GEOLOGICAL SURVEY OF KENTUCKY

N. S. SHALER, DIRECTOR.

REPORT

ON THE

IRON ORES & THE IRON MANUFACTURE

OF THE

KENTUCKY RED RIVER IRON REGION.

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ON THE IRON ORES AND THE IRON MANUFACTURE OF THE KENTUCKY RED RIVER IRON REGION.

This region takes its name from the Red river, a branch of the Kentucky, upon which one of the earliest iron furnaces in the State of Kentucky, or in the West, was established.

The name Red River iron was first applied only to that made by those furnaces situated within the area drained by that stream; but, as the reputation of the iron in the markets of the West increased, the name was also applied to the product of furnaces beyond the neighborhood, but using the same ores, until the Red River Iron region grew to include territory drained by the Kentucky river itself, and its minor branches, the Red river, and the Licking, with some of its minor branches. It includes portions of Estill, Powell, Lee, Menifee, Bath, and Montgomery counties.

A more comprehensive definition of the region, as the term is used in this report, is to describe it as all that region lying between the Kentucky and Licking rivers, in which the Subcarboniferous or St. Louis limestone is found above the drainage. It is, therefore, an area about thirty-five miles long by ten miles wide, lying along the western border of the eastern Kentucky portion of the great Allegheny coal field. The name, as applied, is limited arbitrarily to the area between these rivers, because there are as yet no furnaces situated south of the Kentucky or north of the Licking river for a considerable distance, until the iron district of Carter county, of the Hanging Rock Iron region, is reached.

In discussing this region, there will be described—

I. The iron ores.

II. The iron manufacture.

I. THE IRON ORES.

The geological structure of a large portion of this region is described in detail in the report of Mr. Crandall upon the geology of Menifee county. The general type of geological structure, as there described, prevails over all this region. For the details as to special localities, the reader is referred to Mr. Crandall's report; but a few words of general description of the principal rock formations in this region will be given here, as being necessary to a correct understanding of the position of the ores to be described.

The rocks, which will be met with in almost all of the hills where the main ore of this region occurs, are, in a descending order, as follows: the Conglomerate sandstone and the underlying shales, with beds of coal, of the coal measures; the Sub-carboniferous or St. Louis limestone, and the Waverly sandstone of the Sub-carboniferous formation.

The Waverly, a fine-grained shaly sandstone, usually of a light olive-green tint, is the bed rock in which the streams flow, over the greater portion of the region under consideration, although toward the western border the Devonian black shale occupies this position, and the Waverly rises above the drainage. The Waverly has usually a thickness of about three hundred feet in this region.

Above the Waverly the Sub-carboniferous limestone is found, ranging from thirty or forty feet in thickness in the northern, to one hundred feet or more in the southern part of this region. Topographically this rock is not of great importance, except towards the southwest, where it is at its maximum thickness, and lies very near the top of the ridge, the Conglomerate and other overlying rock having been nearly all removed. Further to the east and northeast, where it lies nearer the drainage level, and the Conglomerate covers a large proportion of the surface, the limestone is thinner and more rarely exposed, being generally covered by the talus from the overlying Conglomerate.

Economically, however, the limestone is of great importance, as it is the rock upon which rests the ore of this region

which has given to it its reputation, and in itself it is valuable for building purposes, and furnishes a flux for the furnaces of the region.

The Conglomerate is the most conspicuous, and, topographically, the most important, of the members of the rock series of this region. It caps the most of the ridges, except on the extreme western border of this region, gradually descending towards the east and southeast, until it finally reaches the drainage level. It is a massive, pebbly sandstone, usually from one hundred to two hundred feet in thickness. Over part of this area it occurs in two members, with coal-bearing shales between. When this is the case, the upper Conglomerate is the most prominent, while the lower is usually not over thirty or forty feet thick, and occurs quite close down to the limestone, with sometimes not over ten feet of space between them.

The ores of this region belong to the class of earthy carbonates, or clay iron-stones and limonites, or hydrated oxides, resulting, with the exception of the ore of one deposit, which will be hereafter especially described, from the alteration and oxidation of the carbonates. They occur in stratified deposits at various geological horizons, not always forming connected strata, but still holding well-defined levels.

In the Waverly shales, toward the base of the series, there are numerous beds or layers of clay iron-stone kidneys, sometimes in considerable thickness. They are usually exposed along the banks and in the beds of the streams, where they have been left when the surrounding material has been washed away. Owing to their high specific gravity, the current has very little effect upon them, and they are thus concentrated in the beds of many of the streams in considerable quantities, so that, to the careless observer, they give the impression that there is a much larger quantity of the ore present in the hills than will be found on closer inspection. These ores have never, to the knowledge of the writer, been worked at any of the furnaces of this region. The reason of this, probably, is, that they are almost always found as hard blue carbonates, a

quality of ore which charcoal furnaces, the only kind as yet in this region, do not use if the limonite ores can possibly be obtained.

These ores are of such firm and close-grained structure that they yield to the oxidizing action of the air, and change to limonite very slowly, and with great difficulty. They are remarkable in this respect. Even when they are found in positions which show that they have been long exposed to the agencies which usually effect this change from carbonate to limonite, it is rare to find more than a thin coating of limonite on the surface of any specimen and along the lines of the weather cracks.

They are sufficiently rich in iron to be of value, and would doubtlessly be considerably used, were it not for the feature above noted. The deposits do not seem to be persistent over very large areas at the same level, but change position frequently. In addition to their irregularity, they commonly occur low down in the hills, where the slope is so steep that it would be impossible to bench for the ores to any depth; and they are usually too thin to pay for mining in any other way. The reason that they are not found near the tops of the hills is, that they lie towards the base of the series, and the Waverly does not extend far enough to the west to bring them to the top, where the slope over the ore would be gentle, and the thickness of overlying material slight, as these rocks soon disappear where the massive Conglomerate and limestone no longer protect them from erosion.

The thickness of these beds or layers of kidney ore ranges from four to eight inches. Were there furnaces in this region capable of using them, large quantities could be cheaply obtained and utilized, but it would not be judicious to rely upon them alone to supply any furnace; their proper use would be as a mixture to use with other ores.

THE LIMESTONE ORE.

The principal ore from which the iron has been manufactured, which has given to this region its reputation in the

markets of the country, is found resting upon the Sub-carboniferous or St. Louis limestone, and is known as the limestone ore. It is geologically the same ore as that already described in a previous report* as the "lower limestone" ore of Greenup and Carter counties.

The limonite of this bed, when at its best, is a heavy, dark red, friable ore, sometimes homogeneous and massive, and sometimes semi-concretionary. It often gives a red powder and streak, while containing its full proportion of combined water. The carbonate ore, from which the limonite is derived, is usually a dense, amorphous, close-grained ore, varying from light grey to dark brown in color.

The ore is found resting upon the surface of the limestone; not always in a regular layer or plate of uniform thickness, but in irregular "rolls," filling depressions in the surface of the limestone, between which the ore is often missing. These rolls are of much greater thickness than the average of the whole bed. They are often found several feet in thickness, while, when the ore occurs with anything like regularity, it is rare to find it averaging more than one foot. There is usually a considerable thickness of fine white shale and clay above the ore. This is a characteristic of the limestone ores in other parts of the State, which helps to distinguish them from other ores.

THEORY OF FORMATION.

In another report, already referred to, on the iron ores of Greenup, Boyd, and Carter counties, the theory of formation of these ores has been discussed, and to that report the reader is referred for a fuller statement than will be given here. It will be sufficient to state, here, the conclusions then reached, without repeating the different theories in regard to their formation, or the facts in favor of the conclusions below stated.

The carbonate or siderite is the original mineral of these ore beds, and from it the limonite, or the "red ore," as it is

*Report on the Iron Ores of Greenup, Boyd, and Carter counties, vol. I, part III, second series.

called, is derived by a process of oxidation and alteration through the agencies of the atmosphere and carbonated waters.

The depth to which the change from carbonate or siderite to limonite has been effected, varies with the character and thickness of the overlying material. Where this is thin, or where it is a porous sandstone, permeable to the atmosphere, the change will be found a long distance back from the outcrop, and sometimes entirely through the hill; but where a great thickness of impervious, dense rock overlies the ore, the limonite will be found only a short distance back from the outcrop, forming a narrow ring around the main body of carbonate ore, decreasing as the slope of the hill above it grows steeper. As the limonite ore is much the most valuable, owing to the fact that, in addition to its superior richness, it is more easily smelted and produces a better grade of iron, it will be seen that those deposits are of most value which are situated near the tops of the hills, where the ore has all been changed to limonite. The area covered by the ore bed, and the total quantity of the ore, when it is thus situated, is much less than when it lies lower down in the hills; but this is compensated by the superior quality of the ore.

The ore seems to have been formed by a segregation of the iron from the shales and clays above the limestone, subsequent to their deposition. Carbonated waters, percolating through these rocks, have taken the ferruginous material into solution in the form of the carbonate, carried it down and deposited it upon the face of the limestone, which, in its turn, was partially dissolved and carried away, thus producing the irregularities in its surface before referred to.

This theory of deposition, by segregation from the overlying rocks, accounts for the following characteristics of the ore, namely, the irregularity of thickness; the tendency to become suddenly calcareous, or to disappear altogether, giving place to a limestone: the comparative freedom from coarse silicious impurities, and the presence, above the ore, of the

thick beds of white clay, from which almost every trace of iron has been removed.

QUALITY OF THE ORE.

Unfortunately, at the time of the examination upon which this report is based, it was impossible to obtain as many thoroughly representative samples of the ore for analysis as were desired, owing to the fact that mining operations were being conducted at only one of the furnaces in this region. At the other furnaces the ore banks had nearly all fallen in soon after operations had been suspended, so that it was, in most cases, impossible to gain access to the ore in order to select average samples for analysis. The furnaces had also consumed almost entirely the stock of accumulated ore before going out of blast, so that it was impossible to obtain, at the stock piles, samples the location of which was known.

For this reason, the number of analyses given below is not nearly so large as desired, or as it would have been, had it been possible to get at the ore, in the banks, at many other places.

The same reason can be given why this report is not much fuller in details of measurements of the ore than it is. The furnace estates comprise but a very small proportion of the total area of this ore region. Except on these estates, no mining operations for ore have ever been conducted, and there is no means of knowing the exact thickness of the ore bed. The amount can only be estimated from the abundance, size, and persistency of the outcrop of the ore on the surface of the hill. This is only an imperfect method, and is subject to great inaccuracies; but it was the only one possible under the circumstances, as it is manifestly impracticable for the Geological Survey to undertake expensive explorations, which require digging. Neither time nor means was sufficient for such explorations.

The following analyses were made by Dr. Peter and Mr. Talbutt, from samples collected by the writer. They were all taken with a view to be as nearly average samples as pos-

sible; but they are not all equally so, for the reason that the amount of ore from which the sample was taken varied considerably. In some cases it was taken directly from the solid ore bed, while in others from the pile of ore lying on the bank:

	1	2	3	4	5	6	7	8	9
Iron peroxide	65.310	59.621	66.329	54.750	75.598	4.049	65.535	74.127	65.591
Iron carbonate	....	....	....	....	....	76.491	....	....	....
Alumina	11.947	12.370	12.532	14.517	1.971	2.014	2.798	3.542	5.762
Lime carbonate	.730	.500	a trace.	a trace.	.540	5.400	.450	.390	a trace.
Magnesia	.140	.144	.173	.047	.258	.514	1.073	.461	.248
Phosphoric acid	.825	.709	.709	.697	.601	.409	.537	.601	447
Sulphuric acid	a trace	a trace.	a trace.	a trace	a trace.	.267	a trace.	a trace.	a trace.
Combined water	11.000	10.400	9.580	8.600	11.730	*1.426	9 800	11.270	11.000
Silica and insoluble silicates	9.580	15.830	9.720	20.830	8.910	9.330	20.480	9.580	16.230
Total	99.532	99.574	99.043	99.441	99.608	100.000	100.673	99.971	99.278
Metallic iron	44.570	41.735	46.440	38.750	52.918	39.758	45.874	51.889	45.914
Phosphorus	.360	.309	.309	.304	.262	.178	.234	.262	.195
Sulphur	....	....	....	....	....	.107	....	....	....

*And loss.

No. 1 is from the Pergam bank, Bath Furnace, Clear creek, Bath county.

No. 2 is from a bank near the head of Clear creek, Bath Furnace.

No. 3 is from the Richardson bank, Bath Furnace, Clear creek.

No. 4 is from the head of Ratcliffe branch of Beaver creek, Menifee county.

No. 5 is limonite ore, from the Tubbs bank, Estill Furnace, Estill county.

No. 6 is the carbonate ore, from the same bank as No. 5.

No. 7 is from Logan ridge, Estill Furnace.

No. 8 is from the Luster drift, Thacker Ridge, near Fitchburg, Estill county.

No. 9 is from the Horse Ridge banks, Cottage Furnace, Estill county.

With the exception of No. 6, all the above analyses are of the limonite ore of this bed.

It is probable that they all show the ore to be a little richer in iron than it really proves to be on actual working in the furnace This is due partly to the personal bias of the sam-

pler, which always acts in favor of the ore, no matter how careful he is, and partly to the fact that the sample is taken cleaner and freer from adhering dirt and clay than it is as it comes to the furnace scales.

It is stated that the average yield of the ore at Bath Furnace is forty per cent. The average in the four samples—Nos. 1 to 4, inclusive—from ore used at this furnace, is 42.77 per cent. of iron. The localities represented by these samples, however, are those which furnish the best ore to the furnace; so that it seems probable these analyses do not represent the ore as much better than it really is. They are all from within a radius of three miles. They are remarkable for the large and uniform per centage of alumina—an amount not heretofore found in any other ores of the State. The phosphorus is also remarkably uniform, although not excessively high for ore of this character. The absence of all except a trace of sulphur, save in the one sample of carbonate ore, is an excellent feature in these ores, and one reason why they are so highly valued. Another point of excellence is the comparatively small amount of silicious matter. This averages less than in any other series of ores in the State, as yet analyzed. This, in addition to the varied character of the other impurities of the ore, no one of which predominates very greatly, renders it easy to smelt, and tends to the production of a high grade of iron, as the silicon is not reduced with the iron, but combines with the other impurities, and passes off into the slag. For the same reason, the ore does not require a large amount of limestone for flux.

Another good quality of these ores, when limonites, is, that they are of an open, porous structure, so that they are easily permeable to the reducing gases of the furnace, which, therefore, act upon them readily. The carbonates are of a closer, denser structure, and are not so easily reduced. It is probable that much of the difficulty in working these ores satisfactorily, is due more to this peculiarity of their structure, than to any excess of impurities, although it is commonly attributed to the presence of sulphur.

DISTRIBUTION OF THE ORES.

For reasons before stated, it is impossible to give accurate and detailed statements of the exact thickness and quantity of the ore for every locality in this region. The most that can be done is to give its thickness at a few prominent places where it has been mined, and some notes as to its apparent relative abundance at other localities.

As stated in a former report,* this ore occurs in abundance along the outcrop of the Sub-carboniferous limestone, from near the Ohio river, in Greenup county, to the southern part of Carter county. Around Olive Hill, where last examined in detail, the ore is present in abundance, and seems to occur with more than usual regularity. From here, south to the Licking river, there have been no detailed examinations made. The region is wholly undeveloped—no mining operations nor pick and shovel prospecting ever having been attempted as yet. To the south of this, although no detailed examinations have been made, the ore has been seen in considerable quantity towards the head of Big Sinking creek, a branch of Little Sandy river, on the very head waters of Tygert's creek, and also on Christy's Fork of Triplett creek, a branch of Licking river.

There is in this vicinity a large amount of ore which will be opened to the world by the completion of the Lexington and Big Sandy Railroad; but, until that is accomplished, must remain wholly undeveloped.

Between Christy's Fork of Triplett creek and the Licking river, nothing is as yet known as to the occurrence of the ore, but there is no reason to doubt its existence there.

South of Licking river the ore occurs in abundance, and has been largely mined. On Caney creek, a stream but a few miles in length, large quantities have been mined for the supply of the Caney Furnace, which was situated upon that stream. It has not been in operation for a number of years. As a consequence, all the ore banks have fallen in, and noth-

*On the Iron Ores of Greenup, Boyd, and Carter counties, part III, vol. I, second series.

ing could be learned in regard to the thickness of the deposits.

On Clear creek, in Bath county, the deposits of the ore are extensive, and of excellent quality. It has been largely mined for the supply of the Bath Furnace, formerly called the Clear Creek Furnace. Several analyses of ore from this vicinity are given in the table. The ore was seen, at a number of openings, from six to sixteen inches in thickness. It is reported to occur frequently in "rolls" or pockets of two to three feet thick or more; but these are usually of limited extent, and soon exhausted. The ore varies so in thickness that it is impossible to give any accurate estimate as to its average; but it is probable that it would be slightly under twelve inches. It is usually found here resting under about five feet of white clay. At this distance above the ore there is usually found in the clay a thin coal streak; but it has never, to the writer's knowledge, been followed far enough back into the hill to be found solid. It is probable that this is the stain of a coal which, in other places, has been opened and found to be about fifteen feet above the limestone. The distance from the ore to the base of the Conglomerate in this vicinity is about sixty feet.

All of the branches of Clear creek cut through ore territory, as do a portion of the branches of Salt Lick creek, the stream into which Clear creek flows. Some of the branches of Salt Lick creek on the west extend beyond the ore field, while the main stream runs so near its edge that only a comparatively small area of ore is found along it.

Although mining operations have been conducted on Caney and Clear creeks at various times for nearly forty years past, yet the supply of available ore is by no means exhausted. Neither of the furnaces has been in constant operation. Caney Furnace was discontinued in 1848, and Bath or Clear Creek Furnace was idle from 1857 or 1858 to 1873. The consumption of ore has, therefore, been comparatively small, and the great mass of available limonite ore is almost untouched. So far the supply available by benching has been

ample, and drifting for the ore has been resorted to at but few banks, and in these cases only where the ore was of more than usual thickness and regularity, so that it could be mined cheaply. The Pergam bank, on Clear creek, is an instance of this kind.

Beaver creek, from its head to its mouth, may be said to run through ore territory. It is a long stream, and drains an ore area of many square miles; but it is at present wholly undeveloped. The ore outcrops in the surface clays are abundant, and in quantities sufficient to indicate that the ore is present in its full average thickness. The Bath Furnace draws a part of its ore supply from the country drained by some of the lower branches of Beaver creek. Leatherwood creek furnishes the larger portion of this. There are numbers of old ore banks on the lower part of Beaver creek, where ore was probably dug for the old forges which formerly were in operation in this vicinity—one on Beaver creek, and one on Licking river below the mouth of Beaver These banks have all fallen in, so that it was impossible to ascertain anything as to the thickness of the ore.

Higher up on Beaver creek ore was formerly mined for the Old Beaver Furnace, which is situated near the mouth of Myers' branch; but this has been discontinued for over forty years, so that the ore banks are in the same condition as those just described. If all accounts be true, however, the ore in this vicinity is more than usually abundant and trustworthy. As the furnace was only in operation ten or twelve years, the total amount of ore consumed was comparatively small—not enough to seriously affect the value of the ore lands, as the great body of ore is comparatively untouched.

The country drained by the branches of Beaver creek on the south has been more thoroughly examined by Mr. Crandall than by the writer, and to his report the reader is referred for details.

From here up to the head of Beaver creek the ore appears in about its average abundance in the outcrop. No mining operations have ever been undertaken here, and, in conse-

quence, nothing in detail is known in regard to the ore. On the head waters of the south and southeastern branches of Slate creek the ore is well developed. It has been discovered at many places recently, since the thorough prospecting which that region has been undergoing in the search for coal. This region holds a large amount of ore as yet wholly untouched. The same is true of the area drained principally by Indian and Gilladie creeks, which flow into Red river from the north, and Chimneytop creek from the south. All this region, as well as that drained by the branches of Slate creek, has been examined more thoroughly by Mr. Crandall than by the writer, and to his report the reader is referred for fuller statements than are given here. Further down Red river the branches from the south cut through an extensive and valuable ore field. Middle Fork of Red river and Cat creek are the principal streams from the south. They head in the dividing ridge between the Red and Kentucky rivers, but a little to the east of where this ridge has been most productive of iron ore in the past. No ore of any consequence has been dug on these streams, except at the heads of some of the most westerly branches, on the Estill Furnace property; but, so far as surface indications are to be depended upon, the undeveloped regions promise to be equally as rich as the developed.

On Red river and its smaller branches considerable ore was formerly mined and carried down the river to the old Red River Forge and Furnace; but these have long since ceased operations, and the ore banks have not been opened since. These ore banks extended out to the west, on isolated knobs, to within a mile or two of the old forge.

The main dividing ridge between the Red and Kentucky rivers, where it is drained by Hardwick's creek, and the most westerly branches of Cat creek and Middle Fork on the north, and by Miller's and Cow creeks on the south, holds the ore in great abundance. This locality has been more extensively worked than any other of the region. It is on this ridge that the Estill and Cottage Furnaces are situated, and from it and its spurs they have drawn their ore supply—one of them, Es-

till Furnace, for the last forty-five years. Nos. 5, 6, 7, and 9, in the table of analyses, are from this ridge. These samples were taken from piles of ore lying at the banks, as it was impossible to reach the ore bed, mining having been discontinued about a year before the time of examination, and the banks, in consequence, having fallen in. At many places in this vicinity all the ore which is available by benching has been exhausted, and in future resort must be had to drifting. For the reason just stated, the face of the ore was seen at few places, so that accurate measurements of thickness cannot be given. It is stated to average somewhat less than one foot in thickness, though often occurring locally much thicker. Ore has been extensively mined along this ridge for a distance of six or eight miles, extending from two to four miles on the east of Estill Furnace to about the same distance west of Cottage Furnace, where the ore disappears, the limestone at this distance coming so near to the surface that the ore has been all removed. The heavy Conglomerate cliffs do not overlie the ore until in the vicinity of Estill Furnace. The lower and thinner Conglomerate overlies it around Cottage Furnace, the distance between being about twenty feet. The limit of mining operations on the east of Estill Furnace is not due to the disappearance of the ore, but to the fact that it cannot be profitably wagoned a greater distance than from the banks at present farthest removed from the furnace. There is an apparent abundance of ore for a long distance to the east along the ridge.

On the spurs of this ridge extending to the south, between the branches of Miller's creek, are situated the numerous ore banks which furnished the supply for the furnaces of the Red River Iron Company, at Fitchburg, on Miller's creek. The best known and most productive localities are called Thacker Ridge and Kobb Mountain. Thacker Ridge lies on the east side of the branch of Miller's creek upon which Fitchburg is situated, and about one mile from that village, while Kobb Mountain is about three miles below, on the same side. The ore banks or benches extend continuously along the outcrop

of the ore from one of these localities to the other. The ore has not only been benched for very deeply, but many drifts have also been run. It does not differ materially in quality or thickness from that on the main ridge at Estill Furnace. It was seen at a few places from eight to twelve inches in thickness; but many local "pockets" have been found in the drifts which reached three feet or more. Although some few minor spurs of Thacker Ridge have been nearly exhausted of their ore, yet there is in this vicinity a quantity of ore amply sufficient to meet all probable demands of the furnaces for a long time to come; for, in addition to the large amount yet remaining in the ridges east of Fitchburg, the ore in the ridge to the west is as yet intact, no mining of any consequence having been attempted there.

South and east of this vicinity, lying within the drainage of the main branches of Miller's creek, there is an extensive ore field, which is wholly undeveloped. It extends, on an average, from six to eight miles to the east. Ore will be found much further to the east; but beyond that distance the limestone is so near the drainage level that the outcrop line of the ore is limited, and the hills rise so steeply above that the amount available by benching is small. For the same reason, the amount of limonite, in proportion to the carbonate ore of the bed, is small, as the great thickness of overlying material prevents the alteration of the ore from carbonate to limonite.

The branches of Miller's creek draining this region head in the Conglomerate, and cut their channels in that rock and the shales below, for several miles, before they reach the limestone; so that the ore does not extend above the drainage level to the heads of these streams.

So far as it was possible to ascertain by merely surface examinations, this region seems to contain the ore in almost or quite as great abundance as the developed localities further north and west. It affords fine locations for the erection of new furnaces, as, in addition to the ore, the timber supply is good, the original unbroken forest still covering the greater part of the area.

Along the Kentucky river, on the north side, the ore is found at its proper level, in greater or less abundance, as far up as Contrary creek, a short distance above which the limestone passes beneath the drainage. On Contrary creek, however, and for some little distance below, surface indications do not promise much ore; but the circumstances are most unfavorable for its outcropping, as the top of the limestone is here almost to the drainage, and the hills rise steeply above. Further down the river, on the Willow Shoals branch, and the river hills above Old Landing, the ore is found in abundant outcrop and of excellent quality. On the Willow Shoals branch there are other ores lying in the shales above the limestone, of excellent quality, but apparently thin. Nothing is known of their horizontal extent.

South of the Kentucky river the limestone ore has not been mined, and its limits and distribution are almost unknown. Time did not admit of extending the examinations on this side to any distance back from the river. The geological features on this side are similar to those on the north, and there is no reason why the ore will not be found in as great abundance, when it comes to be sought for at its proper level. Outcrops of the ore were found on Buck, Ross, Station, Camp, and Doe creeks, and it is reported to occur abundantly on Sturgeon creek. As the limestone does not pass below drainage for some distance above the mouth of Sturgeon creek, it is not improbable this statement is correct, although the outcrops will probably be found more abundantly on the branches from the west, where the limestone is higher than on the main stream.

On all of the streams mentioned, the ore was found within a few miles of the river. In some places the outcrops were abundant, and at others scarce. There was no apparent difference in the quantity and distribution of the ore from a similar area on the north side of the river. The ore seems just as abundant, and of as good quality, as in the undeveloped localities on the other side.

Within the limits named, on this side of the river, there are many square miles of ore territory. The timber is almost unbroken, and exists close to the river in quantity sufficient to supply a number of blast furnaces for many years to come.

THE CLINTON ORE.

In Bath county, on the waters of Slate creek, about five miles south of Owingsville, there is a deposit of ore of a character different from any yet described. Neither geologically nor geographically does it strictly belong among the ores of the Red River Iron region; but as it is a somewhat isolated deposit, situated nearer to this region than any other, and is connected with it in certain economical relations, it will be described here.

The deposit is known as the Old Slate Furnace ore bank. It lies on top of two or three hills, about two hundred feet above Slate creek. It is associated with the yellow Silurian limestone of the Clinton period. It is, in fact, geologically, the same ore as that variously known as the Clinton, fossil, or dyestone ore, which is found along the "great valley" of the Allegheny Mountains from New York to Alabama, and is characteristic of the Clinton period at many other places.

The ore is a limonite, very oölitic and fossiliferous. It bears evidence of having been originally a hematite, similar to the Clinton ore as usually found; but it has lain so long exposed to the action of air and water, protected only by a thin covering of the soil, that it has absorbed water and been converted into limonite. It is a soft, earthy, inferior looking ore; but, as shown by analyses, is much richer than commonly supposed.

It is apparently a stratified deposit, but of comparatively limited extent horizontally. Its maximum thickness is stated at fifteen feet, which is said to be the thickness revealed by a test pit sunk some years since. On one end of the Block House hill the ore is exposed frequently from ten to twelve feet thick. The principal banks are known as the "Block House" bank and "Howard Hill."

The area covered by the ore on these two hills, and two or three smaller isolated knobs, as determined by the Survey of Mr. C. Schenk, Topographical Assistant of the Survey, is 1,943,870 square feet, or 46.9 acres. The average thickness of the ore over the whole deposit is difficult to estimate, as full exposures are rare, except on one end of the Block House bank. It would probably be considerably within the limit to place the average thickness of the whole deposit at ten feet; but for the sake of perfect safety in the following estimate of the quantity of ore in this deposit, it will be placed at eight feet. The determination of the specific gravity of two samples by Mr. Talbutt gave respectively 3.405 and 3.47. With a specific gravity of 3.4, an average thickness of eight feet, and an area of 46.9 acres, the total amount of ore will be 1,475,259 gross tons. With an average thickness of ten feet the amount will be 1,844,073 gross tons.

It is believed that the above estimate is far within the limits of the quantity actually present, as a part of the deposit is nearly twice as thick as the estimated average, and there are few, if any, places where the ore seems to be below the estimate. This ore differs very materially from the Clinton, or dyestone ore, as usually found in other States, in that it seems to be of limited horizontal range. The elevations in the vicinity, besides the hills just named, which are high enough to hold the ore if it were widely extended, are few, and in them, if the ore be present at all, it is so thin that it gives scarcely any outcrop on the surface. Further east, where the dip has brought the rocks down, the ore seems to be wanting. The place of the ore is apparently about forty feet below the top of the yellow Silurian limestone.

At one or two localities within a few miles of these banks, an ore has been observed at the junction of the Devonian shale and the underlying limestone. This ore differs widely in its structure and composition from the Clinton ore. It is a very silicious, porous limonite, and apparently is of recent formation, deposited by the waters of chalybeate springs. At one

of the places where this ore was found the spring is still flowing.

The following is an analysis of a sample of this variety of ore, from a hill called Pilot Knob, near the line of the Lexington and Big Sandy Railroad, in Bath county:

ANALYSIS BY DR. PETER AND MR. TALBUTT.

Iron peroxide	47.321
Alumina	5.418
Lime carbonate	.690
Magnesia	.079
Phosphoric acid	.161
Sulphuric acid	.376
Silica and insoluble silicates	33.330
Combined water	12.050
Total	99.425
Metallic iron	33.125
Phosphorus	.070
Sulphur	.150
Silica	27.600

At Daniel Blevins', a few miles east of this place, an ore was found occupying a similar position, but of somewhat better quality.

QUALITY OF THE CLINTON ORE.

The chemical composition of the ore from the Old Slate Furnace banks is shown by the following analyses by Dr. Peter and Mr. Talbutt, from samples selected by the writer. The samples were intended to be as fairly representative as possible:

	1	2	3
Iron peroxide	76.077	69.728	70.060
Alumina	2.592	8.642	4.540
Manganese	.430	.....	.....
Lime carbonate	.130	.170	.040
Magnesia	.281	.045	.021
Phosphoric acid	.731	1.154	1.620
Sulphuric acid	.030	.134	.031
Silica and insoluble silicates	8.180	7.930	11.530
Combined water	12.300	12.650	12.300
Total	100.751	100.453	100.142
Metallic iron	53.254	48.809	49.042
Phosphorus	.319	.504	.707
Sulphur	.011	.053	.012

No. 1 is from the Block House hill; sample from all parts of the ore exposed.

No. 2 is from same locality; sample from the upper part of bed.

No. 3 is from the Howard hill.

It will be seen by the above analyses that the ore is much richer in iron than is generally supposed. The per centage of phosphorus is also large, as was indicated by the character of the iron made from the ore.

The country in the vicinity of the ore is pretty generally cleared of its timber, so that it is doubtful if this ore will be again used in this vicinity for the manufacture of charcoal iron; but it will in the future be largely shipped to furnaces using stone-coal, in the Hanging Rock region and other localities, where it will be used to mix with the coal-measure ores. The ore is but a short distance from the located line of the Lexington and Big Sandy Railroad, and would furnish a large amount of freight to that road upon its completion. It will prove valuable to mix with the limestone ore of the Red River region, and will be extensively used for that purpose when some means of cheap transportation can be had.

II. THE IRON MANUFACTURE.

The iron manufacture of this region is the oldest in the State of Kentucky, if not in the West.

As yet it has been confined to the production of cold-blast charcoal iron, which is used mostly for the manufacture of car-wheels, for which purpose it is unsurpassed by any iron in the country. It is of great strength, and at the same time chills readily. It has commanded a market all through the West, where it ranks with the best known and most celebrated brands of car-wheel iron in the country.

The first furnace in Kentucky was situated on Slate creek, in Bath county, and was called the Slate Furnace. It does not properly belong to the Red River Iron region, as it used different ore, produced a different grade of iron, and was located some distance from the other furnaces; but as it was the pioneer furnace in the State, and the only one in this vicinity, it will be described here.

According to one authority, it was built in 1791 by Thos. Dye Owings; according to another, it was built in the same year by Jno. C. Owings. It continued in operation until 1838. It used the Clinton ore from the already described banks, which were two miles south of the furnace. The blast machinery was driven by water-power, which was often insufficient to give sufficient blast to keep the furnace working regularly. There were two forges in the vicinity which made bar iron from the pig iron of the furnace.

Mr. Joshua Ewing, who was in charge of the furnace for the last ten years of its operation, states that its production was about three tons per day, using nearly or quite three tons of ore to the ton of iron.

The working of the furnace was very wasteful, as is shown by the character of the slag produced, and the fact that, so large an amount of iron was lost in the slag as scrap, that after the furnace ceased operations, the slag heap was worked over, the slag broken up, and a large amount of scrap iron obtained from it. This excessive waste of iron accounts for the difference between the yield as reported and the per centage of iron in the ore as shown by the analyses. The iron made at this furnace had a poor reputation as regards strength, but was very hard. This was due to the large

amount of phosphorus which it contained, as is shown by the following analysis of a piece of scrap iron from Slate Furnace, by Dr. Peter and Mr. Talbutt:

Iron	92.056
Graphitic carbon	3.640
Combined carbon	.310
Silicon	1.760
Slag	.100
Calcium	.116
Phosphorus	1.080
Sulphur	.218
Total	99.280

This iron is not of as good quality as that made from the limestone ore.

The next furnace established, and the first in the Red River region proper, was on Red river, in the large bend above the mouth of Hardwick's creek, in Estill county. It was built in 1806 or 1808 by Wm. Smith. There was also, at the same place, a forge running four bloomery fires, which was built a year or two previous to the furnace. The supply of ore was obtained from the hills on both sides of the river, some distance above the furnace, and boated down the river in flat-boats to the dam just above the furnace. This dam backed the water sufficiently to render the river navigable for small boats. It also furnished the water-power to drive the blast machinery of the furnace.

This furnace was in operation until about 1830. There was subsequently a rolling-mill erected at this same place, which continued in operation till about 1860, when it was removed, owing to the excessive cost of coal, which was brought down the Kentucky river and wagoned across.

It is stated that the furnace stack was first constructed of the Devonian black shale, which is the prevailing rock in the vicinity. This shale contains a considerable amount of bituminous matter, which, when the furnace became heated, took fire and burned all through the stack, with the result that the rock was so softened and cracked that the furnace had to be rebuilt with more solid material.

The next furnace erected was Beaver Furnace, on Beaver creek, Menifee county. It was built in 1819, by John T. Mason and four others, whose names could not be clearly deciphered from the inscription on the old stack.

This furnace, like the other two, was driven by water-power. There were two forges near, one on Beaver creek below the furnace, and one on Licking river below the mouth of Beaver creek.

The furnace continued in operation until about 1830. It used the limestone ore from the vicinity.

These three furnaces were built and running several years before the erection of the first furnace in the Hanging Rock iron region, which was built in 1822. They, as well as Caney Furnace, on Caney creek, which was built in 1838, by Mr. Joshua Ewing, and went out of blast in 1848, have all been abandoned, from one cause or another; usually either excessive cost of transportation or exhaustion of timber supply.

The active furnaces of this region are five; they are as follows:

Name of Furnace.	When built.
Estill	1830.
Bath	1839.
Cottage	1856.
Red river, two stacks	1869.

Bath Furnace, as already stated, is situated on Clear creek, in Bath county. Estill and Cottage Furnaces are on the ridge between the waters of the Red and Kentucky rivers, while the two stacks of the Red River Company are situated on Miller's creek, about six miles from the Kentucky river. All of these are in Estill county. The machinery of all these is driven by steam.

With the exception of the two furnaces of the Red River Iron Company, which will be described hereafter, these furnaces are all of the old type, with heavy sandstone stacks, in the form of a truncated pyramid.

The principal internal dimensions of these furnaces are shown by the following table:

DIMENSIONS OF BLAST FURNACES IN THE RED RIVER IRON REGION.

	Bath.	Cottage.	Estill.	Red River, 2 stacks.
Height	40′	38′	34′	50
Diameter of bosh	10′ 6″	10′ 6″	10′	12′ 6″
Batter or slope of bosh	58°	55°	55°	55°
Diameter of throat	3′ 6″	3′ 2″	4′	7′
Height of hearth	6′	6′	6′	6′ 6″
Diameter at top of hearth	3′ 8″	3′ 4″	3′ 2″	4′ 4″
Diameter at bottom of hearth	3′ 3″	2′ 8″	2′ 6″	3′ 9″
Number of tuyeres	2	2	1	3′
Diameter of tuyeres	3½″	3½″	3″	4″
Height of tuyere above bottom of hearth	2′ 7″	2′ 8″	2′ 6″	3′ 6″
Number of boilers	2	2	2	4
Diameter of boilers	2′ 10″	3′	3′	3′
Length of boilers	50′	46′	45′	45′
Number of blast cylinders	2	2	1	1
Diameter of blast cylinders	2′ 10″	3′ 4″	3′ 4″	5′
Stroke of blast cylinders	6′	one 6′ / one 5′	5′	4′
Diameter of steam cylinder	1′ 2″	1′ 4½″	1′ 4″	2′
Stroke of steam cylinder	6′	6′	5	4′

These furnaces all use the limestone ore, working with cold-blast for the production of a car-wheel iron. The Red River Furnaces are the only ones which have a hot-blast oven connected with them, and this has not been used since the first year or two of the furnace operations.

The dimensions and arrangement of the two stacks of the Red River Iron Company, at Fitchburg, on Miller's creek, are shown by the accompanying plate. They represent the first attempt at improved furnace construction in this region. They are twin stacks built in a solid rectangular mass of masonry, forty by sixty feet base, and fifty feet high. They worked with closed tops, originally with the bell and hopper apparatus; but this was finally removed, and a thimble-charging apparatus substituted. The hot-blast oven is on top of the stack. The gases are carried down twenty-two feet, through a gas main twenty-six by thirty-six inches in cross-section, to the boilers, of which there are eight, in four nests of two each.

The engines are modern, vertical, direct acting, with steam cylinder twenty-four inches diameter and four feet stroke; blast cylinder five feet diameter by four feet stroke. Everything in connection with the furnaces is constructed in the most thorough and substantial manner. The cost of the furnaces alone, without machinery, was over one hundred thousand dollars, while the cost of the machinery and fittings brought the total cost of the two stacks to nearly one hundred and sixty thousand dollars.

The metallurgical success of these furnaces has been all that was expected; the iron produced was of the very best quality, and commanded the highest prices, and the furnaces produced a large yield on a moderate consumption of charcoal. One stack has made as much as 480 tons of cold-blast iron in one month, on a consumption of 166 bushels of charcoal to the ton of iron; and during one week it made 128½ tons, using only 155 bushels of charcoal per ton. This, however, was exceptional working. The average consumption of charcoal was somewhat greater, and the production of iron less. The following table shows the average yield of the roasted ore, the consumption of charcoal per ton of iron, and the number of years during which the furnaces were in operation, from which these results were averaged. This table includes the two stacks which were respectively named Chandler and Blackstone, and also Estill Furnace, which is the property of the same company:

RED RIVER IRON COMPANY'S FURNACES.

Name of Furnace.	No. years from which averaged.	Average yield of roasted ore, per cent.	Average consumption of charcoal per ton of iron, bushels.
Chandler	4	44.2	231
Blackstone	5	45.1	204
Estill	5	46.4	215

It was impossible to obtain the figures for the yield of the raw ore with any accuracy. It is stated, however, by those connected with the furnace, to be thirty-three and one third per cent. One series of figures, obtained with regard to the

yield from the raw ore at Estill Furnace, gave the average for five years as 33.03 per cent.; but there was some obscurity in regard to some of the items which cast a shade of doubt over their accuracy. The returns for the yield of roasted ore are probably accurate, as they were taken from the daily blast report book.

It is to be regretted that it was impossible to obtain similar returns from the other furnaces of this region. The average yield of the roasted ore at Bath Furnace, for one period of sixteen weeks, was 51.7 per cent. No returns of charcoal consumption were obtained from this furnace.

None of the furnaces of this region are at present in operation, or have been since 1874, with the exception of Bath Furnace, which made a short campaign in 1875, during which less than fifty tons of iron were made.

This is due to the extremely depressed condition of the iron trade all over the country, the prices of pig iron ruling so low at present that it cannot be manufactured in this region and brought into market at a profit. This is owing more to the excessive cost of transportation to market than to the original cost of the iron at the furnaces. Iron can be produced at these furnaces for much less than at many other localities which are nearer to market, as ore, charcoal, and labor are all cheap; but the facilities for transportation are so poor, that it costs from seven to ten dollars per ton to carry the iron from the furnace to market at Louisville or Cincinnati. This tax is so great that, at present prices, it either entirely consumes the profits, or leaves the margin so small that it is not worth the risk.

The furnaces of the Red River Company, on Miller's creek, shipped their iron in flat-boats down the Kentucky river at time of high water, while the other furnaces usually hauled their iron to the railroad, in every case a distance of over twenty miles. Were there railroad or slack-water transportation within a few miles of each furnace, it would be profitable to make iron in this region, even at the present extremely low prices; but the necessity for wagoning it such great dis-

tances, or of awaiting the uncertain rises of the Kentucky river, and the danger of navigation when the rises come, render the cost of transportation entirely too great.

The construction of any of the projected railroads through this part of Eastern Kentucky, or the extension of the system of slack-water navigation on the Kentucky river to the mouth of the Three Forks, will give the desired facilities to a large part of this region, and be followed by the erection of new furnaces where heretofore the ores have lain undeveloped, owing to the difficulty and cost of getting the iron to market.

As a commercial enterprise, the furnaces of the Red River Iron Company have not been successful. From a metallurgical stand-point, the furnaces have been all that could be expected; but the property of which they form a part, and in which they are the chief producing apparatus, has not been profitable to its owners.

After an investment of about one and a half millions of dollars in lands, furnaces, buildings, dwelling-houses, tram-ways, roads, and other improvements, the company has failed to pay the interest on its bonded debt, and the property has passed into other hands, leaving a clear loss of over a million of dollars to the original stockholders.

These stockholders were mostly capitalists from outside the State, and the failure of an enterprise in which they had invested so largely, and which had been so liberally established, cannot fail to greatly injure the reputation of this region as an iron-producing district, and seriously retard its development in the future, by preventing the investment of capital from abroad, as it will inevitably be charged to the incapacity of the region to sustain an extensive iron industry, unless it can be shown that other causes should be charged with the failure.

That this is the case there can be little doubt. In the first place, it can be said that the furnaces were not adapted to the region, nor for the purpose of making charcoal iron. There was no difficulty, so far as the mere working of the furnace was concerned; but the capital mistake was in erecting two

such large and unnecessarily expensive furnaces, away from any line of transportation, with the expectation that they would both be supplied with ore and charcoal from the immediate vicinity. The furnaces each require, to keep them in operation, about double the amounts of ore and charcoal that the older and smaller furnaces use. The large furnaces will each produce, when working anything like full time, from three thousand to four thousand tons of iron per annum. To make this amount of iron will annually strip about four hundred acres of land of its timber, or eight hundred acres for the two furnaces. At this rate of consumption, the land around the furnaces would be cleared so rapidly that, in a few years, the limit of economical haulage of charcoal would be reached. The same would occur with the ore supply. The ore deposits of this region are of such a character that, so long as they are used by charcoal furnaces, which work exclusively the limonite, which is found only near the outcrop, a very large area of the ore bed will be required to supply the demands of a furnace. Only a comparatively small amount of ore is usually obtained at one locality; so that, when a large production is required, the exhaustion of the limonite in any given region is rapid; the workings are removed farther and farther from the furnace, and the cost of hauling the ore increases proportionately. Where the ore is obtained by drifting, instead of benching, this does not take place so rapidly; but, as a general rule, not a great deal of limonite is obtainable in this way, as the ore changes to carbonate on following it under ground, where the overlying rock is thick and impervious. There are many localities near the western edge of this ore field where the thickness of rock over the ore is slight, and the whole ore bed is changed to limonite; but, where this is the case, the total area of the ore is small, as it lies so near the summit of the hill.

The style of furnace adapted to the economic necessities of this region, is either a small cheap furnace, which can use all the ore and timber within easy hauling distance, and then be abandoned after twenty or thirty years without great loss,

or a more expensive, larger furnace, intended to be permanent, located upon some line of transportation, either railroad or river, by which supplies of ore and fuel can be cheaply brought to it from a distance, after that within hauling distance has been exhausted.

With a reasonable cost for transportation of iron to market, a large number of furnaces of either or both of these classes can be sustained in this region, and will produce iron so cheaply that it can be manufactured at a profit in almost any probable state of the market. These conditions apply to the charcoal iron manufacture. With reference to the manufacture of iron with stone-coal or coke, an industry which has not been attempted here as yet, but which is destined at some not far future day to become important, it may be said that the location of furnaces for this purpose, on some line of transportation, is absolutely essential, as the coal will have to be brought from further back in the eastern coal field; for, with a few exceptions, the Sub-conglomerate coals are not at their best development where the ore is found at its best. An additional reason is, that stone-coal iron, being a lower-priced product, will not bear the expense of transportation that charcoal iron can.

The furnaces of the Red River Iron Company are fitted to none of the conditions best adapted to economical and profitable working in this region. They are large, expensively built furnaces, furnished in the most complete and substantial manner, and everything about them showing that they were built to be permanent. They are, however, located six miles from the Kentucky river, to which the iron had to be hauled for shipment. They are, therefore, dependent upon the immediate vicinity for their supply of ore and fuel. Experience has proved that it is inadequate to supply, at reasonable rates, the amount required to keep both furnaces in full operation for the most of the time. The two furnaces require, to keep them in constant operation, about four times the amount of ore and fuel which any one of the older furnaces of this region use.

The records of the two furnaces show that, with the exception of the year 1871, which was the first year after both were fairly started, and when they together produced between seven and eight thousand tons of iron, they have never both been worked to anything approaching their full capacity; and this, too, during part of the time when iron commanded the highest price it has reached for years, and when, therefore, every inducement was offered managers to urge the production of their furnaces to the utmost limit. This proves the original statement, that, to supply two such large furnaces at profitable rates, is beyond the capacity of the region immediately surrounding and within easy hauling distance.

In addition to the mistake in the location and size of the furnaces, they were unnecessarily expensive. The same may be said of all the improvements made by the company. The number and style of buildings, and the investments for roads, tram-ways, &c., were somewhat extravagant. The buildings of one sort and another cost considerably over two hundred thousand dollars, while the cost of roads, tram-ways, inclines, etc., was nearly one hundred thousand. All of these items, added probably to some considerable extravagancies, or at least the lack of economy in the management, combined to make the total investment of capital in the enterprise much greater than could reasonably be expected to pay a good interest, under the most favorable circumstances.

As a further proof of the above statements in regard to these furnaces, it may be stated that Estill Furnace, which, with all its buildings and improvements, cost not more than ten or fifteen per cent. of the total cost of the large furnaces and their improvements, produced, in the five years from 1870 to 1874, inclusive, nearly one half as much iron as was made by the two large furnaces, when, had they been worked up to their capacity, they could readily have made four times as much as the smaller furnace, with its imperfect machinery.

When improved transportation facilities are afforded this region, so that iron can be shipped to market at a reasonable price, these furnaces will be profitably operated, for a portion

of the year at least, with ore and charcoal obtained from the immediate vicinity; but they will be best developed by a railroad which shall bring to them ore and fuel from a distance.

This whole region has a great future before it as an iron manufacturing district. It is capable of sustaining many times the present number of furnaces; but its development must depend upon, and be determined by, new lines of transportation. Until means of transportation are improved, it is useless to look for any great development. The character of the ore deposits must also be considered in constructing furnaces in this region, and only furnaces adapted to them be erected. The experience of the Red River Iron Company proves conclusively that this pattern of furnace is not adapted to this region, unless the furnaces be situated on some line of transportation where ore and coal can be brought from a distance.

QUALITY OF IRON.

The following analyses show the chemical composition of a number of samples of iron from this region:

ANALYSES OF COLD-BLAST CHARCOAL PIG IRONS FROM THE RED RIVER IRON REGION, BY DR. R. PETER AND MR. J. H. TALBUTT.

	No. 1 Cottage.	No. 1 Estill.	No. 1 Red River	No. 3 Red River	No. 5 Red River	No. 1 Bath.	No. 2 Bath.	No. 3 Bath.	No. 4 Bath.
Iron	93.106	92.582	94.174	93.728	93.963	92.631	91.924	93.472	93.004
Graphitic carbon	3.860	3.500	3.340	3.520	2.000	3.840	3.440	3.100	2.700
Combined carbon	.590	1.200	1.110	.780	2.550	.710	1.060	1.510	1.410
Silicon	.914	.960	.447	1.202	.363	1.520	1.319	.652	1.007
Slag	.160	.360	.360	.360	.320	.100	.260	1.600	.260
Phosphorus	.527	.444	.402	.290	.338	.363	.220	.290	.262
Sulphur	.011	.066	.182	.081	.104	.278	.107	.121	.172
Total	99.168	99.112	100.015	99.961	99.638	100.180	98.330	100.745	98.815

Some of the above analyses were more complete than as given here. For the complete analyses, see the report of Dr. Peter.

The excellent quality of this iron is due to the comparatively small per centages of phosphorus and silicon. A comparison of these analyses with those of Hanging Rock hot-blast pig irons, published in volume I, second series, Kentucky Geological Reports, shows a marked difference in the

per centages of these ingredients in favor of the Red River irons. When the Red River ores come to be worked with hot-blast, it is probable that the per centage of silicon will be increased; but the phosphorus will remain about the same.

PRODUCTION OF IRON.

The following table shows the production of iron in this region for the years 1870 to 1874, inclusive. In 1875, there was no iron made at any of the furnaces, with the exception of one lot of forty-eight tons at Bath Furnace.

These figures were obtained from the furnace books for all the furnaces, except Cottage. The returns for that furnace are probably accurate, as they were obtained from the former proprietors:

Name of Furnace.	1870.	1871.	1872.	1873.	1874.
Bath	not in blast	not in blast	not in blast	795	1339
Cottage	*1000	1850	1900	1950	not in blast
Red River Iron Company's Furnaces. Estill	1167	1880	1967	1375	388
Red River Iron Company's Furnaces. Chandler	2109	3855	2564	613	not in blast
Red River Iron Company's Furnaces. Blackstone	772	3529	289	1057	1284
Total	5050	11114	6720	5790	3011

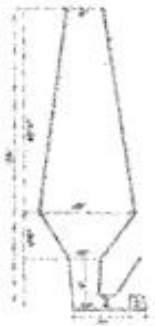
*Estimated.

BLAST FURNACES
OF THE
RED RIVER
IRON REGION.

To accompany the Report of

P. N. MOORE.

ESTILL.



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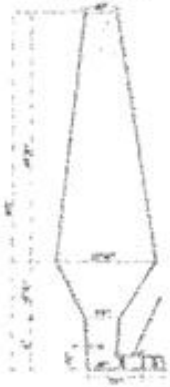

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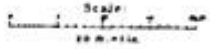
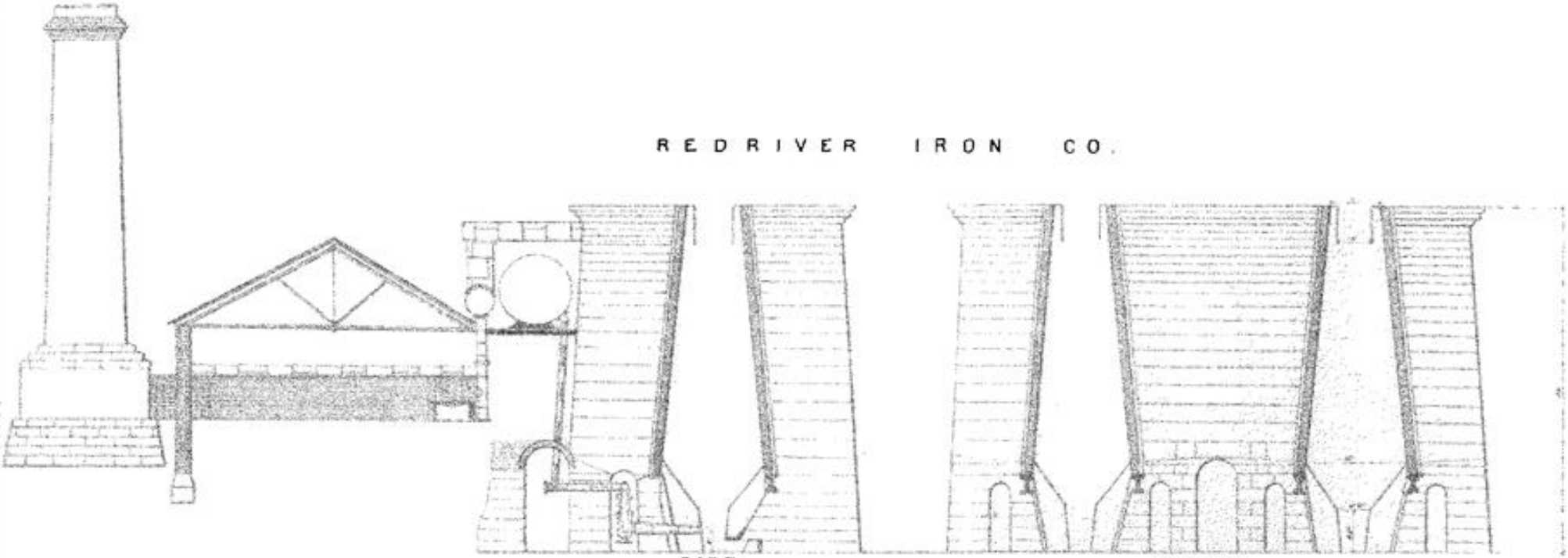


RED RIVER IRON CO.



SIDE

FRONT