MISSISSIPPI STATE GEOLOGICAL SURVEY

E. N. LOWE, Director

BULLETIN No. 10

PRELIMINARY REPORT ON

IRON ORES OF MISSISSIPPI

By E. N. LOWE

Fig. No. 1.—Exposure of Tallahatta Formation on banks of Chunkey Creek at Dunn's Mill, in Clarke County.

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TUCKER PRINTING HOUSE JACKSON MISS

STATE GEOLOGICAL COMMISSION.

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LETTER OF TRANSMITTAL.

JACKSON, MISS., February 24, 1913.

To His Excellency, Governor Earl Brewer, Chairman, and Members of The Geological Commission:

GENTLEMEN—I herewith have the honor to present to you this Preliminary Report on Iron Ores of Mississippi, as a result of investigations carried on during the year 1912, and recommend that it be published as Bulletin No. 10, of the Mississippi Geological Survey.

Very respectfully,

E. N. LOWE, *Director.*

PREFACE.

Our knowledge of the distribution of the Iron Carbonate ores of the north-central counties of Mississippi is as yet very imperfect. It is not known to occur in several counties where it is probably as abundant and of as good quality as in the localities that have been more definitely studied. Future field work in those counties will reveal the presence or absence of these ores in notable quantities. The study of the iron ores of the State has so far been carried on largely incidental to other work in hand.

But for the fact that some erroneous impressions have become rather widely current regarding some of these iron deposits in Mississippi, the publication of this report would have been deferred until the ore-bearing formations had been studied in their entire outcrop in the State. However, in the interior counties without good transportation facilities the occurrence of this ore, unless in much larger quantities than we have reason to expect, is of geological interest rather than of present economic importance.

In the preparation of this Bulletin, the writer wishes to make acknowledgments especially to the following works:

Ore Deposits of the United States and Canada, Kemp.

Economic Geology of the United States, Reiss.

West Virginia Geological Survey Report, Vol. IV, 1909, Iron Ores of West Virginia, G. P. Grimsley.

U. S. Geological Survey Report on Mineral Resources of the United States, 1910.

Geological Survey of Ohio, Vol. V, 1884, Orton.

I am indebted to Professor W. L. Perdue, of the State University, for analyses of ores as follows: Nos. 1 to 9, inclusive.

All the other analyses were made by Mr. R. W. Boyett, also of the Department of Chemistry of the University. Mr. H. A. McGusty, of Enterprise, Mississippi, furnished the photograph for the frontispiece. All the other pictures are from photographs taken by Mr. R. W. Boyett.

I regret that I have been unable to examine the reports made on the Enterprise ores by Mr. Brainard and Prof. Cox. The only data on those reports available to me have been in a typewritten abstract of them furnished me by Judge John L. Buckley, of Enterprise, for which kindness I owe Judge Buckley sincere thanks.

E. N. Lowe.

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IRON ORES OF MISSISSIPPI.

INTRODUCTORY.

Universal Distribution of Iron.—Iron in some form is one of the commonest constituents of the rocks of the earth. Only three other chemical elements, oxygen, silicon and aluminum, enter more largely into the solid crust of the earth, iron standing fourth in the series and embracing 5.08% of the whole.

It is almost universally distributed, entering largely into igneous rocks in composition with silicates of other elements usually. In the sedimentary or bedded rocks it is found very generally as a coloring matter and as a cementing material. In all rocks and in whatever capacity iron is found, it exists in combination. Only very rarely, and then largely from extraneous sources, is iron found in a state of nature as the metallic element.

Iron as an Ore.—In none of the forms above mentioned is iron an ore. In any one of several combinations, the commonest being oxides and carbonates, or in mixtures of these, iron may become an ore, but to become so it must be present in sufficient quantity and sufficiently concentrated to be of commercial importance. The concentration of iron in the formation of ore bodies has undoubtedly taken place in different ways and under diverse conditions. On the whole, however, it may be quite safely said that the zone of weathering and the regions immediately beneath it in the earth's crust furnish the conditions under which the formation of the most extensive and important iron ore deposits have taken place, and are taking place now. Meteoric water has played an important part in the process. When rocks, which have formed at considerable depth within the earth, are brought by any process to the surface or under surface influences, iron is one of the first constituents to undergo change. Oxidation, hydration, or carbonation is most frequently the change that takes place, owing to contact with the gases of the atmosphere held in solution in descending atmospheric waters. In undergoing these changes the iron is rendered soluble, taken up by circulating water, transported a greater or less distance, and there re-deposited under conditions which often result in larger deposits and richer concentrations of the iron, and in combinations available for economic use.

The Ores of Iron.—The commonest ores of iron are the oxides and the proto-carbonate. The oxides are three in number: magnetic oxide (Fe_3O_4), magnetic iron ore, or magnetite; red iron ore, hematite (Fe_2O_3); brown ore, or limonite ($Fe_2O_3H_2O$). The proto-carbonate ($FeCO_3$), is also called siderite or spathic ore. It will be inferred from the methods of formation of these ores that they are found seldom in a state of purity, the commoner impurities being the ordinary rock-forming minerals. These may be mingled with the ore in any proportion, so that we may have all intergradations between the richest and leanest ores. The impurities that are most significate in iron ores, because they affect the quality of the iron produced, are phosphorus, sulphur, silicon, aluminum, titanium, and manganese. These will receive attention later.

Magnetite.—This, the richest ore of iron, is so named because of its strongly magnetic properties. When theoretically pure the ore contains 72.4% of metallic iron. Magnetite is dark grey to black in color, has a dull metallic lustre, hardness of 5.5, specific gravity of 5, and is brittle. Chemically, it is regarded as a combination of ferrous (FeO) and ferric (Fe_2O_3) oxides. Titanium is a common impurity of this ore, replacing part of the ferrous oxide. Magnetite occurs chiefly in the igneous and metamorphic rocks of New York, New Jersey, and Pennsylvania. In 1910 more than 2,500,000 long tons of this ore was produced in the United States.

Hematite.—This is known as the red oxide of iron, and, while the ore is usually red, a variety known as specular hematite is steel gray in color and has a bright metallic lustre. The red ore may be either hard or soft, a soft, earthy variety being called ochre. The theoretical iron content of this ore is 70%. Hematite occurs in stratified and metamorphic rocks, perhaps never in igneous, although the Lake Superior hematites have been by some considered to be of igneous origin. The Clinton iron ores, a peculiar oolitic and, in places, fossiliferous red hematite, occurring in the Silurian rocks, has a wide distribution. Exposed in Wisconsin, these ores extend across Ohio and Kentucky to New York, thence the belt passes south through Pennsylvania, Maryland, the Virginias, Tennessee, and Georgia, into Alabama. The Lake Superior region furnishes more hematite ore than all the rest of the country. In fact, by far the greatest part of the iron made in this country is manufactured from Lake Superior hematite. In 1910, 51,367,007 tons of hematite was mined in the United States.

Limonite.—Limonite has the same composition as hematite with the addition of variable quantities of water. The ore is usually formed under surface or sub-surface conditions, as indicated by its hydrated condition. A variety of limonite known as bog iron ore is a deposit from ferruginated waters in bogs and swamps.

This ore of iron occurs under a variety of forms and colors. It is often concretionary, in tubular, globular, annular, or other shapes; stalactitic, or forming incrusting nodular or botryoidal plates upon exposed rock surfaces; in fibrous masses, or in stratified beds. The color varies from yellow to brown, and even black, with lustre from dull earthy to splendent sub-metallic. The stalactitic forms usually exhibit shining black surfaces, and on cross fracture show rich brown color with radiating fibrous structure. Bog ore is dark grey to black in color, of earthy lustre, and has a spongy, worm-eaten appearance often, because of its mode of deposition around roots and stems of plants.

Limonite ores have a theoretical iron content of 59.89%. They are in demand when sufficiently pure because of their easy fusibility. Most of the brown ores are produced by the southern Appalachian States, during 1910 nearly 3,000,000 tons having been mined.

Spathic, or Carbonate Ores.—Siderite, or iron carbonate, is of less economic importance now than formerly for several reasons presently to be stated. When theoretically pure, this ore has 48.2% of metallic iron, being the lowest of the series here considered. Impurities usually associated with spathic ore are lime, magnesia, clay and silica. With the exception of a deposit of crystaline siderite occupying a fissure vein at Roxbury, Conn., this form of iron is always associated with stratified deposits. The coal measures furnish the most extensive and important deposits, but others occur in the Cretaceous and Tertiary formations. Spathic ore occurs either in stratified beds or in concretionary masses; the former ore is associated with coal beds of the carboniferous, and is called Black Band ore, because of the contained bituminous matters which give the ore a black color; the latter, or concretionary ores, are usually associated with clay, slate, or limestone beds, are light grey to reddish brown in color, dense, and of fine, smooth texture, the masses varying in size from small nodules to flattened masses that weigh a ton or more and often run together into almost continuous beds. These ores have been mined in several States of the Union in the past, but Ohio is now the only State producing iron from carbonate ores.

Pyrites (FeS_2) is an iron compound of common occurrence as a mineral, and of considerable economic importance as a source of sulphur and in the manufacture of sulphuric acid. On account of the presence of sulphur the mineral is of no value as an ore of iron.

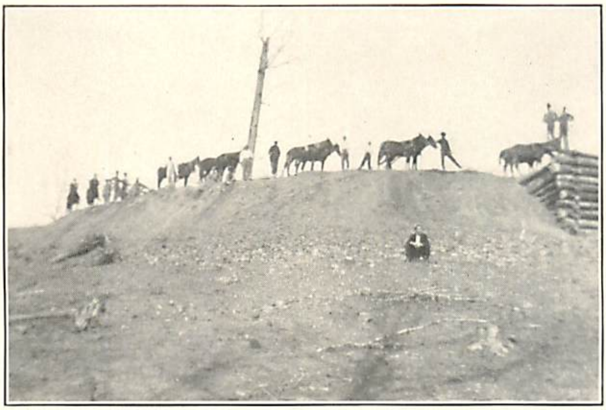
Origin of Iron Ores.—Numerous theories have been advanced to explain the origin of the various ores of iron. Excepting bog ore and some other varieties of the limonitic groups, the formation of iron ores, like many other geological processes, is hidden from view, and the exact steps in the evolution of ore bodies must be inferred from known facts connected with the ores themselves.

Bog Ore.—Iron in greater or less quantity is so generally diffused through the earth's rocks that atmospheric water in passing beneath the surface almost certainly comes in contact with some of its compounds. Surface waters always absorb oxygen and carbon dioxide from the atmosphere, and as they pass into the rock these gases attack the iron which is generally present in the form of ferric oxide (Fe_2O_3). This is insoluble in pure water but in the presence of decaying vegetation the Fe_2O_3 yields up part of its oxygen, which combines with the decaying vegetable matter, thus reducing the ferric oxide to ferrous oxide (FeO), which is soluble. The water takes into solution this ferrous oxide of iron, and as it passes through the rock carries the iron thus changed along with it. Reaching a point of exit in some low, swampy area, the iron is brought again in contact with the atmosphere, takes up more oxygen and is again converted into the ferric oxide (Fe_2O_3). Since this is insoluble it is deposited as a brownish deposit which solidifies to bog ore. Not infrequently, however, much of the iron remains in the ferrous or protoxide condition impregnating the fine clays and silts at the bottom of the swamps, and gives them a bluish color, which on draining or drying up of the swamp oxidizes to red or yellow soils.

Spathic Ore.—The formation of bog ore is going on in numerous places now, and the process can be readily observed. This represents the simplest case of iron ore formation. It is probable that the change from ferric oxide to ferrous oxide in the presence of CO_2 of decaying vegetation frequently results in the combination of the CO_2 with the FeO in the same solution, with the formation of ferrous carbonate ($FeCO_3$). In the presence of excess of decaying vegetable matter, i. e., more than enough to de-oxidize the ferric to the ferrous oxide, the carbonate of iron is deposited as such, and if the process is continued long enough deposits of commercial importance may be laid down.

Plate I.

View of Camp of Memphis Mining and M'f'g. Co., on Reid property, Potts Camp.



Upper location tipple on Reid property, Potts Camp.

Cut on 20-inch seam on Reid property, Potts Camp.

Most of the spathic or carbonate iron ores of this country are found in the coal measures associated with beds of coal. The coal beds seem to have been originally deposited as peat in great marshy areas, and the iron ore has been deposited as the carbonate under the same conditions. The ore beds are inter-stratified with the coal beds, and often the ore is black from the inter-mixture of organic matter, receiving on that account the name of Black Band Ore. Such beds are, of course, formed in the same geological age with the accompanying coal beds. This may not be true of all carbonate iron deposits. Many deposits are not truly stratified but are concretionary or segregational in origin, so that the ore bodies constitute nodular or irregularly flattened lenses that are discrete, or may become more or less confluent into discontinuous beds. The masses tend to follow stratification planes of the enclosing clay or slate beds, but may at times follow joint planes or other open passage-ways along which water travels.

The evidence points to the fact that such deposits are formed independently and, it may be, long subsequently to the deposition of the rock strata in which they are found. The iron has been accumulated by an entirely different process than that of stratification of mechanical sediments. The steps have consisted in the dissolving out of iron of pre-existing ferriferous beds by water most probably containing oxygen and excess of organic matter in process of decay, causing the contained iron to assume the carbonate form; while in a state of solution the iron is transported along open or pervious passage ways which are notably stratification planes, and is finally deposited in lenticular concretionary masses, the long diameter following the stratification planes. In other words, the lines of greatest deposition, and, therefore, of concretionary growth, follow the lines of water flow. The laws of concretion and segregation about which we know little, determine the deposition in nodular form rather than in continuous beds.

From what has been said, it may be seen that concretionary iron may be deposited at any epoch subsequent to the formation of the beds in which it is found. Since, however, these concretionary iron carbonate ores usually require the presence of organic matter in their conversion to carbonates, and since they are nearly always associated with geological formations in which large deposits of organic matter have accumulated under conditions favorable to the accumulation of the ore, it would seem reasonable to infer that the age of the enclosing beds is in most cases approximately the age of the ore masses.

Some carbonate ores are associated with limestone beds in such a way that it is almost certain that the limestone has reacted with iron bearing waters resulting in the formation of iron carbonate which has replaced the limestone, in some cases filling cavities dissolved out of the limestone, in others the substitution being particle by particle.

Limonite ($Fe_2O_3H_2O$) is a hydrus oxide of iron. Under the name brown ore is included a group of closely related hydrated oxide ores of iron of which limonite is only one, but the most important one. The brown oxide of iron is the usual coloring matter of surface soils, and disintegrated rocks. The weathering of the various compounds of iron which enter into rock result in its formation, so that it is the most widely disseminated form of iron. As an ore, however, it is not so important as the red oxide, hematite.

The process described as taking place in the formation of bog ore is practically the same for the limonite ores. The iron in some form disseminated through pre-existing rocks has been attacked by surface water armed with atmospheric gases, dissolved out of the rock, carried by the water until redeposited as the hydrus oxide either by evaporation of the water or by exposure to the atmosphere in a swamp or similar place, or by meeting other solutes that by combination compel its deposition.

Commercially important deposits of brown ore are usually not large and have resulted from the concentration of iron residual from the weathering of ferruginous clays, limestones and other rocks, or from the weathering and leaching of pyrite, chalcopyrite and other sulphide minerals that carry iron. Carbonate iron ores weather into limonite giving rise to occasionally important deposits.

By far the most important ore of iron is the red oxide, **Hematite.** This ore has the same chemical composition as limonite minus the water contained in the latter. The extensive and rich deposits of the Lake Superior region are hematite. These, together with the Clinton ores, are the most important deposits of hematite ores. The Lake Superior ores have been regarded by some as of eruptive origin, others (Brooks and Pumpelly) have looked upon them as altered limonites. Later investigations indicate that these ores were derived from the weathering of originally igneous rocks, the iron being concentrated in the sedimentary deposits resulting from this weathering. These were further enriched by iron dropped by magmatic solutions. It is believed that the iron was first accumulated as ferrous carbonate and ferrous silicate, and that subsequent upheaval of the area to land surface with exposure to weathering has oxidized the ferrous compounds to ferric oxide, or hematite. In undergoing the change, however, the iron has been transported in part and redeposited in troughs. Much of that remaining in place has been metamorphosed into hard red and specular ores.

The Clinton ores exhibit usually oolitic structure and often fossils. These ores are usually bedded or in lenses and are of wide distribution, varying in thickness from a few inches to forty feet. There is considerable difference of opinion regarding the origin of these ores. One theory is that the ore bodies were originally limestone containing disseminated iron, and that the weathering, together with redeposition of the iron and removal of the limestone in solution, has resulted in workable deposits due to residual enrichment. Another view assumes that the ore was an original sea-bottom deposit, and that the fragmentary shells and the oolitic structure point to precipitation of the iron in the marginal waters of the ocean. A third theory, the Replacement Theory, assumes that the original marine deposit was an oolitic and fossiliferous limestone and that at a later period the lime was replaced by iron. Several reasons are advanced in support of each theory, but, on the whole, it would seem that the theory of replacement is the most tenable.

The **Magnetite** ores of iron are not of wide occurrence throughout the country, their distribution being confined to the oldest rocks, either highly metamorphic or igneous. The titaniferous magnetites are of igneous origin, while the non-titaniferous ores,—the only ones of commercial importance,—are probably metamorphic hematites, limonites, or carbonates, the metamorphism of the ore having taken place with the metamorphism of the accompanying gneisses and schists. The occurrence of the ore in lenses and beds adds to the probability of this origin.

Impurities of Iron Ore.—Besides mechanical impurities such as sand, clay and limestone, the two first of which lower the fusibility of the ore, and thus add to the cost of smelting, the last increasing the fusibility and thus acting as a flux, several chemical elements may be present in the ore affecting materially its value for iron manufacture. These will receive short notice here.

(1) *Phosphorus.*—Iron ores are classed as Bessemer and non-Bessemer ores, the basis of classification being the quantity of phosphorus present. Iron has a strong affinity for phosphorus so that in smelting, instead of going off in the slag, it enters the iron. Phosphorus in pig iron in excess of 1-10% is unfit to use in making Bessemer steel, so that an ore that leaves more than that per cent of phosphorus in the pig iron is a non-Bessemer ore. Unless in very small quantity

phosphorus makes the steel brittle and unsafe for many important purposes. For this reason Bessemer ores command especially good prices. While in the acid Bessemer process the phosphorus all remains in the steel, where the basic Bessemer process is used much of it is taken into the slag, so that by this process ores with higher phosphorus may be used.

High percentages of phosphorus render the pig iron lighter in color and more fluid adapting it well for fine casting.

Kemp gives as a simple method for determining the allowable limit of phosphorus in an ore to be a Bessemer ore, the following: Divide the percentage in iron by 1,000.

(2) *Sulphur.*—This is a frequent impurity of iron ores. It renders the iron brittle when hot, causes the steel to crack in rolling, interferes with its welding capacity, and "impairs the soundness of steel castings." In common steel 1-10% of sulphur apparently does little harm but in rails it is best to have less than 0.08%.

Fortunately sulphur is largely removed in the slag and any that remains can be neutralized by manganese.

(3) *Silicon.*—Silicon is one of the commonest impurities of iron ore; it is especially high in many limonite and carbonate ores. While silicon for the most part goes off in the slag, if it runs very high in the ore, enough remains in the iron to give it a gray color and make it brittle. Carbon neutralizes the effect of silicon to some extent.

(4) *Manganese.*—Manganese in small quantities in an ore of iron neutralizes sulphur, makes the slag more fluid, and causes more complete separation from the slag. In proportion from 1.5% to 2% it makes the pig iron brittle, which condition exists until an admixture of 6 to 7% of manganese is reached, when the metal becomes very hard and tough. Maximum toughness is reached when 14% of manganese is present, above which toughness again diminishes.

(5) *Titanium.*—Titanium is present only in the magnitites. Its effects, which are entirely deleterious, are twofold: it increases the infusibility of the slag and causes part of the iron to pass off in the slag. More than 1% is harmful, and if the titanium reaches 3% the ore becomes so infusible as to be useless.

Iron Production of the United States.—The valuation of the mineral output of the United States in 1910 was $2,003,744,869. The coal output stood first with a valuation of $629,557,021, iron being second, valued at $425,115,235. This represents 56,889,734 long tons of ore mined, having an average price for ore of all kinds of $2.47 per ton.

The growth of the iron industry in the country has been both steady and rapid. In 1880 the output of pig iron was 3,375,912 long tons valued at $89,315,569; in 1890 the output was 9,202,703 long tons valued at $151,200,410; in 1900 the output was 13,789,242 long tons valued at $259,944,000.

Of the varieties of ores produced, hematite stands far in the lead, the output for 1910 being 51,367,007 long tons; brown ore stands second with 2,868,572 long tons; magnetite third, with 2,631,835 long tons; and siderite fourth, with only 22,320 long tons. It will thus be seen that under present conditions iron carbonate ore does not figure as an important commercial ore. This is due partly to the low percentage of iron in these ores generally, partly to the limited deposits, and partly doubtless to the exhaustion of wood for charcoal in the regions where carbonate ores occur, these ores having been smelted in the past usually by the charcoal method.

Most of the hematite is produced by the States bordering Lake Superior, where it is associated with the older formations; most of the brown ores come from the Southern Appalachian States; and all the carbonate ore at present mined comes from Ohio. Carbonate ores were at one time of more actual and of far more relative importance in the United States, but the quantity has steadily decreased. This is due partly to the causes above given, but, doubtless, principally to the exploitation of the rich hematite fields of the Lake Superior region and of Alabama. In 1880 the production of carbonate ores in the United States was 823,471 long tons, in 1890 it was 377,617 long tons, in 1900 it had fallen to 76,247 long tons.

Carbonate Ores in the United States.—In the early history of the iron industry in this country competition over large areas was practically unknown, owing to lack of transportation facilities. As a result of this the smelting plants were usually small furnaces with crude equipment, operating upon limited deposits of often low grade ores, and furnishing their output to local markets. Charcoal was very generally used and ores smelted were very largely carbonate ores found in the coal measures. The price of pig iron was high and even with their crude and wasteful methods the early operators often realized large profits. The discovery of the rich hematite ores on Lake Superior; the opening in, 1855, of the Sault Sainte Marie Canal, by which the ores from the upper lakes could enter the ports on the lower lakes; the resultant erection of large and well-equipped plants at advantageous points to command large markets; and the rapid increase of railroads from seaboard ports to numerous points on the lakes and to the interior cities situated usually on navigable streams,—all contributed to bring about sharp competition, lowering of prices of pig iron, the manufacture of better iron output than could generally be offered by the primitive early furnaces, with the result that they were gradually driven to the wall.

Charcoal iron has always commanded a special price because of its toughness and malleability, and it is certain that the charcoal furnaces have disappeared partly because of the exhaustion of wood for making charcoal in the regions where the furnaces were located.

The only State in the United States that has been operating upon local deposits of carbonate ores for a number of years back is Ohio, and its continued output is doubtless due to the proximity of the furnaces to the Ohio River, which furnishes cheap transportation for the output, as well as for coke from the West Virginia coal fields.

A brief discussion of the Ohio carbonate ore deposits, following closely Orton's Report, volume V, will be fairly representative of all carbonate ore deposits east of the Mississippi.

The carbonate ores of Ohio are found in the lower coal measures, and are best developed in the Hanging Rock District of the southern counties near the Ohio River. These ores are leachings from lands surrounding the swamps of the coal measures, transported in solution to the lowlands and deposited in coal swamps as carbonate of iron.

They are divided into two classes: (1) Stratified, or mechanically formed; (2) Concretionary, or chemically formed. The first bear the marks of having been deposited in water in successive longitudinal layers; they are intimately related to the accompanying shales which are water laid. This group constitute the "flag" ores, the "blackband" ores, etc., and contain, as a rule, smaller percentages of iron than the ores of the second class, but are found in greater volume. The blackband ores often contain enough carbonaceous matters to furnish fuel for their own calcination. The percentage of iron is low,—25% to 30%, which may calcine 50%,—but the beds may have a thickness of nineteen feet with a workable thickness of six feet or more.

The second group includes (*a*) Kidney ore; (*b*) Block ore; and (*c*) Limestone ore. Kidney ore is concretionary in origin, the ore being in lenticular or kidney-shaped masses a foot or less in diameter, and segregated by chemical action. These contain from 35% to 50% metallic iron. Block ore is found in horizontal and almost continuous sheets of one or two inches to a foot or two in thickness, averaging about eight inches. These have about the same general structure as the "kidneys," and, like them, are of chemical origin. Limestone ore, as the name would indicate, is closely associated with limestone, often grading into it. It is probably a replacement of limestone by iron carbonate.

The ore bodies of the Hanging Rock District show four persistent seams four to sixteen inches in thickness, besides accumulations of kidney ore in the accompanying shale beds. The main beds of ore are "limestone ore," "big red block ore," "sand block ore," and "little red block ore." The limestone bed is the most important in quantity and richness. Its original state is that of the carbonate, but along the outcrop the ore is oxidized to dark red limonite lying on the limestone in a regular bed. It averages twelve inches in thickness but in places is five feet. The "red limestone" is the richest ore, averaging about 40% of metallic iron. It is the red limestone ore that gives its high reputation to the Hanging Rock District. This ore varies from a hard compact to a soft and ochreous mass, which often has hard curling bands running through it giving it the name of "curly ore." It contains an average of about 10% of silica, 1 1-4% manganese, 3-10% of sulphur, and .3% of phosporus.

The "block ores" occur in three beds below the limestone ore. The upper is six to eighteen inches thick, the second is six inches thick and lies twenty feet below the first, the third is four inches thick, lying forty feet below the second. All the "red block" ores are oxidized in concentric lines. These yield an average of about 33% of metallic iron. The average thickness of the beds is eight or ten inches.

In the Hocking Valley District of Ohio the ores used are all carbonate ores, either the "flag" or "block" ores for the most part. In this district the deeper ores are found at times to become so lean as to be little less than a ferruginous limestone, the percentage of phosphorus at the same time increasing up to 2 to 2 1-2% or higher, making the iron very brittle. Five ores from this district gave on analysis an average as follows: Metallic iron 37.18%, siliceous matter 17.60%, sulphur 325%, phosphorus .71%. Pig iron made from Hocking Valley ores show in an average of twelve analyses, phosphorus .693%. Assuming the average richness of the ore to be 50% iron, this will give, .347% as the average phosphorous content of the ore.

In both the Hanging Rock and Hocking Valley Districts, the ore is mined principally by stripping the overlying material, working back into the hill slopes until such a depth is reached when the mining of the ore together with the cost of smelting practically equals the ore values. The limit of depth is then reached. In the Hanging Rock District a twelve inch bed of average ore justified the removal of twelve feet of loose overlying material. A number of local factors would enter into each case that would require close calculation for each locality.

Similar conditions to those in Southern Ohio exist in the contiguous regions of Pennsylvania, West Virginia, and Kentucky. In the carboniferous of western Pennsylvania the principal carbonate ore beds are the Pittsburg iron ore beds of Fayette County, and the Johnstown ore bed near the base of the lower Barren Measures. In West Virginia black band ore was formerly extensively mined on Davis Creek near Charleston. The beds are no longer mined. The Hanging Rock District extends across the Ohio River into northern Kentucky.

Small deposits of black band ore have been noted in the Triassic beds of North Carolina. Concretionary iron carbonate ore occurs in the cretaceous clays of Maryland and was formerly mined, but operations have ceased. Inconsequential deposits of carbonate ore are known in the Cretaceons of the West, but there has been no development.

It is to be noted that while carbonate iron ore is rather widely distributed over the United States, the deposits are usually small, and have attracted little attention. The iron industry is dominated by the gigantic deposits of rich ores in the Lake Superior regions and Alabama. The consolidation of the enormous interests in the steel and iron industry by which both the ore output and the steel and iron output are controlled to the detriment of small operators, has worked to choke out of the iron business all but the favored few. Hence it is that valuable ore deposits that were formerly worked are now so much idle capital to the nation, and it is to be hoped that with very much improved plants over those formerly used in exploiting these ores the deposits may again become productive capital.

THE OCCURRENCE OF IRON IN MISSISSIPPI.

A trip across Mississippi in any direction would be sufficient to convince anyone of the abundance of iron as a coloring matter in the rocks of the State. Among the most striking features of most of the surface are the red hills. The railroad cuts exhibit walls of red, yellow, or purple sands or clays; the old, worn-out fields too frequently seen, show soils of brown, red, or yellow; the soils of the prairies lie spread out before the eye, when freshly ploughed, so as to show the soil without its coat of vegetation, like a great checkerboard variegated with tawny and brown splotches interspersed among the darker ones; even in the rich alluvial lands of the Delta iron-stained soils are frequent, and the bluish gumbo of the black lands on being burned turn bright red.

Nearly every community has its chalybeate springs flowing from beneath hills of red sand and depositing bog iron in the swamps and marshes. Pyrite in the form of small rounded concretions occur abundantly in the prairie limestone; but even more so as marcasite impregnating the soil in some of the southern counties, to the extent that it is leached out in old-fashioned ash-hoppers by the inhabitants and used as a domestic remedy. At one point in Jefferson County the pyrite occurs in a discontinuous bed six to eight inches thick, the leachings from which form "alum springs." Similar springs at other places in the State issuing from beneath the ground perhaps have an identical origin. Such springs deposit iron oxide.

Besides these natural occurrences of iron widely disseminated in the State, and observed since earliest times, we are occasionally surprised by the discovery of small masses of high grade magnetite and specular hematite, which have obviously reached us by accident. Such specimens were doubtless brought into the State by the Indians at an earlier day.

Putting aside such cases as just mentioned of accidental findings of ores foreign to the State, there really occur in the State deposits of brown ores and carbonate ores that at two or three different times have excited considerable attention.

The first of these "iron booms" occurred in the early eighties at the little town of Duck Hill, situated on the Illinois Central Railroad in Montgomery County. A wandering prospector who had some acquaintance with the appearance of limonite happened into the vicinity, and in his saunterings over the hills that surrounded the little town happened upon some specimens of good grade limonite. He promptly informed some of the citizens that they had valuable iron deposits around the town. Other specimens of the ore were obtained and analyzed with satisfactory results. Immediately excitement ran high and spread rapidly over the State. Companies were formed to develop the properties. Prospecting, for some unknown reason, centered upon one prominent hill a short distance northeast of the town. Several shafts were sunk through the heart of the hill to unknown depths,—perhaps to or below the level of the plain upon which the town is built. In the meantime fields and pastures adjacent to the town had been surveyed into town lots to make room for the expected sudden expansion of Duck Hill. Prices of town property soared. Speculators, prospective business men of the new city, the hangers-on, impecunious spectators of other men's good fortune, poured in on every train. But prospecting failed to find the ore beds, and the boom went suddenly to pieces.

A few years later, in 1887, a somewhat similar excitement took possession of Enterprise, a small town in Clarke County, in Southeast Mississippi. In this case, however, there was more basis for the excitement. Ore bodies of considerable extent really exist in the immediate vicinity of the town, and examination by several men of experience in iron mining elicited from them favorable comment. Their analyses were such as to justify expectations of development. Excitement ran high for some time, and at least one shipment of ore was made to Birmingham where it was smelted. The pig iron was returned to Enterprise where it was exhibited. Capital, however, failed to become interested in the enterprise and interest finally subsided. A discussion of these beds will be given on another page.

Within the last year an extensive and perhaps the most promising deposit of iron so far known to occur in the State has come prominently to notice. This is a rather high grade carbonate ore in the Northern Counties. A rather limited examination with a few analyses of the ore was made by the writer and reported to the Geological Commission at their meeting in May, 1912. A more detailed examination since then gives results that will be embodied in this bulletin.

IRON ORES OF POTTS CAMP DISTRICT.

History of the Origin.—It has long been known that scattered deposits of brown ore, or limonite, occur in different parts of the State, especially in the northern counties. Nearly three years ago the writer collected samples of these ores from several points, notably Grenada, Duck Hill, Pine Valley, in Yalobusha County; Lafayette County at a point eight miles southeast of Oxford; Ackerman, in Choctaw County; and from Enterprise, in Clarke County,—all of which were exhibited at the capitol in Jackson, where they are now to be seen in the State collection. At two points, Ackerman, and southeast of Oxford, in Lafayette County, the fact was noted that large masses of the oxidized ore on being broken open showed the interior to be light grey in color, indicating the presence of iron carbonate. The presence of carbonate ore was surprising because having heretofore seemed to escape notice, but as the quantity of the material was not apparently great at either place, little attention was paid to the discovery. In the two cases referred to above the carbonate ore was associated with lignitic clays in one case and with lignite beds and lignitic clays in the other. The conditions accompanying these carbonate ores were enough like these of the Ohio carbonate fields to lead to further prospecting, which resulted in the discovery of carbonate ores in several counties of north

Plate II.

Blocks of Ore from second seam from top, 20 inches thick, Reid property, Potts Camp.

Abutment for tipple, loose Ore for shipment, Reid property, Potts Camp.

central Mississippi in the lignite belt of the Tertiary Formation. As yet prospecting has not been exhaustive and many new outcrops will undoubtedly be found.

During the winter of 1909-1910 some Birmingham parties who had been interested in brown ore around Russellville, Alabama, hearing of brown ore in North Mississippi, came into the State and began prospecting in the vicinity of Potts Camp in Marshall County. It soon became noised over the State that they had discovered important iron deposits. The writer finding it impossible to visit the locality at that time, Colonel Brian, of Birmingham, who was then visiting in the State, and who was familiar with the iron fields of Alabama, kindly volunteered to examine the deposits around Potts Camp and report to me the results of his examination.

In spite of inclement weather and a light snowfall covering the ground at the time of his visit, Colonel Brian made as careful examination as was possible under the circumstances. Colonel Brian reported that the appearances indicated a blanket deposit of brown ore, masses of various sizes being scattered over the hilltops and slopes; the ore appeared of very good quality, but he could not be sure of commercial quantities.

No further attention was paid to this region on the part of the Geological Survey until the summer of 1911, when the writer stopped between trains and examined the deposits west of Tippah River somewhat hurriedly. In the meantime the Birmingham parties had organized a company, taken options and mineral rights on considerable bodies of land, and erected a tipple and a switch, and shipped several car loads of the surface ore. This examination revealed nothing but several deposits of brown ore of good quality, but the quantity did not seem great.

Early in the spring of 1912, the writer was urgently requested by Mr. W. S. Allen, Vice-President of the company operating at Potts Camp and vicinity, to re-examine the locality with him. He informed me that the company had re-organized under the name of the Memphis Mining and Manufacturing Company, with offices at Memphis. He also informed me of the accidental discovery of carbonate ore on the property. One of his prospectors on breaking open what appeared to be a fine block of brown ore, became very much annoyed on seeing such a fine piece of ore "turn to nothing but rock inside." Mr. Allen, who was standing near, however, recognized the gray "rock" to be iron carbonate. I revisited the locality with Mr. Allen and was surprised to find besides the brown ore, deposits at lower levels in the hills of excellent carbonate ore. The results of this and subsequent examinations of these ore deposits, as well as others in the State, are incorporated in the report that follows.

AREA AND TOPOGRAPHY.

The area of the ore-bearing territory, so far as at present determined, embraces a zone or belt running nearly north northeast and south southwest, 8 to 10 miles wide, and extending to the Tallahatchie River on the south and northward with broken continuity, so far as present prospecting has determined, to a point east of Ashland, giving it a north and south extent of about twenty miles. This area lies in Marshall and Benton Counties, the greater portion being in the latter county.

It will be seen that the territory embraced in the district is approximately 180 to 200 square miles in extent. It must be remembered, however, that the ore has not been found over the whole of the area; there is much territory embraced in the area where ore is not known to exist at all, but where future prospecting may find it. The known outcrops are scattered over the area, and it is quite possible that the district includes more barren territory than ore-bearing. The deposits later to be described in Lafayette and Yalobusha Counties, as well as that in Choctaw, seem to be geologically continuous with those of the Potts Camp area, and that other deposits will eventually be discovered in the intervening counties of the same geological horizon is almost certain.

The whole region was originally part of a high plateau of north-central Mississippi 400 to 500 feet above sea level, which has been extensively cut by erosion into hills and ridges with intervening valleys. As a result the surface of the Potts Camp area is rough, the ridges and hills parting the stream valleys being 75 to 100 feet above the drainage, and having rather steep slopes. The uplands of the region are too rough and the soil too sterile to offer encouragement to farming; so that while some of the more promising parts are open to agriculture, by far the greater part is still in timber, such as pine, oak of several species, hickory and dogwood, though most of the merchantable timber has been cut off.

Two streams of considerable size flow through this area, taking almost parallel courses from north northeast to south southwest. The larger of the two is Tippah River, which lies two miles west of Potts Camp; the smaller, or Ocklimita Creek, lies east and southeast of Hickory Flat. The Tallahatchie River forms the southern boundary of the district, flowing west. These streams have alluvial flats from half a mile to one and a half miles wide. Numerous smaller creeks and branches descend from the uplands to the valleys, cutting deep ravines in the ridges that make the drainage divides.

GEOLOGY.

This ore-bearing region forms part of a broad belt of early eocene Tertiary sands, clays and lignites which occupy all the broad plateau region of north-central Mississippi. It is broadest at the Tennessee line and extends southward, gradually narrowing, and then turns slightly eastward and passes through Lauderdale and Kemper Counties to the Alabama line. This formation was called by Hilgard the Lignitic, but later the name Wilcox has been substituted.

The Wilcox is the thickest of the Tertiary formations in Mississippi, its thickness as indicated both by the width of the outcrop and by well borings being 800 to 900 feet. It overlies conformably the Flatwoods or Porters' Creek Clay of the Midway in all the iron-bearing regions, and in places the carbonate ores lie apparently within the Porter's Creek Clay, though the line of demarcation between the two formations cannot be always made out clearly. It lies beneath the Tallahatta of the Claiborne apparently without break.

In Alabama the Wilcox shows several recognizable divisions, which cannot be traced into Mississippi. Heretofore, there has been no attempt to divide the formation in Mississippi, but recent studies show at least two and perhaps three easily recognizable divisions. The lowest division, which might well be called the Ackerman beds, because typically exhibited in the great cut one mile east of the town of Ackerman, consists of dark gray clays and sandy clays, lignitic clays and lignite, with occasional beds and concretionary masses of carbonate ore. The character of these beds is shown in the following section given by Crider of the Ackerman Cut:

	FEET
11. Lafayette sands and sandstone which has been cemented into a ferruginous mass capping top of ridge. In places this sandstone is 10 to 15 feet thick, cut	20
10. Yellow stratified sand	10
9. Bed of lignite which is not continuous but changes laterally into a dark lignitic clay. When wet the whole mass has a tendency to slide down on the railroad track. Large pilings have been driven into the earth to prevent landslides. There is more or less sand and mica throughout the whole mass of lignite and lignitic clay	5
8. Dark blue clay weathering to gray	6½
7. Impure lignite	1
6. Chocolate-colored joint clay	5
5. Thin band of ferruginous sandstone	½
4. Dark blue clay, similar to No. 8	4½
3. Laminated dark clay	6
2. Laminated clay in which bands thin ferruginous alternate with bands of soft chocolate clay	5
1. Gray micaceous joint clay, weathering to white	5

No. 5, of the above section is a thin bed of red carbonate of iron ore. Masses occur also in No. 1 at the base of the cut.

The above is fairly representative of this division of the Wilcox in Mississippi. Some sections, however, show the blue and gray clays to be rather more sandy, but clay is the dominating character to the extent that at Holly Springs and Oxford wells, after passing through sandy upper and middle Wilcox to a depth of about 350 feet, find no water-bearing beds below in the Tertiary. The thickness of the Ackerman beds is approximately 400 feet. They dip westward beneath the sands of the middle Wilcox, so that at Holly Springs and Oxford they lie 250 to 350 feet below the surface.

The middle Wilcox is prevailingly sandy, the sands being rather coarse-grained, showing cross-bedding, flow and plunge structure, and other irregularities of stratification suggestive of strong and rapidly varying currents of water at time of deposition. The sands are decidedly micaceous and vary in color from white to yellow, red and purple, yellow and red becoming the prevailing tints at the surface, but becoming grayish or greenish beneath the surface on account of the protoxide condition of the contained iron. Clay lenses of pink or white clays with leaf impressions are frequent but usually not extensive. These sands are the real water-bearing beds of the Wilcox, and furnish the water struck in the wells at Holly Springs, Oxford and Grenada, as well as the flowing wells of the upper Delta. The thickness of this division is perhaps 350 feet. Being typically developed at and for several miles east of Holly Springs these beds might appropriately be called the Holly Springs Sands.

In Alabama the uppermost beds of the Wilcox are described as being chocolate-colored clays 200 to 250 feet thick. Crider describes them it as occurring in several localities in Mississippi 150 to 200 feet thick and marking the same horizon as in Alabama. These clays, chocolate-colored when wet becoming pinkish on drying, occur in wells at Duck Hill, outcrop on the Yalobusha River near Grenada, and "can be traced in wells and outcrops along the western edge of the Wilcox to Memphis." These are associated with lignite outcrops near Grenada, Oxford, and Hernando. It is probable that the pinkish, leaf-bearing clays, which occur in the middle Wilcox as lenses, become a more pronounced feature toward the top of the formation, extending into continuous beds. These clay beds form a confining roof over the water-bearing sands of the middle Wilcox furnishing conditions favoring flowing artesian wells on the lower Tallahatchie and in the Delta, whereas eastward no flowing wells exist. Since the correlation of these beds with upper Wilcox beds of Alabama is by no means certain, they might be call d the Grenada Beds, from the place where the whole thickness of the series is typically exposed.

The iron ores of the Potts Camp District are found entirely within the dark gray and lignitic clays and sandy clays of the lowest or Ackerman division of the Wilcox. Indeed, it is probable that some of the deposits toward the eastern extreme limit of the area, may be proved to be in the Porter's Creek clay.

The geological structure of the region is simple. The beds dip rather uniformly toward the west and south, though a slight faulting is shown in the "Blue Cut" on the Frisco railroad, two miles east of Hickory Flat.

ORE BODIES.

The region as a whole presents ore of two kinds, brown oxide ores at the surface capping the hills and lying more or less thickly strewn over the hill slopes, and carbonate, or spathic iron ores beneath the surface, both in the form of beds and of large "kidney" concretionary masses. These are exposed in sections at various points throughout the area. The thin bed of carbonate ore mentioned as No. 5 in the Ackerman section, has every appearance of being sedimentary in origin. It is interstratified with beds of lignitic clay and thin beds of lignite, is uniform in thickness, and shows the same continuity found in the accompanying sedimentary beds. It is almost surely contemporaneous with the immediately underlying and overlying beds of eocene.

The evidence of the mechanical deposition of the beds of the Potts Camp area is not conclusive, though it is probable with regard to one or two beds outcropping west of Tippah River.

Aside from the examples of probable mechanical deposition just mentioned, the carbonate ores are chemical in origin, their accumulation and deposition being due to segregation and concretionary forces. It is probable that the deposition took place during Eocene times, but after the iron-bearing beds were laid down. The process was something like the following: During early Wilcox times much of the land of the present Wilcox area, together with much not now exposed, was low and constituted peat swamps in which at times pure peat was deposited, at other times the same area received less of the vegetable accumulations with the addition of considerable quantities of fine mechanical sediments principally clay, silt, and fine sand. The result of these alternating conditions is alternating bodies of lignite and lignitic clays and sandy clays.

The surrounding lands which furnished these sediments to the peat swamps contained more or less iron disseminated as a cement. The fineness of the sediments would suggest that the lands were low and that weathering of the surface resulted in the complete oxidation and solution of the materials. The iron was brought into the swamps in solution as the protoxide most probably. As a protoxide solution it impregnated the clay beds as they came to rest in the low swamp areas. The same beds received from the swamp solutions containing products of vegetable decay and the conversion of the protoxide to the carbonate of iron took place while the depositional process was still going on. It is probable that the segregation of the iron in concretionary masses and beds was synchronous with the conversion of the protoxide to the carbonate; or the carbonate in solution might have been slowly deposited from a concentrated solution by a gradual loss of water with the uplift of the region into higher and drier land, or with the building up of the low areas and simultaneous lowering of the general surface drainage, or by a combination of these conditions.

The chemically deposited carbonate ores occur in lenticular "kidney" masses varying in size from the size of a man's fist to great blocks weighing a ton or more. These large masses coalesce in most of the outcrops into almost continuous beds from six or eight inches to two or three feet in thickness, the average being about twelve inches. The fresh unoxidized ore is light gray to bluish-gray in color, compact, and remarkably free in many of the outcrops of mechanical impurities. After exposure to the weather for a considerable length of time the gray ore turns red. All the exposed masses show an outer encrusting of limonite, which as it grows thicker forms in consecutive shells. This shelly structure is best seen in the more sandy ores that have suffered long exposure. Much of the brown ore or limonite of the region is evidently derived from the weathering of the carbonate. Often the kidney masses that have been exposed a long time are converted entirely into brown ore. Not infrequently a mass of brown ore will show on breaking open a small nucleus of gray carbonate ore; occasionally the "kidney" is hollow, being entirely of limonite with the cavity filled, or partly filled with what appears to be a very fine white sand, but which on anaylysis proves to be iron carbonate. Such kidney concretions are identical in structure and mode of occurrence with others that show no carbonate.

The topmost bed in all this area is brown ore, which occurs both in beds and as scattered masses. Where in beds these lie just beneath the surface of the hills forming a limonite cap which outcrops around the edge. The loose masses which strew the hill slopes more or less thickly and varying in sizes from a walnut to those weighing a thousand pounds, are fragments broken from what were probably continuous beds. The same ore is found capping all the hills, and it is easy to believe that before the extensive system of erosion valleys were carved out of the plateau, the beds were continuous, and that the ore caps of the hills are but the disconnected fragments, the intervening parts having been removed. If this be true, more of the surface beds have been carried away than remain.

It is probable that these brown ore beds were originally carbonate, and have been oxidized by exposure owing to their position on the hill tops. However, no positive evidence to that effect has been found, and since the beds seem to make the contact between the clays of the lowest division of the Wilcox and the sands of the middle division, and since some of the ore is decidedly sandy with rather coarse sand such as characterizes the middle Wilcox, it is quite possible that this brown ore was originally deposited as limonite and not carbonate.

DESCRIPTION OF KNOWN OUTCROPS.

In discussing the various outcrops of the iron ores in the Potts Camp District, the territory can best be studied by dividing it into three more or less separated areas; viz.: the Potts Camp Area, the Winborn Area, and the Hickory Flat Area.

Potts Camp Area.—A range of hills and ridges lying on the west side of the Tippah River valley and just north of the Frisco railroad, and having a northeast and southwest trend, shows considerable quantities of brown oxide ore lying upon the surface. A switch was run out from the railroad to the point of the hill, a tipple was constructed, and twenty-five carloads of the loose ore was picked up from the surface and reported to have been shipped to Birmingham by the Allen Brothers during 1911. The ore came from the point of the hill nearest the railroad on what is known as the Reid property, owned by C. H. Reid, in S. 8, T. 5, R. 1 W. The ore was collected and hauled to the tipple in farm wagons by green hands and Mr. W. S. Allen reported that there was a ready demand in Birmingham for all that he could ship. However, no further shipments have been made.

Examination of the Reid property showed that some surface prospecting had been done, and that besides the loose ore lying thickly over the surface, a distinct bed of brown ore had been exposed in the prospect holes. This ledge is fourteen inches thick and underlies the top of the ridge, with a covering of only two to four feet of loose earth. The ore is of good quality as shown by the analysis below:

No. 1.—Oxide Ore from Reid Property, Potts Camp.

Fe	53.64
Al	1.45
Mn	8.00
S	0.53
P	0.075
CO_2	0.87
SiO_2	5.34
O and H_2O	20.91
Insoluble	9.18

This bed of ore immediately overlies a bed of gray clay, which is probably the top of the Ackerman Clay. The accompanying figure shows this bed of ore as exposed in a shallow prospect pit. (Fig. 1.)

On the same property a few hundred yards northwest rather low down on the north slope of the same ridge a bed of twelve to fourteen inches thickness outcrops over a small area. The ore appears to be of good quality of brown oxide, though it is probable that if the bed were laid bare some distance back from the outcrop it would prove to be a bed of carbonate ore the edge of which is oxidized to limonite. No prospecting has been done on this outcrop.

Adjoining the Reid property on the north is that of H. J. Gurley of several hundred acres in extent, partly lying in the valley of the Tippah River, but largely also back upon the hills. Over the greater part of the crest and upper slopes of the ridge from the Reid property to Mr. Gurley's residence, about a mile, the brown oxide ore lies thickly strewn in masses from the size of a walnut to boulders of a thousand pounds weight or more, the greater part of which looks to be equally good with that shown in the above analysis. In fact, it is derived from the same bed, the outcropping of which on the top of the ridge can be seen in numbers of places. The ore lying upon these slopes not only thickly covers the surface, but the pick strikes it almost everywhere beneath the surface, where it seems to be disseminated through the soil, though it is doubtful if it extends more than a foot or two beneath the surface. This loose ore has probably all been broken up and let down on the slopes by erosion of the capping beds, as before suggested. The most striking aggregation of large blocks of the brown ore is found on S. 4, T. 5, R. 1 W. of the Gurley place, just up the slope from some negro tenant houses.

About one mile northwest of Mr. Gurley's residence in S. 5, T. 5, R. 1 W., occur outcrops of three beds of excellent carbonate ore. These are on both sides of the small branch upon which was located Mr. Gurley's sawmill at the time of the examination, though the mill has been since removed. The smallest bed is half way up the hill slope on

Fig. No. 2.—Exposure of Brown Oxide Ore on Reid property west of Tippah River, near Pott's Camp.

the right hand side of the stream; the ore is of the very purest grade, clear light gray in color, texture very fine and compact, with smooth fracture. The bed is only about six inches thick at point of outcrop and is most probably segregational in origin.

Another thin ledge eight inches thick outcrops in the opposite bank of the stream six or eight feet above the water's edge. This ledge is not continuous over more than a few rods of area, so far as has been made out; it does not outcrop in a tributary ravine a few rods to the east. The bed dips at a low angle to the south and perhaps east.

About 100 yards further up the mill stream another outcrop of the same ore appears. This is at a lower level than the bed just described, and dips slightly toward the southeast, undoubtedly underlying the other at slight depth. This last bed outcrops just above the water's edge and underlies a low terrace of a few acres in extent made by the little stream before passing under the hill. At the outcrop the overburden is two to four feet of soft earth, which deepens slightly to six or eight feet, next to the hill, where it increases rapidly owing to the rather short slope of the hillside.

This ore bed is twenty inches thick of solid light gray carbonate with a thin incrustation of brown oxide. It has the appearance of being a statified deposit, since at the outcrop examined the thickness of the bed was made up of two distinct layers of about equal thickness with a thin oxidized parting between them. The deposit would appear to underlie all this territory, but covered more or less deeply beneath the hills.

An analysis of this ore gave the following result:

No. 2.—Carbonate Ore from Gurley Place, Potts Camp.

Fe	45.32	(About 67.0 calcined)
Al	1.22	
Mn	3.90	
S	0.01	
P	0.045	
CO_2	33.06	
SiO_2	3.65	
O and H_2O	11.56	in carbonate and hydrated oxides.
Insoluble	1.24	

It will be seen from the above analysis that the ore is almost the pure carbonate, or spathic ore of iron. The extremely low phosphorus adds to the desirability of the ore.

Other and thicker outcrops of carbonate ore have recently been reported along this stream, but they have not been seen by any member of the Geological Survey.

Including the surface bed of brown oxide ore, it will be seen that in this region at least four ledges of ore outcrop above drainage. Others may exist locally, which have not yet been discovered. That other ore beds may exist below the bed of drainage is quite probable, especially in view of the fact that as a general rule throughout the iron-bearing region the best and often the thickest bodies of ore lie at the bottoms of the hills. As a matter of fact, one of the engineers employed by the Birmingham Company made a drilling in the edge of Tippah Valley on Mr. Gurley's land, and claims to have passed through a six foot bed of gray material at a depth of thirty feet, which analysis is reported to have shown to be carbonate ore. However, no member of the Geological Survey saw either the material or the analysis, and cannot be sure that the material was carbonate ore or that it was as thick as reported to us.

About two and one-half miles up Tippah River from the Gurley residence, outcrops on the roadside at the base of the hills a bed of carbonate ore about six inches thick. This ore is of very good quality, though not so pure as that shown in the last analysis. The outcrop is exposed only for eighteen to twenty feet, and extends into the wagon road itself, where the wheels of vehicles constantly shave off the bright red powder from the oxidized edge. Near this locality two wells are reported to have struck gray rock which Mr. Gurley stated was identical with that found on his mill creek and which the drillers called "flint rock." It was most probably carbonate ore. Two beds are reported to have been struck within thirty feet of the surface, each about two feet in thickness. Mr. W. S. Allen, of Birmingham, informed the writer that he obtained specimens of the rock from the well, which he had analyzed and proved to be carbonate of iron.

On the Potts Camp and Hickory Flat wagon road, running parallel with the railroad, several iron ore outcrops are noticeable on the north side near the base of the hills. The beds are discontinuous, showing the shelly concentric structure of concretionary iron; the thickness would average about one foot and the ore is inferior and sandy. These exposures lie principally towards Potts Camp and between there and Winborn, three miles to the east. One bed twelve inches thick just beyond the eastern outskirts of Potts Camp, skirts the hill for a short distance north of the road and then crosses at a point where the road rises upon a higher level.

Winborn Area.—The village of Winborn is situated upon the Frisco Railroad three miles east of Potts Camp. The little town is located on the slope of the hills in part, and in part down on the flat of Ocktimita Creek. To the north of the town are hills similar to those near Potts Camp; in fact, all these hills, as before stated, are remnants of one original highland, the surface of which is now very much cut up by valleys and ravines. On the south side of town the Ocktimita flats extend for a half a mile and abut up against hills and ridges again. The creek is here flowing practically due west.

Half a mile south of Winborn, on the slope of the first ridge, in S. 26, T. 5, R. 1 W., on land belonging to I. N. Bready, an outcrop was examined at a point three hundred yards northeast of the Bready residence. Three outcropping beds were seen, the lowest a thin seam six to eight inches in thickness, and twenty-five feet below the top of the ridge. The other two beds outcrop at levels approximately eighteen and eight feet respectively below the crest of the hill, each twelve to fourteen inches thick.

These at surface are oxidized to a deep brown color, but where freshly exposed, as seen in one or two places where Mr. Bready had been quarrying the material for chimneys and foundations, the bed showed a thin shell of oxide externally but a fraction of an inch thick, beneath which was revealed the gray appearance of the carbonate ore. The ledges are quite uniform in thickness, divided by joints into blocks of large size, and seem continuous beneath the hill, since the outcrops occur at frequent intervals around the points and show on the opposite side of the hill.

The ore here is more siliceous than elsewhere observed, and, as before stated, has been quarried by Mr. Bready for building purposes. In fact, it is evidently so sandy, that he took it for sandstone, and it has that appearance. Some of the material observed in the chimneys of the Bready residence is very dark, almost black, though Mr. Bready states that at the time of quarrying its color was almost white. A sample of the surface oxidized ore taken from the bed eighteen feet below the top of the hill shows the following result on analysis:

No. 3—Oxide Ore from Bready Place, Winborn.

Fe	43.48
Al	1.48
Mn	9.04
S	0.37
P	0.074
CO_2	0.11
SiO_2	19.69
O and H_2O	15.40
Insoluble	10.45

A sample taken from the unoxidized interior of the uppermost bed at the same place had the appearance of fine sandstone, greenish gray in color. On treating it with dilute hydrochloric acid it effervesced actively, and on analysis the following result was obtained:

No. 4.—Carbonate Ore from Bready Place, Winborn.

Fe	40.03	(About 47.0 calcined)
Al	0.65	
Mn	3.02	
S	1.81	
P	0.11	
CO_2	15.92	
SiO_2	14.27	
O and H_2O	16.51	
Insoluble	13.69	

On the Bready property the hills have swung round until they have here a northwest and southeast direction. To the southeast of Bready's residence little ore of any kind, not even loose surface brown oxide, is seen for a distance of two or three hundred yards, but a good deal of ferruginous sandstone. In fact, in this area, all the formations are more sandy than in the Potts Camp area. Even the dark gray clays that usually underlie the ore beds are more sandy than elsewhere observed.

About 500 yards southeast of Bready's residence and on the same ridge is an outcropping of good-looking oxidized ore, which has the appearance of being the exposed edge of a workable ledge twelve to fifteen inches thick, lying one to three feet beneath the surface. The overburden is all loose material. The bed outcrops on the opposite side of the hill, appearing to cap in a continuous bed an area of five or six acres, perhaps as much as sixteen acres, though the evidence is not conclusive for the larger estimate. Drillings could easily establish its presence or absence. All the ore in sight is brown oxide. A sample shows the following analysis:

No. 5.—Oxide Ore from the Bready Place, Winborn.

Fe	39.32
Al	9.78
Mn	12.30
S	3.72
P	0.02
CO_2	0.015
SiO_2	4.36
O and H_2O	19.88
Insoluble	7.46

Another sample from the same bed taken a few yards from No. 5, gave the following analysis:

No. 6.—Oxide Ore from Bready Place, Winborn.

Fe	54.60
Al	1.07
Mn	3.22
S	0.23
P	0.042
CO_2	0.87
SiO_2	17.20
O and H_2O	17.81
Insoluble	4.82

We believe the last analysis comes nearer the general average of the ore than does No. 5.

Good surface oxide in considerable quantity occurs on the hill-slope, just beyond the Bready land to the south and east, on the Byrd Marmon property, but no beds were seen except possibly at one place about 150 yards from the division fence. The conditions are analogous to those seen a few hundred yards away on the Bready land, so that the presence of the surface brown oxide ledge may be reasonably inferred.

No carbonate ore was noted at this end of the property, but it doubtless exists. At Bready's residence a well sunk in the ledge of the Ocklimita flat at a depth of sixteen feet struck rock and further progress was stopped. However, sufficient water was furnished, and no effort was made to penetrate the rock. The water is strongly chalybeate, and it seems quite probable that the rock struck was a bed of carbonate ore. If so, it is at a considerably lower level than any so far noticed in this vicinity, and probably underlies at no great depth the Ocktimita flat.

The surface oxide ores here, as at Potts Camp and at Hickory Flat, four miles further east, are probably derived directly from carbonate beds by oxidation due to surface exposure, and exploration with the drill would probably reveal such deposits beneath these ridges.

North of Winborn all of the ore noted up to date is oxide. Just beyond the north edge of town loose oxide ore lies in considerable quantities over the ground. On the land of W. H. Cruse masses lie scattered over the plowed ground in the field. Two wells on the place encountered ore beds at a depth of twenty-five to thirty feet, and the drills were unable to penetrate it.

On the land of J. F. Taylor, adjoining the Cruse place on the north, beside quantities of loose oxide ore of good grade scattered over the hill slopes, a distinct bed outcrops around the hills having an average thickness of ten inches. This ledge is seven or eight feet below the top of the hill, the over-burden being all loose sandy earth easily removed by shovels. Another ledge outcrops across the road 200 yards north of the school house, but thickness was not determined. All this ore is brown oxide of iron. No carbonate has been seen north of Winborn, but it very probably exists here, since conditions, so far as these were observable, are precisely similar to those on the Bready property, and at Potts Camp, where it does occur.

Hickory Flat Area.—Hickory Flat is situated on the Frisco railroad, four miles east of Winborn. The town is located on the northern edge of Ocklimita Creek flat, the hills here, as at Windom, and Potts Camp, forming the uplands, which approach close to town on the north side. The chain of hills and ridges examined at Winborn on the Bready and Byrd Marmon properties, swing around to the south of Hickory Flat, but are separated from the town by the valley of Ocklimita Creek.

As would be expected, the same conditions prevail here as at Winborn and Potts Camp. The prevailing formations, as in the other localities, are gray and lignitic clays with capping of yellow sands on the highest hills, especially south of the Ocklimita. The iron ore is usually found in the clays or at the contact of sands and clays.

Three miles southwest of Hickory Flat the Ocklimita swings over to the base of the hills bordering its valley on the south side. On the land of J. H. Morehead the road rises by a steep grade to the point of the hill upon which is located the residence of John May. The point of the hill is twenty-seven feet above the valley, and the steep north slope shows the following exposure:

8. Soil, red clay	3 feet
7. Lignitic clay	2 feet
6. Shelly sandy iron carbonate	3-4 inches
5. Gray sandy clay	2 feet
4. Iron carbonate in large masses	12-14 inches
3. Lignite	6 inches
2. Gray clay	12 feet
1. Lignitic clay	6 feet

The ore described as No. 4, of this section, outcrops around the point of the hill, but in recent prospecting by the Memphis Mining & Manufacturing Company, the bed has been laid bare. While ore occurs in large kidney concretions or blocks weighing 1,000 to 2,000 pounds, the laying bare of the ledge shows that they have a remarkable tendency to coalesce so as to form almost continuous beds. This outcrop is in S. 30, T. 5, R. 1 E. The ore is twelve to fourteen inches thick and of good quality. The bed passes from the point of the hill where exposed back under the ridge, underlying about thirty acres to a depth of ten to fifteen feet.

On Section 31 outcrops of fifteen inches thick occur on the south side of a small creek ten to twelve feet below the surface of the hill on which stands the house of B. Nolan, on land of J. H. Morehead. The ore bed shows all around the point of the hill, but the ore appears rather siliceous. The exposed surface is deep brown due to oxidation, but the same bed recently exposed is entirely of carbonate ore.

At a point seventy-five yards east of the house of B. Nolan a pit has been dug in the slope of the hill twenty by twenty feet in size in which the carbonate ore bed twelve inches thick forms a continuous floor to the pit throughout its area. The bed is continuous with the ledge just

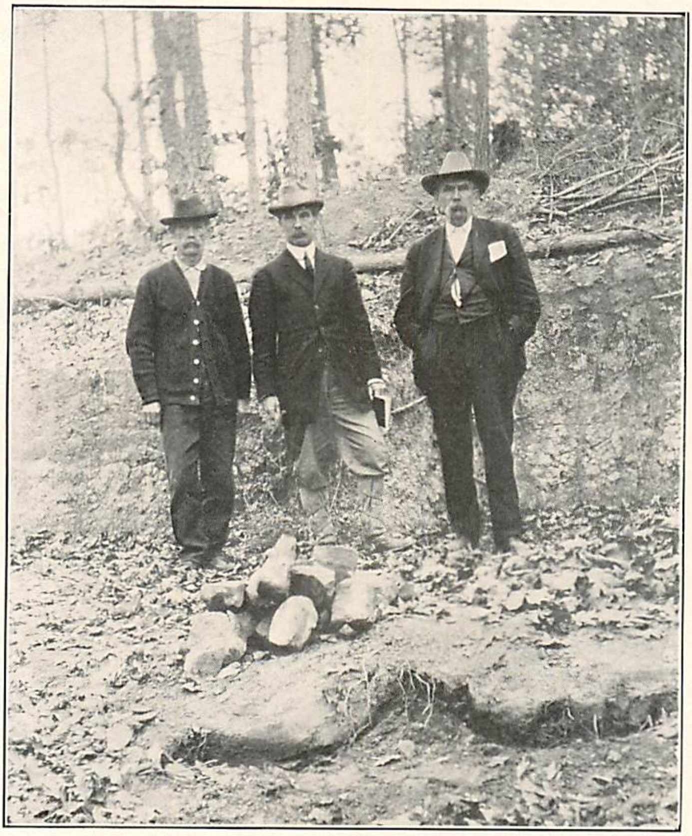


Fig. No. 3.—Exposure of bed of Carbonate Ore on hill slope on land of J. H. Morehead, near Hickory Flat.

described, but the ore is less siliceous and is red carbonate. The overburden here is two to five feet of loose earth and gray clay.

Almost seventy-five yards east of Pit No. 1, is a second pit on the same level in which the ore bed is again uncovered to almost the same extent, and showing bed of same character of ore, of same thickness and equally good quality. The ore is here in gray clay as in first pit. Overburden two to four feet. Figure No. 3 shows imperfectly the body of ore on the bottom of this pit.

A few rods north of Pit No. 2, is Pit No. 3. This is a small excavation, eight to ten feet square, and exposes on its bottom the same bed of ore twelve inches thick. This may be slump from No. 2, as it lies about eight feet lower down the slope. It may possibly be another seam at a lower level, perhaps the same as was struck in the old well south of Nolan's house which we will discuss presently.

Pit No. 4 is about 100 yards east of No. 2, and undoubtedly uncovers the same seam. The ore is carbonate and in the same large flattened lenticular masses as seen at the hill below May's house. This pit is perhaps the largest examined. The ore is somewhat thicker here than at the other excavations, fourteen inches or more, and quality remarkably good. The continuity of this bed throughout this region as indicated by these excavations, is very encouraging as proving the probable existence of workable beds of ore of commercial quality.

Pit No. 5 is about one mile east of Pit No. 1, and is about sixty feet long and twelve feet wide. It exposes a continuous bed of the same kind and quality of ore as seen in the four just described, and of equal thickness. (This was not seen by the writer, but was described by Mr. Morehead, on whose land it is.)

At a well sunk about three years ago at a point 200 yards south of the Nolan house on S. 31, T. 5, R. 1 E., a bed of pure carbonate ore was struck at a depth of fifteen feet. As stated by Mr. Morehead, the material when freshly brought to the surface was light bluish gray in color, but at the present time the fragments lying around the old well are oxidized by exposure to a deep red, though showing grayish tint on being broken open. A sample picked off the pile at the well gave the following result on analysis:

No. 7.—Carbonate Ore from Well on Morehead Place.

Fe	50.49	(Calcined 66.6%)
Al	3.29	
Mn	10.21	
S	0.52	
P	0.30	
CO_2	25.12	
SiO_2	5.28	
O and H_2O	4.11	
Insoluble	5.06	

According to Mr. Morehead the well was discontinued because of the difficulty of penetrating the material with a pick. The thickness of the bed was not determined. A few rods west of the first well another was sunk with the same result.

Both of these wells were located at an elevation several feet lower than the ledge of ore underlying Nolan's house, so that the bed struck in the bottom of the wells at a depth of twelve to fifteen feet could hardly be the same, since there is no appreciable dip of the former. Besides, the ore of the lower bed appears to be of purer quality. It probably is continuous under Morehead's field with the bed cut by a ditch one-fourth of a mile west of the first well.

At a point where exposed in the ditch on the west side next to the hills the bed is twenty inches thick, lying beneath three or four feet of cover at the ditch, but getting deeper,—up to fifteen or twenty feet,—under the hill. This ore bed which, so far as examined, was all oxidized, could be traced along the ditch only for a few yards,—eight or ten,—and it was impossible to determine whether this was because of the slumping from above, concealing the outcrop, or because the bed pinched out. A rather distinct terrace running along the base of the hill possibly marks the covered outcrop of the ledge.

All along up the ditch for 300 yards boulders and "kidneys" of both oxide and carbonate ore are thickly strewn upon the bottom. These vary in size from three or four ounces in weight to masses a foot to a foot and a half in diameter, the large masses being high grade carbonate ore, but none could be positively determined to be in place, though a few masses looked as though they might be jutting points of a hidden ledge, until at a point 300 yards up the ditch. Here the current of the water had undercut the bank on the west side, which stands as an almost vertical face sixteen to eighteen feet high. A recent slump has exposed the whole face of the bluff for a distance of ten or twelve yards. The material of the upper half of the bluff is a dark gray sandy lignitic clay overlying a stratum composed of a bed of carbonate ore of excellent quality twelve inches thick. This stratum is distinctly concretionary, the bed where continuous thinning out or thickening within a very few feet, while for part of the distance it is composed of lenticular masses of large size lying closely together. Below this ore stratum the material to the base of the section is gray massive clay. In the ditch at the foot of this bluff are large masses of excellent gray carbonate ore, with smaller masses up to blocks that would weigh 75 to 150 pounds, all of which has slumped from the ledge above. Since the out-cropping ore beds in this vicinity, so far as observable, have little, if any dip, and since the ledge observed at the slope just mentioned is at a level of at least ten or twelve feet above the one mentioned as outcropping on this ditch 300 yards further down, it is improbable that the two are the same, the twelve inch bed of carbonate ore seeming to overlie the twenty inch ledge which outcrops lower down the ditch. The lower ledge, if continuous up stream as far as the slump which reveals the upper ledge, must lie beneath the level of the bottom of the ditch, since it is not in sight at this point.

Below is given an analysis of the twenty inch oxide bed:

No. 8.—Oxide Ore from Morehead Ditch.

Fe	56.61
Al	13.02
Mn	10.89
S	1.06
P	00.072
CO_2	1.18
SiO_2	10.29
O and H_2O	1.21
Insoluble	5.57

A sample of the carbonate ore taken at the slump just described gave the following analysis:

No. 9.—Sample of Carbonate Ore Taken at Slump.

Fe	47.12	(Calcined 68.0).
Al	2.02	
Mn	6.26	
S	1.14	
P	0.034	
CO_2	29.06	
SiO_2	4.80	
O and H_2O	9.01	
Insoluble	1.08	

On a little creek that crosses the road about 250 yards south of the house of B. Nolan, in Section 31, and not more than 100 yards up the stream from the crossing a new slump of earth on the south bank reveals a bed of carbonate ore fifteen inches thick, which passes back beneath the surface of a field lying on the south side of the stream. The ore body is exposed for only a short distance, but has the appearance of being a continuous bed. The ore has the appearance of being of good grade, and somewhat oxidized. The overburden at the outcrop is but two to three feet of loose soil, and cannot be much greater over the level field of several acres. Other exposures farther up the stream seem more siliceous than the first exposure.

In S. 6, T. 6, R. 1 E., on land belonging to J. H. Morehead, three-fourths of a mile south of the residence of R. J. Morehead, and one and one-fourth miles south of the exposure just described, several excavations have been opened on slopes of the hills leading down to a small unnamed creek. The largest pit exposes over a surface of sixty feet by twenty feet a solid floor and great outstanding masses of carbonate ore, slightly oxidized. The masses are flattened, lenticular in shape, of immense size, and twelve to twenty-four inches thick. The ore is somewhat siliceous, but of very good grade. The face of the pit is inclined at a high angle and shows a solid slope of ore. Fully 100 to 125 tons of ore is exposed in this single excavation. (See Fig. 4.)

Forty yards west of this pit is a natural section on the creek bank which shows masses of ore fourteen to sixteen inches thick exposed for several yards; this is apparently the same ledge as exposed in the pit. Here the overlying material is gray lignitic clay, slightly sandy and thickly laminated. The clay exposed in the pit is more massive, not lignitic, and resembles somewhat Porter's Creek clay of the Midway Formation.

About 100 yards south of these exposures another pit twelve by thirty-five feet shows a solid floor of iron carbonate blocks which make practically a continuous bed, slightly siliceous, and twelve to sixteen inches thick. In this pit the overburden is six feet thick and consists of gray clay with reddish joint planes.

A small pit fifteen by six feet shows ore at the bottom,—in a solid mass; the thickness was undetermined, but the deposit was probably part of the same ledge as the last and the thickness presumably the same. This pit is about sixty feet west from the last. The overburden in all these pits varies from three to six feet in thickness, the material being loose soil to a depth of a few feet, below which is tenacious joint clay.

The only other excavation in this vicinity is forty feet south of the last and twenty by six feet in size. Beneath seven feet of massive, tough, gray clay, from which project two large concretionary masses of carbonate ore, is exposed a floor of thick iron concretions, twelve to fourteen inches thick, two to four feet in diameter, and of quality equal to that exposed in the pits already described.

On the Crawford Place, now owned by Mr. W. H. Henry, of Hickory Flat, about one mile southeast of the last locality, in S. 5, T. 6, R. 1 E., two small excavations on a hill slope show each a body of iron carbonate at the bottom, under five or six feet of gray clay. The ore appears to be of good quality, though somewhat silicious. The thickness was not ascertained.

All the iron deposits so far considered, lie within one or two miles of the Frisco railroad, but other deposits worth discussing occur further away from transportation. Several miles east of Ashland, in Benton County, outcrops are reported the ore of which has been analyzed for Hon. W. A. McDonald, of Ashland, with satisfactory results, but we

Fig. No. 4.— Great masses of Carbonate Ore out-cropping on land of J. H. Morehead, 3 1-2 miles southwest of Hickory Flat.

have had no opportunity to examine either the deposits or the analysis of the ore.

In the vicinity of Flat Rock Church, seven miles northeast of Hickory Flat, on the Blue Mountain road, are several outcrops of carbonate ore worthy of attention.

One mile west of Flat Rock Church, in Benton County, the head waters of Ocklimita Creek have undercut a high bank on the land of T. M. Gadd. The cut is one-fourth of a mile south of Mr. Gadd's residence and presents a vertical face sixteen feet high on the right banks of the creek. The ore bed is five to six inches thick of good quality, and lies beneath sixteen feet of dark gray clay, showing horizontal bedding and containing a little fine sand and mica scales. The clay weathers to a tawny clayey soil something like the brown loam. A sample of the ore analyzed, gave the following result:

No. 10.—Carbonate Ore from T. M. Gadd's Land.

	BEFORE CALCINATION.	AFTER CALCINATION.
Fe	40.81	53.81
Mn	4.92	6.48
P	.11	.14
S	.11	.14
SiO_2	6.50	8.57
Al	4.29	5.65
CO_2	29.53	
Insoluble	5.80	7.64

This outcrop is located in S. 8, T. 5, R. 1 E.

Half a mile south of Flat Rock Church in the pasture of Hugh Jackson is an outcrop of fair grade of iron carbonate which occurs in a drainage ditch. This ditch runs north and south and is five or six feet deep, occupying a depression in the pasture. It is cut through two or more feet of loose colluvial material, overlying gray clays which become somewhat darker and more massive toward the bottom. Two beds of carbonate ore occur in the ditch, each being six to eight inches thick and consisting of large flattened "kidney" concretions weighing 1,000 pounds or more. It appears rather siliceous, and the lower bed is quite dark, almost black, owing to considerable organic matter. While the quantity here is considerable it is not great. This outcrop occurs in S. 15, T. 5, R. 2 E.

No. 11.—Carbonate Ore from Ditch of Hugh Jackson.

	BEFORE CALCINATION.	AFTER CALCINATION.
Fe	39.24	53.10
Mn	4.25	5.75
P	.13	.17
S	.21	.28
Al	3.78	5.11
Insoluble	5.64	6.29
CO_2	31.91	

On S. 16, T. 5, R. 1 E., on land of J. Q. Hunter, two parallel drainage ditches 150 yards apart, four and one-half to six feet deep have laid bare a bed of carbonate ore. Both ditches cut through gray clay below which is found the iron on the floor of the ditches. Here the ore is found in more continuous beds than on Jackson's place, and the quality of the ore is better, as will be seen by the analysis. The ore bed is eight inches thick. Below is given an analysis of a sample taken from the east ditch. (See Fig. 5.)

No. 12.—Carbonate Ore from Ditch of J. Q. Hunter.

	BEFORE CALCINATION.	AFTER CALCINATION.
Fe	41.14	56.93
Mn	4.68	6.47
P	.11	.15
S	0.07	0.07
SiO_2	5.15	7.12
Al	0.79	1.09
Insoluble	0.75	1.03
CO_2	33.90	

In the west ditch on the same land a nearly continuous ledge ten inches thick outcrops upon the bottom forming the floor for a considerable distance. The quality of the ore is equally good with that found in the east ditch, and is more abundant and nearer the surface. Both ditches cut across low flat lands and the beds of ore exposed undoubtedly extend under the flats which cover a field of ten or fifteen acres. (See Fig. 6.)

In the same ditch a short distance from the skirting hills at its head, and at a somewhat higher level than the ore bed, is exposed what appears to be a log twenty inches in diameter and spanning the ditch a distance of fourteen feet, and passing into the bank on either side; how much longer it is has not been determined. It is five feet underground, lies embedded at each end in the gray clay, and has what appears to be remnants of concentric layers of bark, which is absent from the trunk except near the two ends where they are partly protected by the clay in which they are embedded. The interesting feature about this apparent tree trunk is the fact that the whole trunk is of red carbonate ore of very good grade. A sample was taken, an analysis of which is given below: (See Fig. 7.)

No. 13.—Carbonate Ore from the Tree Trunk.—J. Q. Hunter's Ditch.

	BEFORE CALCINATION.	AFTER CALCINATION.
Fe	40.33	50.31
Mn	4.17	5.20
P	0.29	0.36
S	Trace	Trace
SiO_2	3.05	3.80
Al	5.35	6.65
Insoluble	0.21	0.26
CO_2	24.25	

In spite of the fact that this apparent tree trunk shows the tapering columnar shape of a tree and concentric layers of bark, it is very

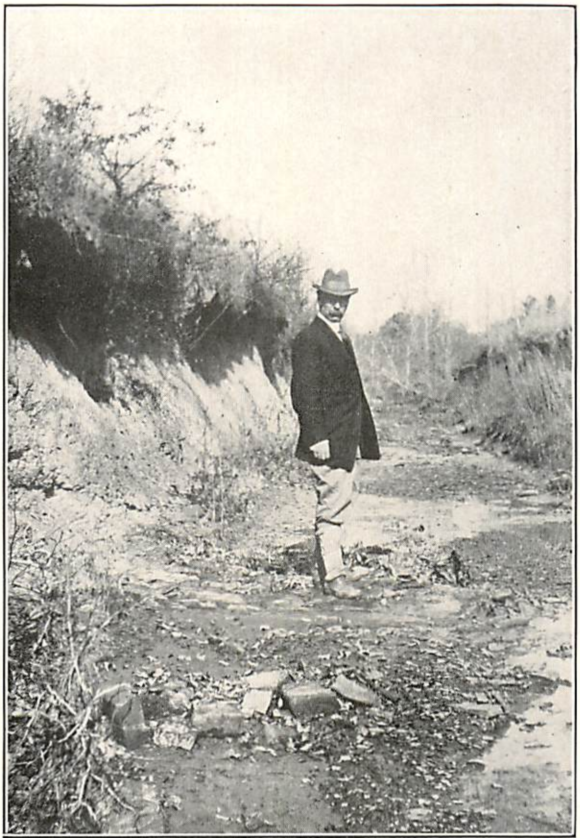


Fig. No. 5.—Exposure of Carbonate Ore on floor of east ditch on J. Q. Hunter's land, near Flat Rock Church, Benton County.

doubtful if it was ever really a tree. It is most probably an interesting columnar concretion of iron carbonate; no vegetable tissue or structure is visible to the eye, there is no branching so far as exposed, and the so-called bark may be only the concentric shells of superficial oxidation, such as we so often see incrusting concretionary masses of carbonate iron ore.

On the land of J. W. Sanders, in S. 20, T. 5, R. 2 E., abundant outcrops of carbonate ore is reported to occur, though we have not had opportunity to examine these deposits.

POSSIBILITY OF DEVELOPMENT.

Quantity of Ore.—It is impossible until further prospecting has laid bare the ore beds at different levels and over much larger areas, or until the drill is used, to make even an approximate estimate of the quantity of ore available in the Potts Camp District. There has as yet been no prospecting beneath the surface, so that the outcropping beds around the hill slopes exposed in natural sections or uncovered in excavations of limited extent, furnish all the definite information we have of the extent of the deposits. Several wells sunk for water in the flats bordering the streams have struck carbonate ore beds at different places, but the extent and thickness of the deposits in most cases were not ascertained.

The testimony of well-drillers in this region is that these "flint rocks," as they have been accustomed to call the gray carbonate ore, are struck in nearly all the wells sunk, and that very often the well has to be abandoned because of difficulty of penetrating the rock. Such was the case in the wells put down on the land of J. H. Morehead near the residence of B. Nolan. Analysis of the ore brought up gave the result shown on page 35. The well of I. N. Brady, half a mile south of Winborn, it is reported, struck the iron ore at depths of 15 to 30 feet.

It would be not unreasonable to suppose that the beds of ore almost universally struck in wells throughout the Potts Camp District are perhaps continuous beneath the surface. How many beds exist, their depth beneath the surface, their thickness, their continuity or discontinuity, the quality of the ore, and other facts of importance to be known in order to estimate intelligently the value of the deposits of ore, could best be obtained by putting down numerous drill holes with a core drill, and until this is done any estimate on the quantity of ore beneath the surface would be scarcely more than a guess. Whether the beds are thick enough beneath the surface to justify expectations of development is as yet unknown. That large quantities of carbonate ore exist beneath the level of drainage can hardly be doubted, but whether any of it can be recovered economically may be questioned.

The ore beds, above drainage, outcrop so frequently on the hill slopes, and have been exposed at so many places, especially in the vicinity of Hickory Flat, that while we would not attempt an estimate of the quantity, we are safe in saying that it runs into the millions of tons.

As has been seen the ore bodies occur mostly in continuous beds of "block ore," the beds varying in thickness from a few inches to 2½ feet, the average being about 1 foot to 14 inches. The hill sides show usually three, sometimes four beds outcropping at levels from a few feet below the tops of the ridges to the bottom. Much of the ore will never be recovered because too deeply buried to be mined economically. Sufficient could be recovered, however, by a process of stripping off the overburden at small cost to justify working the deposits where they are favorably located.

Quality of Ore.—While the brown oxide ore is much less abundant in this region than the carbonate, it is of sufficient importance to have received some consideration in the estimates of quality. As already stated, the oxide ores lie mostly upon or just beneath the surface, and is probably oxidized from the carbonate by surface exposure. Lying as they do, largely upon the sarface, in any development of the region these brown ores would be among the first to be exploited.

The State Geological Survey has analyzed five average brown oxide ores from .this District, the result summarized being as follows:

Metallic Iron	49.53
Manganese	8.69
Suplhur	1.38
Phosphorus	0.057
Silica	18.88

It will be seen that the percentage of silica is rather high. This is due mainly to the fact that the ores taken from the vicinity of Winborn are more highly silicious than elsewhere in the area. An average of the silica content of oxide ores from the outcrop at Potts Camp and on the Morehead property at Hickory Flat is 7.81 per cent, which is, in our opinion, nearer an average of the whole than the figure given in the above table.

On analysis of eleven average samples of carbonate ores taken from representative outcrops over the whole area the following results were obtained:

Metallic Iron (after calcination)	57.9
Manganese	5.6
Phosphorus	0.18
Sulphur	0.47
Silica	7.41

The analyses of carbonate ores from the region near Flat Rock Church, seven miles northeast of Hickory Flat, show a rather lower percentage of iron and higher phosphorus than those in the immediate vicinity of the line of the Frisco Railroad. Omitting these, the table showing only carbonate ores within two or three miles of the railroad, stands as follows:

Metallic Iron	62.15
Manganese	5.77
Phosphorus	0.122
Sulphur	0.87
Silica	13.345

An average of 17 ores, inlcuding carbonate ores all calcined, which have been furnished us by the Memphis Mining and Manufacturing Company, and which were taken from their properties at Potts Camp and Hickory Flat, give the following results:

Metallic Iron	55.07
Manganese	4.072
Phosphorus	0.079
Sulphur	1.15
Silica	13.12

From the same sources we have analyses of eight additional carbonate ores, which give (not calcined) the following:

Metallic Iron	45.2
Manganese	1.074
Phosphorus	0.059
Sulphur	Not determined.
Silica	Not determined

From the foregoing analyses, it will be readily seen that the oxide ores are undoubtedly commercial ores, and that their low phosphorus and sulphur content fit them for making the highest quality of soft malleable iron, and well adapted to the manufacture of the best grades of Bessemer steel.

The carbonate ores with a few exceptions are remarkably high grade. The percentage of metallic iron in iron carbonate theoretically pure is 48.2; a comparison of this figure with the iron in the last table given above will show but three per cent of impurities in the ores included in the analysis. A similar comparison with the uncalcined carbonate ores, the analyses of which are given in the preceding pages, will show for most of the ores a like approach to theoretical purity. On calcination the iron content rises in most cases to 60 to 65 per cent.

As a group the ores are remarkably low in phosphorus and sulphur. The deposits just south of Winborn show high percentages of phosphorus and at the same time are low in iron, so that by leaving these and exploiting the other deposits the ore would fall within the class of Bessemer ores. The oxide ores are uniformly low in phosphorus and sulphur, and mixing these with the carbonate ores would raise the grade of the whole. There can be no doubt that by mixing the two kinds of ores and by using charcoal for smelting, the highest quality of Bessemer steel can be manufactured from these iron deposits.

It may be well to make some comparisons between the carbonate ores of the Potts Camp District and those of the Ohio Iron Carbonate field, which furnishes all the carbonate ores of the country today.

The "Black Band" ore of the Hanging Rock District shows an iron content of 25% to 30%, which calcines somewhere near 50%. "The Kidney", or Concretionary ores, of the same region, contain 35% to 50% of metallic iron. The "Red Limestone" ore, the most important ore of the District, averages about 40% of metallic iron, 10% of silica, 1¼% manganese, .3% or sulphur, and .3% of phosphorus.

In the Hocking Valley District, where similar carbonate ores occur, analyses of five ores gave an average as follows:

Metallic Iron	37.18
Silicious matter	17.60
Sulphur	0.325
Phosphoric Acid	0.71

Pig iron made from Hocking Valley ores showed in 12 analyses a percentage of phosphorus of .673. If we assume that the average richness of the ore is 50% of iron, this will give .347 as the average percentage of phosphorus in the ores used, since none of the phosphorus goes off in the slag.

In every particular the carbonate ores of the Potts Camp District are superior in quality to those of Ohio. The iron content is decidedly greater. Silicious matter is less than one-half that of the Ohio ores, and the percentage of phosphorus is about one-half. The "Black Band" ores have an advantage over the Mississippi ores in the presence of carbonaceous matter sufficient in some cases to calcine the ore.

Accessibility of the Ore Bodies.—All the important outcrops described in the foregoing pages, with the exception of those in the

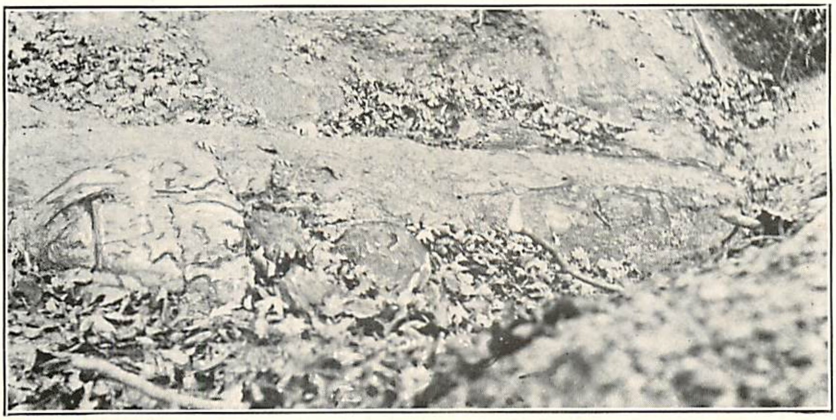


Fig. No. 6.—Bed of Carbonate Ore exposed in west ditch on J. Q. Hunter's land, near Flat Rock Church, Benton County.

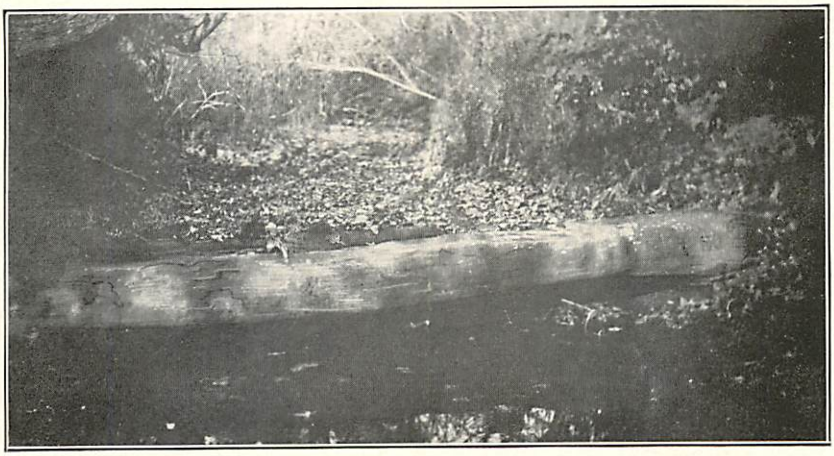


Fig. No. 7.—Tree-like columnar concretion of partly oxidized Carbonate Ore exposed in west ditch on land of J. Q. Hunter, near Flat Rock Church, Benton County.

vicinity of Flat Rock Church, in Tippah County, seven miles northeast of Hickory Flat, and the outcrops mentioned as reported near Ashland, in Benton County, lie within two or three miles of the Frisco Railroad. The railroad follows from Hickory Flat to the Tippah River, two miles west of Potts Camp, along the edge of Ocklimita Creek Flat. At a short distance west of the Tippah it touches the point of the ridge along which outcrops the principal ore beds of the Potts Camp area. A short spur and tipple have been constructed here to recover the surface brown ore. By extending the switch along the base of the hill, which could be done without grading or other expense than laying the rails, the carbonate beds that outcrop around the edge of the hill on the Reid and Gurley properties could be easily reached. A spur not to exceed a mile and one-half in length, along the edge of Tippah bottom would reach most of the known outcrops.

At Winborn, a track laid across Ocklimita bottom, half a mile in length, would reach the outcropping beds of carbonate ore on the Bready land. At Hickory Flat the railroad track runs within half a mile of the first outcrops on J. H. Morehead's land, and a spur a mile long would reach nearly all of them, the track traversing the whole of the distance of the low flat of Ocklimita Creek and a small tributary branch. The farthest outcrops on the Morehead property could be reached by building a track along a small creek bottom for a distance of two and one-half to three miles, but there is every reason to believe that the intervening hills are as rich in ore as those on Morehead's land, the only difference being that there have been no efforts made on the intervening lands to uncover the ore. Natural outcrops occur frequently. So far as surface indications may be trusted the ore beds underlie all the hills and ridges throughout this region.

METHODS OF DEVELOPING THE ORE BODIES.

Mining.—At the present time our knowledge of the ore bodies of this district is limited to those outcropping above drainage. That there may be ore beds equally good and equally extensive below as above that level we have no reason to doubt. As already stated, wells very frequently strike beds of carbonate ore below the surface at depth from 15 to 30 feet, but few have been penetrated, and we know practically nothing of them. Systematic prospecting with the core drill would be necessary to give adequate knowledge of such deposits. However, it is extremely improbable that any ore beds lying below drainage, unless lying very near the surface, will ever be exploited, for the reason that so far no thick beds have been found in this field that would justify the expense of underground mining. Further, carbonate iron ores, as compared with Hematite, and Magnetite are low grade ores, and unless under unusually favorable conditions, could not be mined economically by underground methods. In the carboniferous iron fields of Southern Ohio carbonate ores have been mined to some extent by "drifting," or following the horizontal beds beneath the surface. In that case, however, the overlying materials are hard rocks and easily supported, whereas, the overlying beds in the North Mississippi iron field are soft and yielding clays that would necessitate very careful and expensive timbering of the mine to prevent caving.

The economically available ores of the district are those beds that outcrop around the slopes of the hills and ridges and that are not too deeply buried to be reached without much difficulty. The method used almost exclusively in the Hanging Rock District is by "stripping", that is, by removing the overlying materials where the outcrop occurs on slopes, and laying bare the ore bed, and quarrying it out like stone from a quarry. The stripping and removal of the ore go on until the depth of the overlying material reaches a point where the expense of its removal and the smelting of the ore approximate so closely to the value of the ore to be mined that the process cannot be carried further economically. The limit of the economic mining at that point is then reached and work must be transferred to some other point.

This method of mining is particularly well adapted to conditions in Potts Camp District. Each slope has three or four beds outcropping, and the slopes are usually not so steep but that large quantities of ore from each bed could be recovered before the limit of profitable working would be reached. The surface of the country is so extensively cut up into ridges and valleys that, while very much of the original surface with its contained ore has been removed by erosion, what remains is in the right shape to make much of its ore available.

The material overlying the beds is so soft as to be easily removed with steam shovels or scrapers, and it would be possible to work the beds in the same hill all at once or in succession from below upwards. There would need be no lifting of the ore at all but every movement would be down grade until loaded on the cars. The switches themselves would all be gently down grade, or could be made enough so that the full car going down would pull the empty up to the mine.

In the Hanging Rock District of Ohio experience has proven that 12 feet of loose earth cover can be stripped off economically to recover a bed of ore 12 inches thick. It is almost certain that in the

Potts Camp District even a thicker overburden could be removed for the reasons that in this district the overlying material is less consolidated than in Ohio, and the Mississippi ore is of higher grade. By moving the machinery along the hills, as the available ore becomes exhausted in one place, adjacent territory could be taken up.

Smelting and Marketing the Ore.—Two alternatives confront those who undertake developments in this District; either to mine and sell the ores as such, or to erect smelting plants, reduce the ore, and market the pig iron. The furnaces at Birmingham, Alabama, consume about 10,000 tons of brown ore per month, which, on account of its low phosphorus content, is mixed with the red ores of that District to improve the quality of the iron produced. All the Potts Camp brown ore would no doubt find a market there, since all that has been shipped out—25 car loads— has met with ready acceptance at Birmingham.

Since all but the surface ore of the District is Carbonate ore, which by all reasonable inferences, must form the bulk of the ore, a calcining plant will probably be necessary in the mining district. Abundance of timber suitable for the manufacture of charcoal for calcining the ore, stands on the land where the ore occurs, and by erecting by-product ovens the cost of calcining could be greatly reduced.

Low phosphorus ore is at a premium and much in demand in all the great iron and steel plants in the country. Immense quantities of Swedish ore are annually imported by the steel manufacturers of the Eastern States because of its low phosphorus. In 1910 Swedish ore was imported to the amount of 259,911 long tons, having a valuation of $1,391,976, or a little over $5.36 per ton. It is probable that the low phosphorus ore of Mississippi put on board steamer at Memphis could be put into Atlantic ports at a price to compete with the foreign ore. On the basis of 6 mills a ton a mile, a freight rate on the ore to Memphis, which is only 60 miles from the ore district, would be 36 cents per ton; adding to this 15 cents for loading on board at Memphis, would make the cost to put on board vessel at Memphis, 51 cents per ton. It is probable that the ore shipped by water from Memphis could be put at Atlantic coast points for about $3.25 per ton, including mining cost. With a market value of $5.36 per ton of ore of this grade, there would remain a margin of profit of $2.11. Or assuming the market value of the ore to be 8½ cents per unit and the percentage of iron in the ore to be 58, the market value of the ore would be $4.93 per ton, and the margin of profit $1.68.

It will be seen that a market for this grade of ore can be had at the furnaces at Birmingham with a margin of profit, or that handled by way of Memphis much wider markets may be reached, and still have, so far as our present calculations can determine, a good margin of profit.

Should a developing company desire to reduce the ore and market the pig iron instead of the raw ore, one of two plans might be considered. In the one case, furnaces might be erected at some central point in the ore district on the railroad, and the ore be smeltered on the ground, or in the other case some accessible and nearby railroad center might be selected as the site of the furnace to which the ore would be hauled from the mines. In either case, a calcining plant would have to be established at the mines to treat the carbonate ores. This would not need to be very extensive and the calcination would better be done with charcoal which could be made from timber on the mining property and in the immediate vicinity.

If the ore is to be smelted at the mines, our opinion is that the use of small inexpensive charcoal hot blast furnaces would be the most economical procedure. The timber easily accessible to the plant covers large areas of hill lands that are not valuable for agriculture. It is not supposed that this timber would last indefinitely, but the supply would not be exhausted for many years. In the Ohio iron field the Pine Grove hot blast furnace consumed in making one ton of pig iron 131 bushels of charcoal, or 3.56 cords of wood. The Hecla Coal Blast furnace used 201 bushels of charcoal to 1 ton of iron.

It will thus be seen that the consumption of timber is heavy in producing charcoal iron, but this iron brings a special price in the market. Charcoal can be made for 6 cents per bushel, but by erecting by-product ovens this can be reduced. Assuming that 1 ton of pig iron will consume 131 bushels of charcoal, we have the cost of charcoal consumed to be $7.86. Estimating the cost of putting the ore at the stack at $2.00 per ton, labor at the kiln at $1.50 per ton, and flux at 50 cents, the total cost will be $11.50. Charcoal iron has been selling in Alabama at the furnace for $22.00 to $27.00 per ton. In 1910 at Pittsburg, Bessemer pig iron sold at $19.90; Basic iron at $18.75; Gray Forge iron at $17.40. Gray Forge iron is high in silica and phosphorus and of much lower grade than that of Potts Camp; but taking even the price of that low grade iron for a basis for calculation, it will be seen that the margin of profit on this iron would be, based upon the costs of production given above, $5.90 per ton. Taking the price of charcoal iron as a basis for our estimates, the margin would be $10.50 per ton.

The consumption of charcoal would be so great that eventually coke would probably have to be substituted for it in treating the ores. The furnaces would have to be located where coal for manufacturing coke could be economically obtained. As stated above, Memphis is only 60 miles from the fields and located, as it is, on the Mississippi River, it is possible for slack and nut coal suitable for making coke to be brought in by water very cheaply from the Pennsylvania and West Virginia coal fields. At the same time it is near enough to the iron deposits that the calcined ore could be put into Memphis at minimum cost. Further than that Memphis would be a strategic point for the location of the furnaces because the output of pig iron could be transported by water to the whole Mississippi and Ohio Valleys, and through the mouth of the Mississippi to the Gulf and Atlantic Coast points.

It is possible that slack and nut coal which would be suitable for coke manufacture could be put into Memphis by barges at a cost of $1.25 to $1.50 per ton. By erecting by-product ovens in connection with the coking ovens, the by-product output could be put upon the market at prices to almost pay the expense of coking, thereby increasing in an equal ratio the margin of profit, and at the same time making it possible to handle ores of a lower grade at a profit.

Fluxing Material.—Having briefly discussed the fuel and transportation as effecting the development of the Potts Camp ores, a word may be added regarding fluxing material, an important item in connection with iron manufacture. If the smelting plant should be located in the mining district the most accessible material for fluxing purposes is the soft limestone of the Selma Chalk 30 miles southeast of Potts Camp. This formation outcrops over a broad area running north and south of Tupelo. Two samples from Okolona south of Tupelo gave the following analyses:

	No. 1.	No. 2.
Silica (SiO_2)	8.80	8.70
Alumina (Al_2O_3)	2.86	0.00
Iron oxide (Fe_2O_3)	4.08	6.00
Lime carbonate (CaO)	45.51	45.62
Magnesium carbonate (MgO)	.36	1.77
Volatile matter (CO_2)	31.11	34.40
Sulphur trioxide (SO_3)	.38	1.11
Moisture	6.35	1.10

The analyses show the suitability of the material for fluxing. This limestone is found in boundless quantities, lies at the surface and outcrops on both sides of the Frisco Railroad for miles.

With the furnaces located at Memphis this limestone would perhaps be less accessible than the limestones of Tennessee, Kentucky, or Illinois, that could be brought in by water, even more cheaply though further away.

IRON ORES OF LAFAYETTE COUNTY.

The southern parts of the Potts Camp District have not been examined carefully. Some outcrops of both brown oxide and carbonate ores are known to occur on the lower Tippah near its junction with the Tallahatchie, but little is known of either the quality or the extent of the ore beds. On the south side of the Tallahatchie River, however, in Lafayette County, the land has been more carefully gone over, and numerous outcrops of both oxide and carbonate ores are known.

Distribution of Ores.—In Lafayette County a rather sharp line can be drawn nearly north and south west of which no iron ores of the kind described as characteristic of the Potts Camp District have been found. This line cuts the county into an eastern one-third and a western two-thirds, the eastern division containing all the iron ore of the county. The most western locality where carbonate ores have been found is at Chandler Springs 2½ miles east of Taylors in the southern part of the County.

The eastern third of the County differs distinctly from the more western parts in the outcrops of gray and lignitic clays over large areas, giving rise to sticky, tenacious, red clay soils, which pass down through mottled subsoil to the underlying gray clays. Passing westward these become more and more deeply buried under red and yellow sands. The iron ores are found only in association with the gray and lignitic clays, never in the overlying sands.

Geology and Topography.—The iron deposits in Lafayette County are identical in character, occurrence, geology, and other essential features with those of Potts Camp. There is no real break separating the two fields, the division being merely one of convenience. Here, as in the Potts Camp District, the ores are good grade carbonate ores that by weathering on exposure have given rise to more or less extensive surface deposits of brown oxide ore. As there, so here, the ores are chemically segregated flattened "kidneys" of large size and beds of irregular thickness, and the ore beds are sandwiched in between beds of gray and lignitic clays and sandy clays. The enclosing beds and probably the ores themselves are of early Wilcox age near the base of the Eocene Tertiary. The ore-bearing beds we have referred to the lowest division of the Wilcox which we have called the Ackerman Clays, from the type locality in Choctaw County.

Topographically, Lafayette County is part of the same plateau that embraces all of North Central Mississippi 450 to 500 feet above sea level. As in the Potts Camp area, over the eastern half of the County deep and mature erosion in the old plateau has given rise to a rough hilly surface. In the western part of the County the erosion has not cut up the surface so extensively, so that a thick capping of brown loam soil, which has been almost entirely removed in the east half of the county, covers the older formations. The ore becomes deeply covered here, but gradually approaches the surface until outcropping in the edges of the valleys and in the stream beds in a line six to eight miles east of Oxford. Deep erosion of the Yocona River in the southern part of the County has caused the exposure of the ore-bearing beds farther west than elsewhere in the County.

DESCRIPTION OF KNOWN OUTCROPS.

On the south side of Tallahatchie River and less than one mile from the mouth of Tippah, several ledges of ore outcrop 100 or 200 yards east of the residence of G. A. Harris in a lane leading down to the river. This outcrop is in Section 33, T 6, R 2 W. The beds aggregate four to five feet in thickness, but are highly silicious. The ore has been oxidized by exposure unless originally oxide, which is improbable. Analysis of a sample of this ore gave the following:

No. 14.

Fe	39.32
Mn	2.28
P	0.11
Al	1.33
CO_2	3.02
S	0.14
SiO_2	11.17
Insoluble	17.92

These beds, as already noted in the Potts Camp field, are closely associated with gray clays, of the lower Wilcox. Good looking outcrops of carbonate ore occur in Sections 33 of Township 6 and R 4 E, and 10 of Township 7, R 2 W, along the course of Holder Creek, which empties into the Tallahatchie. On the hillslope at G. A. Harris's place between his residence and the mill is a notable outcrop of the gray clay with lignitic bands, the same is observed on the upper hill west of Bagley's bridge over Holder Creek, and carbonate ore in disconnected large "kidney" masses appear at the foot of the slope near the creek in Bagley's pasture below the bridge.

The hills on each side of Holder Creek on the Abbeville and Rocky Ford road show outcrops of iron ore, but all seen were of inferior quality, being quite silicious. That on the west side of the creek appears as only disconnected flattened concretions of large size; on the east side a continuous deep brown ledge a foot to 15 inches in thickness crosses the road on the hillslope. This ledge dips with the hill, and so appears much thicker than it really is. Two other beds appear on the hillslope but none of the deposit appears to be of workable quality, being largely mixed with sand.

A sample of oxide ore taken from an outcrop on a hill one mile south of the Abbeville and Rocky Ford road and three miles east of Bagley's bridge over Holder Creek gave the following analysis:

No. 15.

Fe	46.06
Mn	2.14
P	.068
S	.02
Al	.78
CO_2	.1
SiO_2	13.37
Insoluble	6.07

On the place of Captain J. L. Shinault, nine miles northeast of Oxford, occur outcrops of the ore, both oxide and carbonate, at several points. For the most part the outcrops follow the course of Holder Creek which flows across the plantation in a course slightly to the west of north. On the west half of Section 22, T 7, R 2 W, on a point of a ridge between Holder Creek and a small tributary, and just above an old sawmill site, an abandoned wagon road has cut deep into the gray clay of the lower Wilcox and laid bare a bed of gray carbonate ore. The ledge is 6 to 7 inches thick and in a short distance passes back beneath heavy cover. Analyses of the ore gave the following results:

No. 16.

	Before calcination.	After calcination.
Fe	49.9	59.49
Mn	2.28	2.65
P	.111	.132
Al	.3	.35
S	.07	.083
CO_2	19.7	
SiO_2	6.46	7.68

At the extreme northeast corner of the Shinault place on a point of a hill with a steep slope to Holder Creek, in Sec. 16, T 7, R 2 W, was found considerable quantities of honeycombed oxide ore, but no regular bedded outcrops. The lower part of the slope facing Holder Creek is of gray clay—gray joint clay appearing also in the bottom of the creek, such as is often associated with the carbonate ore, and it may be possible that beds of this ore occur in the hill, though none could be seen, the whole slope being covered with loose soil and slump material.

About one mile east of the residence on the Shinault place, in Sec. 21, T 7, R 2 W, at the base of a long hill of reddish sands the gray clays again outcrop, bearing a thin bed of carbonate ore six inches thick, which outcrops across the road just west of the waste-way of the mill-pond. A sample of this ore analyzed as follows:

No. 17.

Fe	48.56
Mn	2.59
P	.08
Al	.34
S	.02
CO_2	12.00
SiO_2	5.03
Insoluble	.09

The result of calcining this has not been determined, but it will be readily seen the ore is remarkably pure and the iron content high. It is also low in sulphur and phosphorus, so that the ore in undoubtedly a valuable one if it can be found in sufficient quantity.

One fourth of a mile north of this outcrop, in Section 28, T 7, R 2 E, on a hillslope just above the old Holder water-mill race a recent slump shows a face of gray sandy clay 20 to 25 feet high. Five ore horizons are revealed, though the beds are not continuous, showing great flattened lense-shaped masses that will weigh 500 to 1,000 pounds. These beds average about 10 inches in thickness and are all rather highly silicious. A sample taken from the second ledge from the bottom is perhaps representative of the best ore at this place. Analysis gave the following:

No. 18.

	BEFORE CALCINING.	AFTER CALCINING.
Fe	39.73	47.97
Mn	2.01	2.42
P	.065	.078
Al	.017	.02
S	.028	.033
CO_2	21.00	
SiO_2	11.21	13.52
Insoluble	6.86	8.28

Outcrops of ore of similar grade occur on the slopes of all the hills in this vicinity, especially toward the east. Half a mile east of Holder's mill some good grade ores, both oxide and carbonate, outcrop on the hill-slopes, but the extent of the deposit is undetermined.

On the Abbeville and Rocky Ford road, 5 miles from Rocky Ford, on Tallahatchie River, a good looking outcrop occurs in the public road on land belonging to Tom Hollins (colored). Two beds appear on the hill-side, the upper a few feet beneath the top of the hill, the lower, 20 feet further down. In both cases the ore, which was originally carbonate, has been oxidized to brown ore. The upper ledge is 10 to 12 inches thick, the lower one 8 to 10 inches. A sample of each was analyzed; there was little difference in the quality of ore in the two beds, but an average of the two gave the following on analysis:

No. 19.

Fe	52.44
Mn	2.99
P	.18
S	.07
SiO_2	4.83
Al	1.54
Insoluble	3.39
CO_2	1.62

It is probable that deposits of carbonate ore occur along the Tallahatchie in the vicinity of Rocky Ford; some has been reported there, but it has not been seen by any member of the Geological Survey. The ore-bearing clays outcrop in a broad belt from the mouth of Tippah to Rocky Ford on the Tallahatchie, and extending southward through the County. Lafayette Springs lies near the center of the belt, which in the southern part of the County embraces both Paris and Delay. High sand hills characterize much of this territory, especially toward the western border, where the gray clays pass beneath the sands of the Middle Wilcox.

Sixteen miles northeast of Oxford, at the bridge over Wolf Creek, one-fourth mile north of the residence of Mr. Baalam Harris, a good outcrop of ore is noticeable in the creek-bed. This can be followed up the creek for a hundred yards or more, much of the loose ore lying in the bed of the stream. The bed averages about 12 inches in thickness and lies under a few feet of loose earth. It is probable that the ore lies beneath the level field that lies to the north of the creek. A sample of the ore taken above the bridge gave the following analysis:

No. 20.

Fe	40.06
Mn	3.30
P	.24
S	Trace
SiO_3	8.01
Al	6.89
Insoluble	14.03
CO_2	6.71

All the observable ore at this outcrop has been oxidized by exposure, as indicated by the deep red color, and, in the above analysis by the low percentage of CO_2.

Half a mile north of the bridge on Wolf Creek an outcrop of a bed of ore occurs in the road. This ore is highly oxidized and very largely honey-combed. The outcrop does not show over more than a few rods of ground. The bed is 6 to 8 inches thick. Prospecting might lay bare the beds lower down the slope of the hill as well as reveal the extent of the outcropping bed. A sample of the ore analyzed as follows:

No. 21.

Fe	53.52
Mn	2.61
P	.15
S	.14
SiO_2	3.78
Al	2.28
CO_2	Trace
Insoluble	2.53

Large deposits of carbonate ore are reported from the vicinity of Lafayette Springs, and doubtless exist, though the examination of that area has not as yet been made in detail. A sample of carbonate from the Holmes place, Section 36, T 8, R 2 W, 12 miles east of Oxford, and near Altus postoffice on the Oxford and Lafayette Springs road, has been submitted to the Geological Survey for analysis. This sample was taken from a bed of undetermined thickness and gave the following analysis:

No. 22.

	BEFORE CALCINING.	AFTER CALCINING.
Fe	45.67	62.08
Mn	2.79	3.79
P	.13	.176
S	.06	.012
SiO_2	2.81	3.82
Al	.87	1.18
Insoluble	.80	1.08
CO_2	32.2	Not given

Six miles southeast of Oxford, on the Delay road, a noticeable outcrop of brown iron ore occurs in the road and on either side, on land belonging to Charley Slack (colored). This outcrop is in Section —, T, R, W. The ore occurs in large rounded masses of sizes varying in size from that of a man's fist up to boulders weighing several hundred to a thousand pounds. The ore outcrops on the southeast slope of a long hill, and is associated with the outcrop of a bed of gray clay very similar to that accompanying the outcrops of carbonate ore at Potts Camp and Hickory Flat. The bluish gray clay is here exposed in a thickness of at least 25 feet beneath the red sands and brown loam which cap the hill. Five feet of the uppermost part is a sandy clay somewhat laminated. Beneath this is a bed three feet thick of almost pure gray joint clay. All the rest is, like the top, a slightly sandy clay, becoming less sandy toward the bottom.

The iron ore is all associated with the sandy gray clay of the central parts, none being found above this level. Some thin bedded ferruginous sandstone is let down from above in thin plates upon the eroded clay, on the upper slope of the hill. None of it approximates an ore, however, and seems to have been formed at the base of the red sand.

While all this ore lies thickly strewn and partly buried on a little flat in the road, and so far as observed, is all brown oxide, it was almost certainly originally carbonate ore in beds. A sample of the oxide ore from this outcrop gave the following anaylsis:

No. 23.

Fe	60.28
Mn	2.31
P	.065
S	.17
Al	.28
CO_2	None
SiO_2	.63
Insoluble	None

A hollow concretionary mass of brown ore from the same locality had a mass of whitish gray powder enclosed in it. Suspecting this to be carbonate of iron an analysis was made of the white material and gave the following results:

No. 24.

	BEFORE CALCINATION.	AFTER CALCINATION.
Fe	45.85	64.69
Mn	4.78	1.56
P	.061	.086
Al	.15	.17
S	.04	.056
CO_2	35.6	
SiO_2	1.11	1.56
Insoluble	None	None

In the light of the above analysis the material was proved to be beyond doubt iron carbonate, and since elsewhere in this iron field the brown ore is derived from the carbonate, as proved in numerous instances, it is almost certain that these beds were originally beds of iron carbonate. The deposit has the appearance of occurring in two separate ledges with a thin parting between but the masses are so scattered over the outcrop that this could not be determined with certainty. The thickness of the beds is 10 to 12 inches each. About six feet below the level of these ledges a small bed of the ore seven inches thick outcrops in a ditch on the east side of the road. Less than 300 yards west of the road on the land of Charley Slack a slightly elevated ridge north of the field shows a noticeable outcrop of brown oxide ore. The masses lie thickly scattered over the sarfuce as if broken from an outcropping ledge.

On the south side of Pumpkin Creek, in Section 20, T 9, R 2 W, on the land of Mr. W. D. Porter, an outcrop of iron carbonate occurs in the slope of a hill which has a vertical height of 35 feet, and a length of 75 yards. The public road from Oxford to Delay traverses this slope, and on the east side of the road a wash has trenched the hill-slope to a depth of 5 or 6 feet. The material exposed from the bottom to within five feet of the top is dark gray lignitic clay, with six thin beds of carbonate iron ore intercalated between the clay beds.

Beginning at the bottom, bed No. 1 is about an average of 5 inches in thickness, is light gray in color, of fine texture, and is weathered on the outside to a reddish oxide 1-8 to 1-6 inch in thickness. Bed No. 2 is separated from No. 1 by 4½ feet of gray clay, is similar in character to No. 1, but is discontinuous, consisting of large flat lenticular masses averaging about 7 inches in thickness. Bed No. 3 pinches out within a few yards, and is only 4 inches thick. Bed No. 4 is rather more continuous than No. 3, of similar character and has an average thickness of 6 inches. The vertical distance between Nos. 2 and 3 is four feet, between 3 and 4 is ten feet. Bed No. 5 is somewhat discontinuous thinning in places to a mere film of iron, but averaging about 4 or 5 inches thickness, when existing in masses. This is separated from the next below by seven feet of gray clay, and from the next higher bed by about the same thickness of gray clay.

The topmost bed of ore, No. 6, lies just beneath the grass roots near the top of the hill at this point, passing beneath a few feet of cover farther back on the hill. It is entirely oxidized, about one foot thick, and overlies six or seven feet of yellowish gray sandy clay. The ore is quite sandy, and much inferior to the ore of the other seams.

All the ore except the topmost dip at an angle of 5 degrees toward the southeast. No. 6 dips slightly in the same direction but much less, the direction of dip is such that all the beds dip into the hill upon the slope of which they outcrop. The clay is more sandy between beds 1 and 2 than higher up. Between 3 and 4, and 4 and 5, the clay is jointed, almost clear of sand, and is decidedly lignitic. Between 5 and 6 the material as before stated is much more sandy, lighter colored, and shows considerable oxidization, as does the ore. An analysis of an average sample of this ore gave the following result:

No. 25.

	BEFORE CALCINING.	AFTER CALCINING.
Fe	42.33	59.25
Mn	2.89	4.04
P	.07	.098
Al	.44	.61
S	.01	.01
CO_2	34.9	
SiO_2	5.48	7.67
Insoluble	.65	.909

About 200 yards farther up Pumpkin Creek and just back of the residence of Ned Jones is a slump showing a fresh face of 16 feet, the following structures appearing:

3. Laminated and sandy gray clays to top of slump. The mass of the hill slopes back from the slump, rising 30 feet higher, but structures all covered.
2. Lignite (rather sandy), showing in places flattened tree trunks; this bed a short distance up stream is replaced laterally by lignitic clay and sand, 18 inches.
1. From water's edge, dark lignitic clay, 6 feet.

In the bed of the creek all along the foot of the hill abundance of carbonate ore of good grade is to be seen in masses of sizes from that of a walnut to that of a foot ball. No outcropping ledge is in evidence until at a wash cutting into the face of the hill 150 yards up stream from the ford above the bridge, where a bed six feet above the water's edge is revealed; it is 14 inches thick and of fair quality, but inferior to that shown in the last analysis.

The hill slope on the south side of Pumpkin Creek is so thickly covered with vegetable mold and loose material that any outcropping ore beds might easily escape notice. Half a mile up the ridge where the old Camp Ground spring enters Pumpkin Creek, the surface of the point of the ridge is thickly covered with honey-combed oxide ore of apparently good quality, which probably marks the outcrop of an ore body at this place. Farther up the ridge, about one-half mile west of Kingdom Church, on land of Hughlet Johnson, two beds of ore outcrop in a pathway down the north face of the hill. The lower bed is about 12 feet below the top of the hill and is seven inches thick. A foot and a half farther up the hill another small bed outcrops, four inches thick. Both beds were of brown oxide ore of good quality. Other beds, possibly outcrop lower down the slope, though none were seen.

On a long hill slope 200 yards northwest of the new Kingdom Church, in Sec. 16, T 9, R 2, W, an exposure having a vertical height of 50 feet exhibits near the base 8 to 10 feet of lignitic clays, all the rest of the section being gray clays with intercalated beds of iron ore.

The topmost bed of ore is so sandy that it is rather a ferruginous sandstone than an ore. It lies only 3 to 4 feet below the top of the hill and is 10 inches thick. The next lower bed is 5 feet below the top of the hill, 8 inches thick, slightly sandy and of rather inferior quality. The next bed below the last is separated from it by 1½ feet of clay, is 6 inches thick, and the ore is oxidized carbonate, of good quality. The lowest ledge is 10 feet below the top of the hill, is 10 inches thick, and appears to be somwhat silicious, but of fair grade. The beds have a noticeable dip toward the southeast. A sample from the third bed from the top gave the following analysis:

No. 26.

Fe	51.04
Mn	2.00
P	.09
Al	.79
S	.02
CO_2	.01
SiO_2	11.51
Insoluble	6.03

A bed of oxidized ore outcrops in the public road near the 9-mile board on the Oxford and Delay road, on land of Miram Carpenter, Sec. 20, T 9, R 2, W. The bed is 6 to 7 inches thick and lies 3 feet beneath the top of the hill. The ore has the appearance of an oxidized carbonate, and is of good quality.

At the Rocky Ford Crossing on Yocona River in southeast Lafayette County, on the land of R. C. Jones in Section 30, T 9, R 3 E, the following bluff is found just below the crossing:

5. Rather heavy bedded lignitic clay to within 3 feet of the surface, the soil being red silty clay.......7 feet
4. Bed of lignite apparently pure.......2 feet
3. Bluish sandy laminated clay, the upper three feet purer clay, more massive, and highly lignitic.......10 feet
2. Bed of dense fine-grained gray iron carbonate continuous along the base of bluff.......4 inches
1. Bluish sandy clay.......1 foot

Analysis of ore from this outcrop gave the following:

No. 27.

	BEFORE CALCINING.	AFTER CALCINING.
Fe	39.84	52.91
Mn	2.67	2.87
P	.099	.89
Al	.52	.38
S	.02	.02
SiO_2	9.34	5.59
Insoluble	.009	.099

At this point and for some distance down the stream the bed of the river is thickly strewn with fragments large and small, of this carbonate ore.

A short distance further up and on the south side of the river, just above the mouth of the Panther Spring Creek the Yocona Bluffs lie a little back from the river and present on their slopes two outcrops of iron ore at different levels. The upper lies 7 feet below the crest of the ridge, the next lower being about 8 feet below the first. What appeared to be a third outcrop is not quite clear; it lies below the other two and may be masses of the ore that have rolled down from above. It shows two large masses of ore a short distance apart horizontally, and at a level of 5 or 6 feet below the next higher ledge. The middle and upper outcrops are 8 to 10 inches thick, apparantly not dipping, and occur as occasional protruding masses of two distinct levels, but not as continuous beds. The upper outcrop is not as pure as the lower, being considerably higher in silica. With the exception of the bed of carbonate outcropping at the ford of Yocona, all the outcrops of ore bodies observed in this section are not continuous ledges, but in lenticular concretionary masses, varying from a few pounds in weight to 1,000 pounds or more. A sample of ore from the upper outcrop just described gave the following analysis:

No. 28.

	BEFORE CALCINING.	AFTER CALCINING.
Fe	38.59	45.08
Mn	2.77	3.23
P	.109	.12
Al	.46	.53
S	.04	.046
CO_2	17.6	
SiO_2	9.75	11.32
Insoluble	6.21	7.25

The middle ledge on anlysis gives 54% of metallic iron.

Half a mile south of the ford on Yocona on land of R. C. Jones occurs an outcrop of a continuous ledge of silicious oxidized ore. The creek running from Panther Springs has cut a channel through it, the bed of ore projecting over the water of the little creek on each side in a distinct ledge having no appreciable dip, though a little lower down the creek evidence of southward dip is plain. The ledge is one foot thick and forms a continuous outcrop for 75 yards along the creek. The quality of the ore is not high, analysis of a sample giving the following:

No. 29.

Fe	34.65
Mn	2.85
P	.174
Al	.012
S	Trace
CO_2	3.2
SiO_2	10.46
Insoluble	22.58

Two and one-half miles east of Taylor in Southern Lafayette, the most westerly outcrop of iron carbonate so far observed in the County, occurs at Chandler's Spring. The spring is situated at the base of a bluff which when visited by the writer, showed recent slumping. The hill rises above the spring on the east side about 35 feet high, the lower 18 feet showing the fresh surface of the slump. The formations as revealed in this hill are gray clays at base for a height of 10 feet above the spring, and slightly sandy. A bed of silicious iron ore 6 inches thick outcrops just above this clay, oxidized on the surface so as to show dark brown color, but on breaking the oxidized exterior shells off in layers, and reveals within whitish-gray carbonate ore. The bed dips 5 degrees to the southwest. A sample from this bed shows the following result after calcining:

No. 30.

Fe	56.06
Mn	3.27
P	.086
Al	.209
S	.21
SiO_2	9.38
Insoluble	4.75

Above this bed the formation becomes much more sandy, laminated and somewhat oxidized into a yellowish color. A thickness of 12 to 14 feet of this material overlies the iron ledge and is in turn overlaid by a higher bed of iron ore about 8 inches thick, which seems to be wholly oxidized. This ore bed dips parallel to the first. Above this ore the hill is topped with the orange red sands so abundantly developed in all this section, a thin veneering of brown loam making the surface soil to a depth of 3 or 4 feet. This upper bed of ore outcrops as a bed and as loose masses of oxide ore strewn thickly over the ground north of the spring, covering two or three acres in extent, so far as observed. A sample of this oxide ore gave the following on analysis:

No. 31.

Fe	51.87
Mn	1.88
P	.061
Al	.43
S	.092
CO_2	4.6
SiO_2	7.37
Insoluble	None

South of the spring 200 or 300 yards the spring branch enters Yocona River at the base of a bluff showing recent slumps. No iron is in sight, but the materials exposed are sandy clays of light gray color above, and dark lignitic clay toward the base. Around the point of the hill, on the banks of Yocona, the steep bluff shows at 12 feet above the river flat a dark brown bed of highly silicious iron about 10 inches average thickness. It seems not to be identical with the beds observed at the spring.

Iron in Yalobusha County.—Little prospecting has been done in Yalobusha County, so that the extent of iron deposits in that County is not known. So far, our knowledge is limited to one deposit in Pine Valley, 10 miles east of Water Valley. The ore is of good quality of brown oxide, but some specimens in the State collection from that locality appear to be partly oxidized carbonate. The extent of the outcrop is limited and the bed is 8 to 10 inches thick, lying practically on the surface.

A good sample of oxide ore has been received from an outcrop near Coffeeville, the extent of which is as yet unknown. This sample on analysis gave the following result:

No. 32.

Fe	55.15
Mn	3.05
P	.28
S	Trace
SiO_2	3.96
Al	3.13
CO_2	None
Insoluble	2.62

Careful prospecting in this and counties lying east and southeast in the lower Wilcox Belt will most probably reveal the presence of other more extensive outcrops of the carbonate ore bodies.

Future of Lafayette County Iron.—Comparing the deposits in Lafayette County with those farther north, it appears that the outcrops are more scattered, the beds on the whole less continuous and thinner, and analyses show the ore to average a rather lower grade. Further, the deposits all lie several miles from any line of transportation. Without transportation facilities it is impossible to expect development in this section. Should future prospecting reveal more extensive deposits than are at present known in this region, and should these deposits be so situated that large bodies of ore could be reached at some one point, or in close juxtaposition, there should be little difficulty in getting a branch railroad from the Illinois Central or the Frisco. But so far the known outcrops are too limited and too widely scattered to invite the interest of the railroads.

Should the ore ever become commercially important, the same methods of mining and smelting mentioned in connection with the Marshall and Benton County ores would apply to those of Lafayette and Yalobusha Counties. In fact, the same methods would have to be used throughout the Wilcox Belt, since the ores are identical, and occur under the same set of conditions wherever they have been found.

Iron in Grenada County.—Our attention was directed some years ago (in 1909) to deposits of iron in Grenada County. These beds are found from one-fourth of a mile east of the 3-mile board on the lower Graysport and Grenada road for 2 or 3 miles farther east. The settlers sometime speak of this iron rock as volcanic rock because of its dark color and the presence of concentric ridges and furrows marking the surface of some of the masses looking somewhat as if the rock solidified from material of pasty consistence flowing out and congealing in concentric rings. Of course, the structure is not volcanic but due to the segregation of the iron along certain lines.

The topography of this region is very rough, the hills being steep narrow ridges between broader valleys and reaching an elevation of 250 feet above the valley at Grenada. The hills are all capped to varying depths with reddish brown sands, which are in places intensely red, in others light yellow and cross-bedded. The material is undoubtedly Wilcox, in many places the stratification being distinct and passing apparently without break into the clays of the Wilcox. About 2 miles east of Grenada the light gray clays of the Wilcox appear in the cuts underlying the red sands.

The "iron rock" forms ledges 10 to 12 inches thick along the roadside for a mile or two. It is especially noticeable half a mile east of the 3-mile board. In every case observed, the iron, which occurs in continuous beds, shows a peculiar bi-partite character, consisting of two zones, an upper and a lower, of dissimilar appearance. The upper is usually thicker, darker in color, coarse and sandy in texture, approximating in character ordinary brown ferruginous sandstone; the lower zone is usually 3 to 4 inches thick, is of lighter brown color, fine and dense in texture, giving it somewhat a flinty appearance. This "iron rock"—for it can hardly be called an ore—lies invariably at the contact of the red sands with the clays; none of it has been observed within the clays; as in the case of the ores in Lafayette, Benton and Marshall Counties, and none of it presents the "kidney" concretions so characteristic of those ores.

The percentage of iron is doubtless as good as in some of the lower grade ores, but that of silica and alumina is high. This iron was doubtless leached from the red sands and re-deposited as the hydrated oxide at the line of contact of sand and clay. The deposition at the base of the sand has resulted in the cementation into a solid mass of several inches of the basal sand, at the same time the iron has impregnated 3 or 4 inches of the upper surface of the clay, thus forming a continuous bed along the contact, the upper two-thirds of which is made up of highly ferruginated sands, the lower one-third of the iron-charged clay, hence giving it the bi-partite character already mentioned. There is no evidence of carbonate of iron, and in its origin and character this iron is entirely different from that of Marshall, Benton and Lafayette Counties.

There is no probability that this deposit will ever be used as an ore of iron, though it might have value as a road making material. It is quite probable, however, that in the more eastern parts of Grenada County, carbonate iron ores exist similar to that of the northern counties of the State.

Iron Ore in Montgomery County.—A good many years ago a pronounced excitement prevailed over the State about rich and extensive iron deposits reported to have been found at the little town of Duck Hill in Montgomery County. Even at the present time some of the inhabitants of the County, and especially of the town have a lingering suspcion that such deposits of iron exist there, but for which fact, Duck Hill would hardly have place in this Report. A few loose fragments of good grade limonite picked up in the hills adjacent to the town gave rise to the excitement, but more careful prospecting at the time failed to reveal it in quantity.

More recently the locality has been successively examined by Dr. Calvin S. Brown, of the Geological Survey, and by the writer, the latter having visited the locality on two different occasions. In no case have deposits of any consequence been found. A few good hand specimens have been found showing the botryoidal structure and highly lustrous black surface, as if varnished, seen in specimens of pure limonite. The iron is undoubtedly leached from the red sands with which it is associated, and the accumulation is confined to very limited deposits.

The sands associated with the limonite are perhaps middle Wilcox, though possibly Lafayette.

Iron in Webster County.—While examinations of the iron deposits of Webster County have not yet been made, more or less of extensive outcrops have been reported from there. It is extremely probable that the brown oxide represents the outcropping edges of beds of carbonate ore, the oxides being reported from sections of the County where the carbonate bearing clays of the Wilcox should outcrop.

IRON ORES OF CLARKE COUNTY.

A rather unique iron-bearing deposit occurs in the vicinity of Enterprise, the county seat of Clarke County. Clarke County is in southeast Mississippi, bordering upon the line of Alabama. Enterprise is situated in the northwestern part of the County, lying on both sides of the Chickasawhay River one mile below its origin in the confluence of Oketibbee and Chunkey Creeks. The town lies at about the point of contact of the Tallahatta or lower Claiborne, and the Lisbon or upper Claiborne beds. The formations underlying the river alluvium at the town and outcropping in all the surrounding hills are marine marls containing a considerable percentage of lime, highly silicious, and rich in glauconite; hence their color varies from deep olive green to rich yellowish red where the glauconite has undergone weathering. These marls are usually highly fossiliferous.

The topography of the region surrounding Enterprise is rather broken and hilly, the capping of the hills being red and yellow nonfossiliferous sands, presumably of Lafayette age. These sands lie directly in contact with the underlying red weathered marls, which constitute the so-called "iron ore."

As just stated, the iron ore of this region is really a highly oxidized reddish yellow glauconitic marl of marine origin, rich in casts and nuclei of marine shells of generally rather small size, with occasional fish teeth. The unchanged marl is dark green from the abundance of glauconite present, and even the red oxidized material shows abundantly the coarse grains of galuconite. Silicious material is always present in high percentage, though the quantity is in many places obscured by a large proportion of clay. The iron in this ore is largely in the hydrated oxide condition, though partly still unchanged from the carbonate condition.

In its original condition the "ore" was simply a highly galuconitic marl deposited under marine conditions about the close of the Lower Claiborne time. This was later elevated and exposed to atmospheric conditions resulting in the oxidation of the glauconite, with the formation of the sandy aluminous mass rich in hydrated iron oxide.

Simply the oxidation of the glauconite would hardly be sufficient to give the percentages of iron usually present in the ore. The iron content has probably been enriched by two other processes: First, by residual concentration; second, by subsequent leaching from the overlying ferruginous sands. If, as suggested, the overlying sands are of Lafayette age, the surface of the Claiborne marls were, after upheaval into land surface, long subjected to weathering, leaching, and re-deposition of the iron at lower levels while the surface was gradually being lowered and the materials removed by denudation. This process alone might easily explain the percentages of iron found; but since at a later period the ferruginous sands were spread over this weathered surface of marl, it is probable that some leaching from the sands has tended to enrich the marls in iron.

The best known exposure of this ore outcrops on the land of Mr. H. A. McGusty near the base of a hill-slope one and one-half miles northeast of Enterprise. It is exposed in a pit 7 feet deep, the hill above having a thick capping of the red Lafayette sands. The ore bed is 6 to 14 feet thick and overlies a gray shell marl rich in fossils, a species of scutella being especially abundant in this underlying marl where it is exposed on the left bank of the Chickasawhay within the town of Enterprise; the same ore bed outcrops in the bank of the Cemetery Creek and along the bank of the River. Here, as at the locality just mentioned, it is underlaid by the scutella fossil bed. Sample of ore taken from the pit on Mr. McGusty's place gave the following result on analysis:

No. 33.

Fe	24.23
Mn	1.91
P	.88
S	.04
SiO_2	12.50
Al	6.15
Insoluble	18.66
CO_2	5.40

The low percentage of CO_2 in the above analysis proves that the iron of the "ore" is almost entirely oxidized. A sample taken from the outcrop at the Cemetery bridge shows the presence of more carbonate, as the next analysis proves:

No. 34.

	BEFORE CALCINING.	AFTER CALCINING.
Fe	21.25	25.73
Mn	1.71	2.07
P	.96	1.16
S	.17	.17
SiO_2	10.25	12.41
Al	4.63	5.61
Insoluble	21.25	25.73
CO_2	10.00	

Two and one-half miles northwest of Enterprise near junction of Chunkey Creek and a tributary at what is known as the Linton Hill, formerly part of the Col. L. B. Brown place, the ore again outcrops in a hill-slope. The material is very similar to that at McGusty's, is 8 to 10 feet thick, and underlaid by the same gray shell marl and overlaid by red sands. A representative sample of ore from this locality gave the following analysis:

No. 35.

Fe	30.32
Mn	1.75
P	.78
S	.06
SiO_2	9.06
Al	2.61
Insoluble	23.35
CO_2	2.50

At Dunn's Water Mill four miles northwest of Enterprise occurs the last outcrop in that direction. At this point a deep gorge of Chunkey Creek has laid bare 65 feet of the Tallahatta, or lower Claiborne aluminous rock, above which lies five feet of the scutella bed found at Enterprise, here highly glauconitic. This is overlaid by nine feet of highly ferruginated oxidized glauconitic marl having casts and moulds of shells. This bed constitutes the "iron ore." Gray clays and red sands reach to the top of the section, a vertical distance of 40 feet. The ore at this outcrop shows irregular enrichment, certain lines showing much better grade than the general mass. A sample from this locality gave the following analysis:

No. 36.

Fe	32.21
Mn	1.85
P	1.12
S	.09
SiO_2	9.04
Al	6.74
Insoluble	6.42
CO_2	1.20

At this point the scutella bed, which just below Enterprise is 12 feet above the water level, is 70 feet above the river, making a dip toward the south of both the scutella and ore beds of 14½ feet to the mile, without allowing for the fall of the river. (See Frontispiece.)

The only locality south of Enterprise which has furnished material of sufficient promise to seem to justify examination and analysis is at the old Moore mill site on the west bank of the Chickasawhay three-fourths of a mile below town. This material is a very dark almost black nodular marl, the color being due to the abundance of glauconite. The material shows the effect of but little oxidation. The thickness of the deposit is not known, only a few feet, 7 feet thinning down to 2 feet, being exposed above the water's edge. It is probably identical with the oxidized iron marl at McGusty's and Dunn's mill. A sample of this material gave the following result on analysis:

No. 37.

	BEFORE CALCINATION.	AFTER CALCINATION.
Fe	23.55	28.95
Mn	1.91	2.34
P	1.53	1.88
S	.15	.18
SiO_2	12.52	15.39
Al	3.39	4.16
Insoluble	10.64	13.08
CO_2	22.80	

Col. L. B. Brown, of Enterprise, states that a body of "iron ore" similar in character with that of Enterprise occurs in a cut on the west bank of Long Creek ten miles east of Enterprise. He further states that he has noted outcrops of the same material at the town of Union, in Newton County, and has traced it into Neshoba County, where it occurs in large quantities near Laurel Hill. The writer has not seen any of these outcrops, but has much reason to accept the correctness of Col. Brown's observations. The Lower Claiborne materials outcrop in the region mentioned, and it is quite likely that outcrops of the oxidized glauconitic marls of the formation constituting "iron ore" may occur.

In 1887 A. F. Brainard, of Birmingham, Alabama, examined and reported upon the iron ores at Enterprise, thinking favorably of their development. Three analyses of samples taken by him are as follows:

No. 2.	Iron	51.11
	Silica	7.54
	Phosphorus	.078
No. 3.	Iron	42.32
	Silica	19.32
No. 6.	Iron	46.80
	Phosphorus	00.28

He gave no results following roasting the ore. The deposits were later examined by E. T. Cox, at one time State Geologist of Indiana. Samples collected by him gave average analyses as follows:

Metallic Iron	38.15
Phosphorus	.28
Silica	19.82
Sulphur	Trace

The writer has visited all the ore-bearing deposits in the vicinity of Enterprise, having examined them on several occasion, since in company with Dr. C. Wythe Cook, of the United States Geological Survey. Average samples from representative outcrops were taken and carefully analyzed, and the results both before and after calcination of the ore were noted. Anaylses of five samples (as given above) gave the following result before calcining:

Metallic Iron	26.31
Manganese	1.81
Phosphorus	1.05
Sulphur	.10
Silica	10.67
Alumina	4.70
Insoluble material	16.06
Carbon dioxide	8.38

Three of the above five samples analyzed showed but little CO_2, the two that showed high CO_2 were calcined, with the following average results after calcination:

Metallic Iron	27.34
Manganese	2.20
Phosphorus	1.52
Sulphur	.175
Silica	13.90
Alumina	4.88
Insoluble matter	19.40

The average iron content of the same two samples before calcination was 22.40; it will thus be seen that the general average of the five samples is raised somewhat, but the ore is still a lean ore. The silica and insoluble ingredients are high and the percentage of phosphorus is too great to justify expectations by the acid Bessemer process.

It is to be noted that in the various series of analyses there is some diversity of results obtained, enough to justify difference of opinion as to the value of the deposits. The analyses reported by Mr. Brainard averaged 46.7% iron. Based upon this, together with a rather low phosphorus content obtained, a favorable opinion was formed of this ore, and a sample of iron obtained from it was analyzed by Witherow, of Pittsburg, who said of it that he thought it would make a fine Bessemer pig, and that if the quantity was present the future of the deposits was bright for iron and steel production.

Prof. Cox, whose analyses have been given above, and which showed a lower iron content, with silica and phosphorus about the same, expressed the opinion that this iron would become important because of the quantity, facility of mining, and uniformity of quality of ore, removing the necessity of sorting preparatory to smelting; at the same time he expressed the opinion that it contained too much phosphorus for the acid Bessemer process.

The results of analyses made by the Mississippi Geological Survey during the year 1912 show much less favorably than those of former investigators. The samples were carefully collected by the State Geologist himself, and are believed to represent a fair average—they are certainly not below an average—and the analyses were very carefully made by our chemist; so that we have confidence that the analyses show the average quality of the ore. While we regret that our results make a less favorable showing of these ores than the results of former investigators, we feel constrained to base any opinion we may express of these iron deposits entirely upon the results of our own examinations.

In the light of these results we are not sanguine of immediate development of these deposits. That this iron is not a Bessemer ore seems evident. Because of fields already developed so nearby and furnishing ores that are equally good in all, and much better in some respects, under present commercial conditions it is not probable that these ores will come into the market at an early date.

It may be said of these deposits, however, that they lie easily accessible to two railroads that enter Enterprise, and hence spur tracks could be run to the ore beds without grading and at a minimum cost of construction. The ore is soft and friable and lies at the surface over considerable areas, so that it could be mined in open cuts about as easily as clay could be removed from a pit.

The ore is too lean to be shipped out economically for smelting elsewhere, but, if developed, would have to be smelted at or in the immediate vicinity of the mine, and since abundance of timber occurs on the ground suitable for the manufacture of charcoal it would be economy to use charcoal for smelting.

Prof. Cox, in reporting upon this ore, estimated the cost of manufacture of a ton of pig iron from this ore by the charcoal method, giving the following figures:

3 tons of Iron ore at 50c per ton	$ 1.50
100 bushels charcoal at 3½c per bu	3.50
Limestone flux	.50
Labor	1.50
Extras	.50
Total	$ 7.50

It is probable that this estimate is somewhat too low. It is hardly probable that less than 125 bushels of charcoal would be consumed in the production of a ton of pig iron, and that the charcoal could be made for less than 5 or 6 cents per bushel. At 5 cents a bushel, 125 bushels of charcoal will cost $6.25; leaving the other figures as they are, this would make the cost of a ton of pig iron $10.25. The average price of Gray Forge pig iron at Pittsburg is about $15.00 per ton, so that if the pig produced from the Enterprise ore should be of this grade, there would be a margin of $4.74 per ton, assuming the cost given above for making the pig. By the time the output of the furnace reached the iron markets, this margin would be further reduced.

By using such methods in developing this field as suggested above and in the discussion of the Potts Camp iron fields, it might be possible to secure a margin of profit, but it would hardly be such to be classed as a tempting enterprise for capital.