENDEN, AND CALDWELL COUN- TIES, INCLUDING A SKETCH OF THEIR GENERAL WEALTH.

LIVINGSTON COUNTY.

This county is quite irregular in its outlines. Part of it lies between the Cumberland and Tennessee rivers, extending, in a tongue as it were, up those streams to the "*Narrows*," while the greater portion lies north of the Cumberland, the Ohio river forming the western boundary, and Crittenden county joining on the east.

Taken altogether, the county is a broken country, made up of high winding ridges, some of which rise to a height of 400 feet above the level. The highest point is, perhaps, between 500 and 600 feet above the Ohio river.*

Although the greater portion of the county is ridge land, there is yet much of it well adapted for farming, embraced in the rich valleys of the Ohio and Cumberland rivers, and the wide valleys and table lands north of the Cumberland.

The county embraces about 295 square miles of territory.

GENERAL GEOLOGY.

The geological formations found in the county are the quaternary and carboniferous.

The Quaternary.—This includes in descending order alluvium and bluff beds or loess.

I. *Alluvium.*—This division is made up of beds of sand, clay, loam and pebbles, as follows:

a. Soil and black loam, composed of decayed vegetable matter, etc., alternating with thin layers of sand.

* These heights are approximated.

b. Buff clay.

c. Red clay, with masses of earthy iron ore.

d. White and yellow sand, grains very small.

e. Pebbles. These are usually quite smooth and rounded, and are mainly of chert and hard sandstone. They vary in size from half an inch to three inches in diameter. They are often cemented by iron, and so consolidated as to form compact beds of conglomerate.

These beds are frequently exposed on the tops of the ridges, and might be mistaken as being of a date older than here ascribed to them.

II. *Bluff beds (or Loess?)*.—This is a yellowish to brownish buff, somewhat sandy, porous clay. When dry it is quite pulverulent. It is developed in the bluffs of the Ohio river especially, and covers the hills at many places in the vicinity of Smithland.*

Carboniferous.—Under this head are included rocks of the coal measures and the lower or sub-carboniferous.

I. *Coal Measures.*—This formation is but sparingly developed, the only members found being the conglomerate and accompanying coal beds.

The conglomerate caps the ridges in many parts of the county; sometimes attaining a thickness of sixty feet, and again, represented by a few feet only. It does not always contain pebbles; on the contrary, it frequently passes abruptly from a hard, gritty sandstone, quite conglomerated (the pebbles varying in size from that of a small shot to that of a hen's egg), to a fine-grained compact rock, *entirely destitute of pebbles*.

* At Carrsville a few boulders of quartzite, syenite, granite, and hornblende rock were observed. They vary in size from six inches to two feet in diameter. They are much worn and rounded, in this respect having the character of *glacial drift*; several of them were examined for evidences of scratches, but none discovered. Their history is somewhat obscure. It is not probable, however, that they were transported to their present location by water, as the specimens occupy a circumscribed area, and none are known to occur elsewhere in the county.

There was an Indian burial-ground at Carrsville, and perhaps a fortification, so that the boulders may possibly have been brought for some purpose by the ancient people who built there. Another fact in regard to them is, that they are arranged in a line one after the other, partially covered with earth.

Though doubtful as to their having been brought to their present location by any means other than human, no locality in Illinois, from whence they could have been procured, can be given. It is possible for them to have been brought from Missouri.

In volume IV, page 388, and volume III, page 531, of Owen's Geological Reports on Kentucky, Lesquereux identifies this coal as No. 1 B. In his description of that coal, he states that it is the first above the conglomerate; it seems he did not see the conglomerate which *overlies* it here, showing Coal 1 B to be an *inter-conglomerate* coal, provided he was correct in the number.

The sandstone, 40 feet thick, mentioned by Dr. Long* as underlying coal three feet thick, at the Trapnel coal bank, in the vicinity of Caseyville, is doubtless the equivalent of the inferior conglomerate of Livingston county.

The coal at Trabue's dips at the angle of 10° , course north 35° west, at the entry; this angle, however, does not appear to be constant. The mines are worked very little, and, consequently, were in such condition that they could not be entered.

One mile southeast of Smithland, — Gordon (colored) dug for coal in the shales below the conglomerates, but without success. No coal of importance exists there.

There seems to be no reason to believe that any extensive coal beds exist in the county. There may be, however, outliers of coal (equivalent to the beds at Trabue's) in certain parts of the county not yet explored for the mineral.

II. *Lower Carboniferous*.—Two divisions of the lower carboniferous, the Chester and St. Louis Groups, may be distinguished in this county. The exact line of division between the two could not be satisfactorily ascertained, as the time requisite for such detailed examinations as would have accomplished that result could not be spared.

The Chester Group is made up of an alternating series of limestones, sandstones, and marly shales. Rocks belonging to this division are exposed at Smithland and Carrsville, and pretty generally throughout the county.

The St. Louis Group is separated from the Chester by a sandstone.

*Vide volume IV, Owen's Geological Report, page 388.

The most abundant fossils are *Lithostrotion Canadense*, *Productus cora*, *Athyris subquadrata*, a *Spirifer* and *Pentremites Koninckiana*. As seen in this county, the beds are crossed in all directions by veins of calc. spar, some of them two inches wide. Calcite also occurs in masses throughout the rocks, (filling cavities), and is quite abundant.

Fluor-spar is also present in the rocks, but is less common than the calcite.

The general color of the limestones is dark drab; some of the beds, however, are dark blue and bituminous.

Towards the top of the group, beds of gray to white, beautifully oölitic, limestone occur; capable of being burned into excellent white lime, and answering admirably for building purposes.

The greatest measured thickness of this group, as displayed in this region, is about one hundred and eighty feet.* This, however, is not the total thickness; it may be twice as great.

The St. Louis Group is of special interest in the lead region, as it is in the vicinity of it that most of the lead is obtained.

SPECIAL GEOLOGY.

The Lead Deposits.—The lead deposits have attracted attention for a number of years, but only in the last ten have any systematic explorations for the mineral been made. More work has been done in the past two years than ever before. Although a number of shafts and pits have been sunk in various parts of the county in search of lead, the returns have been meagre indeed.

There have been, however, no *deep* shafts sunk, the deepest being one at the Royal mines, mentioned on a succeeding page. All others range in depth from 10 to 50 feet, rarely, if ever, more than 50 feet, and seldom exceeding 40 feet in depth. It cannot be said, therefore, that any extensive operations have been carried on; on the contrary, under the circumstances, the digging has been quite shallow.

*A shaft at the Royal mines shows it to be more than two hundred and fifty feet in thickness.

Mode of Occurrence.—As a general thing the lead occurs as aggregations of cubic crystals and granules of galena, disseminated through masses of fluor-spar, calc. spar, and limestone, all mingled together in red or greenish clay, filling a fissure between two walls of rock dissimilar in character.

One of the walls is limestone and the other a very hard, quartzose sandstone, often resembling chert, and striking fire with steel.

This silicious rock appears to be a wedge between limestones.

It always presents the appearance of a rock resting on edge; both sides are usually well defined, and it is seldom more than 25 feet across; occasionally the width is as great as 50 feet. It does not stand in a true vertical position, but is inclined at an angle varying from 60° to 80° .

Limestone is frequently exposed on both sides of it, not always in immediate contact with, but still near to it.

The strata are tilted on the one side or the other of it, and lie irregularly, sloping away from it.

The origin of this wedge-like mass possesses much interest, for it takes a prominent position in the solution of the problem concerning the origin of the lead, and, consequently, upon the question regarding the character of the deposits and their worth.

Its present position is evidently due to a dislocation in the rocks. At first view the rock has much the appearance of having been forced from below upwards, extending from as low down in the lower carboniferous series as can be seen, up to the base of the coal measures.

At one locality it is found resting against the St. Louis limestone, while at another it rests against the conglomerate, *apparently* cutting through the Chester limestones, etc. Certain facts connected with it, however, prove conclusively that a hypothesis that it was forced up from below is untenable. Although the strata are somewhat tilted on the one side of the rock, on the other they are horizontal, or dipping *with* the sandstone, and not away from it.*

This fact is so well recognized by the miners that they term the sandstone the *hanging-wall* and the limestone the *foot-wall*. Again, the rocks on either side are seldom of the same age. On the west they may be St. Louis and on the east side Chester beds; such is the case at the Royal mines.

These facts, in connection with others made apparent in the course of the report, can lead to no other conclusion than that this wedge was originally a horizontal sandstone occupying a position above the St. Louis Group, near to if not immediately at the base of the Chester Group. By some such force as that exerted by an earthquake, it has been torn from its true position and precipitated in a previously existing chasm, carrying with it limestone beds belonging to the Chester Group.

It is not probable that this sandstone owes its present position to one movement of the earth, but to a combination or successive series of them.

It seems that at first great breaks were made in the rocks, caused possibly by the concussions produced by earthquakes, leaving the strata in a position something as represented in figure 2, plate II^a.

Subsequently a series of disturbances, resulting from a lateral movement of the earth, crossed the country. The first movement would dislodge the already disturbed rocks from their bedding and precipitate the superior ones into the chasm, while the succeeding one would bring them closer together, as represented in figure 3, plate II^a. The upper beds on one side would be thrown down, while the lower ones, it seems, would merely receive an increased angle of inclination.

On the opposite side the upper beds would retain their position, except in the vicinity of another fracture.

In some instances the entire rocky mass on one side of the fracture seems to have been depressed, but still retaining a nearly horizontal position.

The fractures were of course quite deep, but narrowing all the while, the deeper in the earth they penetrate, and were at

* This is illustrated in the plate representing the sub-structure of the region at the Royal mines.

least partially filled with extraneous material before the subsequent faulting occurred.

The quartzose sandstone has nowhere been recognized in a horizontal position; as it does not always present the same physical characters, however, it may occur so, and not have been noticed in my hurried journeyings across the country.

On the Cumberland river, opposite Smithland, a hard, gritty, thin-bedded sandstone is exposed, exhibiting a thickness of 5 feet or more. It dips at an angle of from 20° to 25° , course south 60° east, strike north 30° east. It is exposed for about two hundred yards up stream, and then disappears. At its northern extremity it becomes more quartzose in appearance, is in thicker beds, and seems to make a curve, the course of the strike changing to north 40° east. This sandstone is represented by figure I, plate II^a.

At Smithland, above the ferry, ten feet or more of jointed sandstone, underlaid by blue shale, is exposed in the river bluff, about 50 feet up from the water. It is quite hard, and in character much resembles the sandstone just mentioned, and probably is the same. It is nearly horizontal, though dipping slightly south, 15° or 20° east. If these sandstones are equivalent, and there is every reason to believe they are, and one is dipping as much as 25° , while the other is nearly horizontal, they give additional evidence towards solving the question as to the origin of the sandstone wedge.

It is a noteworthy fact that the sandstone on the north bank of the Cumberland river is in a line with, and has about the same strike of, the quartzose sandstone seen at the Woods' mines.

Taking into consideration all the facts collected, the only reasonable conclusion is, that the masses of sandstone seen in different parts of the county, jutting up from the ridges and resembling dykes, are not uplifts but *down-throws* caused by a remarkable faulting of the rocks.* The number of these

* Since the foregoing was written it has been learned from Mr. Joseph Walton, Superintendent of the "Royal Mines," that in one of the pits there the sandstone disappears at the depth of one hundred and fifty feet, and limestone is exposed on both sides of the shaft.

This is practical and conclusive proof that the sandstone came from above.

down-throws necessarily depends on the number of fractures in the first instance.

It will be seen from the foregoing that the lead occurs in masses of fluor-spar and calc. spar, filling fissures following the *line of a series of down-throws*.

Character and Derivation of the Deposits.—There can be no reasonable doubt that the fissures, in the upper part of which the lead is concentrated, have great depth; that they penetrate far into the crust of the earth.

That this must necessarily be the case, is displayed by the scale on which the rocks are faulted. There must also be some material filling these fissures, constituting veins; which, extending the full depth of the fractures, may be denominated *true veins*.

The origin of true veins is referred to dislocations of the rock strata, effected by some great mechanical force, such as is exerted by earthquakes; they, consequently, traverse a formation independently of its character or stratification, and are supposed to extend indefinitely downward.

True veins may be defined, in simple language, as indefinitely deep fissures filled with some material which may or may not be accompanied by lead or some other metal. But in passing from one character of rock to another, the vein-stone or filling matter of the fissure may change materially; it may be very poor in ore or entirely destitute of it.

There are, therefore, numbers of true veins, which, if not absolutely bare of metalliferous deposits, are nearly so.

There are, in fact, many instances in which a vein is rich in ore for only a certain depth, beyond which the ore entirely disappears, or is so lean as to preclude the working of it with profit.

There are, also, many true veins that are not metalliferous.

Consequently, the fact of the veins in question being true veins does not carry with it the conviction that the lead found in the upper part is coextensive with the vein. On the contrary, having in mind the peculiar derivation of the ore, it is fair to presume that its depth is limited to the base of the

lower carboniferous *limestones*, perhaps not extending below the St. Louis Group.

In other words, that the metalliferous matter filling the upper part of the fissure must be considered as forming a separate and distinct part of the vein, as it now exists, having no intimate connection with the matter below.

The metal originally existed either in bedded veins or segregations just at the top or near the top of the St. Louis limestone, or as impregnations in the rocks.

There are certain circumstances connected with the deposits which seem to give some basis for supposing the lead to have partly been in *bedded veins*; but I am disposed to consider, rather, that it occurred as *segregations* and *impregnations*.

Whether it was wholly inclosed in the upper beds of the St. Louis Group, which have been destroyed, or whether it was most abundant in the lower rocks of the Chester Group, is a question to be decided when the deposits may be studied in all their minutiae.

It is probable that the galena was disseminated in greater or less quantities through the rocks of the St. Louis Group in its entire vertical extent. My impression is, however, that the major portion of the metal was in seams and bunches and impregnations in the upper rocks; which, perhaps, belonged in part to the Chester, but more particularly to the St. Louis Group.

This much is certain: where the veins occur that are rich in the metal (they are in the blue or geodiferous limestone, as it is termed in another report*), there is at least 75 feet of the upper division of the St. Louis Group entirely absent.

It is possible, therefore, that at the time of the faulting of the rocks, heretofore mentioned, these rocks *bearing the metal* were thrown down in the fractures.

That subsequently waters charged with solvents, possibly derived from organic matter (vegetable or animal), percolating through the mass, dissolved out the lead, which was precipitated, assuming the character it now presents.

It is not necessary, however, in demonstrating that the lead came from above, to assume that the rocks should have been thrown down in the fractures.

As the strata gradually wasted away under the destructive influence of chemical agents, and the solvents eliminated the lead, it would be deposited in the fissures open for its reception.

In fact this latter solution of the problem is more in accordance with the present state of the deposits, as they exist in this and Crittenden counties, than the former.

From the manner of its distribution through the spar it would seem that in age, according as they were deposited in the fissures, the lead is the eldest, then the fluor-spar followed by calcite.

The fluor-spar nearly always has a bituminous odor, as have also some of the limestone beds.

Instances also occur where hardened bitumen fills cavities in the material which bears the galena. It would seem as if the bitumen was closely related to the lead in its deposition, and had participated to a large extent in the extraction of the metal and spars from the rocks.

The lead evidently did not come up from below in heated vapors, else the structure of the lodes would be more symmetrical.

That it came from above appears; from the irregularity in the nature and structure of the deposits; from the frequent occurrence of limestone fragments in the vein matter (some of them containing galena), and from the fact that at one locality the galena-bearing fluor-spar was found lying horizontally and then traced to where it enters a nearly vertical fissure.*

The history of the lead in all its details is certainly of interest. In a general reconnoissance, however, this subject, though an important one, could not receive that attention necessary for a clear exposition of the matter.

*The nature of certain of the deposits in Crittenden county also tend to verify the statement.

*See report on the region adjacent the Louisville, Paducah and Southwestern Railroad.

That the major portion of the ore came from above seems, at this date, with what light can be obtained on the subject, to be the most reasonable conclusion.*

Owing to the peculiar nature and derivation of the deposits, it is difficult to decide on a proper and descriptive name for them, in the ordinary classification of metallic deposits. However, considering them simply as aggregations of fluor-spar and galena in fissures limited in their depth, they approach very near to segregated deposits, and may be denominated, for the present at least, as *vertical segregations* (or segregated veins) occupying the upper part of true vein fissures.

General and Special Description of Deposits.—As indicated on the map, there are at least three faults, and consequently lodes, so to call them, crossing the county.

Two of them are nearly parallel, coursing north 30° to 57° east, while the third has a course about north 32° east. The latter is supposed to be the lode opened at Fair View, Illinois, which crossing into Kentucky at Carrsville recrosses the river, back into Illinois, near Bay City. It is known as the *Fair View Lode*, and is supposed to be the same as that at Rosiclare.† Of this, however, I have no personal knowledge. The other two are known respectively as the *Latrobe Lode* and the *Excelsior Lode*.

On these two the greatest amount of work has been done. Each lode may be traced across the country by the immense masses of quartzose sandstone, standing nearly vertically on the ridges, and in many instances forming the ridge line.

The *Latrobe Lode* is the one on which the shafts at the Royal mines are located.

Following the line of the fault, several shallow pits have been sunk.

Pits were sunk on the lode on the Donake, Coker, and Levan farms, all near each other, out of all of which lead and

fluor-spar were obtained. The Donake pit has greater local celebrity than the others; it has been opened for a longer period, and more mineral obtained from it.

On Mrs. Mitchel's old place, now the possession of Messrs. Waller & Co., and on Mrs. Cox's property, near Salem, lead and fluor-spar have also been obtained. On the former place the quartzose sandstone forms the eastern and greater part of a ridge, and stands out in a huge mass with rough outlines, about 50 feet in width.

The rock pitches south 55° east, at an angle of from 75° to 80° , with a strike north 35° east.

On the west side of the hill, near the base, a pit was dug many years ago, and lead procured from it.

Fragments of limestone were found at the mouth of the pit (which is now almost entirely filled with debris) containing much fluor-spar.

The sandstone extends the entire length of the ridge, with limestone on the west side.

At Mrs. Cox's place no pit has been dug, but much fluor-spar and calc. spar occur in the quartzose sandstone. Some lead was also found in it. More spar was found in it at that place and on Rev. Collin Hodge's land (at the old "wash-hole") than at any other place in the county. At Mr. Hodge's, limestone is exposed on both sides of the sandstone, not immediately in connection with, but near to it. On the northwest side the limestone approaches within 20 feet of it, while on the opposite side the limestone is 300 feet away from it.

The *Excelsior Lode* has a general course parallel with the *Latrobe Lode*.

Pits have been sunk on it at Mr. Henry Woods', Mr. Robert Woods', and Mr. Tisdal's (now deceased); all of these places are near together, and from three to four miles south of Salem. Galena was obtained from each shaft sunk.

The quartzose sandstone forming the hanging wall of this lode is seen on the south side of the Cumberland river, about four and a half miles northeast of Smithland. No lead has yet been found in connection with it south of the river.

*The supposition that it was all eliminated from the *inclosing* rocks would not explain the character of the deposits as they are found at a number of points in the lead district, especially in Crittenden county.

†The mines known as the "Rosiclare Lead Mines" are not immediately at the village, but to the west of it.

The only place at which any work has been done on the *Fair View Lode* is at Carrsville, and this will be noticed hereafter. On the farms of the Messrs. Lemen, about two miles west of Salem, there is an exposure of quartzose sandstone resembling that seen at the Royal mines and at the Messrs. Woods'.

The mass juts up to a level with the conglomerate, which lies on the east side of the sandstone. Passing over a low hill, from the place where the sandstone was seen, Chester limestones and sandstones are found, and though having no instrument with which to make exact measurements, they appeared to be on a level with the conglomerate, or even to occupy a higher topographical position.

The sides of the quartzose sandstone are striated in some places, as if having undergone severe friction. It seems that, subsequent to the down-throw of the quartzose sandstone, the rocks on the east settled down, bringing the conglomerate on a level with the Chester limestones and shales on the western hills, and, as a consequence, bringing the faulted sandstone on a level with the top of the conglomerate.

It may also be that the Chester rocks have been slightly elevated; they are found at one place dipping southeast, toward the point of fracture.

Whether the sandstone seen at Mr. Lemen's extends any considerable distance is not known, as no attempt was made to trace it.

Should it be found to have any extent, it is possible that lead may be found in connection with it, as it has the same physical characters as that seen at places where the mineral is known to exist. I do not, however, think it worthy any especial attention, particularly as it is high up in the series, and no galena of consequence has been found above the geodiferous limestone of the St. Louis beds.

On Mr. J. K. Hudson's place, the southeast corner of the old Jonathan Ramsey survey, a pit was dug about twenty years ago in the search for lead.

It was filled with debris when the locality was examined. Red clay and fluor-spar, both clear and purple, were taken from the hole. No lead was found. The hole was dug in a ravine by the side of grey limestone. The nature of the deposit could not be ascertained.

The following are special descriptions of those localities at which there has been the most work done in searching for lead.

Tisdall's Shaft.—This is on land belonging to the Tisdall heirs. It is located at a point about two miles north of Pinkneyville.

The pit was sunk to the depth of 57 feet on a ridge strewn with fragments of limestone and quartzose sandstone. The sandstone is broken off from a mass forming the backbone of the ridge. It has occasional threadlike seams of fluor-spar traversing it, but with no galena in connection with it. It extends in a line coursing north 45° east.

The shaft was sunk a short distance away from the sandstone. Fluor-spar bearing lead was reached at 20 feet below the surface. After penetrating about 16 feet in the spar it was found to be dipping towards the sandstone. Then passing down to the full depth of the shaft, red clay and rotten fluor-spar formed the material for the entire distance. Occasional masses of calc. spar were met with in the clay, some of them large and containing lead.

The limestone found on the surface, which seems to be the wasted beds of the St. Louis Group, is dark grey in color, emitting a bituminous odor when fractured. Masses and irregular seams of calc. and fluor-spar occur in the rock, crossing it in all directions. This shaft is on the Excelsior Lode.

Robert Woods' Shaft.—This shaft is about half a mile northeast of Tisdall's, and is sunk on the same lode. The shaft was sunk to the depth of thirty-five feet. Fluor and calc. spar mixed with a silicious material were reached at sixteen feet below the surface. Masses of agglomerated fluor-spar, calc. spar, limestone and silica, forming quite a hard rock, are found all through the vein. A little lead was found in them, but rather sparingly disseminated, and in small particles.

When the spar was first encountered, about a foot of red and black clay was found, passing over the top of it out towards the limestone, as represented in figure I, plate III^a.

The vein has not a regular, well-defined structure, but is composed of fluor-spar in irregular masses, mixed with silicious matter in an olive-green silicious clayey material.*

(Some of the masses of spar are quite large, weighing, perhaps, thirty or forty pounds.

No clay occurs between the spar and the walls. On the southeast side of the shaft masses of limestone, with seams of fluor-spar traversing them, were found.

Not much lead was taken out from this shaft. It occurs widely disseminated through the spar, etc., but in small particles.

The vein is about eight feet wide.

Henry Woods' Shaft.—This shaft is near the former, about three miles nearly northeast from Pinkneyville.

It is sunk on the same lode (the "*Excelsior*") as the foregoing.

Limestone and sandstone were found on each side of the vein.

(Two shafts were sunk, only a few feet apart, in each of which fluor-spar was reached.

In one shaft it was found in a horizontal position, reposing about two feet above the limestone, with clay between. In the other it filled a nearly vertical fissure.

The Messrs. Hewlett, who sunk the shafts, then cut an opening from one shaft to the other, following the fluor-spar, which was found to be connected. Figure II, plate III^a, exhibits a cross-section of the shafts

(The vein is mostly red clay and fluor-spar mingled together. In places the fluor-spar predominates. An occasional silicious fragment cuts out the spar for a short distance. Masses of calc. spar and limestone occur throughout the vein; in their vicinity masses of amber-colored, cellular fluor-spar, with some

*This silicious matter, essentially quartz, has probably been taken from the sandstone by fluoric acid. This is probably the history of the silicious material found in all of the pits.

silicious matter, occur, accompanied by small particles of galena.

Where cavities occur in the vein they are usually filled with red clay.

Fluor-spar and a little galena were found in the quartzose sandstone ("silicious" or "hanging wall") near the exterior.

Several pits have been dug in this locality, near each other; galena was obtained in each of them.

The following is a description of different specimens of the material taken from the vein at Mr. Woods':

1. Ferruginous clay. Seems to be very silicious. Incloses fluor-spar, bearing galena.
2. Fluor-spar disseminated in a matrix of almost pure quartz. A few cubes of galena inclosed in the spar. A little blende disseminated in the silicious material.
3. Mostly fluor-spar (some silicious material), with cavities lined with mammillary incrustations of *silicate* (?) of zinc.
4. Like No. 3, but containing, besides the zinc, small cubes of galena distributed promiscuously through the mass.
5. Cellular mass of light amber-colored fluor-spar, with some of the cavities filled with red clay.
6. Cluster of purple fluor-spar crystals.
7. Cluster of purple fluor-spar crystals, with cubes of galena disseminated through it.
8. Like No. 7, but more silicious.
9. Light amber-colored cellular fluor-spar, with a little *Cerussite*.
10. Dolomitic limestone and calcite, with galena and blende.
11. Dolomite crystals from the limestone wall.
12. Silicious and calcareous material, with fluor-spar containing cubes and flattened masses of galena. (From "boulders" in the clay and spar.)

Dupont's Shafts, at Carrsville.—Three shafts were sunk at Carrsville, on what is supposed to be the *Fair View Lode*. They are all in rocks of the Chester Group, and little lead was found.

Shaft No. 1 was sunk through greenish and dark colored marly clays of the Chester Group, overlying a heavy-bedded limestone. Neither lead nor fluor-spar was found.

Shaft No. 2 is eighty-one yards distant from No. 1, course south 40° west, and is south 34° west from the Fair View shaft (in Illinois).

It was sunk through drab to nearly white fine-grained sandstone to the depth of forty-five feet. X

At that depth a drift was started and carried forty-five feet, with a course north 45° west.

At the end of that distance a hard, white, somewhat quartzose sandstone was encountered; this was contiguous to, but still distinct from, the sandstone first penetrated. This quartz-

ose sandstone was passed through and found to be four feet wide, apparently resting on edge. An opening six feet wide was then entered, filled with a heterogeneous mass of the following character:

No. 3 is an agglomeration of calcite, dolomite (?), and sandstone. Has the appearance of small fragments of quartzose sandstone cemented by calcite. Contains a little fluor-spar, blende, and galena; the latter occurs in small, rough, irregular granules.

4. Mostly calc. spar resting on quartzose rock. The calc. spar has tarnished, worn, irregular masses of lead distributed through it.

5. Extremely fine-grained saccharoidal, somewhat friable sandstone. Grains of sand invisible. Contains much dolomite (?) and some fluor-spar.

On the opposite side of this mass an extremely fine-grained sandstone, saccharoidal in texture, was encountered, containing dolomite and a little fluor-spar.

A few rough, irregularly shaped crystals of galena were attached to the surface, next to the fissure.

Shaft No. 3 is but a few feet distant from No. 2; nothing of importance was obtained in it.

We have here a practical demonstration of the fact that the lead is not wholly confined to the St. Louis beds, but is also present in the strata above. It is not so abundant as in the limestones below, however, occurring as mere strings and small particles in the rocks.

This discovery of lead in the rocks at Carrsville is of much interest; the manner of its occurrence is evidence of its having been held in solution, or rather to have been in still higher rocks than the ones now carrying it, and to have been deposited in its present place by the percolating fluids.

It is within the possibilities that traces of lead may be found even so high up as the base of the coal measures.

The Royal Mines.—These mines, formerly known as the "River Valley Mines," are situated on the Cumberland river, near a well-known knob designated as "Bissell's Mount."

They are about three miles from Smithland by land, and somewhat further by water. At the time the mines were visited they were not in operation; the shafts were in such a condition as to preclude the possibility of examining them, nor have they at any time since, up to the present writing, been in a suitable condition for descending them.

Three shafts were sunk; one caved in from lack of proper timbering (so it is stated), the other two had water in them. The examinations were, consequently, confined to the surface workings, the only knowledge of what was below being obtained from the material lying at the mouth of the old shaft and from those who had worked in it.

This kind of knowledge certainly is not so reliable as that obtained from a personal examination; but no opportunity for entering the shafts was afforded, and it will have to be used as being better than none.

Of the three shafts sunk, only one is open for work at present; it is 175 feet deep, being the deepest of any in southwest Kentucky.

The shafts are located on the Latrobe Lode, the character of which is well defined. On the west side of the fissure, which varies in width from 8 to 15 feet, the St. Louis limestone is exposed, showing a thickness of 105 feet. On the east side the quartzose sandstone is also well exposed, exhibiting a width of about 12 feet, and standing nearly vertically, inclined at an angle of perhaps 75 degrees.

Immediately east of the sandstone thin limestone beds of the Chester Group crop out, resting on edge. They occupy a breadth of about 150 feet. Then the limestone terminates and blue calcareous shale comes to view. One hundred feet beyond where the shale sets in the rocks are once more nearly horizontal, a jointed sandstone (equivalent to the sandstone seen at Smithland?), some 10 feet or more in thickness, coming to view, standing out in a vertical escarpment.

All the rocks included between the St. Louis limestone and this Chester(?) sandstone are tilted at high angles, dipping about southeast.

The St. Louis limestone, however, is almost horizontal, and the Chester sandstone dips very little, course southeast.

The sandstone is about on a level with the top of the St. Louis limestone. There is evidently a very considerable drop in the rocks where the sandstone is exposed, as the Bissell Mount shows at least seventy-five feet of additional limestone coming above that at the shaft.

The following figure is a rough profile sketch of the structure of the region in the immediate vicinity of the mines, looking south.

Very little knowledge concerning the new shaft was gained; but Mr. Walton, the Superintendent, states that the quartzose sandstone disappears at 150 feet from the top of the shaft, and limestone takes its place.

The lead is sprinkled through fluor-spar in granules, small cubes, and bunches.

The masses of galena vary from less than the size of a pea to crystals half an inch in diameter.

In some of the large pieces of spar lying at the mouth of the old pit the lead was apparently in sheet-like masses; but upon breaking the spar they were found to be aggregations of small crystals arranged in a line with each other and brought close together.

In some of the spar the cubes are large and thickly disseminated, but in most of it the mineral is sparsely distributed, and in small cubes. Sometimes almost imperceptible particles of the galena are all that is to be seen in a piece of spar many pounds in weight.

In working the vein it was found that the galena varied in quantity greatly, and in size from that of a small shot up to masses that would weigh from 10 to 12 pounds; these were rare, however.*

The pile of spar examined came from the old shaft, which was sunk to the depth of one hundred and forty-two feet.

Col. Callahan, formerly one of the proprietors of the mines, gives the following statement in regard to the structure of the

* These masses were doubtless collections of crystals.

vein in the old shaft, according as his memory served him. The new shaft being on the same vein as the old one, and not far from it, the description will, it is believed, be in a measure applicable to it.

According to the statement of Col. Callahan, the fluor-spar (carrying galena) was met with at sixteen feet below the surface.

The spar was about two feet wide, with blue clay on each side of it, making up eight feet, the width of the fissure. The clay had many "bowlders" of quartzose (?) rock with drusy cavities set with fluor-spar crystals. Thin seams of fluor and of calcite also occurred in them, as well as occasional particles of lead.

This was the structure of the vein for the first ten feet. At that depth the spar disappeared and the entire fissure was filled with the clay and bowlders. The lead disappeared with the spar, and was found on the hanging-wall.

This continued for about 50 feet. Then there was 40 feet of "porous rock," with a little clay on each side. No lead was found in it, but was still seen coating the hanging-wall. Upon passing through the "porous rock" a silicious bed containing spar—mostly fluor—was encountered, and constituted the vein for 25 feet. No lead was found in it.

At the termination of the 25 feet a dark green shale, 3 to 5 feet thick, full of iron pyrites, was entered.

Upon passing through the shale, fluor-spar, bearing galena, was once more obtained.

The foregoing is, of course, not presented as being strictly accurate, but is sufficient to show the great irregularity in the structure of the vein.

Subsequent to the visit to the mines, it was learned that lead was more abundant in the new shaft than in the old one.

So little personal knowledge could be gained at the mines, that it would be fair neither to the proprietors nor to the Survey to express an opinion as to the merits of the mines. The few facts at hand would convey the impression that the

prospects are not very bright. It is a matter certainly to be regretted that free access was not afforded to the new shaft.

The conclusions deducible from the observations made in Livingston, especially, may be summed up as follows:

1. The strata have undergone a system of faulting, the rocks overlying the St. Louis Group having been, in part, thrown down in great fissures in the rocks of that group.

2. These rocks included a conspicuous sandstone, which probably occurred near the base of the Chester Group, and which, where in connection with the veins of fluor-spar, has undergone a metamorphosis, becoming exceedingly compact and firmly cemented, quartzose in character and often cherty.*

Also, that this rock frequently forms one of the walls of a lead lode for a certain depth.

3. The lead occurs as aggregations of crystals and granules, carried in fluor-spar occupying the upper part of fissures along the course of some of the faults; which fissures are those of true veins.

4. That the lead in great measure came from above. That it was originally in the upper or grey limestone division of the St. Louis Group, and has been eliminated from it by chemical, assisted by mechanical operations, and deposited in fissures in the lower or geodiferous limestone.†

5. The deposits may be denominated vertical segregations or segregated veins.

6. There are at least three of these veins or lodes crossing the country, all nearly parallel with each other, and there may be more.

CRITTENDEN COUNTY.

This, the adjoining county on the east to Livingston, is, as a whole, very broken; perhaps more so than Livingston. On the tops of the ridges, however, and in the valleys between, there is much land that is fertile, yielding good returns to the farmer. Good timber is in abundance, and water plentiful.

* This is supposed to be due to the action of fluoric acid, which possesses the property of dissolving quartz.

† See report on the region adjacent the Louisville, Paducah and Southwestern Railroad.

GENERAL GEOLOGY.

The geological structure is the same as that in Livingston county, including the *Quaternary* formation, and rocks of the *Coal measures*, *Chester Group*, and *St. Louis Group*, of the carboniferous period.

Coal Measures.—The same divisions of this formation that are found in Livingston are present in this county. The rocks are more widely distributed, however, and beds of coal more abundant.

Coal is pretty generally distributed over the eastern third of the county, and is reported in a number of places in the southwestern part of the western half.

The conglomerate is exposed frequently throughout the entire county.

Chester and St. Louis Groups.—These groups present the same characteristics as in Livingston county.

The beds of the St. Louis Group are frequently found containing masses of calc. spar, and with seams of the same material traversing them.

At the Milford bridge, over Deer Creek, 4 miles above its mouth, 6 feet or more of fine-grained, dove and drab limestone, crops out in the banks of the stream. Small geodes of quartz, and drusy cavities set with quartz and calcite, are abundant in the rock. *Zaphrentis spinulifera* was the only fossil found; but it is very probable that the rock belongs to the geodiferous division of the St. Louis Group.

On Mr. D. J. Ellington's place, on Paddy's-row Creek, about four and a half miles due west from Carrsville, limestone, equivalent to that seen at Milford bridge, crops out.

Some little work was done there in the search for lead, but without success.

Thin seams of calc. spar and fluor-spar traverse the rock in all directions. Numerous cavities filled with calcite and small quartz druses also occur in the rock.

The Lead Deposits.—The character and origin of the lead deposits in general is the same as in Livingston county. There may be one exception.

The lead has not received the attention in this county that has been given it in Livingston; still, several pits have been dug in search of it.

The first shaft examined was *The Deer Creek Mining Company's Shaft*, on Robert Larue's land, five miles nearly due north from Salem.

Two shafts were sunk near each other.

No. 1.—This is abandoned. It was sunk to the depth of forty-eight feet. For thirty feet down the material was red clay, with masses of earthy, dirty-grey limestone, with much calcite disseminated in masses. A little galena was found in the calcite, in small particles and seams. The lower eighteen feet was in masses of reddish-colored limestone with much calcite attached, and an agglomeration of limestone and calcite, with a few particles of lead disseminated in it.

A little bitumen was also noticed in the mass. It is stated that at the bottom the calc. and fluor-spar were more abundant, and that the lead increased in quantity also.

Shaft No. 2 is the one at which work had been progressing shortly before the mines were visited. When the region was examined the shaft was partially filled with water, and as complete an examination as was desired could not be made. The shaft was sunk to the depth of 35 feet, passing down between quartzose sandstone and limestone. The crevice is filled with compact, massive fluor-spar, with particles of galena disseminated irregularly through it. The vein is 7 feet wide. Figure III, plate III^a, exhibits the character of the vein at the upper part; all that was visible.

The galena, so far as known to me, and I judge from the heap of fluor-spar thrown out at the mouth of the shaft, is very sparingly distributed through the vein matter.

Mr. James states, however, that the quantity of lead seemed to increase somewhat towards the bottom of the shaft.

The quartzose sandstone is exposed just east of the shaft.*

The vein courses north 35° east, and inclines at an angle of 65° or 70°.

* The figure has the sandstone reversed.

On Wm. D. Coleman's land, three quarters of a mile north 37° east from the Deer Creek Mining Company's shafts, three or four shafts were sunk for lead. The quartzose sandstone seen at the Deer Creek mines is exposed on the hill above the shafts. No lead was obtained there. The shafts appear to have been sunk too far away from the sandstone.

At Mr. Robert Larue's place, near his house, about 500 yards northwest from the Deer Creek mines, a shaft was sunk to the depth of 20 feet, passing down by the side of limestone. The limestone is grey, crossed by veins of fluor-spar, and with masses of calc. and fluor-spar disseminated through it. Small cubes of galena are sparsely distributed through the spar and the limestone in the vicinity of the spar. Occasional masses of chert occur in the limestone, with seams of fluor-spar cutting directly across them.

Limestone is exposed on both sides of the shaft, but seems to be tumbled on one side.

On Mr. Holly's place, one quarter of a mile from Larue's shaft, course about southwest, three pits were sunk. They were filled with debris and water when visited. Mr. P. C. Barnett, who accompanied me, states that limestone was exposed on both sides of the shafts. At one, an opening occurred in the limestone, out of which large masses of purple and limpid fluor-spar were taken. When first seen, the opening was about 8 feet wide, but towards the bottom was closing, and diminished to 4 feet.

Galena is distributed through the fluor-spar in specks and small cubes, with occasional masses the size of an ordinary marble.

A few of the pieces of fluor-spar found at the mouth of the shaft will weigh thirty to fifty pounds. Fragments of limestone are also to be seen at the mouth of the shaft, with ramifying streaks and thread-like seams of fluor-spar through them.

The opening seems to be continuous for some distance, and courses north 25° to 35° west.

These deposits are no doubt simply *segregations* filling cavities in the limestone. It is possible that (for a limited time) a profitable deposit of lead may be found in the vicinity.

Columbia Mines.—These mines, the property of Messrs. Barnett, Blue, and Hodge, are the oldest lead mines in the southern part of the State. Lead was procured from them, and smelted in a primitive manner, by the early settlers.

The mines are situated near the Marion and Smithland road, about five miles from Marion. A number of shafts have been opened at one time or another, but are now either wholly or partially filled with debris. The only shaft in operation was, at the time the mines were visited (November 26th, 1874), partially filled with water, so that the examination was, in great degree, confined to the surface. No opening was in such condition as to fairly display the nature of the deposits.

There appears to be some complexity in the occurrence of the lead, and till more systematic explorations are made there will still exist difficulty in determining the true nature of the deposits.

That there is an extensive deposit of lead, and one that will last for a considerable time, there is no doubt.

My opinion is, however, that the lead does not occur in true vein fissures, as is generally supposed.

The limestone in which the lead occurs is very cavernous; so much so, that the whole country seems to be undermined. "Sink-holes" are numerous, caused by the roofs of caverns giving way, some of which give access to caverns.

We may reasonably suppose cavities and long fissures, extending in various directions, to have existed in the limestone (produced in the same manner as caverns, *i. e.* by the erosive action of water) previous to the formation of the lead deposits as they now exist.

There is, indeed, scarcely any other way to account for the fissures, and, consequently, determine the nature of the deposits, than that they are due partly to shrinkage of the strata, and in part to the action of water, in washing out cavities and cutting channels through the limestones, as the rocks in which

the greater portion of the lead occurs are pretty horizontal, showing no evidence of disturbance.

These fissures may extend for a mile or more or for only a few hundred yards, and, similar to caverns, have a general though irregular course. In a set of fissures all may not have the same course, but some may cross others at various angles.

From the manner in which the lead has been obtained at these mines, I am induced to believe that the greater portion, if not all of it, associated with fluor-spar, calc. spar, and blende, occupies just such irregular fissures and openings in the limestone, forming what may be termed segregated veins and deposits.

This would lead to the conclusion that the galena was originally inclosed in the overlying rocks, which have wasted away and allowed the lead to be precipitated in solution, filling the cracks, cavities, and fissures in the rocks below. The irregularity in the deposits, and the number of cross-fissures, lend force to this supposition.

It is not a settled fact, however, that there is not a down-throw near the mines, similar to those in Livingston county.

Quartzose sandstone, apparently identical with that found in connection with the lead in Livingston, is found in the vicinity of the mines. It may form one of the walls of a vein similar to those in that county.

Should such a lead-bearing vein be found to exist here, these mines, in themselves, present a beautiful illustration of the origin of those deposits.

Plate IV^a, figure 4, is a rough-sketch map of the mines.

The lead is carried in fluor-spar and silicious matter, and is more abundant at some of the shafts than others.

At the *Glass shaft* (the one now in operation) the galena lies in large masses and cubes, distributed through fluor-spar, calc. spar, and silicious material, the latter predominating. The depth of the shaft, at the time when the mines were visited, was said to be 38 feet, the width of the vein varying from 1 to 5 feet.

In sinking the shaft, the material passed through in the first 19 feet consisted of red clay, with fragments of limestone and masses of galena inclosed in spar and silicious matter, distributed through it. According to Mr. Tompkins, two wall rocks were found at this depth, limestone on the west and sandstone on the east, continuing thus to the bottom of the shaft, with no clay between, except in cavities in the vein material.*

In the next 10 feet the crevice varied from 1 to 5 feet in width, entirely filled with spar and silicious matter, bearing galena.

About 20 per cent. of the material taken out of this space was lead. In the lower eight feet the vein averaged four and a half feet in width, with an increase in the per centage of lead. Judging from the appearance of the material piled near the mouth of the shaft, the per centage of lead may be estimated at one fourth or a little more. This may be an over-estimate, however, as there is much zinc blende accompanying the galena.

Work at this shaft was suspended when the locality was visited. Mr. Glass states that there was no perceptible decrease in the quantity of lead towards the bottom.†

Shaft No. 2 was sunk in the same fissure as was *No. 1*. The lead is distributed through hard silicious matter, filling a crevice about two and a half feet wide, between two walls of limestone. The vein has a course north 39° west, passing from shaft *No. 1* (the Glass shaft) through *No. 2* to *No. 3* (the Barnett shaft), at which shaft it seems to end.

Four shafts were sunk on the fissure between *Nos. 2* and *3*, out of which lead and spar were obtained; they are now partially filled with debris.

At the *Barnett shaft* (*No. 3*), the course of the fissure is north 40° west, till it reaches the north end, where it is stopped by what is apparently another fissure crossing it, with a course

*At the time of my visit the shaft had 15 feet of water in it, and no opportunity was afforded me to see the sandstone. I cannot, therefore, account for its presence. It is not visible on the surface, and this is the only shaft in which sandstone is reported. The walls of the one just a few yards north, as well as of all the others, are limestone.

†As indicated on the map, Messrs. Henry and James Glass have purchased 55 acres of the land from Messrs. Barnett, Blue, and Hodge, with the expectation of mining extensively.

about north 10° east. The cross-fissure is filled with greenish shale, etc., from above.

The lead was distributed through fluor-spar and silicious material, between two walls of limestone.

Greenish silicious clay shale rests immediately against the ends of the limestone at the north end; next to this there is from six to eighteen inches of black clay, and then green shale for five feet or more.

On the west side (north end) of the shaft a vertical seam of fluor-spar is wedged in between the green clay and the black clay, extending nearly to the surface. It varies in thickness from one quarter of an inch to two inches; is thickest towards the top, becoming quite thin towards the bottom, and perhaps disappears entirely within a few feet.

The black clay accompanies it all the way, and resembles a seam. The green shale rests against the black clay with well-defined stratification, the strata showing a dip of 45°, course about northeast; this appears as if it had come from above the limestone.

Occasional very small particles of lead are found in the seam of fluor-spar, though they are scarce.

The green shale is occasionally banded with a soft ochreous-yellow material; two or three fragments of limestone, with the edges rounded, were also seen towards the top.

At the north end a large limestone fragment extends across the end of the shaft. It was probably brought down with the shale which rests against it.

The green clay becomes quite silicious and hard, and is about two and a half feet wide in the middle of the end of the shaft, containing much purple fluor-spar and calc. spar, the former predominating. Figure I, plate IV^a, is a sketch of the end of the shaft on the west side. A is the limestone; B, green clay; C, black clay; D, fluor-spar; E, green shale.

On the east side (north end) the black clay is quite thin, while the green clay is two feet wide, with patches of bright ochreous-yellow silicious clay.

That part of the limestone abutting against the clay is porous and quite silicious near the surface. Lead occurs in this portion of the rock in irregular masses, following its edge, from as far down in the shaft as could be seen to the top, in some instances assuming the character of small veins, quite limited in extent.

Figure 3, plate IV^a, is a sketch of the east side of the shaft. A is the limestone; B, green clay; C, black clay; E, green shale.

Except in that portion lying directly across the end of the shaft, no lead was found in the green clay, and there it is in the lower part, in the vicinity of calc. spar. The limestone forming the sides of the shaft is cherty, and on the exposed surfaces is soft.

Galena occurs in the limestone on either side of the shaft in thin vertical seams, cutting the rock transversely, or in irregularly distributed masses.

The fissure crossing at the north end of the shaft has an irregular course, on one side bearing north 8° east, and on the other north 30° east.

Nineteen yards from No. 3, course north 37° west, *Shaft No. 4* was sunk in the endeavor to catch the vein worked at No. 3, but without success. Neither lead nor spar was obtained, the material taken out being a dark to nearly black shale.

Ninety-nine yards from shaft No. 3, course north 8° east, a shallow shaft, No. 5, was sunk.

Hard quartzose sandstone is exposed in the west side, with purple fluor-spar clinging to the sides and occupying cavities.

This rock much resembles the "hanging-wall" of the lodes in Livingston county and in the western part of this county, and it may be an indication of such a lode crossing this property. This can be definitely settled only by sinking shafts. There is no well-defined exposure of the sandstone, so that the direction of its course could not be accurately determined. At the shaft it appears to have a course south 20° to 30° east; but the black shale at shaft No. 4 resembles the shale generally found in the proximity of the quartzose sandstone in Liv-

ington county. Such may be the case in this instance, and the lode (if one exists) would then pass north of the Barnett shaft in a direction about south 20° west. As limestone is exposed on the creek, across the course which the sandstone *apparently* takes, the latter is probably near the correct course.

At the *Old Mill Shed*, considerable spar containing lead and blende was taken from a crevice between limestone walls. Blende is much more abundant than the galena.

The spar is said to have exhibited a width of three feet; it was covered with water when the locality was examined.

Fluor-spar occurs in vertical seams, and in crystals studding the sides of cavities, in the limestone; also in small irregularly distributed masses. Some of the seams are an inch in width, while many are mere thread-like veins.

The zinc is quite abundant, and, in the greater portion of the limestone, is disseminated in minute, but closely-connected particles, without being associated with spar.* The limestone is always quite silicious in the vicinity of the spar.†

Attempts have been made to prove this crevice a continuation of that at the Glass shaft, but there seems to be no reason for considering it as such. It is more presumable that two distinct fissures exist, and that the fissure at the Glass shaft (should it extend so far) crosses this, or coincides with it, at a point near where the limestone is marked on the map, north of the Marion road.

Much lead is said to have been taken from shafts Nos. 6, 7, and 8. It occurred in large masses, inclosed between limestone walls.

These shafts are not exactly on a line with each other; but they are, without doubt, connected, the fissure having an irregular course.

From the *Old Mill Shed*, within twenty-five yards of the *Whim shaft* (No. 6), limestone is exposed at intervals along the creek.

* A little *cadmium* is combined with the blende.

† This is an instance of replacement; the lime has been dissolved out, and the silica, carried by the fluor-spar, taken its place. This limestone is interesting as forming another link in the history of the lead—additional evidence that it came from above.

Up the creek, about 130 yards above the shed, masses of fluor-spar, with some silicious matter bearing galena, are seen occupying an opening in the limestone forming the bed of the creek. The limestone has been cut away from them by the running water, leaving a fissure twelve feet wide, the course of which is north 8° east. The limestone lies horizontally, and, no doubt, the spar was formerly in immediate connection with it, as a sort of vein; this gives a tolerable idea of the nature of the deposits. This may extend for some distance on either side of the creek, perhaps coinciding with other fissures.

More excavating has been done south of the Glass shaft, in a ravine, than elsewhere on the property. A number of shallow pits were dug promiscuously in the hollow, out of every one of which lead and fluor-spar were obtained in variable quantities.

It would seem as if the lead occurred in pockets, or that there was an extraordinarily large cavity filled with the mineral.

Just how the lead occurred, whether between limestone walls or not, could not be learned. The digging was done many years ago. Although the lead does not occur in the fissures of true veins, still its abundance is a matter undoubted.

There is a better showing of the ore near the surface at these mines, and in their vicinity, than in any other part of the county, and there is little doubt that it will last for a considerable time. It is probable, however, that its vertical extent is more limited than generally supposed.

Memphis Mines.—These mines, also known as the *Belt mines*, are located on the old Belt property, about 4 miles northeast of the Columbia mines. Very little galena has been procured from them, their interest centering in the large deposits of fluor-spar occurring at them.

It is nearly all of the clear, massive variety. The deposits are of the same nature as those at the Columbia mines.

The mines were not in operation when visited, and my conclusions are mostly based on information received from Rev.

Isaac McMurray (who accompanied me), and from Mr. J. C. B. McMican.

The first shaft visited is No. 1, four miles northeast from the Columbia mines.

It was sunk to the depth of 60 feet in limestone, no spar being found.

A few yards north of the shaft, masses of clear fluor-spar occur in red clay. At an opening about 30 feet south 60° west of the shaft, large masses of nearly pure white fluor-spar were also found in a crevice. These lie in a line south 45° west from the pit north of the shaft, and are, no doubt, connected with the spar at that place.

A shaft, known as the "*Rye Field Shaft*," was sunk in a field south of No. 1, and much fluor-spar obtained.

The course of the crevice south of shaft No. 1 is south 45° west, and there is little doubt that the Rye Field shaft is sunk on it.

The Beck Shaft (No. 2).—This is about one quarter of a mile nearly due west from No. 1. More work has been done at it than elsewhere on the property. It was partially filled with water; Messrs. McMurray and McMican, however, furnished the desired information.

The latter gentleman lives near the mines, was a frequent visitor to them, and descended the shaft several times.

The shaft was sunk to the depth of 160 feet, in limestone. A large quantity of remarkably fine fluor-spar was taken out; some of it is still to be seen piled near the mouth of the shaft. It is beautifully clear, almost wholly without impurities.

The spar was reached at ten feet below the surface, and continued until a depth of seventy-five feet was reached; it was then passed through and very little obtained below.

Mr. McMican says: "The spar occurred in large masses in the limestone, and a great quantity was taken out." Very little lead was obtained; that found was distributed in small particles through the fluor-spar.

The limestone is drab and light grey in color, and filled with seams and masses (filling cavities) of calc. spar.

Shaft No. 3.—This is about three hundred yards from the Beck shaft, course south 30° east, as well as could be estimated.

It was abandoned when visited. It was sunk to the depth of about fifty feet, and appears to be entirely in limestone, the color of which is drab and light grey, probably a continuation of the bed at the Beck shaft.

Scarcely any lead was obtained. Fluor-spar and calc. spar occur in seams and masses in the rock.

On the west side of the shaft, a little below the level of the top, a pit was dug down through red clay to the depth of ten feet.

A drift was then started with a course south 18° west, under a sandstone.

Everything was in a tumbled condition, so that the drift could not be entered.

Fragments of fluor-spar carrying particles of galena were found on the pile of material taken from the pit, but whether they came from the clay in the pit or from under the sandstone could not be determined.

Nor could any satisfactory conclusion concerning the sandstone be arrived at. It may have been brought down by a slide, or by a settling of the strata, as the region abounds in sink-holes, or it may be merely a large mass tumbled from its true position.

Again, it may be in place, and overlies the limestone at the shaft; in this case it is probably the sandstone at the base of the Chester Group.

The lead deposits at, and in the vicinity of, the Belt mines seem to be very small, but there is a vast quantity of first-rate fluor-spar. With an increasing demand for this mineral as a flux, by the various manufacturing industries, there is reason to suppose that the spar alone will pay for the working.

The Grace Shaft.—This is located on land belonging to Messrs. McMurray and Blue, one mile and a quarter northeast of the Crittenden Sulphur Spring.

This is an old pit, sunk probably thirty years ago. It is now nearly filled with debris. Near the surface, red clay with

masses of fluor-spar and fragments of sandstone intermingled, was passed through.

Considerable fluor-spar, but no lead, was obtained.

The Campbell Shaft.—This is about seventy-five yards nearly due west from the Grace shaft, and is on Mr. W. Spring's land, near the line of McMurray and Blue.

It was sunk to the depth of thirty feet. Much fluor-spar and calc. spar were obtained. Calc. spar predominated; large masses made up of crystals of the "nail-head" variety, some of them weighing fifty pounds or more, were seen lying near.

The shaft was sunk by the side of a limestone outcrop, on the west. Whether there is limestone on all sides could not be determined.

The spar seen at the top occurs in red clay, between horizontal layers of limestone; it also seems to lie in heavy horizontal beds below the limestone, with red clay between. Some parts of a bed are entirely limestone, and this passes laterally into calc. spar.

The following is the general arrangement of the beds for the depth visible, which, however, is but for a few feet:

1. Grey, sub-oölitic limestone, with red clay between the layers.
2. Red clay, with masses of calc. spar at the lower part.
3. Masses of limestone, calc. spar, and fluor-spar combined.

This section is a very pretty illustration of the derivation of some of the fluor-spar deposits.

Near the Campbell shaft there are numerous sink-holes, one forming the entrance to a cavern.

Mr. McMican states that spar (whether fluor or calc. he did not know) is to be seen clinging to the walls, and in little "pockets" in limestone forming the sides of the cavern.

Indeed fluor-spar and calc. spar are found nearly everywhere in this region, either strewn over the surface or connected with limestone.

It does not, however, always have lead in connection with it; so that, although deserving attention, it is not a certain guide to lead deposits.

As a conclusion concerning the lead deposits of this region, it may be stated, that in some instances they may be worked at a limited profit.

It would be best, however, that no expensive machinery be erected; but rather that the ore, when in sufficient quantity, be carried to such places at which crushers and furnaces are already built; the most profitable arrangement, perhaps, being to dispose of it to the smelters in its crude form.

Rosiclare and Fair View, Illinois, offer these facilities.

According to analyses by Dr. Peter and Mr. Talbutt, it is useless to mine the ore for the amount of silver contained in it; the per centage is so small that the amount obtained would not pay for the separation.

CALDWELL COUNTY.

GENERAL GEOLOGY.

The geological formations in the county include the quaternary and carboniferous.

Quaternary.—The usual divisions as indicated in the Livingston county report are present. The *drift* is more fully developed towards the western part of the county, however. It is the repository of excellent iron ore, of the limonite variety. So far as my observation extends, the drift is mainly composed of rounded pebbles of chert mingled with red clay, and is the result of the wasted beds of the lower carboniferous rocks, mostly from the St. Louis Group. Typical fossils of the St. Louis Group are frequently found in it.

Occasional pebbles of quartz and fragments of sandstone are also met within it. The quartz pebbles probably came from the conglomerate; the sandstone may have come either from the coal measures or lower carboniferous.

Without attempting an elaborate discussion as to the history of the iron ore, it is suggested that it may possibly have an intimate relation to the chert, as that has always a ferruginous tinge, is usually somewhat cellular, and accompanied by a deep red ferruginous clay.

This clay is quite silicious, and there are instances which seem to clearly indicate that it was derived from the chert.

Carboniferous.—The rocks of this age occurring in Caldwell county belong to the coal measures and sub-carboniferous.

The *Coal Measures* are represented by the conglomerate and associate coals, near the railroad, and by higher sandstones and coals (possibly two), towards the north, in the vicinity of Tradewater river.

Caldwell is really richer in coal than is generally supposed, the limits of the coal field extending further to the west than has heretofore been estimated.

The conglomerate coals are near to the surface at several places on Tradewater, displaying a thickness of four feet in some localities.

There is reason to consider the coals of Caldwell as worthy of further attention, and to believe that some benefit to the county may be derived from them.

Lower Carboniferous.—The St. Louis Group and the Chester Group are both present in the county. They are fully described in the report on the region adjacent the Louisville, Paducah and Southwestern Railroad.

The St. Louis Group is distinguished as being the lead-bearing formation, and for affording the beautiful oölitic limestone so well adapted for building purposes.

There is, perhaps, no better building stone to be found in the western portion of the State than is to be obtained in this county; not excepting the celebrated Bowling Green oölite.*

Besides the oölite for fine work, the lower blue limestone will answer for ordinary purposes, and some of the beds towards the top are admirable for such masonry as foundations, bridge piers (light work), and culverts.

Much interest has been manifested as to whether or not limestone suitable for *lithographic* purposes exists in the county. None was observed that in any way could be used for that purpose.

*It is probable that they occupy *about* the same geological level.

The typical fossil corals of the St. Louis Group, *Lithostrotion Canadense* and *L. proliferum*, are quite abundant in some parts of the county. A fine specimen of the *Lithostrotion* was presented to the Survey by a young lady of Princeton; huge masses of it were also seen on the Wilson Warehouse road, about one mile from Princeton.

As is the case wherever it is known to occur in this part of the State, this division of the lower carboniferous is quite cavernous. A cavern extends under part of the town of Princeton through which a stream of water flows, gushing forth at the "Big Spring." A number of wells are said to have been sunk through the roof of the cavern, and a seemingly inexhaustible supply of water obtained in this stream.

The Lead Region.—Galena is reported to have been discovered in a number of places in Caldwell county, generally as bunches clinging to the walls of caverns or filling small cavities in the rocks. No place of importance is cited, however, except in the northern part of the county on the head waters of Donaldson Creek, about nine miles northwest of Princeton.

There has been, indeed, very little attention given to the lead deposits; much less than in either Livingston or Crittenden county.

The occasional reports circulated to the effect that lead has been discovered in fabulous quantities at various localities are all traceable to one common source—legend. From our present knowledge it is deemed safe to say that galena occurs in more or less abundance throughout the St. Louis Group, in its entire extent, and is liable to be found wherever rocks of that group are exposed. With one exception, no systematic explorations for the mineral have been made in the county; this was on the property of Judge Marble, of Princeton.

Mr. Marble's shaft is on the head waters of Donaldson Creek, about four miles a little north of east of Fredonia, and about nine miles nearly northwest from Princeton. The rocks belong to the St. Louis Group, with the Big Clifty sandstone? (base of the Chester Group) capping the high ridges in the vicinity.

Several veins cross the property, all having about the same general course—nearly east and west. The width of the fissures is not uniform, however, nor are they always filled with metal, but are sometimes designated merely by streaks of fluor-spar. When the locality was visited the weather was very unfavorable, so that no attempt was made to trace the several fissures, and they may not be so extensive as supposed. A fairly accurate knowledge of the nature of the deposits in the adjoining counties, Livingston and Crittenden, aided considerably, however, in the comprehension of the character of the veins, or more appropriately (because not so distinctive), deposits of this region.

The vein on which Mr. Marble's shaft is located is said to be from three to four feet in width, coursing nearly due east and west. When examined, the pit was nearly filled with water, so that no personal knowledge as to the appearance of the vein was obtained. Both walls are limestone, the sides inclining at an angle of about 25 degrees.

According to the affirmation of one of the miners, the fissure was gradually widening towards the bottom, and the lead becoming more concentrated. The material taken from the fissure consists of fluor-spar, with galena distributed through it in small cubes and in masses about an inch in diameter. Towards the bottom the lead is said to have occurred in larger masses, some of them weighing from seven to eight pounds; the general size, however, was not much over a pound.

The galena is distributed pretty generally throughout all the material taken from the fissure, but in such small particles that the aggregate is but little when compared with the amount of fluor-spar in which it is inclosed.

Zinc sulphide and some galena were found in fragments of the wall rock.

In the lead region of Caldwell the character of the deposits seems to differ somewhat from the typical ones of Livingston and Crittenden counties.

The metal seems to fill crevices and openings in the limestone, produced by shrinkage of the rocks, and by erosion.

They approach more nearly in character to those at the Columbia mines (Crittenden county) than to any others.

There appears to be two classes of veins in the lead region of southwestern Kentucky, both deriving their lead from the same source. In one the lead occupies the upper part of a true vein, as is the case at the Royal mines, Livingston county, and in the other the metal fills incidental cracks, fissures, and cavities in the limestone. This latter class is not so persistent in longitudinal distance as the former, nor is there any definite calculation to be made as to the depth to which the lead extends. But when at all rich in lead, they seem to be more valuable, in proportion to their extent, than the first class, in that the lead is more concentrated. It is to the second class that the deposits of Caldwell county belong.

So far, no true veins (in the strict sense of the word) bearing galena have been found in the United States, except in the manner of those in Livingston and Crittenden counties, and in the southwestern portion of Illinois. All our lead deposits extend to a comparatively shallow depth.

In Missouri, one of the principal lead-producing States, two classes are distinguished, the gash vein and the segregated deposit, with their several modifications.

In southwest Missouri, where an immense amount of lead has already been obtained, and as yet without any apparent diminution in the quantity, the lead occurs (using a general and collective term) as segregations. In northwestern Illinois, Iowa, and Wisconsin, the galena occurs as gash veins, with local modifications, none of them extending to any great depth. In the southwestern part of Kentucky and Illinois the lead occurs in the upper part of true veins, or rather the *fissures* of true veins, as segregated deposits and in veins approaching gash veins in character.* It will be seen, therefore, that it is not necessary for the lead to occur as a true lode to be of value,

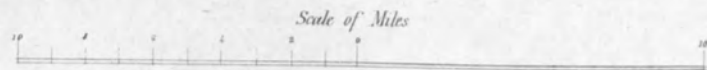
* *Gash vein* is a term designating mineral deposits occupying fissures confined to a single member or set of strata of a formation, and is always limited in depth to where a marked change in the chemical and lithological character in the strata occurs. It holds an intermediate position between segregated and true veins, and is sometimes hardly distinguishable from a segregated vein.

which fact does not seem to be understood by those interested in mining in this region. The typical deposits in Caldwell would, perhaps, take an intermediate position between a true vein and a gash vein, extending to a depth greater than the latter, but not so deep as a true vein; approaching more nearly in character to a gash vein, however.

As a conclusion, it may be said, that it is by no means impossible for a profitable deposit of lead to be found in this region; but, forming an opinion from the past results, there does not seem to be much probability that such will be the case. The mines at Rosiclare, Illinois, are located on veins similar to, if not identical with, some of those in Livingston county, in this State. If the mines there are not remunerative, ours certainly will not be. It is recommended, therefore, that no great expense be incurred in further prosecuting the search for lead, but rather that those already interested in mines which do not really offer solid inducements, be content to let the matter rest as it is.

This advice is given with the earnest desire to save the people of Kentucky from any useless expenditure of their money, and not with a wish to needlessly depreciate our mineral wealth.

As long as Missouri and other lead-producing States can afford lead at such little cost for mining and smelting, neither Kentucky, nor any other State with similar deposits, will be able to successfully enter the market with them.



- Sandstone
- × Quartzose Sandstone
- * Conglomerate
- ⋈ Limestone
- △ Lead
- ⚡ Lead Shaft
- Coal

MAP EMBRACING

the

LEAD REGION

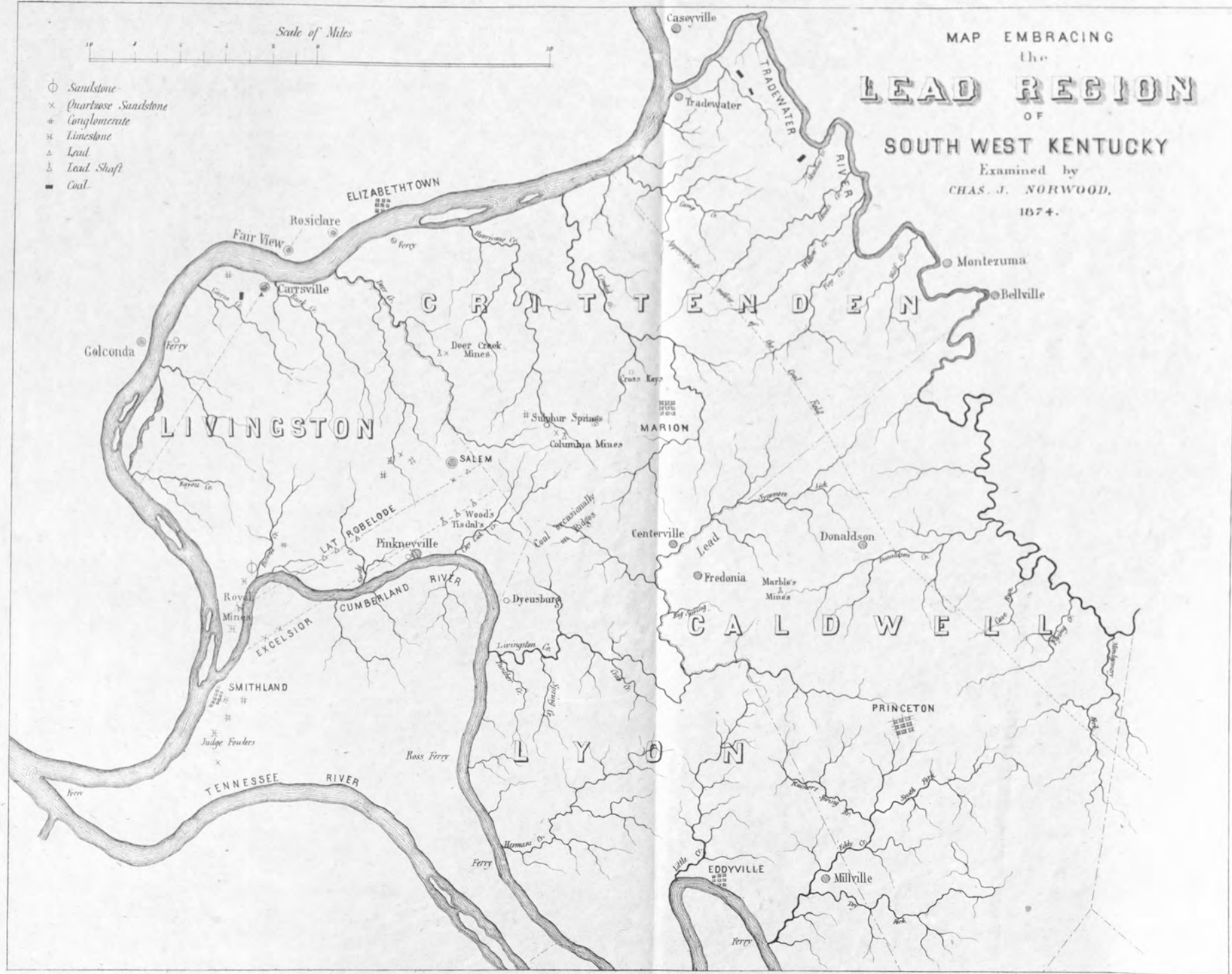
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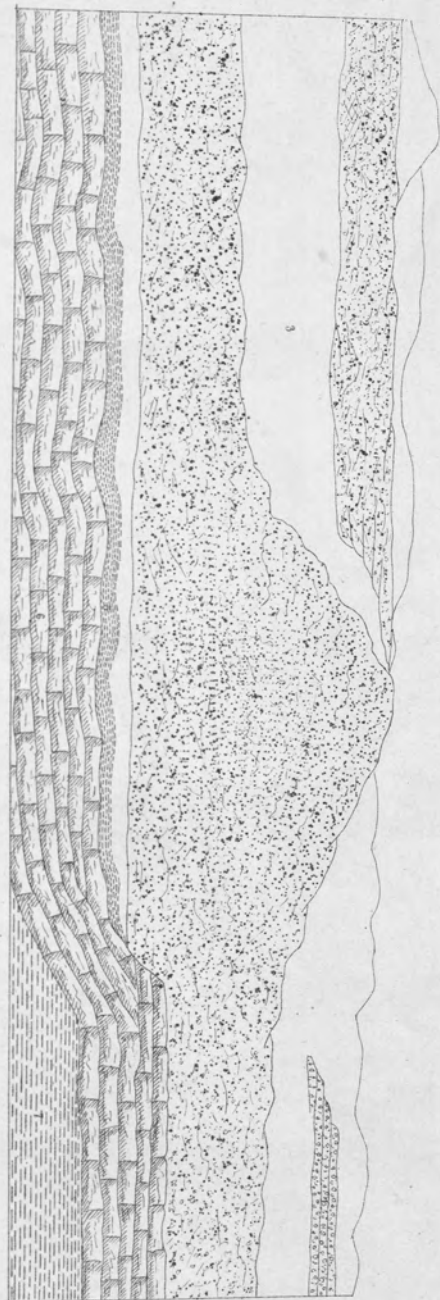
SOUTH WEST KENTUCKY

Examined by

CHAS. J. NORWOOD,

1874.





Outline sketch of the Rocks from
Cartersville to a point $\frac{1}{2}$ mile Below
 Livingston Co.



Fig. 1.

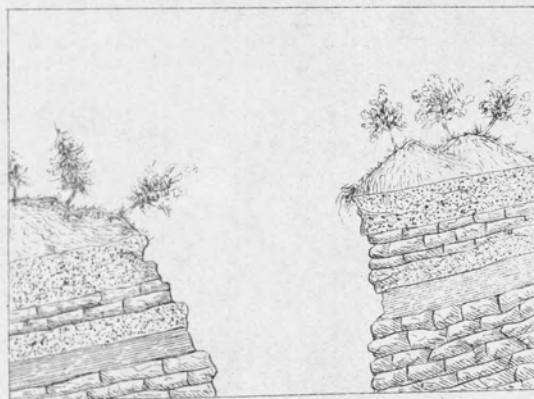


Fig. 2.

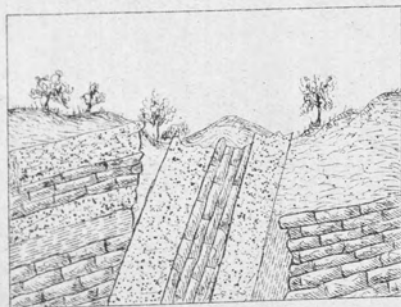
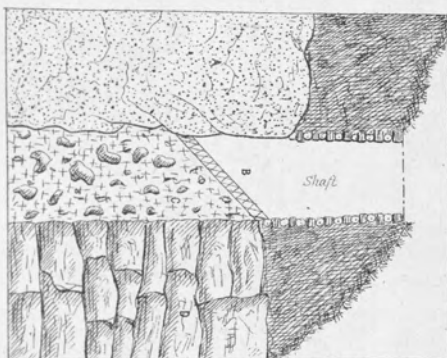


Fig. 3.

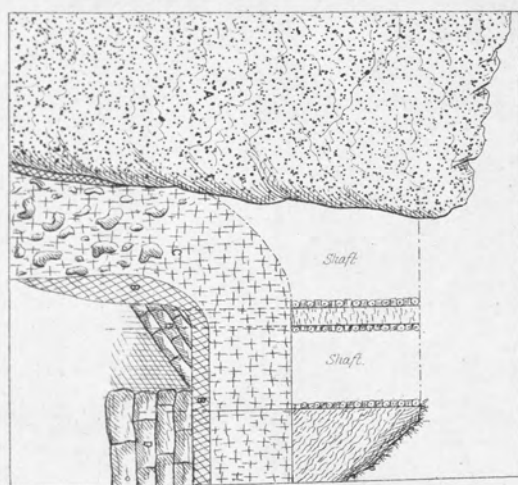
- A. Quartzose Sandstone.
- B. Clay.
- C. Flour Spar Limestone fragments & Lead.
- D. Limestone.



ROBERT WOODS'
LEAD SHAFT
3 Miles South of Salem
LIVINGSTON CO.

Fig. 1.

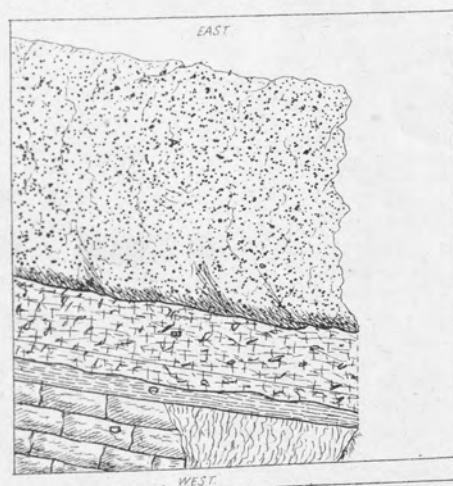
- A. Quartzose Sandstone.
- B. Clay.
- C. Rotten Flour Spar & Lead.
- D. Limestone.



HENRY WOODS'
LEAD SHAFT
3 Miles South of Salem
LIVINGSTON CO.

Fig. 2.

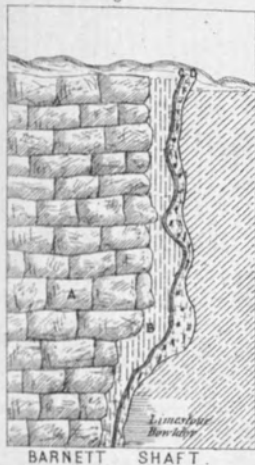
- A. Quartzose Sandstone.
- B. Calc & Flour spar with Galena.
- C. Shale.
- D. Limestone.



DEER CREEK MINING COS
LEAD SHAFT
CRITTENDEN, CO.

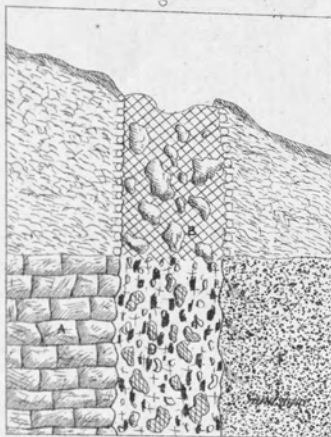
Fig. 3.

Fig. 1



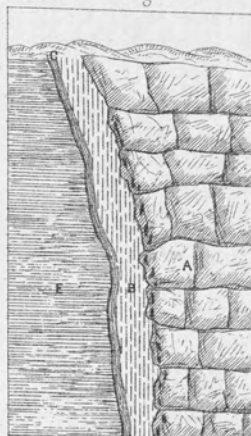
BARNETT SHAFT.

Fig. 2



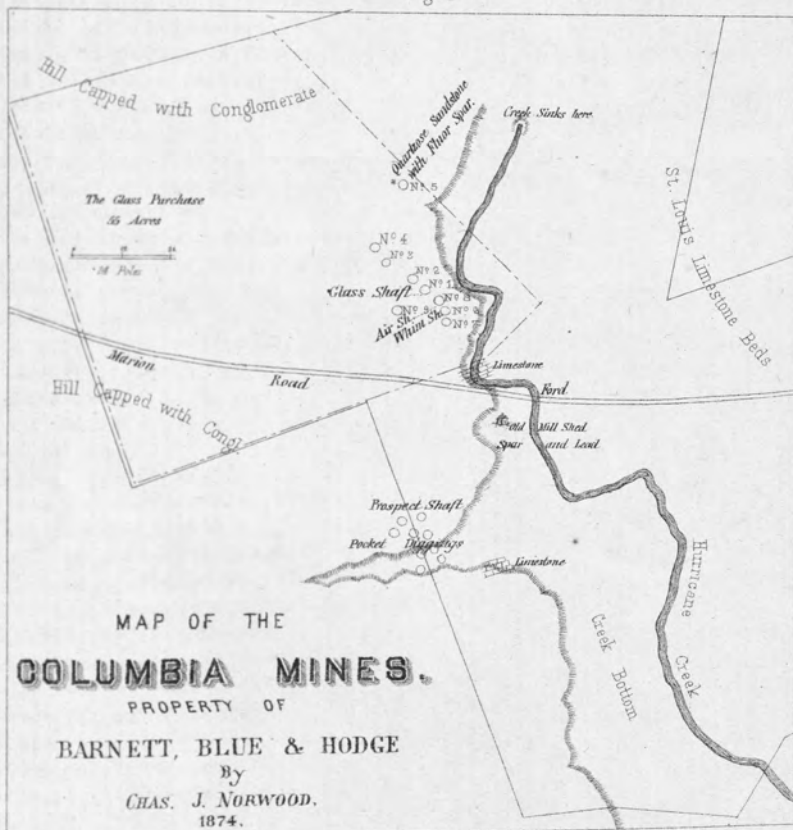
GLASS SHAFT.

Fig. 3



BARNETT SHAFT.

Fig. 4



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