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,

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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.

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	....	....	....	....	....	10.594	....	....
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	....	....	....	....	....	trace.	....	....
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	.361
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	....	....	....	.071	....	....	.107	.042	.035	.108	.342
Phosphorus	.276	.062	.161	.218	.234	.026	.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

thrown away in selecting the ore, which, had each furnace the means to cheaply and quickly determine their value, could be made a source of profit.

(*b*) THE BLOCK ORES.

The feature which gives the name to these ores has been already stated. They occur in regularly stratified beds at certain well-defined geological levels, with a uniformity and persistence which is much greater than in either of the other classes of ore. The different beds maintain a remarkably uniform character and thickness over large areas, presenting few of those sudden changes which are so characteristic of the limestone ores. Some of them hold their quality, thickness, and geological position over a large territory, hardly varying forty feet in distance from a given datum, or six inches in thickness in many square miles. The beds vary greatly among themselves in quality and thickness; having for common characteristics the feature to which they owe their name, their cleavage into cubical blocks, and the fact that the most common impurity is silicious matter in the form of coarse sand mechanically intermingled.

The beds of ore usually occur resting in clay and bituminous shales; sometimes upon a coal, and sometimes with a sandstone overlying.

Often a series of kidneys, nodular masses or segregations of ore, is found in the shales above the bed of block ore, lying thickest close to the bed, and growing thinner above. When this is the case, the kidneys are usually of better quality than the block ore. More rarely the place of the bed or plate of block ore itself is occupied by a series of these kidneys, lying regularly at the proper level, but not forming a connected layer. The beds of ore seem to have been deposited after the underlying rock, and before the overlying, while the kidneys segregated, perhaps at the time, perhaps afterward, from the ferruginous mud which formed the overlying shale. It is a noticeable feature of the block ores that an increase in thickness is usually accompanied with an increase in the

amount of sand intermixed. This fact is so general, that it can almost be taken as a rule, with few exceptions, in judging the value of block ores—the thicker the bed the leaner and more sandy the ore, and vice versa, the thinner the bed the richer the ore. It seems that the amount of iron held in solution by the waters of deposition at each level was constant, and where deposited quietly, the resulting bed of ore was thin and comparatively pure; but where the water was disturbed, and held mechanically suspended silicious ingredients, it was thicker and leaner.

GEOLOGICAL POSITION.

The geological position of the block ores is between the two limestone ores already described. No block ore which is more than a local deposit of very limited range has been found above the level of the ferriferous limestone. The most reliable and valuable bed of block ore occurs at from seventy-five to ninety feet below the ferriferous limestone. Ranging from sixty-five feet below this to fifty feet above, a number of other block ores are locally found. This group will be known as the upper block ores, and the principal member of it as the main block ore.

The next level of the most reliable block ores is about two hundred and fifty feet below, at from forty to sixty feet above the sub-carboniferous limestone, or where this is wanting, the Waverly sandstone. There are a number of block ores near this level, some as low down as fifteen feet above the limestone, and some extending as high as one hundred and twenty-five feet.

These will all be known as the lower block ores. At other levels there are occasional beds of ore, but they are usually local, and will be described by their local names.

The block ores, like all the others of this region, are found as limonites and unaltered carbonates or earthy siderites. The different beds vary so greatly in appearance and chemical composition, that a general description cannot well be given here, but must be left to the discussion of the separate beds.

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 additonal 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	50.206	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	.570	.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 Tygert 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 Tygert 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. . .	. . . .	. . . .	27.758	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.	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	.07+	.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 fouud 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 Kinnikenick 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. Estimat ing 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:

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	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 occured 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-oölitic 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 supposd 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 *stigmaria* 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 ferriferous 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 anv 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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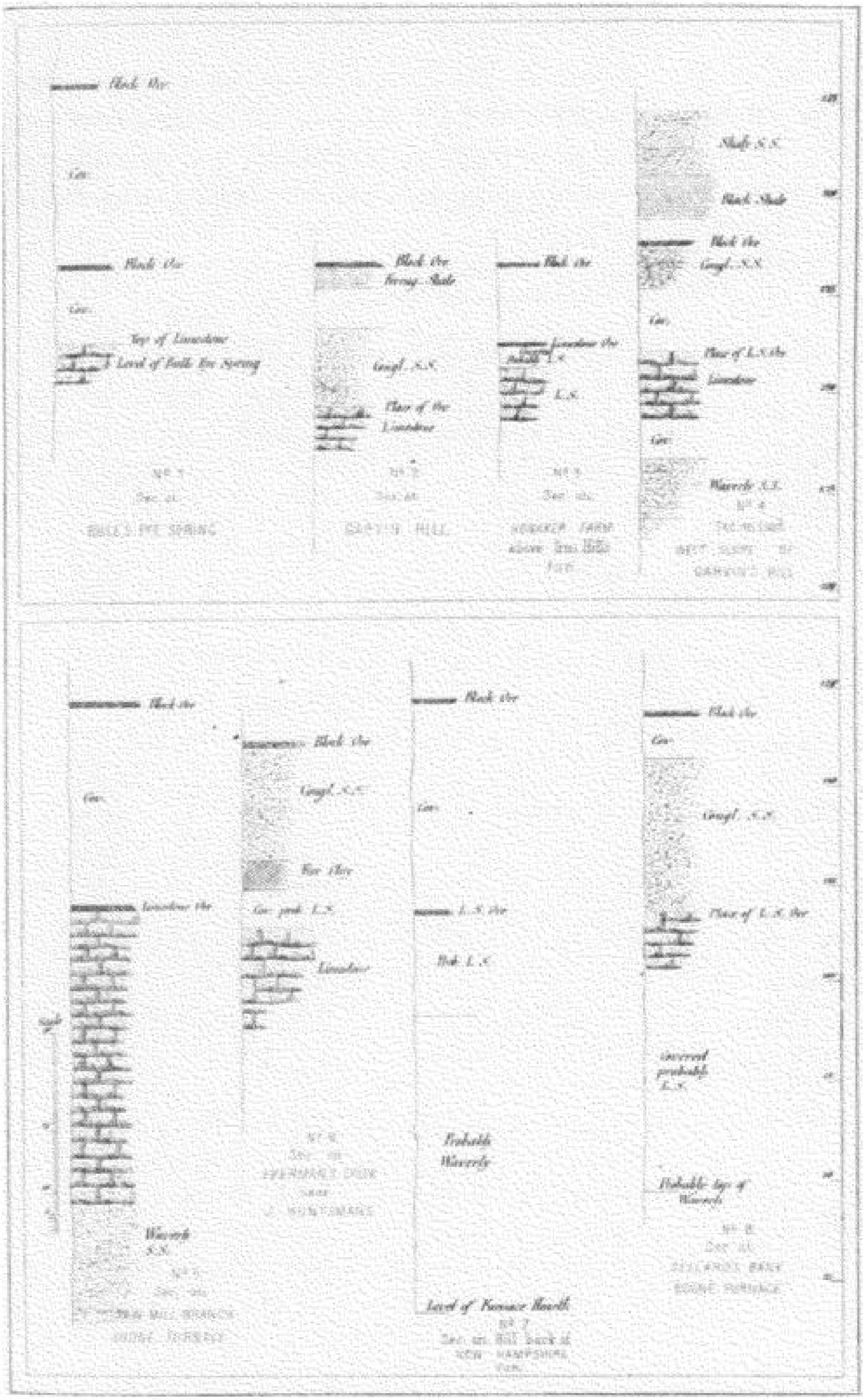
Black Ore
Cov.
Top of Limestone
Level of Buffalo Ore Spring
Ferrous Shale
Congl. S.S.
Place of the Limestone
Limestone Ore
L.S.
Shale S.S.
Black Shale
Place of L.S. Ore
Limestone
Waverly S.S.
Fire Clay
Cov. prob. L.S.
Prob. L.S.
Probable Waverly
uncovered probably L.S.
Probable top of Waverly
Level of Furnace Hearth

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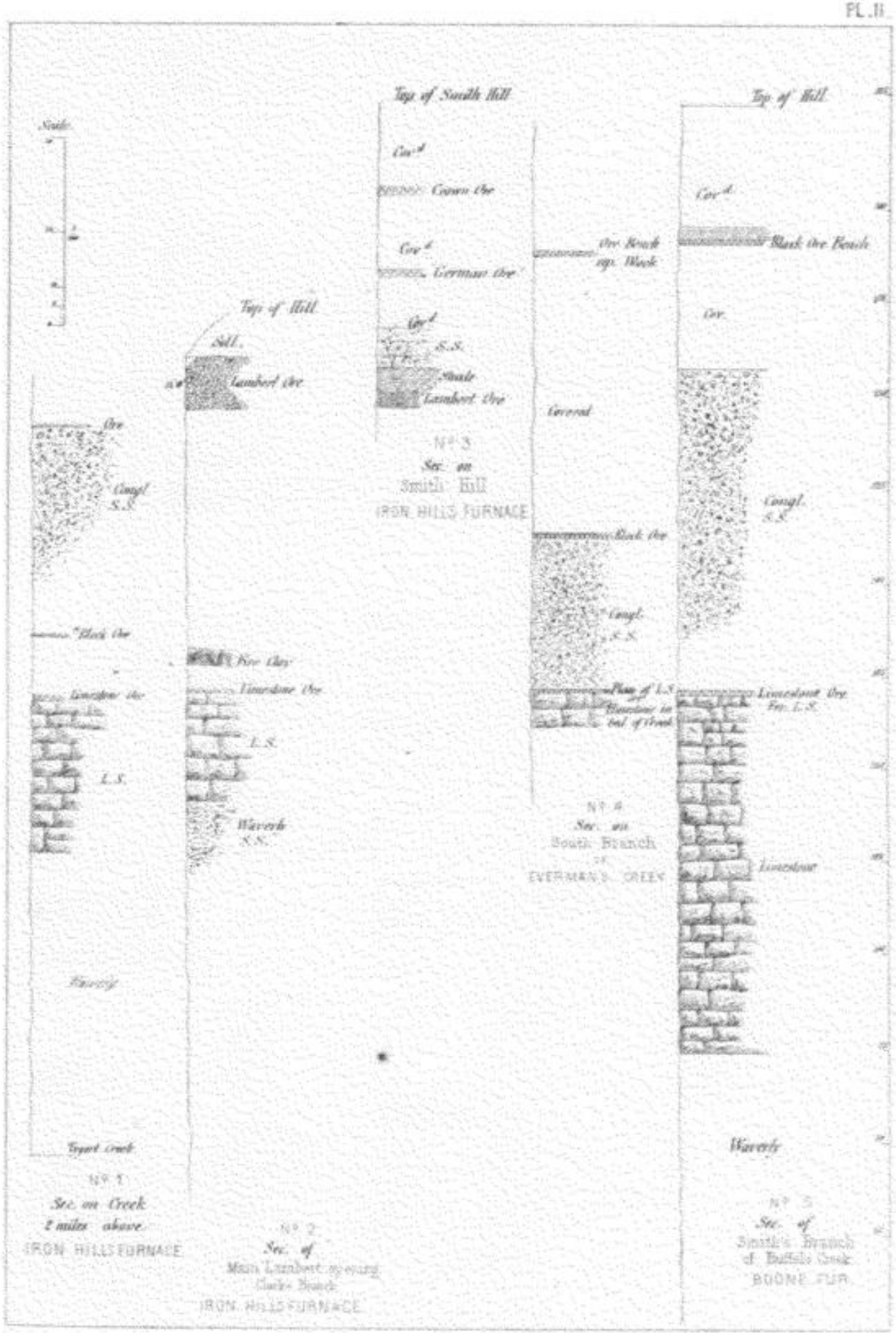
Scale
Ore
Congl. S.S.
Black Ore
Limestone Ore
L.S.
Tygart Creek
No 1
Sec. on Creek 2 miles above
IRON HILLS FURNACE
Top of Hill
Sdl.
Lambert Ore
Fire Clay
Limestone Ore
L.S.
Waverly S.S.
No 2
Sec. of
Main Lambert opening
Clarks Branch
IRON HILLS FURNACE
Top of South Hill
Cov.d
Cannel Ore
Cov.d
German Ore
Cov.d
S.S.
Shale
Lambert Ore
No 3
Sec. on
Smith Hill
IRON HILLS FURNACE
Ore Bench opp. Week
Covered
Black Ore
Congl. S.S.
Place of L.S.
Limestone in bed of Creek
No 4
Sec. on
South Branch
of
EVERMAN'S CREEK
Top of Hill
Cov.d
Black Ore Bench
Cov.
Congl. S.S.
Limestone Ore
Top L.S.
Limestone
Waverly
No 5
Sec. of
Smith's Branch
of Buffalo Creek
BOONE CO.

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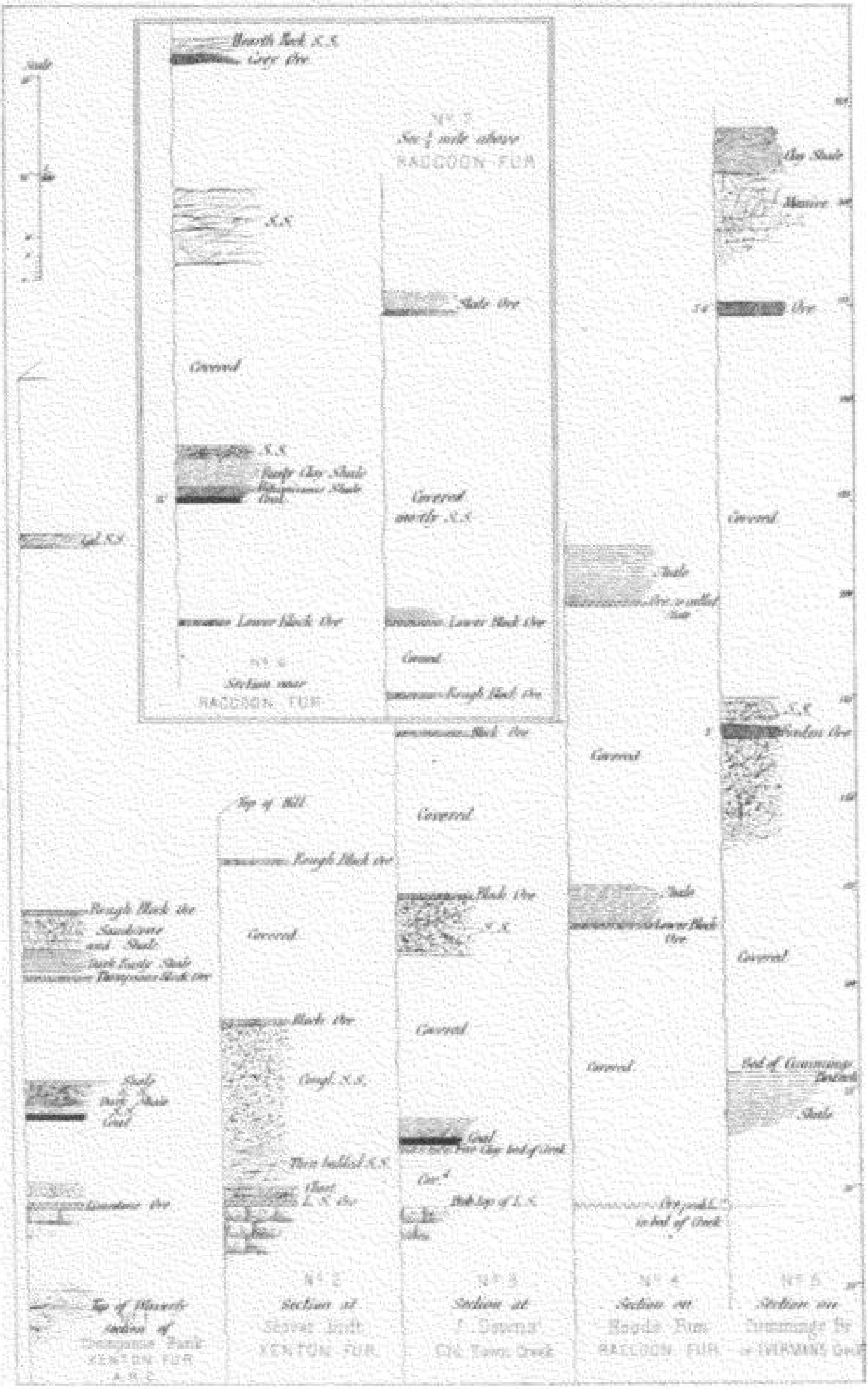
Scale
Hearth Rock S.S.
Gray Ore
No 7
Sec ½ mile above
RACCOON FUR
S.S.
Shale Ore
Clay Shale
Massive S.S.
Ore
Covered
S.S.
Rusty Clay Shale
Bituminous Shale
Coal
Covered
mostly S.S.
Covered
Shale
Lower Black Ore
Lower Black Ore
Covered
No 6
Section near
RACCOON FUR
Rough Black Ore
Black Ore
S.S.
Covered
Covered
Top of Hill
Covered
Rough Black Ore
Black Ore
S.S.
Shale
Lower Black Ore
Covered
Rough Black Ore
Sandstone
and Shale
Dark Rusty Shale
Bituminous Black Ore
Covered
Black Ore
Covered
Congl. S.S.
Covered
Shale
Dark Shale
S.S.
Coal
Shale
Coal
Thin bedded S.S.
Chert
L.S. Ore
Limestone Ore
Prob. top of L.S.
in bed of Creek
Top of Waverly
Section at
Thompsons Bank
KENTON FUR
No 2
Section at
Stover Shaft
KENTON FUR
No 3
Section at
J. Downs'
Old Town Creek
No 4
Section on
Roads Run
RACCOON FUR
No 5
Section on
Cummings Br.
or EVERMAN'S GAP

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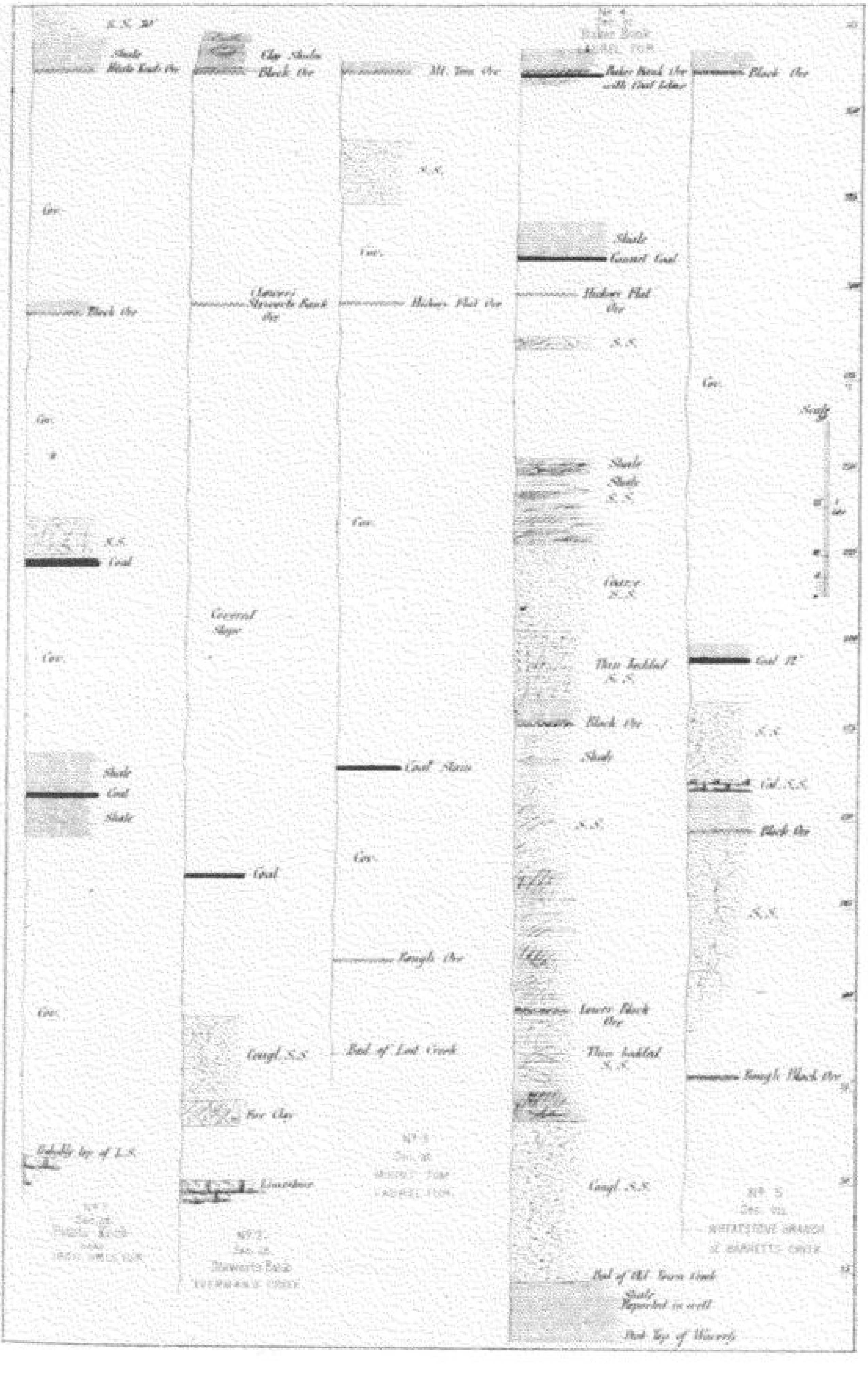
Shale
Black Ore
Clay Shale
Black Ore
Mt. Town Ore
Baker Bank
Baker Bank Ore
with Coal below
Black Ore
S.S.
Cov.
Shale
Cannel Coal
Black Ore
(Lower)
Stewarts Bank
Ore
Hickory Flat Ore
Hickory Flat
Ore
S.S.
Cov.
Scale
Shale
Shale
S.S.
Cov.
S.S.
Coal
Coarse
S.S.
Covered
Slope
Cov.
Thin bedded
S.S.
Coal
Black Ore
S.S.
Shale
Shale
Coal
Shale
Coal Stain
Cal. S.S.
S.S.
Black Ore
Coal
Cov.
S.S.
Rough Ore
Cov.
Lower Black
Ore
Congl. S.S.
Bed of Lost Creek
Thin bedded
S.S.
Rough Black Ore
Fire Clay
Probably top of L.S.
Limestone
Congl. S.S.
Bed of Old Town Creek
Shale
Reported in well
Prob. Top of Waverly

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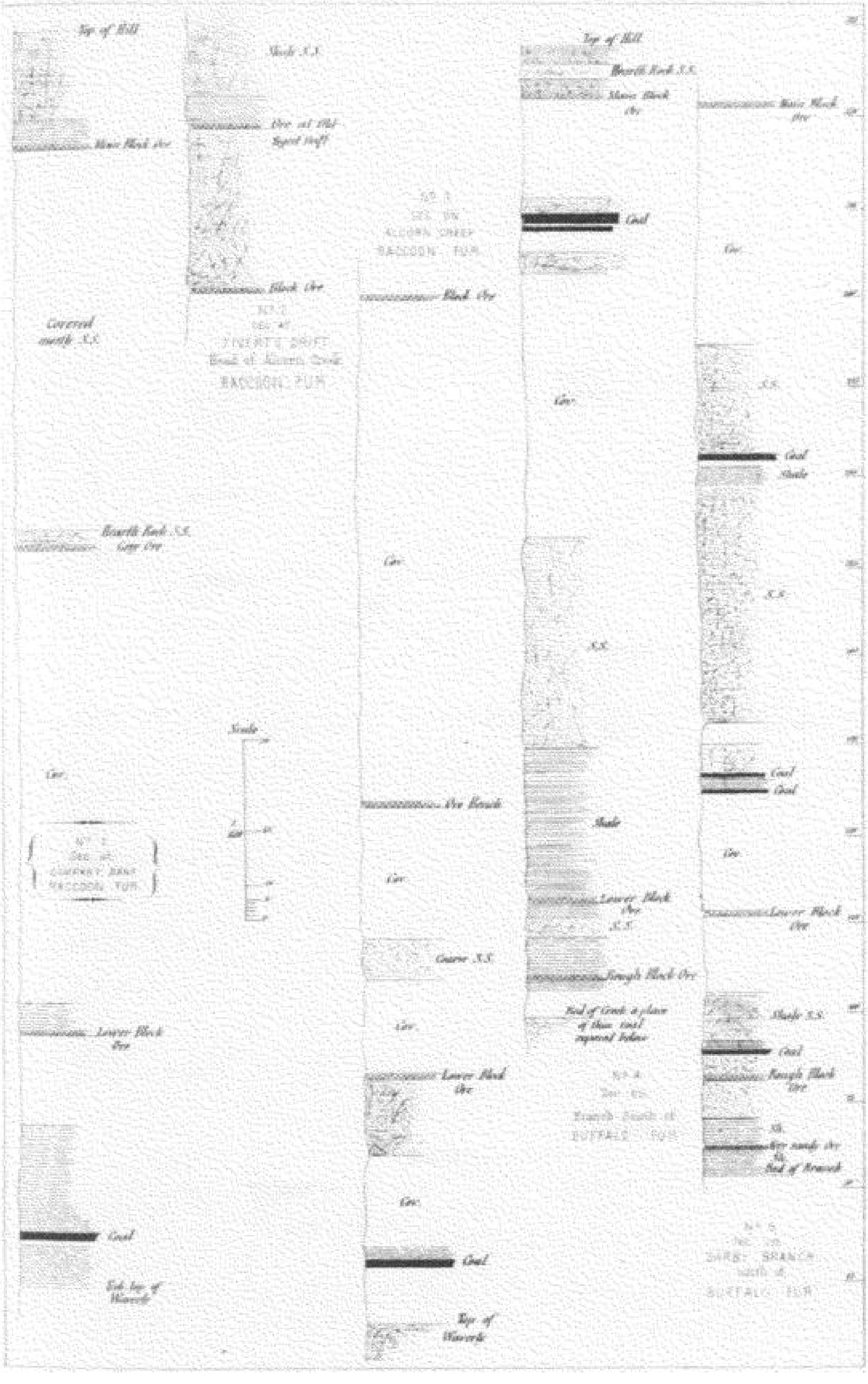
PL. V.



Top of Hill
Covered
Cov.
Coal
Block Ore
Lower Block Ore
Coarse S.S.
Top of Waverly
Shale
S.S.
Rough Block Ore
Scale
No 3
Sec. on
Alcorn Creek
RACCOON RUN
No 4
BUFFALO RUN
No 5
DARBY BRANCH
BUFFALO RUN

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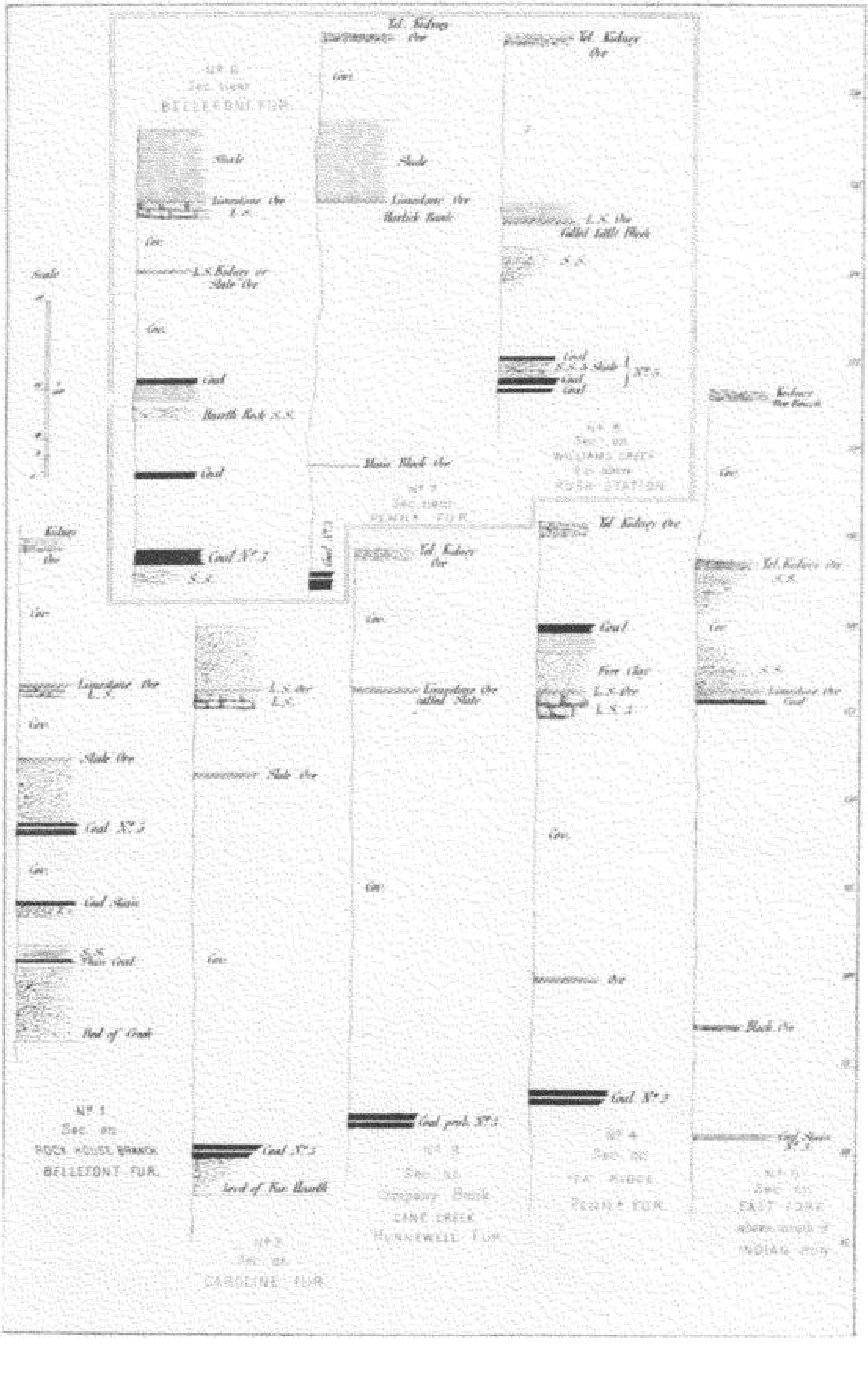

Nº 6
Sec. near
BELLEFONT FUR.
Shale
Limestone Ore
L.S.
Cov.
L.S. Kidney or
Slate Ore
Coal
Hearth Rock S.S.
Coal
Coal Nº 3
S.S.
Yel. Kidney
Ore
Shale
Limestone Ore
Harlick Bank
Main Block Ore
Nº 7
Sec. near
PENNª FUR.
Yel. Kidney
Ore
L.S. Ore
Called Little Block
S.S.
Coal
S.S. & Shale
Coal
Coal
Nº 3
Nº 8
Sec. on
WILLIAMS CREEK
ROSS STATION
Scale
Kidney
Ore
Limestone Ore
L.S.
Slate Ore
Coal Nº 3
Coal Slate
S.S.
Thin Coal
Bed of Creek
Nº 1
Sec. on
ROCK HOUSE BRANCH
BELLEFONT FUR.
L.S. Ore
L.S.
Slate Ore
Coal Nº 3
Level of Fur. Hearth
Nº 2
Sec. at
CAROLINE FUR.
Yel. Kidney
Ore
Limestone Ore
called Slate
Coal prob. Nº 3
Nº 3
Sec. at
Company Bank
CANE CREEK
HUNNEWELL FUR.
Yel. Kidney Ore
Coal
Fire Clay
L.S. Ore
L.S.
Ore
Coal Nº 3
Nº 4
Sec. on
PENNª FUR.
Kidney
Ore Breast
Yel. Kidney Ore
S.S.
Limestone Ore
Coal
Block Ore
Coal Slate
Nº 3
Nº 5
Sec. on
EAST FORK
INDIAN FUR.

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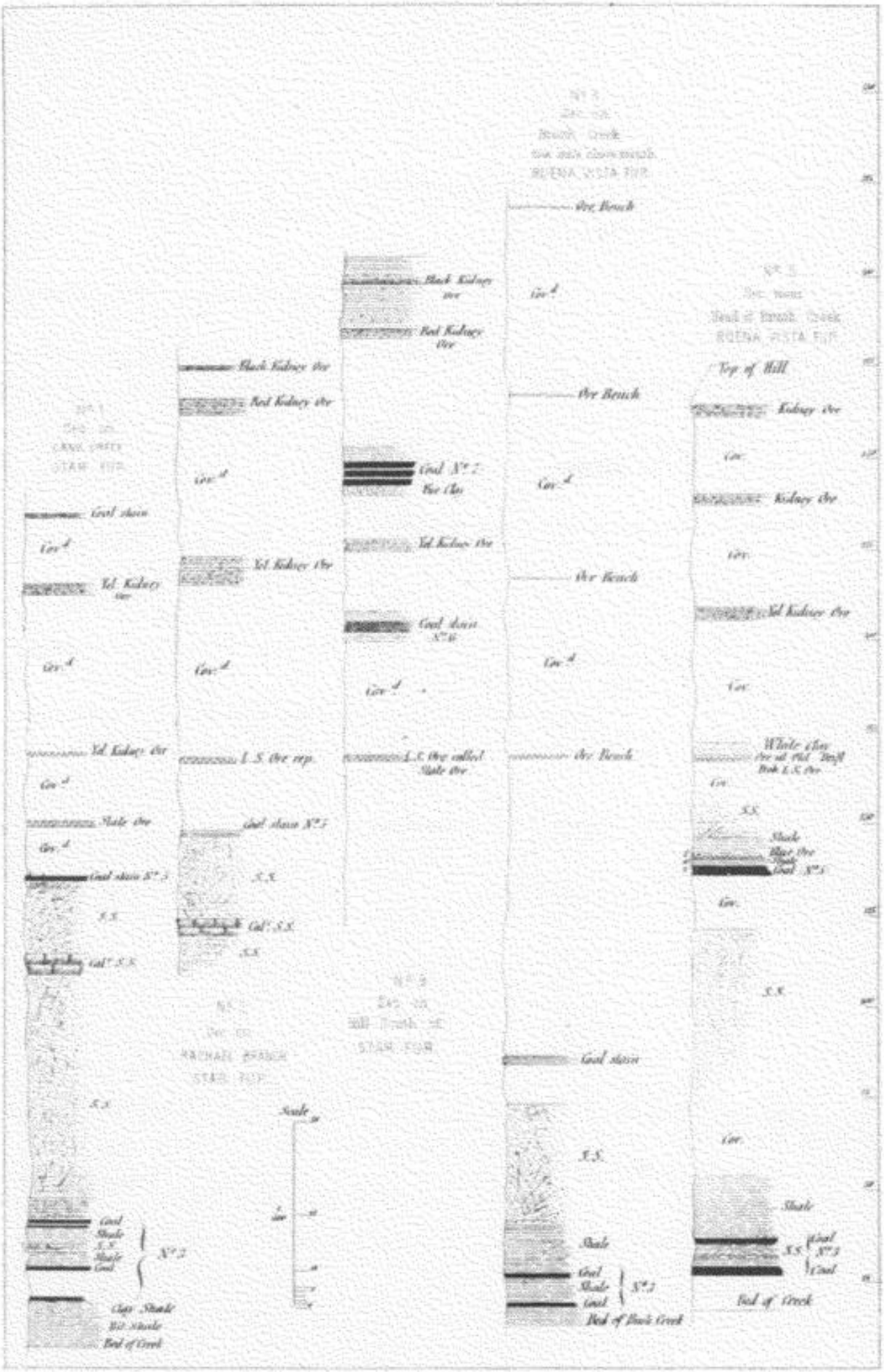
Coal shale
Gov.t
Yel. Kidney Ore
Gov.t
Yel. Kidney Ore
Gov.t
Shale Ore
Gov.t
Coal shale N.o 3
S.S.
Cal.o S.S.
S.S.
Coal
Shale
S.S.
Shale
Coal
N.o 2
Clay Shale
Bit. Shale
Bed of Creek
Black Kidney Ore
Red Kidney Ore
Gov.t
Yel. Kidney Ore
L.S. Ore rep.
Coal shale N.o 3
S.S.
Cal.o S.S.
S.S.
Scale
Black Kidney Ore
Red Kidney Ore
Coal N.o 2
Fire Clay
Yel. Kidney Ore
Coal shale N.o 6
Gov.t
L.S. Ore called Shale Ore
Ore Bench
Gov.t
Ore Bench
Gov.t
Ore Bench
Ore Bench
Coal shale
S.S.
Shale
Coal
Shale
Coal
N.o 3
Bed of Black Creek
Top of Hill
Kidney Ore
Gov.
Kidney Ore
Gov.
Yel. Kidney Ore
Gov.
White Clay
Ore at Old Bluff
Brok L.S. Ore
Gov.
S.S.
Shale
Blue Ore
Shale
Coal N.o 3
Gov.
S.S.
Gov.
Shale
S.S.
Coal
N.o 3
Coal
Bed of Creek

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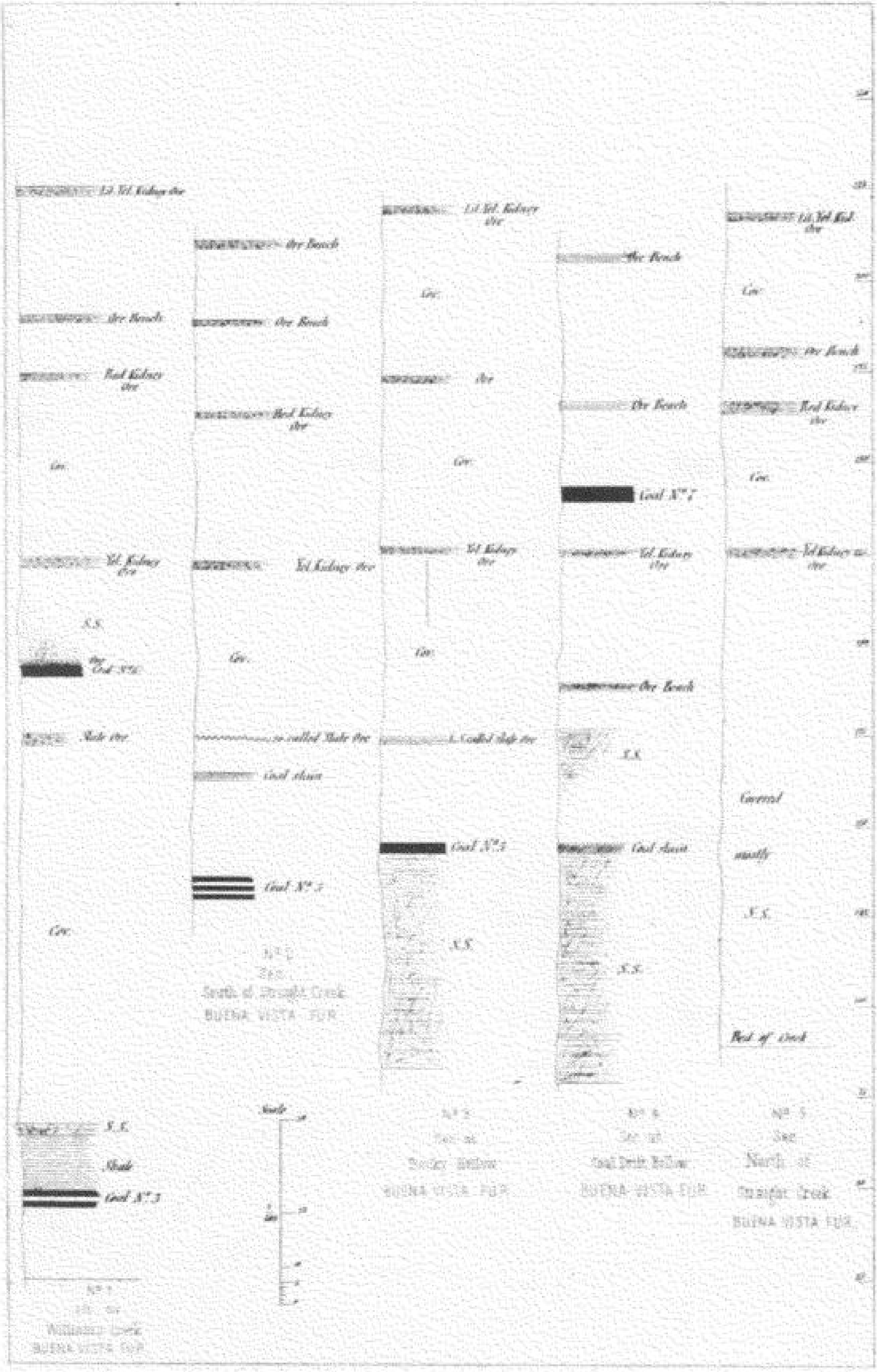
Lt. Yel. Kidney Ore
Ore Bench
Red Kidney Ore
Cov.
Yel. Kidney Ore
S.S.
Ore
Coal No. 6
Slate Ore
S.S.
Shale
Coal No. 3
BUENA VISTA FUR.
Yel. Kidney Ore
so called Slate Ore
Coal slain
Coal No. 5
South of Straight Creek
BUENA VISTA FUR.
Scale
Coal No. 5
BUENA VISTA FUR.
Coal No. 7
Coal slain
BUENA VISTA FUR.
Covered
mostly
Bed of Creek
North of
Straight Creek
BUENA VISTA FUR.

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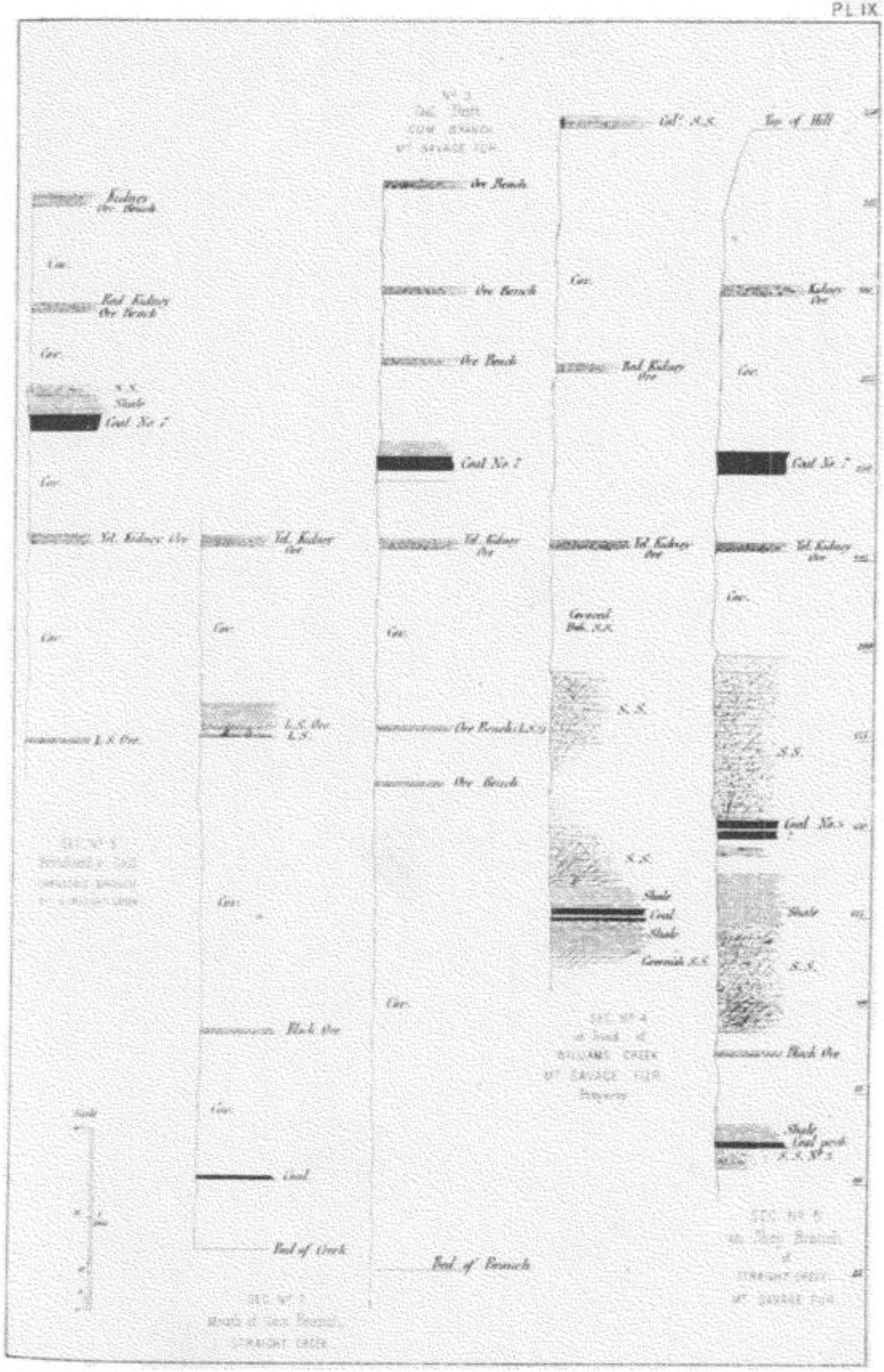
Kidney Ore Bench
Red Kidney Ore Bench
S.S.
Shale
Coal No. 7
Yel. Kidney Ore
L.S. Ore
Ore Bench
Coal
Red of Creek
Coal No. 7
Red of Branch
Coal S.S.
Red Kidney Ore
Covered Bak. S.S.
Shale
Coal
Grennish S.S.
Top of Hill
Coal No. 5
Black Ore
Shale
Coal parch
S.S. No 3
Scale