GEOLOGICAL SURVEY OF KENTUCKY.

N. S. SHALER, DIRECTOR.

REPORT ON

THE LIMONITE ORES

OF

TRIGG, LYON AND CALDWELL COUNTIES,

KNOWN AS THE

"CUMBERLAND RIVER ORES."

BY WM. B. CALDWELL, JR.

PART VIII. VOL. V. SECOND SERIES.

STEREOTYPED FOR THE SURVEY BY MAJOR, JOHNSTON & BARRETT, YEOMAN PRESS, FRANKFORT, KY.

251 & 252

This page in the original text is blank.

INTRODUCTORY LETTER.

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

DEAR SIR: The following report is a continuation of the former paper on Western Kentucky, and will close, for the present, work in that region. The next report will be on the Eastern Kentucky district—the coals and iron ores. In making the following report, I have dwelt upon the question of steel, because ores suitable for the manufacture of even common grades of steel are so rare in the United States, and especially south of the Ohio river. This renders an ore, which can be used, far more valuable than its percentage of metallic iron would indicate.

WM. B. CALDWELL, JR.

This page in the original text is blank.

THE LIMONITE ORES OF TRIGG, LYON, AND CALDWELL COUNTIES, KNOWN AS THE "CUMBERLAND RIVER ORES."

These ores were mentioned in my general report on "Ores and Coals of Western Kentucky," a paper submitted in February, 1878. Since then, my time has been devoted to the chemistry and metallurgy of steel-making; and, with the opportunity of thoroughly investigating the use of brown ores for the purpose, I have been more than ever impressed with the importance to the State, and more especially to Western Kentucky and Louisville, of the ores of which this paper will treat. The region has already gained a reputation for excellent iron, particularly for boiler plate, and "Cumberland River Iron Works" and "Hillman's Boiler Iron" are well known; but the advantages of the district are not known. If so favored a region lay in Ohio, Pennsylvania, or any State north or east, great developments would have been made long ago, and many thousand tons of iron would be annually brought over the Elizabethtown and Paducah Road to Louisville.

This report is intended, as all the Survey reports are, to bring to public notice the undeveloped wealth of the State; but in this paper it is intended, especially, to call attention to the fact that, only one hundred and seventy-five miles from Louisville, are extensive deposits of an ore suitable for making steel, a fact which is undeniable, and that the iron made from it could be put down at Louisville at a less cost than such iron sells at Pittsburgh or elsewhere.

In order the more efficiently to show the character of the ore, quality of iron produced, etc., Trigg and Centre Furnaces will be discussed at some length; for here we have practical proof of the working of the ore, and of the excellent quality of pig and wrought iron made; but first, a general description of the district: The Tennessee and Cumberland

rivers enter Kentucky only a few miles apart, and cross the State side by side to the Ohio. Between the rivers, and on the eastern bank of the Cumberland, from Tennessee down to Livingston county, just beyond the crossing of the Elizabethtown and Paducah Road, about thirty miles in length, lies the iron ore deposit.

The coal measures extend southward into Caldwell county, about five miles from Princeton, where there is a deposit of the ore; and on Caney creek, about fifteen miles from Princeton, several five-foot veins of excellent coal have been opened.

It would be useless here to do more than mention the fact that the coals of Western Kentucky are suitable for iron-making, and can be mined very cheaply; for they were fully discussed in the former paper, with numerous analyses of coal and coke, and figures showing cost of mining.

The ores are in great abundance on the river banks and on the railroad. At and near Kuttawa, the crossing of the Cumberland, on the property of Governor Charles Anderson, are several extensive beds or pockets of ore, which were once mined largely for a charcoal furnace run there by Mr. Kelly, now of Louisville.

The railroad cuts through a heavy deposit, and there are mines at distances varying from one half to three miles. These deposits are a fair average of the occurrence in the whole region. The ore seems to have been deposited in the form of "pot ore" and "kidney," and at some points as "pipe ore," in a clay and chert formation, but subsequently subjected to disturbances which have mixed the broken pots, etc., more or less intimately with the clay and chert. Whether this was the manner of formation or not, and what the nature of the disturbances was, whether simply upheavals or the natural disintegration from washing down of the strata, is of no moment here. The appearance of the beds indicates such a process, and this describes sufficiently well, to any one who has not seen them, the nature of the deposits; but, I must add, that the masses of ore, uncontaminated with clay or chert, are often very large, weighing sometimes tons, and that the

smaller lumps may be easily taken out free. The only drawback is, that a certain quantity of dead work must be done in removing the clay and chert. This, however, is not at all expensive.

As to the amount of ore in a bed or pocket, it would be impossible to calculate, as none of them have ever been exhausted; the part above ground being apparently all ore and clay, and the ore seeming to run down the surface to a considerable depth.

The extent to which this commingling of ore and chert has been carried on varies considerably in different deposits, and also in the same deposit; but the ore, when carefully mined, as it is for use, varies very little in composition, as several analyses in my previous paper, and further analyses below, will prove. Ascending the river, deposits of ore are found here and there along the river and railroad. Above Eddyville, a station on the river and railroad, there have been several charcoal furnaces—Monmouth, Fulton, etc., and lately Centre and Trigg.

The old furnaces made iron when there was but little communication with distant points, and ten tons a day was a very large yield, but it was cold-blast charcoal iron. It was common then to make large sugar-kettles, iron pots, and common castings by running the iron from the furnace directly into the moulds, and it was a profitable business.

In these days of hot-blast coke furnaces, making sixty tons, and even much more, a day, the iron business on a small scale scarcely pays; and the combination of practical with theoretical knowledge of furnaces and the working of metals has brought the industry so far forward that production exceeds consumption, although many new uses are found for iron every day. On account of this over-production the industry has suffered severely during the past five years, and only highly favored localities can succeed—localities combining the following advantages: Abundant supply of good cheap coal near cheap ore, limestone, and water, and with transportation facilities to a near and good market. Or for charcoal iron, which

always brings a higher price for certain purposes, good cheap ore must lie in a well timbered country, with plenty of limestone and water, with the same requisite transportation facilities. Such localities exist in Western Kentucky for coke iron and for charcoal iron.

CHARCOAL IRON.

The furnaces referred to above—Centre and Trigg—will afford evidence of the adaptability for charcoal iron, excepting that transportation is not as cheap as it might be.

About ten miles above Eddyville are the boiler-plate works of D. Hillman & Sons, for which the furnaces in question were run, and which I will describe briefly after speaking of the furnaces.

TRIGG FURNACE.

This furnance is on the eastern bank of the Cumberland, about three miles inland, and five miles above the rolling mill just mentioned. It has been out of blast for some time, but is well kept, and in good condition.

The stack is large and well shaped, has closed top and down-take pipes for the gases, which are utilized for heating the blast. The hot-blast ovens are arranged so that they can be fired with fuel or with waste gases, or both. There is a good steam hoist for raising ore and fuel to the tunnel-head. Three horizontal blowing engines furnish blast, and these are well preserved. Altogether, the plant is in good condition, and would require but little work and repairing to start up again. The ore banks about the furnace are very extensive, and are only about one mile distant, the ore being brought by cars down grade on a narrow gauge tramway, and empty cars hauled back by mules. This ore is of the same general character as that in the other parts of the region, occurring in great beds, and more or less mixed with chert and clay. It requires very little mining, only being at all expensive on account of the dead work in removing clay and chert. Immense pits have been dug, leaving a bottom of ore, which

extends to a considerable depth below the general level, and these pits continued into the hill. The drawback to this method of mining is the water which accumulates, and for that reason it would, in the end, probably be economical to tunnel or drift into the hill, and then work passages off to the sides, and also to work down.

Mining it, however, as it was done, was very cheap, not costing over $1 10 to put the ore down at the furnace, and to keep it very clean and free from chert. This was the easier from the fact that the lumps of ore are individually quite free from impurity, and are often of great weight, so that when gotten out and broken up they need no further cleaning. As to quality, the ore is very similar to that already mentioned. On page 8 of the former report are several analyses of limonite ores from the district, and the following show the similarity, as also the excellent character of the ore.

1. Ore taken from bank worked for Trigg Furnace.

2. Ore taken from bank near by, which had also been worked.

	1.	2.
Iron oxide	70.31	69.93
Alumina	2.54	3.12
Lime	1.89	1.53
Magnesia	1.48	1.62
Water	10.70	10.21
Silica	12.91	13.45
Total	99.83	99.86
Metallic iron	49.210	48.950
Phosphorus	0.091	0.087

Limestone is abundant and good; and, being at hand, could not cost more than seventy-five cents per ton.

Good charcoal timber surrounds the furnace and ore banks, and, although the furnace has been worked for some years, the timber is not thinned out. I was told in the country there that contracts could readily be made to furnish charcoal at four

and a half cents per bushel; but, putting it at five and a half cents a bushel, the fuel for a ton of iron would not cost over seven dollars. Labor is abundant and cheap, the native population being glad to get work; and then there are many negroes, already trained to the work, who make excellent furnace hands. Water is plentiful and constant from a large spring and creek.

With the raw material at the furnace for the figures above stated, the cost of making iron would be about $14 25 per ton, and should not be more, as the estimates are full.

Charcoal, per ton of iron	$7 00
Ore, two and one fourth tons	2 50
Limestone, two thirds ton	50
Labor and incidentals	3 00
	$13 00
Add ten per cent. for any loss	1 30
	$14 30
Add two dollars, freight to Louisville	2 00
Total	$16 30

And we have a warm-blast charcoal iron of the best quality—equal in all respects to irons selling at Louisville now for twenty-three dollars, No. 1, and eighteen dollars "Mill" grades. Supposing the furnace to make half of No. 1 and half "Mill," the average would be twenty dollars and a half, which would leave a handsome profit.

The iron would have about the following composition, this being an analysis of Trigg iron:

Iron	94.71	per cent.
Carbon	2.87	"
Silicon	1.93	"
Phosphorus	0.18	"
Sulphur	trace.	

CENTRE FURNACE.

Returning to the rolling mill, and crossing the Cumberland, we find Centre Furnace, two miles off to the west, in Lyon county. The site of the old Fulton Furnace is near by.

Centre is also a large charcoal furnace, with modern improvements — a large stack, in good condition, good out-

buildings, steam hoist, horizontal blowing engines, etc. The surrounding hills are full of ore, and several mines have been worked quite close to the furnace.

The ore is of the same general character as that in Trigg and Caldwell counties, is mined in the same way, just as cheaply, and yields as well in the furnace. Analysis shows it to be as pure, the following being an average sample taken from one of the mines:

Iron oxide	71.13
Alumina	2.29
Lime	2.61
Magnesia	1.48
Water	10.89
Silica	11.26
Total	99.66
Metallic iron	49.80
Phosphorus	0.092

This furnace is also surrounded by good charcoal timber; water is abundant, and limestone of good quality quite near. The cost of making iron would then be about the same as at Trigg Furnace.

The iron from these furnaces has been used to make the boiler-plate so well known on the steamboats in our Western rivers, and which has gained so general a reputation for excellent quality and uniformity. The process, however, is the most expensive used in iron working, and hence the mill has not kept in full blast during the past year or so. The pig iron is treated in small charcoal knobbling fires—that is, it is made into wrought iron by puddling in charcoal. The charcoal blooms or balls are shingled, rough rolled, cut and piled, then heated and rolled. The bars are cut and piled for plates, heated and rolled to plates of different sizes and thickness. The rolling mill is quite extensive, consisting of large rolling mill building, out-houses, machine shops, etc., knobbling furnaces or fires, refinery, hammers, shears, etc.

The plate trains are, for large plate 26-inch, and for small plate 18-inch, well arranged and adapted for the work. By the process of "knobbling or sinking" the 0.18 per cent. of phosphorus is reduced to 0.03 per cent., which, to a great extent, accounts for the excellence of the plate, and its great strength. Having shown what the ore is capable of in making charcoal iron and wrought iron from it, I will refer to the question of making a cheap iron suitable for steel, using coke as fuel in the blast furnace.

COKE IRON.

The fact has already been mentioned that the coal field of Western Kentucky extends to within a very few miles of these ores, and that the coal, which is of excellent quality for iron smelting, occurs in veins five feet in thickness.

The E. & P. Road cuts through this coal field, and already the line of the road is dotted with numerous coal mines, which furnish coal to Louisville at a price lower than Pittsburgh can send it. Coke ovens have already been erected, and the coke has a good reputation with iron men.

Along this road are many points which would be excellent furnace sites. There is Rockport, where the road crosses the Green, a river navigable at all seasons, and Nortonville, the crossing of the E. & P. and St. Louis and S. E., and many other places in the coal field; or, if one preferred taking coal to the ore, there are favorable locations in the ore region. Either way the distance need not exceed thirty or forty miles, and could be put at much less.

Coal can be mined very cheaply, and two tons coke should not cost over $2 75 at the mines; if freight for thirty miles were added, it would not be over $3 50. The ore can be mined for one dollar—say $2 50 for two and one fourth tons—freight on two and one fourth tons thirty miles would make it, with the loading and unloading, about $3 50. Then the cost per ton of iron would be—

	At the coal.	At the ore.
Coke, two tons	$2 75	$3 50
Ore, two and one fourth tons	3 50	2 50
Limestone, three fourths ton	60	60
Labor and incidentals	3 00	3 00
Total cost	$9 85	$9 60
Freight to Louisville	1 50	1 75
	$11 35	$11 35
Add ten per cent. on total cost	96	98
Cost at Louisville	$12 31	$12 33

These estimates are for a grade of iron from which steel for rails or merchant bar or "shapes" could be made at a low figure. Any concern which could buy such iron at Louisville for sixteen dollars would not need to fear failure in steel-making.