MINERAL PAINTS.

SOUTHERN RED HEMATITE AS AN INGREDIENT OF METALLIC PAINT.

By Ernest F. Burchard.

INTRODUCTION.

At certain localities in northwestern Georgia and southeastern Tennessee the Clinton oolitic hematite 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 metallic paint that has given these beds of ore an unexpected importance.

The reasons why this ore can be profitably mined for paint material and not for iron making 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 involving 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 deposits is likely to be such that a larger quantity of shale than ore would have to be removed either to win the ore or to provide the head room necessary for regular mine work, thereby rendering it doubtful whether the ore could profitably be worked for iron, even if the quantity 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 of haulage by wagon to the nearest railroad. Ordinary grades of iron ore, such as are smelted in the district, are not suitable for paint manufacture, and therefore they can not 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.

Most of this ore that is used for paint is ground by mills at Chattanooga, but a part of it goes to Birmingham. The paints made are the reds and dark browns, and a considerable quantity of the ground oxide is sold for coloring sand-lime bricks and mortars for pressed-brick work.

Geologic maps of the Chattanooga and Ringgold quadrangles show the distribution of the Rockwood ore-bearing formation in this region. These maps have been published in folios Nos. 6 and 2, respectively, of the Geologic Atlas of the United States, issued by the United States Geological Survey, and are available in many public libraries and in the offices of many mining companies. To persons familiar with the region the beds containing ores of value for iron making are fairly well known, but much of the territory intervening between the iron-mining centers has never been prospected with reference to the value of the ores for paint manufacture.

GEOLOGIC RELATIONS AND DEVELOPMENT.

GEORGIA.

Wildwood.—Along the west base of Lookout Mountain extends the anticlinal Lookout Valley. On both sides of this valley is exposed the Rockwood formation, with its strata dipping away from the axis. In Lookout Valley this formation consists of about 600 feet of calcareous shale, with some beds of blue limestone and fossiliferous hematite. Above the Rockwood and separated from it by a few feet of black Chattanooga shale lies the Fort Payne chert; below the Rockwood is the Chickamauga limestone. The Fort Payne chert has offered greater resistance to erosion than the adjacent rocks, and its base forms the crest of a ridge on either side of Lookout Valley, with the Rockwood shale on the inner slopes of the ridges. The Alabama Great Southern main line traverses this valley at distances of a quarter to half a mile from the eastern ridge.

The eastern ridge, particularly at New England, furnished soft iron ore to Chattanooga furnaces for many years, but now the ore obtainable by trenching or stripping has become exhausted and mining activities are for the most part temporarily suspended. At Wildwood, however, where the soft ore has been found suitable for paint manufacture, there is still some ore available for that purpose, part of

which was awaiting shipment in May, 1906. The rock lies nearly flat here and shows the following section:

Section of paint-ore bed at Wildwood, Ga.

	Inches.
Shale.	
Ore	8
Shale	¾
Ore	10
Shale	½
Ore	9
Shale.	

Estelle.—East of Lookout Mountain the Rockwood formation becomes thicker and contains less limestone, sandy shale and beds of sandstone being developed. At Estelle is exposed a good railroad section of the formation, nearly continuous from the Chickamauga limestone below to the Chattanooga shale above, and from this section, in which the rocks dip at angles of 5° to 9°, the thickness is computed to be 960 feet. The ore seams are just below the middle of the formation. Two ore beds about 25 feet apart, outcropping on the northwest side of the Pigeon Mountain syncline, are worked extensively at Estelle for iron ore to supply the Southern Steel Company's furnace at Chattanooga. The beds at this place dip 5° to 14° S. 50° E., and are to a large extent under a shallow cover, especially the upper bed. The lower bed is so thoroughly leached and so pure in places that the ore from certain openings at the mine is sold for paint manufacture rather than for smelting. On the west side of the hollow through which the Chattanooga Southern Railway passes are two openings, driven on the strike of the beds for 200 feet or more entirely in soft ore. The cover over the beds here is only 16 to 20 feet thick. Where covered by enough shale to include the higher ore bed the ore of the lower bed becomes hard. The following section shows the character of the lower ore bed at a distance of 200 feet from the mouth of one of these openings.

Section in soft-ore opening at Estelle, Ga.

	Inches.
Shale.	
Soft ore	4
Hard shale or "jack rock"	5
Soft ore	15
Shale	2
Soft ore	8
Shale.	

The composition of some of the ore from this place is shown by the following analysis:

Analysis of soft ore from lower seam, Estelle, Ga.

[Authority, Southern Steel Company, Chattanooga.]

Ferric oxide	72.86
Insoluble	21.00
Phosphorus	.40
Manganese	.30

TENNESSEE.

The red-paint ore produced in Tennessee is obtained mainly from White Oak Mountain and a smaller ridge lying to the east of it. The mines are all within 4 miles of Ooltewah, a station on the Southern Railway 15 miles east of Chattanooga.

White Oak Mountain is developed on the west limb of a narrow syncline that trends N. 15° E. The Rockwood formation, here consisting largely of hard brown sandstone, forms the ridge of White Oak Mountain; also the lower ridge, about a mile farther 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 twenty 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, 2 miles long, between these gaps, considerable soft ore has been removed in past years. At present underground mining is in progress here. On the Tallen, Parker, and Craven properties a bed 14 to 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 leached. The material is very fossiliferous and apparently 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:[a]

Partial analysis of Ooltewah paint ore.

Silica (SiO_2)	11.90
Iron oxide (Fe_2O_3)	83.14

The mines on these properties are being worked by lessees, who pay 25 cents a ton royalty on the ore taken. The ore is hauled by team 1½ miles to Wells switch at a cost of about 50 cents a ton, or wagonload, and it brings $2.85 on the cars. The freight, 30 cents a ton to Chattanooga, is paid by the purchasers. Each miner gets out about 1 ton of ore per day, and wages run from $1 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 per ton these ores are not available for making iron.

[a] Bowron, W. M., The Iron Ores of the Chattanooga District, Chattanooga Chamber of Commerce, November, 1903, p. 4.

North of Wells switch, or Julian Gap, the ore is being worked in a small drift with upshoots. The ore is a deep red, firm material with flattened grains mingled with fragments of crinoid stems, all of pure hematite. The bed varies in thickness, thinning from 14 down to 5 inches owing to a squeeze from the overlying 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 to 7 inches thick, occurs 3 feet below, but is not worked.

In the valley east of the Craven property considerable ore in lumps and pebbles of the size of cobblestones has been strewn by erosion down the stream gullies and over the fields. This pebbly ore is being gathered and shipped to the paint manufacturers.

The total shipments from Wells switch amount 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 1 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 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 4 miles soft ore has been stripped for furnace use. At present underground drifts and slopes about 1 mile north of the railroad, owned by the Chattanooga Paint Company, are in operation. About 35 tons of paint ore a week are shipped from this point. The approximate composition of the ore is as follows:[a]

Analysis of ore from Chamberlain tract, north of Hinch's switch.

Silica (SiO_2)	16.45
Ferric oxide (Fe_2O_3)	80.00
Phosphorus (P)	.28
Water (H_2O)	1.81

[a] Bowron, W. M., op. cit., p. 4.

THE MINERAL-PAINT ORES OF LEHIGH GAP, PENNSYLVANIA.

By EDWIN C. ECKEL.

During the summer of 1906, while the writer was in southeastern Pennsylvania examining the brown iron-ore deposits of that region, advantage was taken of a favorable opportunity to examine the well-known "paint-ore" mines and works near Lehigh Gap, in Carbon County, Pa.

Geology of the deposits.—A typical section in this district would be about as follows, from above downward:

Section containing paint ore:

	Feet.
Black slates (Marcellus).	
Clayey limestone ("Upper Helderberg")	0–6
Clay	0–1
Paint ore	0–6
Clay	2–20
Sandstone (Oriskany).	

The paint ore is an impure iron carbonate containing considerable clayey matter and some lime carbonate. Near the surface it weathers into brown oxide of iron. The "bed" of paint ore is not continuous, but thickens or thins, and in places disappears entirely. As to its continuity in depth no definite data are available, but at several mines the ore is said to thin markedly in depth, while the limestone bed thickens. These conditions can perhaps be interpreted best by assuming that the "paint-ore" deposit is the result of a replacement of the "Upper Helderberg" limestone.

Other occurrences of iron ore in the vicinity lead to the same conclusion. About one-half mile west of Millport, for example, the Oriskany sandstone shows an interesting exposure. Here a white residual clay is being worked in or below the Oriskany sandstone, which itself has been extensively quarried for sand. The point of interest is that the upper beds of the sandstone show replacement by brown ore along bedding and joint planes, while in places the replacement has affected the mass of the rock. Some specimens show a mass of brown ore inclosing scattered grains of sand. Evidently the

cementing material of the sandstone is less resistant than the grains themselves; but at times even the sand grains show replacement by brown ore. The result, on a very small scale, is the formation of ores like those of the Rich Patch, Lowmoor, and Longdale mines of Virginia.

Character of the paint ore.—The typical paint ore is light blue in color and rather distinctly laminated. Except for weight it might readily be mistaken for a sandy shale. Occasionally fossils are present in the ore, in which case it looks still less like an iron ore. Grains and nodules of iron pyrite are scatterd through the ore, but not to any considerable extent. The larger nodules of pyrite are picked out before the ore is sent to the kiln, and some sulphur is roasted off, but a sufficient number of small grains remain to give the paint a sulphur content of one-half to 1 per cent.

Analysis of crude paint ore, Lehigh Gap district, Pennsylvania.

Silica (SiO_2)	16.21
Alumina (Al_2O_3)	5.49
Iron oxide (FeO)	44.50
Manganese oxide (MnO)	1.19
Lime (CaO)	3.51
Magnesia (MgO)	1.08
Sulphur (S)	.67
Phosphorus (P)	.02
Carbon dioxide and organic matter Water	24.35

The analysis given above was made by Mr. A. S. McCreath.[a] The sample analyzed is evidently far richer in iron than the average material used in the manufacture of paint, as can be seen in comparing the above analysis with the analyses of finished paint given later.

Methods of manufacture.—Two firms are now operating in the district. Prince's Manufacturing Company is operating two kilns (one west of Millport, the other at Bowman's), and three mills, all at Bowman's. The Prince Metallic Paint Works operates kilns and a mill about half a mile east of Lehigh Gap.

The kilns used in the district are circular internally, with an interior section about 5 feet in diameter and about 16 feet in height. The fuel used is wood, burned in two furnaces, the heat being conveyed to the charge by a checkerwork of brick.

The ore is charged at the top of the kiln at the rate of 8 to 10 long tons a day. As the kiln holds about 16 tons, the ore is roasted for about two days. One cord of wood will roast 8 to 10 tons of ore. During the roasting the ore loses from 10 to 20 per cent in weight, and the lumps assume a brownish-yellow color on the outside. When broken open and pulverized, the powder is a deep brownish red.

[a] Ann. Rept. Pennsylvania Geol. Survey for 1886, pt. 4, p. 1404.

The roasted ore is crushed to about quarter-inch size in a Mosser pot crusher and then pulverized by millstones. The latter are of several types. At a plant at Bowman's five of the six stones in use were French buhrs; the other was a vertical rock-emery mill. At the Lehigh Gap plant all of the seven mills were rock-emery. Four of them were horizontal under runner stones; the other three were vertical. It is generally assumed that six sets of stones will handle the product from one kiln.

Character of the product.—The composition of the metallic paint from this district is fairly indicated by the following analyses:

Analyses of finished metallic paint, Lehigh Gap district, Pennsylvania.

	1.	2.	3.	4.
Silica (SiO_2)	37.20	37.20	35.30	37.79
Alumina (Al_2O_3)	9.60	9.40	10.70	10.61
Iron oxide (Fe_2O_3)	43.30	42.70	43.30	41.28
Manganese oxide (MnO)	.35	1.40	1.83	1.27
Lime (CaO)	.10	1.70	2.00	3.00
Magnesia (MgO)	3.35	1.70	1.91	2.03
Sulphur trioxide (SO_3)	2.38	1.88	1.95	1.94
Phosphorus pentoxide (P_2O_5)	.17	.14	.15	.14
Carbon dioxide and organic matter (CO_2)	2.40	2.60	1.50	2.68
Water	.60	.60	.90	.....
Metallic iron (Fe)	30.30	29.90	30.30	28.90
Sulphur (S)	.95	.75	.78	.77

Analyses 1, 2, 3 furnished by Mr. Thompson, president Prince Metallic Paint Company; analysis 4 quoted from Ann. Rept. Pennsylvania Geol. Survey for 1886.

The paint made in this district is a browner red than that made from the oolitic red hematites at Franklin, N. Y., and Chattanooga, Tenn. It is used mostly for car and other structural work, very little being used as mortar color.

Until quite recently the standard package for this paint was a 300-pound barrel, but now the larger consumers (car shops, etc.) prefer a 500-pound barrel. A portion of the product is packed in 100-pound kegs.