# A study of the economic Iron Ore Deposits of Tenn.

Including Reports on LaFollette, Rockwood, Ooltewah & Sweetwater occurrences.

Submitted as a Thesis for a degree of Bachelor of Science in Mining Engineering University of Tennessee.

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SOFT IRON ORE IN TENNESSEE.

For a distance of three miles along a range of low hills near Sweetwater, Tenn., a body of soft iron ore has been traced and has been opened up at different points.

The ore is found in a body of indefinite dimensions, in which traces of stratification are slightly perceptible, and suggest a derivation by disintegration from a hard bedded deposit.

The ore has a fine granular texture, like moist sand although streaks and bands of clayey and loamy ore are found. Some nodules of manganese oxide occur. The surface of the area is strewn with fragments of a fossil limestone, rich in iron but not sufficiently rich to be valuable as an iron ore. The body varies from place to place in color, being at some points a brilliant red, which material would be suitable for paint, in others a bluish shade, and at other points nearly black. It is near the impossible to judge of the smelting quality of the ore by its color, or from its consistency, whether clayey or sandy.

The origin of this ore has been studied by different geologists but no conclusion of any definiteness has been reached. It is possibly associated in time of origin with the fossilif-

erous Clinton iron ores, but its physical condition is altogether different from that noticed of the Clinton ores. A determined effort to exploit this ore has been made toward the Northern end of the range, a distance of about 1000 feet from the Bristol & Chattanooga Division of the Southern Railroad. A siding has been put in here, but as yet the ore is transported from the mines to the cars by wagons only. The mining is carried on in open cut and the ore is of such soft variety that it can be picked and shoveled. The ore is used by the Virginia Iron Coal & Coke Company, by the Chattanooga Iron & Coal Company, and by the La Follette Coal Iron & Railway Company, and has given satisfaction. Its greatest drawback is its fine granular texture, but this difficulty may be overcome in the same manner as the soft iron ores of the Lake Superior region are utilized. Some of the ore approaches Bessemer grade as to the phosphorous content, and the manganese present is highly prized. The following shows the analyses of the carload shipments of the ore to different iron works:-

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Iron | 43.20 | 47.84 | 48.18 | 49.30 | 57.90 | 59.20 |
| Phosphorous | .11 | .51 | .42 | .20 | .15 | .22 |
| Manganese | 1.37 | 2.78 | 1.64 | -- | -- | -- |
| Silica, | 21.50 | 16.22 | 18.44 | 16.56 | 3.24 | 5.30 |
| Al-2 0-3 | | 11.41 | 9.30 | | | |
| H-2 O | 22.00 | | | 15.25 | | |

No. 1 reported by Va. Iron Coak & Coke Co.,
No 2 -3 " " Chattanooga Iron & Coal Co.
No 4 -5-6 " LaFollette Coal Iron & Ry. Co.

IRON ORES OF TENNESSEE.

ROCKWOOD DISTRICT-

Location and Extent.

The Rockwood District lies in the Tennessee River Valley between Harriman and Dayton Tenn., and extends eastward form the base of the Cumberland Escarpment- or Walden Ridge, for about ten miles. The area is principally in Roane County. There has been some mining carried on along the west side of the valley between Harriman and Spring City a distance of 25 miles. The Rockwood formation outcrops along the river bed near the mouth of White Creek. Ore has been mined at 5 or 6 places in this strip. Six miles to the east of Euchee there is another outcrop of Rockwood formation about ten miles in length from northeast tosouthwest. There are mining operations going on at the upper end which is near Welker.

The ore outcropping along Walden's Ridge is very near the Queen & Crescent and the Tennessee Central Railroads.

The ore mined at Euchee is carried in boats down to a point opposite Dayton. The Welker ore is also shipped down the river from Seven Islands to Caney Creek. Railroads operate in conjunction with the boats.

ROCKWOOD-CARDIFF AREA.

Strips of the Clinton formation outcrop along the southeast side of the Cumberland Mountains. The outcrop is not continuous to a very great distance on account of faulting. The Clinton formation is composed of shale, sandstone, and iron ore beds. It usually forms the foot hills in front of the Cumber-

land Escarpment. The beds which dip to the northwest are overlain by the Mississippian chest and limestone, shale, and beds of coal. The Clinton formation rests on the Chickamauga, under which is the Knox dolomite. The next formation belongs to the Cambrian. The Rockwood formation is found to contain one workable ore bed, which lies between Rockwood and Harriman, and also at a few points as far south of Rockwood as Glen Alice. The average thickness of the ore bed is about 3¼ feet. Between Rockwood and Cardiff the normal thickness of the ore varies between 2½- 4 ft., which includes a few shale partings ½ -1 inch thick.

No prospect drilling has been done between the ends of the present slopes and the escarpment of Walden's Ridge, so that the character of the ore beyond the present workings is unknown.

The coal used in the ovens for the manufacture of the coke has the following analysis:

Coal Analysis- Rockwood, Tenn.

| Constituent | Unwashed. | Washed | Coal with Sp. Gr. 1.37. | Coal with Sp. Gr. over 1.37 |
|---|---|---|---|---|
| Ash | 17.24 | 12.32 | 6.77 | 38.06 |
| Vol. Matter | 30.44 | 30.36 | 31.83 | 23.10 |
| Fixed Carbon | 52.17 | 57.17 | 61.25 | 38.69 |
| Sulfur | .73 | .66 | .55 | .80 |
| Moisture | .50 | 2.00 | - | - |

The Roane Iron Company owns about 8000 acres of coal land along Walden's Ridge. The bulk of the coal is being mined from the slopes directly behind the furnace stacks at Rockwood. The coal here--occurs in a long trough which pitches under the mountain at an angle of about 80° d The cross entries are driven at such slope that the proper drainage may take place toward the slope. All coal showing a thickness of over 4 feet is worked. The coal is bituminous and shows good coking qualities. 350 coke ovens of the Bee Hive type produce the coke used in the reduction of the ores at this place.

Analysis of cokes used in furnace.

| Where made, | Ash | Volatile Carbon | Fixed Carbon | Sulfur |
|---|---|---|---|---|
| Rockwood | 15.65 | 2.23 | 81.97 | .48 |
| " | 13.75 | 1.83 | 84.27 | 1.21 |
| " | 13.22 | 1.55 | 85.07 | .45 |
| " | 12.78 | 1.54 | 85.50 | 6.85 |
| LaFollette | 10.92 | 3.55 | 85.38 | .70 |

Analysis of Limestone used in the Blast furnaces at Rockwood Tenn.

| Sio-2 | $(Fe\ Al)_2$ 0-6 | C aa O | Mg O | Mg. Cs-3 | CaCos | Alkali total |
|---|---|---|---|---|---|---|
| 2.55 | 2.05 | 50.85 | 2.12 | 4.55 | 90.80 | 95.25 |
| 3.81 | 2.67 | 46.95 | 4.54 | 9.55 | 83.84 | 93.37 |
| .82 | .82 | 32.10 | 19.52 | 41.05 | 57.32 | |
| 2.40 | 1.24 | 48.10 | 4.92 | 10.31 | 85.90 | |

The Principal ~~s~~ quarries of the Roane Iron Company are situated about 1¼ miles southwest of the furnace and are reached by a narrow guage railroad. The supply of rock is practically inexhaustable.

WELKER MINE.

This mine is owned and operated by the Rome Iron Company. In the east slope of both parts of the ridge, which extends from Round Islans in a south of southwest direction, is a fairly thick bed of Clinton ore with a shale parting. The measures are folded into a syncline. The ore lies in two long, cannoe shaped synclinial basins 4-4½ miles in length and about one third mile wide. It outcrops on the limbs at the ends of the syncline. The soft ore extends to a depth of 150 feet on the east limb of the syncline in the northeast basin. Ore is soft to a depth of 400 feet. The upper thickness is 5 feet while below the shale parting the ore is 2 feet thick.

Mining operations have been carried on only in the upper portion from a point near the Tennessee River southwestward for about 3.5 miles. Mining by stripping has been carried on here for more then twenty years and is still the only kind of mining at this place. The shale can be stripped to a depth of 30 feet with profit near Hackler's Gap. Ore is mined from the vertical bed on the east limb of the syncline. At the extreme north end of the basin, the overlying shale has been removed from the ore beds .

The change from the soft to the hard ore occurs just below the permanent ground water level- a striking example of the change is given in the stripping operations.

At present there are about 150 men employed at these mines. The cost of mining is about $1.00 per ton.

The product is carried on the Company's Railroad from the mines to the Tennessee River, where the cars of ore are transferred to a barge and towed by a steamboat down the river to a point near the mouth of Caney Creek. Here they are picked up by a locomotive and hauled over a branch of the Cincinnati, New Orleans & Texas Railway as far as Cardiff. From this point the ore is carried over the main line of this railroad to the furnaces at Rockwood.

The Roane Iron Company produce about 12,000 tons of ore per month.

THE FURNACE PLANT.

Although the furnaces have been in operation for several years both of them are in fairly goodcondition. Only one furnace is in operation at the present time since the demand for foundry pig iron is not great. The average daily capacity is 150 tons pig iron and the average % yield of iron on theore is 40.

Furnaces number <u>one</u> and <u>two</u> are 75 feet high, 16 ft diameter at the base and 10 ft. diameter at the tuyeres. The 32 boilers, 5 Woods 250 Hp 3 Wheeler 300, 24 Walsh & Widnes 80 Hp each, at the furnace, have an aggregate horse power of 4000. There are 7 standard guage locomotives used in connection with furnace and ore haul. The Roane Iron Company have about 60 cars and 8 -10 ton slag pots.

All castings used by this company are made in their own foundry. The Foundry has two cupolas whose diameters are respectively 42" and 60". One 6" x 8" Engine runs the two blowers which furnish 48" air each. Sand Moulds are used. One

pattern maker is employed to keep all forms and patterns in shape, while two moulders , two helpers and one cupola man, one foreman , one foundry man do the foundry work.

The machine shop which is in close proximity to the furnace as well as to the foundry , is equipped with 3 laths , 16", 24", 48" respectively; one planer 37" X10'; one hack saw; one power punch & shear; an air ~~horse~~ is used to lift material about in the machine shop; one 1½" bolt machine; one set of hand rolls and one hand bucking machine. One shop engine 10" x 16, which runs at 125 r p m furnishes power to machine shop; the air cylinder which is attached is 6" x 16".

There are eleven men employed in the machine shop, five of whom are machinists, one boiler maker, two boiler maker helpers and one apprentice. The balcksmith shop has one steam hammer and two forges. One blacksmith and one helper sharpens all drills for the limestone quarry and does all the other blacksmith work for the coke ovens, washer, blast furnace and machine shop. Eight Hugh Kennedy Stoves 70 & 80 ft. high. Six blowing engines from Magbeth Iron Company, Cleveland, Ohio. The steam cylinders are 42" x 5' and the air cylinders are ~~X~~ 42" x 5'. Steam pressure average is 85# and air pressure varies between 9 and 15# .

Roane County ranks first in the production of iron ore and also in pig iron. Lawrence comes second.

There are *eight* slopes, all near Cardiff, now in operation. Brown Mining Company operate the mines under contract.

| Name of Slope, | Cardiff, | Clymer, | Patten, | Evans, | Prospect, | Wright, | Baker, | Carter. |
|---|---|---|---|---|---|---|---|---|
| Length in ft. | 1000 | 400 | 800 | 500 | 400 | 600 | 800 | 1200 |
| No. Men Emp. | 75 | 15 | 60 | 20 | 30 | 40 | 90 | 40 |
| No Tons. Pro. | 150 | 30 | 100 | 30 | 50 | 90 | 175 | 75 |

These slopes are 5' x 6' x 7'. All the slopes are provided with steam hoisting plants varying in capacity from 70 to 90 horse power. The water which is necessary to handle is small and a Knowles Pump having a 4" discharge is used for the first lift and one with a 2" discharge is usdd for the second lift. The Cole fans are used exclusively in the ventilation of the mines. The average cost of mining a ton ore for the Rockwood District is about $1.00.

MINING OPERATIONS.

The ore was originally won by driving the slope down to the top slate at about the angle of dip. Entries were turned off to the ore at a distance of 100-200 ft. Since then, although the first cost is much greater, the slopes are driven in the south slate on account of it being much stronger. Entries are turned off every 100 ft., and rooms are turned off every 30 ft. and a pillar of 20 ft. is left standing between every room. The ore in

the pillars is usually taken out as that portion of the ore body is removed.

Average charge used in Furnace at Rockwood.

Roane Iron Company Furnace No. 2, Dec. 22-1910

| No Charges to furnace. | Pounds of Coke | Stock per Charge. Lime | Co. Ore. | River Soft, | R.H. | M.C |
|---|---|---|---|---|---|---|
| 47 | 5800 | 850 | 7500 | 2100 | - | 600 |

Analysis of iron ores Rockwood Tenn. 1910

Samples taken from all cars that came in for two weeks except hard river ore.

:-

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| Location | Cardiff | ROCKWOOD Clymer | CARDIFF. Patton | Evans | Prospect | Wright | WALKER MINE River Soft | R.H. |
|---|---|---|---|---|---|---|---|---|
| Date | 6-6-10 | 6-6-10 | 6-15-10 | 6-16-10 | 6-17-10 | 6-6-10 | 6-20-10 | 6-6-10 |
| No. of cars sampled. | 38 | 24 | 12 | 19 | 7 | 25 | 15 | 12 |
| % of iron d. | 40.80 | 43.90 | 39.60 | 39.40 | 38.50 | 38.70 | 44.60 | 25.60 |
| Sio.2 | 10.08 | 8.12 | 12.02 | 6.96 | 8.96 | 9.18 | 15.42 | 26.68 |
| H.2 O | .96 | 2.76 | 1.96 | 2.04 | 1.14 | 2.86 | 16.64 | .20 |
| Metalis iron. | 40.41 | 42.69 | 38.81 | 38.62 | 38.08 | 37.63 | 37.24 | 25.55 |
| Insol.Sio. 2 | 9.98 | 7.90 | 11.78 | 6.82 | 8.86 | 8.92 | 12.98 | 6.61 |
| Al. 2 O,3 | 5.47 | 5.35 | 6.56 | 6.43 | 4.78 | 6.12 | 6.56 | 3.09 |
| Ca O | 9.60 | 11.00 | 8.05 | 12.25 | 11.65 | 10.75 | .35 | 23.70 |
| Ca. Co 3 | 17.14 | 19.65 | 14.37 | 21.87 | 20.80 | 19.37 | .62 | 42.32 |
| Mg. O | 2.66 | 1.82 | 2.60 | 1.82 | 2.64 | 2.31 | .41 | 1.11 |
| Mg. Co 3 | 5.58 | 3.82 | 5.46 | 3.82 | 5.54 | 4.85 | .85 | 2.34 |
| P | .58 | .55 | .60 | .64 | .60 | .56 | .52 | .44 |
| Co. 2 | 10.46 | 10.64 | 9.18 | 11.62 | 12.05 | 11.16 | .71 | 19.85 |
| H-2 O Comb. | 1.07 | 2.31 | 3.96 | 3.11 | 1.42 | 3.78 | 10.30 | 5.67 |
| S. | .33 | .07 | .04 | .11 | .08 | .09 | .02 | .068 |
| Loss on ignition. | 11.53 | 12.95 | 13.14 | 14.73 | 13.47 | 14.94 | 11.01 | 25.52 |
| Mn. | .15 | .10 | .15 | .10 | .25 | .20 | .78 | .15 |


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IRON ORES OF TENNESSEE.

LAFOLLETTE DISTRICT.

The Clinton formation outcroping along the foot of the Cumberland Mountains is ore bearing from Cumberland Gap Va. to LaFollette, Tennessee. Near Cumberland Gap there are three ore beds ranging in thickness from 6 inches to 30 inches. Only the upper bed which ranges in thickness from 15 to 20 inches is workable. Southwestward toward LaFollette the ore increases in thickness to 3½ feet. Here practically all the soft ore has been mined out so that only a hard ore carrying 26-32 % metalic iron remains. It is estimated that about 16 million tons of such ore is still available in the Cumberland Gap-LaFollette District.

At LaFollette the iron outcrop runs parallel to the Cumberland Mountains, and is easily traced on the outcrop for several miles ~~northward~~ eastward and ~~southwest~~ southwest of that place. The dip of the vein in this vicinity is very great, being almost vertical. The thickness varies from 2.5- 3.5 ft. with no shale parting.

The slope mine is located just south of the water gap in the mountains, and is driven at an angle of 30° in a southwest direction. The slope connects with two levels which are 60 feet apart. Square set timbering is used in the slope. All

the timb ering necessary to use in the stopes (is the timbering necessary to use in the stopes) is the stull, which prevents the closing in of the two walls. Notches are usually cut in the sides of the stopes to hold the stulls in place until the lateral pressure begins to hold them. With the exception of six or seven feet of ore just above the level, all the ore is mined out. Ore chutes or necks are opened up, usually at every 25 or 30 feet for the purpose of removing the ore from the stopes. The slope of the chutes are about 45 degrees.

Rand ratchet drills are used. 15-20 men are employed to a shift of ten hours and the mine is run by two shifts. One man working 10 hours and using a ratchet drill can average 7 holes, each hole being 1½ inch in diameter and 4 feet deep. Drill men are paid $1.65 per day; other laborers receive $1.00-$1.15 per day. The mine drains into a " sump" which is 40 feet deep and the water is pumped once a day to the surface. The levels slope toward the foot of the ~~river~~ main slope and the loaded cars run by gravity down the level, and one mule pulls the empty cars back to the ore chutes. 40% dynamite is used. The ore is hand picked on the cars, after reaching the surface, and also in the bins over the railroad track. The power is furnished by two 75 HP boilers and a Rand Stage Compressor. The engine house is located across the creek from the slope. Two men are here employed. This mine is operated by the LaFollette Iron Company. This Company operates also the coal washer, coke ovens, limestone quarry, machine shop, blast furnace and Seneca Iron Mines.

The coal used in the washer is purchased from the LaFollette Coal Iron & Ry. Co. The washer is modern in every respect, being one of the Stewart jig type . The coal crusher is one of the Williams Patent. The capacity of the washer is 1000 tons per day.

There are two distinct types of coke made; the 72 and the 48 hour coke. The charge in each case is 7 and 5½ tons respectively. The coke yield is about 50%. All the ovens are the bee hive type and are built in four rows; two single and two double. There are 298 ovens and the estimated cost of each is $500.00.

The limestone quarry is located about half way between the ovens and the furnaces. The strata are about vertical and yield a good limestone for flux. The limestone from this quarry has been used for twenty years to make lime and it is still in use for this purpose as well as for a flux in the blast furnace. It is also used as macadam. Two Ingersol Rand Percussion drills keep the rock broken down. The crusher used here is a jaw type machine, made by Austin Mfg. Co., Harvey, Illinois.

ANALYSIS of LIMESTONE from LAFOLLETTE IRON COMPANY'S QUARRY, LAFOLLETTE, TENN.

| | i | ii | iii | iv |
|---|---|---|---|---|
| Sio | 1.67 | 3.20 | 2.18 | 3.00 |
| Fe at 212°F. | .75 | .52 | .72 | |
| Al 2 0 3 | .44 | 1.88 | .89 | 1.11 |
| CaO | 49.40 | 51.00 | 50.80 | 49.20 |
| Mgo | 3.64 | 1.12 | 1.71 | 3.42 |

ANALYSIS of ORES USED IN BLAST FURNACE of LAFOLLETTE IRON CO.

| Location | Seneca mine. | Slope mine. | Brown Ore (Georgia) | Brown (Etowah) |
|---|---|---|---|---|
| H 20 | 5.00 | 6.00 | 10.00 | 9.00 |
| Fe at 212 | 27.10 | 32.35 | 40.94 | 46.30 |
| Si0 2 | 20.76 | 8.00 | 19.00 | 15.46 |
| Al 2 0 3 | Undet. | 10.84 | 4.65 | 6.59 |
| Coo | 10.22 | 22.05 | Trace | Trace |
| Mgo | 4.67 | 3.17 | Trace | Trace |
| Phos. | ---- | .64 | .64 | .38 |
| Mn | ---- | 1.26 | 1.54 | .61 |
| S | ---- | ---- | ---- | .07 |

SENECA MINE.

This mine is located about two miles southwest of slope mine and LaFollette. The ore tipple is on the L.&.N. railroad and is about 1/4 mile from the mine. The mine level is driven towards the southwest. The level runs under the spurs of the mountain, the level already being driven through the first hill and is about half way through the hill adjoining. The tunnel through the hill slopes both ways but the slope on the north side is much the greater.

The tram road from the mine slopes toward the tipple. Threecars are carried at a trip and a mule is used to pull cars back to mines.




Section parallel to addet showing position of tunnel with respect to surface of the ground.

The ore is winding but the general direction of the strike is parallel to the mountain range. 10-15 men are employed; stoping is carried almost to the surface and the ore ~~bucks~~ feeds into ~~clusters~~ chutes which are opened at times to load the cars beneath. Vein is almost vertical, 40% dynamite is used.

BLAST FURNACE PLANT,------ LAFOLLETTE, TENN.

There is one blast furnace here which has a height of 73.5 ft. The original height was 95 ft. but it was cut down to 85 ft. and then down to the present height. The smoke stack is 175 ft. high. There are four Kennedy Stoves 80 ft. high. The water stand-pipe is 60 ft. high. There are six brick cased boilers, which are constructed so as to burn waste gases under them. Average steam pressure is 100#. The blast is furnished by three blowing engines, of 1000 horse power each. Average temperature of blast is 900°. Sometimes the temperature is as high as 1200° but there is no advantage gained from the high temperature in that it burns out the stoves. The ore is kept in 6 or 8 feet of the top of the furnace. They make high silica slags often running as high as 55% sio. The amount of native ore used constitutes about 1/6 of the amount of ore smelted.

The foreign ores used come principally from Georgia and average about 40% Fe.

A ~~forum~~ former charge used in the furnace is as follows:-

| | |
|---|---|
| Coke | 6,400# |
| Ore | 13,470# |
| Lime-S | 36,70# |
| | 23,540# |

The cahrges used at the present time are shown below.

| | | | |
|---|---|---|---|
| 1 | Fossil Ore($\frac{1}{3}$- 1/6) | 4140# | Native |
| | Boones Path (1/6) | 2070# | Virginia. |
| | Brown Ore ($\frac{1}{2}$) | 6210# | Georgia. |
| | Lime S. | 3400# | |
| | Coke | 1220# | |
| | Total | 17.040 # | |
| ii | Fossil Ore | 3840 | |
| | Etowah | 3840 | |
| | Cummock | 1920 | |
| | Boone's Path | 1920 | |
| | Lime S | 3240 | |
| | Coke | 1220 | |
| | Total | 15.980# | |

The analysis of the coke used in the furnace varies between :-

75-80% Fixed Carbon

3.5- 4.5% Volatile Combustible

.72-75% Sulfur

13.5-14% Ash.

Red Hemotite Iron Ores of Tenn. used as metalic Paint.

At certain localities in southeastern Tennessee the Clinton oolitic hemotite occurs in beds too thin to be profitably mined as iron ore under present conditions. Much of this red ore is of the " soft" variety and contains an unusually high percentage of ferric oxide, with but little silica and alumina and practically no lime. Its chemical composition renders it an ideal red paint material and owing to its physical condition, it is easily crushed and ground. With the rapid increase of building in the South together with the manufacture of railroad cars and structural iron, has come a demand for metalic paint that has given these beds of ore an unexpected importance.

The reason why thisore can be mined profitably, for paint material and not for iron are briefly these: In order to bring the cost of production within the limits of market prices of smelting ores, mining must be conducted on a scale envolving the use of power, cables, and general mine equipment, and usually a railroad spur a mile or more in length would have to be built. The total amount of ore in sight indicates that the beds would be exhausted too soon to warrant this outlay. Furthermore, the nature of the deposit is likely to be such that a larger quantity of shale than ore would have to be removed either to win the ore or provide the head room necessary for regular mine work, thereby rendering it doubtful whether the ore could be

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profitably worked for iron, even if the qyantity in sight were assuredly greater. When the right kind of ore occurs under these conditions it is sufficiently valuable to paint manufacturers to bear the cost of mining by hand and haulage by wagon to the nearest railroad. Ordinary grades of iron ore, such as are smelted in this district, are not suitable for paint manufacture and therefore they cannot compete with the more expensive material here considered, although a small amount of high grade ore that would otherwise be smelted is sold by the iron producers to paint makers on account of the good price it commands.

Occurrence and Developement.

The red paint ore produced in Tennessee is obtained mainley from White Oak Mountain and a smaller ridge lying to the east of it. The mines are all within four miles of Ooltewah, a station on the Southern Railway, fifteen miles east of Chattanooga.

White Oak Mountain is developed on the west limb of a narrow syncline that trends north 15° east. The Rockwood formation, here consisting largely of hard brown sandstone, forms the ridge of White Oak Mountain; also the lower ridge, about a mile further east, on the east limb of the syncline. The upper portion of the formation appears to contain the ore beds and their inclosing shales. Nearly 25 years ago soft ore was obtained in large quantities from surface workings near the cuts of the Southern Railway through Julian Gap and McDaniel Gap, and from the strip

of White Oak Mountain two miles long, between these gaps, considerable soft ore has been removed in past years. At present underground mining is in progress here. On the Tallon, Parker and Craven properties a bed 14-18 inches thick containing in places a shale streak, is worked by slopes and short drifts driven along the strike of the bed, with rooms turned up and down the dip. The main openings perhaps 30 inches in height, are high enough only to admit a shallow car and the miners must crawl in on hands and knees, and work in a sitting posture. The roof over the main entry is in most places supported by posts, but a few of the rooms are timbered. None of the workings have been carried underground more than 75 feet. The beds dip 22° 25° S 65 E., but there are many minor crumplings in the strata that change the dip considerably and make mining more difficult. The ore is so firm that it has to be blasted, yet it is thoroughly crushed. The material is very fossiliferous and apparantly contains only a moderate amount of silica for a well leached ore. The partial analysis of an Ooltewah paint ore from this locality is as follows:-

SiO2------11.90

Fe2O 3 83.14.

The mines on these properties are being worked by lesees who pay 25¢ per ton royalty on ore taken. The ore is hauled by teams 1-1/2 miles to Well's Switch at a cost of about 50¢ per ton, or wagon load, and it brings $2.85 on the cars. The freight 30¢ per ton to Chattanooga is paid by the purchasers. Each miner gets out about one ton of ore per day, and wages run from $1.00 to $1.50 per day. It is plain that the cost of the ore

is such that while red ore for smelting sells at about $1.00 per ton, these ores are not available for making iron.

North of Well's Switch or Julian Gap, the ore is being worked in a small drift with upshoots. The ore is deep red, firm material with flattened grains, mingled with fragments of Crinoid Stems, all of pure hemotite. The bed varies in thickness, thinning from 14 down to 5 inches owing to a squeeze from the overlaying shale. The average thickness is about 10 inches and it seems possible to mine a bed as thin as this where there is but a short wagon haul to the switch. A second seam of ore 6-7 inches thick, occurs 3 feet below but is not worked.

In the valley east of the Craven property considerable ore in bumps and pebbles of the size of cobblestones has been strewn by erasion down the stream gullies and over the fields.

The pebbly ore is being gathered and shipped to paint manufacturers. The total shipments from Well's Switch amounts to about 50 tons per month.

In the ridge on the east limb of the White Oak Mountain syncline, north of Hinch's Switch the red ore occurs apparently in two beds, but examination discloses the fact that a single bed of ore has been repeated by a close, overturned fold. Locally the same bed is displaced and repeated by faulting, and one mile south of Hinch's Switch the entire Rockwood formation on the east limb of the anticline is engulfed in a fault.

The ore where it is mined north of the railroad in the east ridge averages about 12 inches in thickness although it reaches 16 inches in places. Within the seam are a few partings of shale locally developed. Blocks of the ore show slickensides perpendicular to the bedding . From Hinch's Switch northward for four miles soft ore has been stripped for furnace use. At presnttunderground drifts and slopes about one mile north of the railroad owned by the Chattanooga Paint Company are in operation. About 35 tons of paint ore are shipped per week from this point. The approximate composition of the ore is as follows.

Analysis of ore from Chamberlain track N. of Hinch's Switch.

| | | |
|---|---|---|
| Silica | $SiO_2$ | 16.45 |
| Ferris Oxide | | 80.00 |
| Phosphorus | P | .28 |
| Water | $H_2O$ | 1.81 |
| Total | | 98.54 |