A VIEW SHOWING THE ETOWAH RIVER AT THE WESTERN & ATLANTIC RAILROAD BRIDGE, NEAR CARTERSVILLE, GEORGIA, AND THE ADJACENT RIDGES.

GEOLOGICAL SURVEY OF GEORGIA

W. S. YEATES, State Geologist

BULLETIN No. 13

A PRELIMINARY REPORT

ON THE

OCHER DEPOSITS

OF

GEORGIA

BY

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LETTER OF TRANSMITTAL

GEOLOGICAL SURVEY OF GEORGIA,
Atlanta, Oct. 12th, 1903.

To His Excellency, J. M. TERRELL, *Governor.*

SIR: — I have the honor to submit the report of Dr. Thomas L. Watson, formerly Assistant State Geologist of Georgia, but now Professor of Geology in Denison University, Granville, Ohio, on the Ocher Deposits of Georgia, to be published as Bulletin No. 13 of this Survey. This work was begun by Dr. Watson, before he severed his connection with the Survey; and arrangements were made with him, whereby he completed the field-work during the summer of 1902, and furnished the report later on.

Since ocher is not known to occur in Georgia, in commercial quantities, outside of Bartow county, Dr. Watson's investigation of the subject was confined to this county.

Very respectfully yours,

W. S. YEATES,
State Geologist

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INTRODUCTION

The field studies which form the basis for this report extend over parts of two field seasons. Systematic field work in the area was begun late in the summer of 1900 and was completed during the field season of 1902. The work was necessarily interrupted and the report unduly delayed by the writer's resigning the position of Assistant Geologist on the Geological Survey of Georgia in 1901, to accept the Chair of Geology in Denison University at Granville, Ohio.

Field study was not exclusively limited during either season to examinations of the yellow ocher deposits alone, but was devoted to systematic work on both the manganese and the ocher deposits of the State, at the same time. Since the area, which includes the yellow ocher deposits forming the subject of this report, is also the principal manganese-producing district in the State, and in the Southern Appalachians; and since the ore deposits of the two metals are more or less closely associated in occurrence, field study of the two subjects could readily be prosecuted together.

The importance which Georgia had rightly achieved as a producer of a certain kind and grade of ocher demanded a careful study of the area by the State Geological Survey. The objects of the study were accordingly to examine into the limits of the belt and the complete economic importance of the deposits, and to make as complete a report bearing on the geology of the ore deposits of the district as the time allotted would permit. While the report is necessarily of the nature of a preliminary rather than of a final one, the facts relating to the general geology of the district, the mode of occurrence of the ocher deposits, and the general areal distribution of the deposits have been determined. It is expected, therefore, that future work will in general tend to confirm rather than to change the facts here presented.

ACKNOWLEDGMENT.— To the State Geologist, Professor W. S. Yeates, the writer is especially indebted for uniform courtesy and aid in advancing the work in every possible way and in making the report as full and comprehensive as it was possible. The writer is further indebted to Professor Yeates for the negatives of nearly all of the half-tones illustrating the report. To the very generous and kindly interest of Captain John J. Calhoun of Cartersville, Georgia, in the work, the writer owes a deeper debt of gratitude than he can acknowledge. The thorough knowledge of the district from long residence in it, and the time of Captain Calhoun were generously accorded the writer. To many other citizens of Cartersville and the county, especially the managers of the several ocher plants, who in many ways rendered invaluable assistance, the writer most gratefully acknowledges his thanks.

THOMAS LEONARD WATSON.

Granville, Ohio, June 10, 1903.

THE YELLOW OCHER DEPOSITS OF BARTOW COUNTY, GEORGIA

CHAPTER I

GEOLOGY OF THE CARTERSVILLE DISTRICT

Position of the District

The Cartersville District is limited to an area in the southeastern portion of Bartow county in Northwest Georgia. It derives its name from the town of Cartersville, the county-seat of Bartow county, located on the Western & Atlantic railroad, about 50 miles northwest of Atlanta. The area is one of the most productive ore districts in the Southern Appalachians. The position of the area is shown on the accompanying map of the fourth and fifth districts of Bartow county, which includes about 70 square miles, nearly equally divided between the Paleozoic formations on the west and the older crystalline and metamorphic rocks of the Piedmont plateau and Appalachian mountains on the east. The irregular line separating the two groups of formations marks the position of the Cartersville overthrust fault, the most important structural feature of the region.

Previous Descriptions

The following are the more important papers which refer in whole or in part to the geology of the Cartersville district:—

Hayes, C. W., Overthrust Faults of the Southern Appalachians. Bull. Geol. Soc. Amer., 1891, Vol. 2, pp. 141-154.

Hayes, C. W., Geological Relations of the Iron Ore-Deposits in the Cartersville District, Georgia. Trans. Amer. Inst. Min. Engrs., 1901, Vol. 30, pp. 403-419.

———— Geologic Atlas of the United States, Cartersville Folio, U. S. Geol. Survey. (In press.)

Spencer, J. W., The Paleozoic Group, Geological Survey of Georgia, 1903 (Bartow County), pp. 99-107.

McCallie, S. W., A Preliminary Report on a Part of the Iron Ores of Georgia (Polk, Bartow and Floyd Counties), Geological Survey of Georgia, 1900, Bulletin 10-A, pp. 109-176.

Watson, Thomas L., Geological Relations of the Manganese Ore-Deposits of Georgia, Trans. Amer. Inst. Min. Engrs., 1903.

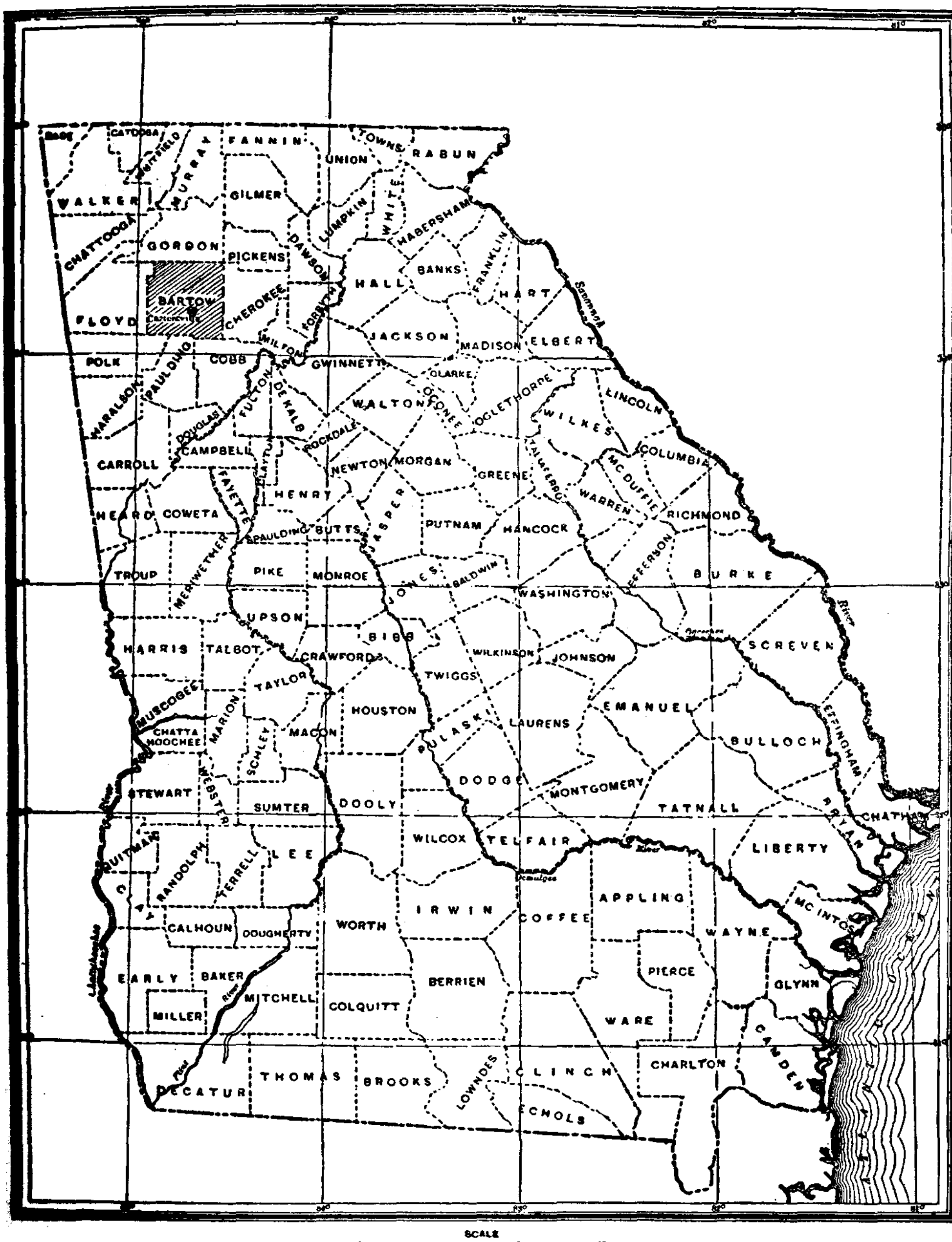
———— The Manganese Deposits of Georgia. Bull. 14, Geological Survey of Georgia. (In press.)

Stratigraphy of the Cartersville District

As indicated on the geological map,[1] the rocks belong to two geologically distinct groups, which show marked differences as to age and kind. To the west of the Cartersville fault — the west half of the map — the rocks are sedimentaries, and include quartzites, sandstones, shales and limestones of Cambro-Silurian age. No igneous rocks are known to occur in this area.

To the east of the fault line, the rocks are metamorphic crystallines derived in part from original igneous masses and in part from original sediments. Over parts of the area, it is difficult to say with certainty whether the original rock was igneous or sedimentary in origin. The altered sediments include conglomerates, slates, schists and probably some of the gneisses. Wide variation in composition characterizes the intrusive rocks, ranging from ex-

[1] See page 16.



General Map of Georgia Showing Position of Bartow County.

tremely basic rocks of the diabase type to acid granites, with perhaps diorite as the most common type. The rocks on this side of the fault show increased metamorphism toward the southeast. The original igneous masses are no longer composed of massive rocks, but owing to the intense pressure-metamorphism they are schistose in structure. This is strikingly shown in the belts of basic schists and gneisses which cross the southeastern portion of the mapped area in a southwesterly direction; and again, in the large area of granite occupying the middle eastern portion of the map. The border portions of the granite-mass are altered into a distinct augen-gneiss.

No fossils have been found in the Ocoee series of sedimentary rocks included within the area mapped. Because of the absence of fossils and because of the rocks bearing evidence of extreme age, Hayes[1] has grouped them as Algonkian (Ocoee) in age.

Returning to the Paleozoic formations on the west side of the fault, the rock sequence becomes, named in ascending order:—

Cambrian	1	Weisner quartzite
	2	Beaver limestone
	3	Rome and Conasauga shale
Silurian	4	Knox dolomite

The first three formations belong to the lower and middle Cambrian. The entire thickness of Knox dolomite is here grouped as Silurian, although the lower portion of the formation should probably more properly be classed with the Cambrian. Of these formations, only the Weisner quartzite is ocher-bearing.

THE WEISNER QUARTZITE. — The yellow ocher deposits of the Cartersville district are limited exclusively to the Weisner quartzite (Chilhowee sandstone of Safford), and in this connection the formation becomes the most important one in the district. The principal area of the quartzite forms a narrow continuous belt, approximately fifteen miles in length and several miles wide, in the central portion of the area mapped. Its eastern limit is the Cartersville fault, which marks the contact of the formation on the

[1] Geological Relations of the Iron Ore Deposits in the Cartersville District, Georgia; Trans. Amer. Inst. Min. Engrs., 1901, Vol. 30, p. 408.

east with the rocks of the Ocoee series. Near the middle western margin of the map, faulting exposes two narrow strips or bands of the quartzite, marked by the entire absence of ocher. Owing to the structural conditions and to the lack of adequate exposures of the formation, its thickness could not be accurately determined, but, over the Cartersville district, it will average not less than 2000 feet.

Lithologically, the formation as would be expected, is not entirely uniform and homogeneous, but, in places, shows considerable variation both in composition and in texture, as well as in color. It is composed principally of a heavy, fine-grained vitreous quartzite varying from light to dark gray in color, and, in places, containing beds of fine conglomerate. Numerous intercalated beds of a drab to darker color and siliceous shales of varying thickness, much crumpled, contorted and altered in places, are a characterizing feature of the formation. The larger quartzite area shown on the map is highly impregnated in places with large and small crystals of pyrite. This mineral is equally abundant in both the quartzose and shaly portions of the formation. The two mineralogically unlike beds, shale and quartzite, are likewise ocher-bearing, and the difference in composition of the rock serves as a basis for making two grades of the ocher. The ocher occurring replacing the shaly beds or layers is prevailingly darker in color, because of the large proportion of admixed clay derived from the shales which cannot be separated from the refined product; while the ocher found replacing the quartzite proper is uniformly lighter in color because of less admixed clay.

The effects of intense pressure-metamorphism are clearly evident in all parts of the quartzite formation. Compression forces acting in a northwest-southeast direction have thrown the beds into numerous irregular folds, and in addition, the formation has been greatly crushed and brecciated over most of its parts, especially in the ocher-bearing portions.[1] So extensively crushed and shattered is the quartzite in some of the larger ocher-openings in the district that it is almost impossible to determine the original bedding. As evidenced by its brecciated condition in many places, the formation is presumably cut by numerous faults, but such lines of fracture,

[1] See plate II and fig. 2.

if they exist, have not been traced. The resulting structural conditions of the quartzite have probably been particularly favorable to certain chemical and physical action relative to mineral formation. Further alteration and the associated minerals of the quartzite are discussed in a subsequent part of this report under the origin of the ocher deposits.

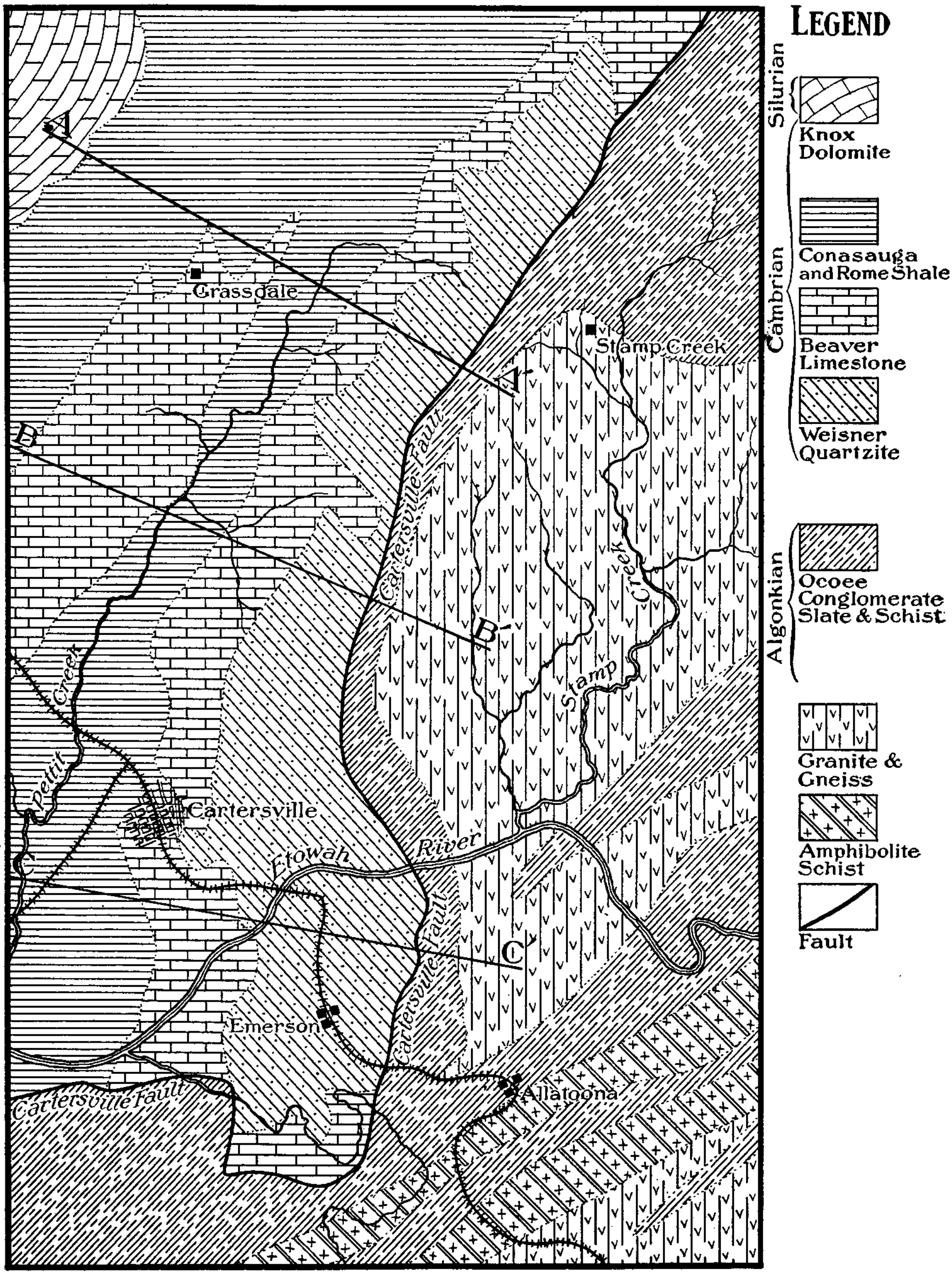
The composition of the quartzite beds proper is shown in the following chemical analysis made by the N. P. Pratt Laboratory, in Atlanta, of specimens of the rock collected by the writer from different exposures of the formation:

Silica, SiO_2	90.36
Alumina, Al_2O_3	1.52
Iron Sesqui-oxide, Fe_2O_3	.57
Iron Sulphide, FeS_2	1.50
Lime, CaO	.27
Magnesia, MgO	.27
Soda, Na_2O	.43
Potash, K_2O	.16
Manganese Oxide, MnO_2	none
Titanium Oxide, TiO_2	.07
Barium Sulphate, $BaSO_4$	4.46
Water at 100° C.	none
Water above 100° C.	.31
Total	99.92

Attention is here called to the percentages of iron sulphide (pyrite) and barium sulphate (barite) present in the rock. The occurrence of pyrite as crystals in the rock is referred to above. The mineral barite is present to a greater or less extent in all the ocher deposits of the district, but its presence in the fresh rock is nowhere indicated either macro- or micro-scopically. The very small percentages of lime and alkalies shown in the analysis confirms the microscopic study of a large number of thin sections of the rock, in the nearly complete absence of the feldspars. A few sections, however, showed sporadic grains of both microcline and striated plagioclase.

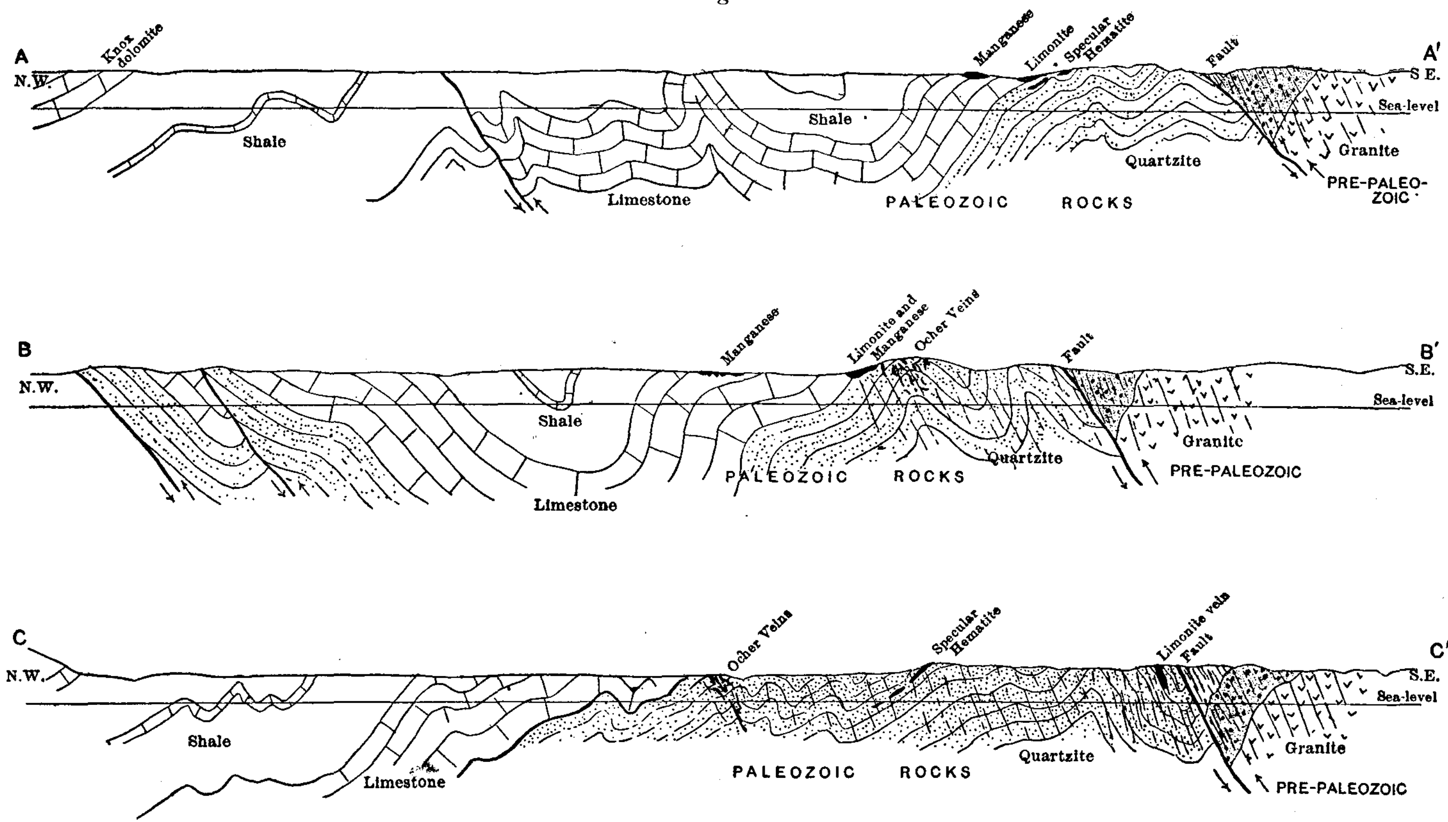
THE BEAVER LIMESTONE. — Next above the Weisner quartzite, is a thickness of 800 to 1200 feet of a gray crystalline magnesian

Fig. 1



Geological Map of the Cartersville District, Bartow County, Georgia. (After C. W. Hayes).

Fig. 2.



Sections on Lines Indicated in Fig. 1, Showing Geological Structure of the Cartersville District. (After C. W. Hayes.)
Scale, Horizontal and Vertical, 1 Inch = 5,000 Feet.

limestone which is shaly in places and contains occasional masses of chert. Hayes correlates this limestone with the Beaver limestone of East Tennessee which has there been determined as Lower Cambrian.[1] No fossils are yet known to occur in the Georgia equivalent of this limestone.

In the Cartersville district, the Beaver limestone extends as a narrow belt of lowland along the western margin of the Weisner quartzite. Over this area, exposures of the fresh limestone are seldom seen and its surface is covered by a deep mantle of residual red clay derived from the decay of the limestone, by which the formation may be readily traced. A second area of the limestone occupies a part of the middle western portion of the map and is separated from the narrow belt along the western margin of the quartzite by a narrow strip of shale. This limestone has been recognized and described over other parts of the Georgia Paleozoic area.

The limestone yields with comparative readiness to the atmospheric agencies producing decay, its insoluble oxidized portions remaining as a residual clay covering, on the underlying surface of the fresh limestone. Along the quartzite margin, the limestone decay is admixed in greater or less abundance with quartzite fragments of varying sizes and in all stages of decay, derived from the decay of the Weisner formation. The Weisner quartzite and the Beaver limestone are the two most important ore-producing formations in the Cartersville district. None of the ocher deposits are associated with the limestone; but they are entirely limited to the quartzite.

THE ROME AND CONASAUGA SHALES. — Overlying the Beaver limestone, is a considerable thickness of shales belonging to the Rome and Conasauga formations. The shales vary from olive clay shales to those of the siliceous type, with the greater thickness composed of the former type. To the west of the Cartersville district, in the vicinity of Rome, the two formations are readily separated into the Rome sandstone, red, white and brown, included interbed-

[1] Geology of a portion of the Coosa Valley in Georgia and Alabama. Bulletin, Geol. Soc. Amer., 1894, Vol. 5, p. 467.

ded sandy shales, and the Conasauga olive clay shales with thin seams of interbedded limestone near the bottom and top.

The extent of these shales in the Cartersville district is well shown on the geological map,[1] the northern part of which is occupied by them; and continuing southward between the narrow belts of the Beaver limestone, they pass through and to the west of the town of Cartersville to the position of the fault line near the southwest corner of the map. The shales usually appear reddish or yellow at the surface, where weathered, and dark bluish gray below the lines of drainage. The soft clay shales are rocks rapidly worn down by disintegration; and hence they usually stand at lower levels than the surrounding rocks and are generally valley producing.

A general idea of the composition of the Conasauga shales in the Cartersville district may be gained from the following chemical analyses: —

	I	II	III
SiO_2 (Free, Sand)	62.30	39.20	52.82
SiO_2 (Combined)	9.30	19.40	
Al_2O_3	11.50	18.05	26.17
Fe_2O_3	5.59	8.31	9.46
MnO_2	.60	——	——
CaO	none	none	trace
MgO	1.30	1.55	1.08
K_2O	4.20	4.63	2.71
Na_2O	.35	.33	.20
TiO_2	1.10	.68	——
H_2O (Combined)	3.80	7.60	7.00
H_2O (Hygroscopic)	.15	.40	.23
Total	100.19	100.15	99.67

I. Light colored hydro-mica shale on the ridge above the Etowah iron bridge south of Cartersville, on the border of the metamorphic zone. Paleozoic Group, Geol. Survey of Georgia, 1893, p. 284. J. W. Spencer. (McCandless, analyst.)

II. Light red shale in the valley, one mile southwest of Cartersville. Paleozoic Group, Geol. Survey of Georgia, 1893, p. 284, J. W. Spencer. (McCandless, analyst.)

[1] See page 16.

III. Oostanaula (Conasauga) shales about two miles northwest of Cartersville. Paleozoic Group, Geol. Survey of Georgia, 1893, p. 285. J. W. Spencer. (McCandless, analyst.)

THE KNOX DOLOMITE. — Beyond the limits of the Cartersville district, the Knox dolomite is one of the most persistent formations in the Georgia area. It is also one of the most important ore-producing formations in the State, but is of no importance as regards either extent or ore-producing in the present connection. Only a very small area of the Knox dolomite, which occurs in the extreme northwest corner of the mapped area, is shown on the geological map of the Cartersville district.

Where best developed, the foundation is from 3000 to 5000 feet thick and is composed of a massive gray crystalline magnesian limestone, containing an abundance of nodules and lenses of chert. Exposures of the fresh dolomite are seldom seen, as its surface is thickly mantled by the residual cherty clays derived by decay from the limestone. The large proportion of the insoluble chert masses and fragments in the residual decay render the formation easy to trace. According to the amount of iron present in the fresh rock and the conditions of weathering, the residual decay of the dolomite is colored deep red, yellow or gray. From a large number of chemical analyses made of specimens over all parts of the dolomite area, the calcium and magnesium carbonates show the following ranges in percentage amounts:—

Calcium Carbonate ----------	34.07 to 53.44 per cent.
Magnesium Carbonate -------	36.32 to 55.74 per cent.

The residue is composed of silica, iron and aluminum oxides.

STRUCTURE OF THE CARTERSVILLE DISTRICT

The Cartersville district forms a part of the southern Appalachian region, lying partly in the Appalachian Mountains and Piedmont Plateau provinces and partly in the Valley province, as is shown on accompanying geological map. The region has been subjected, in common with the Southern Appalachians in general, to intense compression in a northwest-southeast direction. As a result of

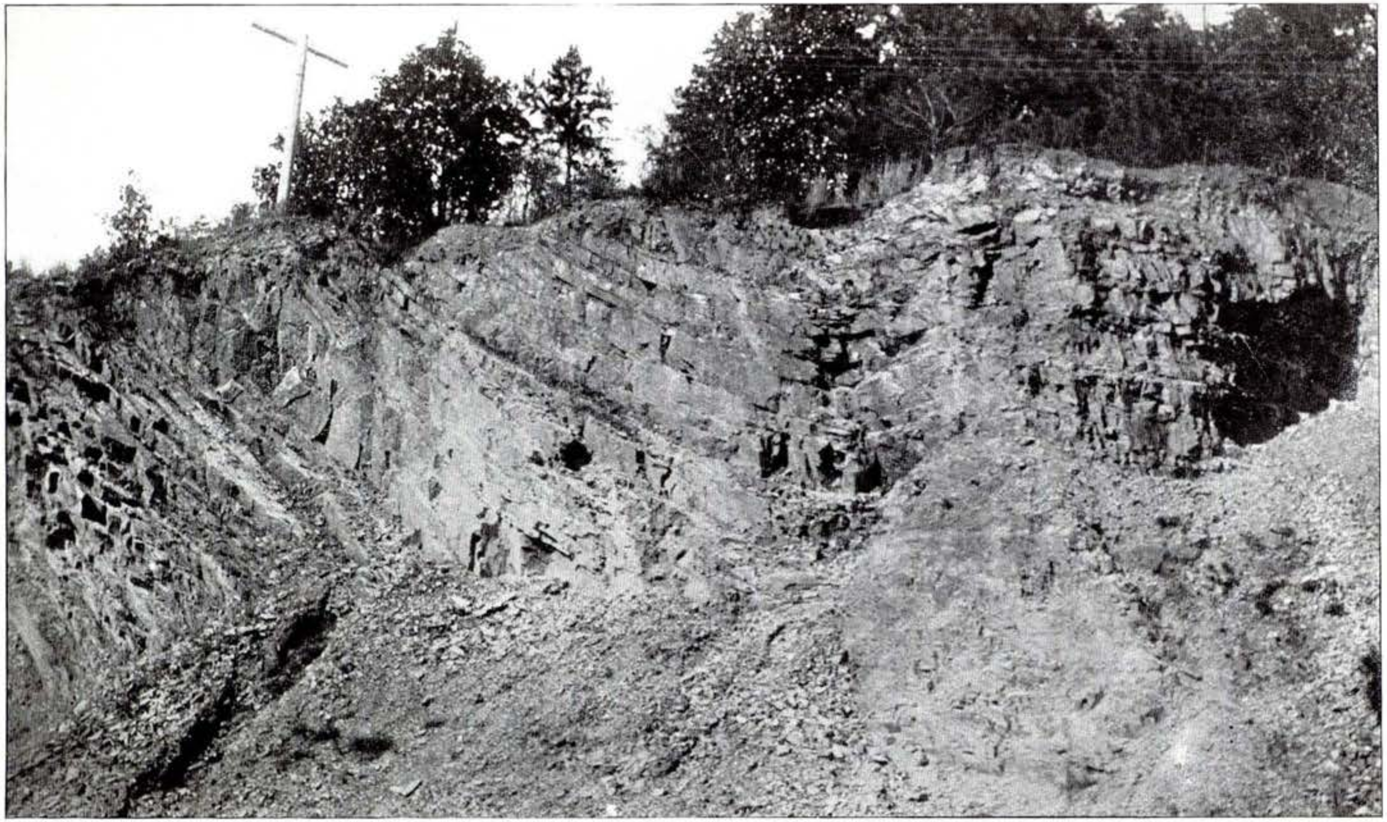


Photo. by Thomas L. Watson.

AN EXPOSURE OF WEISNER QUARTZITE ALONG THE WESTERN & ATLANTIC RAILROAD AT THE IRON BRIDGE OVER THE ETOWAH RIVER, 1 MILE EAST OF CARTERSVILLE, GEORGIA, SHOWING THE CRUSHING AND FOLDING OF THE QUARTZITE this compression, the Paleozoic sedimentary rocks to the west have been folded and faulted and the older rocks to the east have been mashed and squeezed, and the slaty and schistose structure developed in them. A further result is shown in an upward and westward thrust of the older rocks to the east on the younger rocks to the west, producing the Cartersville fault, the principal structural feature in the region. Furthermore the rocks in places have been profoundly altered from combined physical and chemical action, so that they bear little or no resemblance to the original ones from which they were derived.

The more massive formations appear to have resisted folding to a greater degree than some of the less massive ones. This is particularly true of the great thickness of Knox dolomite to the west of the mapped area, which is marked by the absence of any extensive folding; and to a less degree it applies to the Weisner quartzite. Sections made along the lines AA′, BB′ and CC′, on the map, give a good representation of the structural relations of the rocks in the mapped area.[1]

The Weisner quartzite, the formation of most importance in this report, shows marked evidence of intense compression over the entire area. The formation was arched into a broad anticline composed of innumerable minor folds of more or less regularity, as seen in figure 2. Numerous exposures of the quartzite examined by the writer in the mapped area bore evidence of great crushing and in many cases brecciation, and presumably the formation is intersected in many places by faults, although they could not be definitely located for the lack of sufficient exposures. As elsewhere shown in this report under the genesis of the ocher deposits, the folding and compression of the quartzite produced conditions favorable for the promotion of chemical action, which resulted in the solution of parts of the quartzite, and instead, the deposition of the hydrated oxide of iron — ocher.

THE CARTERSVILLE OVERTHRUST FAULT.— As previously stated, the Cartersville fault is one of the principal structural features of the region. Hayes has accurately traced and described the fault

[1] See map on page 16, and fig. 2.

in Georgia. So thoroughly in accord is Dr. Hayes's description of the fault in the Cartersville district with the writer's study of the region, that I quote in full from him, as follows: —

"The line marking the Cartersville fault departs in this region from its rather regular course across northwestern Georgia, making a distinct embayment to the eastward in passing around the belt of lower Cambrian quartzite and limestone. On either side of this region the fault brings the soft slates of the Ocoee series in contact with Cambrian shales of a similar character. The actual plane of contact between the formations on opposite sides has been observed at many points. The older rocks above always have a well developed slaty or schistose structure, and are but little more altered immediately at the fault than elsewhere. The underlying rocks, on the other hand, are much more intensely folded and brecciated immediately at the fault than a few feet distant. The fault plane itself is usually marked by a bed of breccia, a few inches or feet in thickness, and made up of the comminuted fragments of the formations on either side. This fault plane dips to the eastward, usually at angles varying between 5° and 20°, and is parallel, in a general way, with the cleavage and bedding of the rocks on either side.

"The Weisner quartzite varies greatly in thickness within a short distance. It has the appearance of a delta-formation rather than an evenly distributed littoral or marine deposit. North and south of its present outcrops in this region, it probably becomes very much thinner, and its local thickening has doubtless influenced the structure in this region. Another factor which has been important in producing this peculiar structure is the presence of the great mass of granite to the east of the fault. This is the only point at which massive rocks of this character approach so near to the fault-line. They are usually separated from the western margin of the metamorphic rocks by a belt, several miles in width, of readily yielding slates and schists. It is evident that the conditions for the formation of a thrust-fault of great lateral extent are much more favorable in bedded sedimentary rocks than in the massive igneous rocks, such as the Corbin granite. The latter appears to have acted like an immovable buttress against which the rocks from the west were thrust. It will readily be understood that, on account of these massive quartzites on the west, and the still more massive igneous rocks on the east, this portion of the Cartersville fault differs materially from that to the north and south; and further, the reasons will be seen for the very considerable alteration, both physical and chemical, in the valley-rocks adjacent to the fault."[1]

Topography of the Cartersville District

Examination of the topographic map of the Cartersville district indicates that, with respect to surface configuration, the district is easily divisible into two nearly equal, unlike areas. The line separating the two areas is fairly well defined, and is an irregular one. It approximately parallels the position of the Cartersville fault, located one to three miles west of the fault line and it marks the contact between the Weisner quartzite and the Beaver limestone. That part of the district north of the Etowah river and west of a line drawn northeast through Cartersville marks a rather smooth plain, etched out of the soft shales and limestone of Cambrian age. Its average elevation above mean sea level is between 800 and 900 feet. Slight inequalities in the form of irregular hills or minor ridges rise 100 to 125 feet above the general surface of the plain. Elevations of less than 800 feet (750 to 775 feet), are recorded in places along some of the larger stream courses. Westward the plain grades into the Knox dolomite plateau, a slightly more resistant magnesian limestone, whose general average elevation is but little above that of the Cartersville portion of the plain of the Paleozoic rocks.

Beginning with and including the long central band of Weisner quartzite, that part of the mapped area to the south of the Etowah river and east of the plain already defined, is a second area whose surface is higher than and in marked contrast to that of the Cambrian plain described. The larger portion of this area forms the northwestward extension of the Piedmont plateau. Its general

[1] Hayes, C. W., Geological Relations of the Iron Ores in the Cartersville District, Georgia. Trans. Amer. Inst. Min. Engrs., 1901, Vol. 30, pp. 409-410.

surface elevation will average less than 1000 feet above mean sea level, with numerous irregular hills and ridges which rise over all of its parts several hundred feet above the general plateau surface. The surface then is an irregular one, trenched by comparatively deep and narrow stream channels, cut through in many places the thick covering of decayed rock into the hard rock beneath. The northeast corner of the area forms the equivalent lowering portion of the Appalachian Mountains, showing elevations of 1800 to 2000 feet. This marks the roughest surface in the district.

The higher and more roughened surface of the eastern half of the mapped area is etched out of geologically old, highly tilted and disturbed metamorphic crystalline rocks, whose age for the most part is pre-Cambrian. The rocks were derived in part from original igneous masses and in part from original sedimentaries.

The entire district covered by the map is well watered. Its drainage is through numerous nearly north and south flowing streams tributary to the Etowah river, the master stream of the region, which flows in a general westward course two miles south of the town of Cartersville.

Rock Weathering in the District

The region bears evidence of having been continuously above sea level for geologically a long time, and accordingly the rocks have been subjected for an equal period to the active agents of rock decay. The formation and accumulation of the residual decay has been in excess of removal; thence the underlying rock surfaces over all parts of the area are usually quite deeply covered with a mantle of residual decay, composed of the insoluble parts of the rocks from which it was derived. Difference in hardness has resulted in a like difference in the readiness with which the terranes have yielded or resisted sub-aerial decay; thence the residual mantle is proportionately thick or thin. It is thickest over the areas of limestone and thinnest over the areas of quartzite and shale. Similar difference in composition of the rock terranes produced marked variations in the chemical and physical properties of the derived decay. The decayed product of the limestone is usually a deep red ferruginous

GEOLOGICAL SURVEY OF GEORGIA

W. S. YEATES, STATE GEOLOGIST

TOPOGRAPHIC MAP OF

CARTERSVILLE DISTRICT GEORGIA

U.S. GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

GEORGIA
CARTERSVILLE SPECIAL MAP

H.M. Wilson, Geographer in charge.
Topography by E.S. Ela, Geo. H. Guerdrum and C.C. Bassett.
Triangulation by U.S. Coast and Geodetic Survey.
Surveyed in 1903 and 1905.

ENGRAVED MAY 1902 BY U.S.G.S.

APPROXIMATE MEAN DECLINATION 1903.

Scale $\frac{1}{62500}$

Edition of Aug. 1906.

Contour interval 20 feet.

Datum is mean sea level.

clay with or without admixed chert fragments, as the original fresh rock was chert-bearing or not. That derived from the harder and more resistant quartzite is a light gray siliceous clay, in which the proportion of clay is relatively smaller than that derived from the limestone. So strongly marked are the properties of the residual decay derived from the lithologically unlike rock terranes, that the area of originally fresh rock can be easily differentiated and traced with considerable accuracy by its decay. Exposures of the fresh rock are seldom seen over parts of the region. A thickness of 100 feet and more of the decay-covering is frequent in the district.

Over the quartzite area, the greatest thickness in the decay is attained in the valley bottoms, thinning near and on top of the ridges. Along the steeper ridge slopes, exposures of the comparatively fresh, firm and hard quartzite are by no means uncommon. On the ridge tops, large reefs and broken masses of the hard quartzite are frequent, rising many feet above the surrounding decay-covered portions of the rock. The residual mantle derived from the quartzite is largely admixed with fragments of various sizes of the quartz rock in all stages of decay, from partially discolored hard rock to masses of loose, incoherent quartz grains or sand.

Ore-Deposits of the District

The Cartersville district forms one of the most productive ore districts in the Southern Appalachians. Besides ocher, the district is one of the largest producers of the ores of iron and manganese in the State. It is the only producer of yellow ocher. In addition to these, some baryta has been mined and shipped from the area. The latter product, while rather largely distributed over portions of the region, has not proved profitable, for the reason that it is rarely sufficiently concentrated for mining alone and it is not of sufficient purity to make a desirable grade of marketable baryta.

The ores are frequently very closely associated with each other; but recent study of them shows the genesis of the different ore deposits to have been quite different. The deposits of yellow ocher are rarely entirely free from some admixture of one or of all of the other types of ores mentioned. These are usually present only in small quantities in the ocher, and generally in sufficiently large fragments to admit of nearly complete separation from the ocher by the usual process of cleansing described elsewhere in this report.

In many cases, manganese oxide in the form of very finely disseminated grains or powder is not entirely freed from the refined product, and it is claimed that a faint greenish cast is thereby imparted to the ocher. The deposits of ocher and manganese are frequently in juxtaposition, and the openings employed in working the manganese are now used for mining the ocher. Such occurrence is well illustrated on the property of the Blue Ridge Ocher Company, where large quantities of manganese ores were formerly mined, and the tunnels and shafts are now utilized for removing the ocher. On the same property, a large quantity of hard and porous, spongy masses of limonite, occurring as thin lenses and irregular seams in the ocher beds, was being removed with the ocher during the summer of 1902.

At the Etowah river, two miles southeast of Cartersville, on the Georgia Peruvian Ocher Company's property, large clusters and groups of magnificent barite crystals are found in the pockets of ocher and in the fractures and caverns of the quartzite. The usual occurrence of the barite is in divergent groups of massive tabular crystals, giving a crested appearance and grading into both straight and curved laminated masses. Crystal groups weighing twenty-five pounds and more are not uncommon.

Dr. C. Willard Hayes[1] classifies the iron ores of the Cartersville district into (1) specular hematite, and (2) brown hematite or limonite. Of these varieties, the limonite is the more important, since the specular hematite is found at only two points in the district in quantity sufficiently large to be profitably mined. On the ground of genetic relationship, the brown hematite deposits are further divided into (1) concentration deposits, and (2) fault deposits. Other varieties of limonites are classified and described by Hayes occurring outside of the district; but they have no importance as commercial deposits within the Cartersville area. The

[1] Hayes, C. W., Geological Relations of the Iron Ores in the Cartersville District, Georgia. Trans. Amer. Inst. Min. Engrs., 1901, Vol. 30, p. 411 *et seq.*

deposits of yellow ocher have essentially the same composition as the limonite; but they differ in physical characteristics.

The manganese ores have been shown by the writer[1] to be secondary accumulations derived probably from the Beaver limestone and Weisner quartzite by sub-aerial decay, and subsequently concentrated by physical and chemical processes in the residual clays derived from these formations, as is shown in their present mode of occurrence.

In addition to the groups of crystal aggregates of barite from the ocher beds, described above, crystalline nodules and masses of barite, varying in size, occur embedded in the residual clays, derived from the decay of the sub-terranes of the district. More or less of this form of barite is widely distributed over the district. It varies in color from a distinct gray to nearly white, and small shipments of it have been made from time to time.

[1] Watson, Thomas L., Geological Relations of the Manganese Ores of Georgia. Trans. Amer. Inst. Min. Engrs., 1903. (Author's edition.)

——— ——— —, The Manganese Deposits of Georgia. Bulletin 14, Geological Survey of Georgia (In press).

CHAPTER II

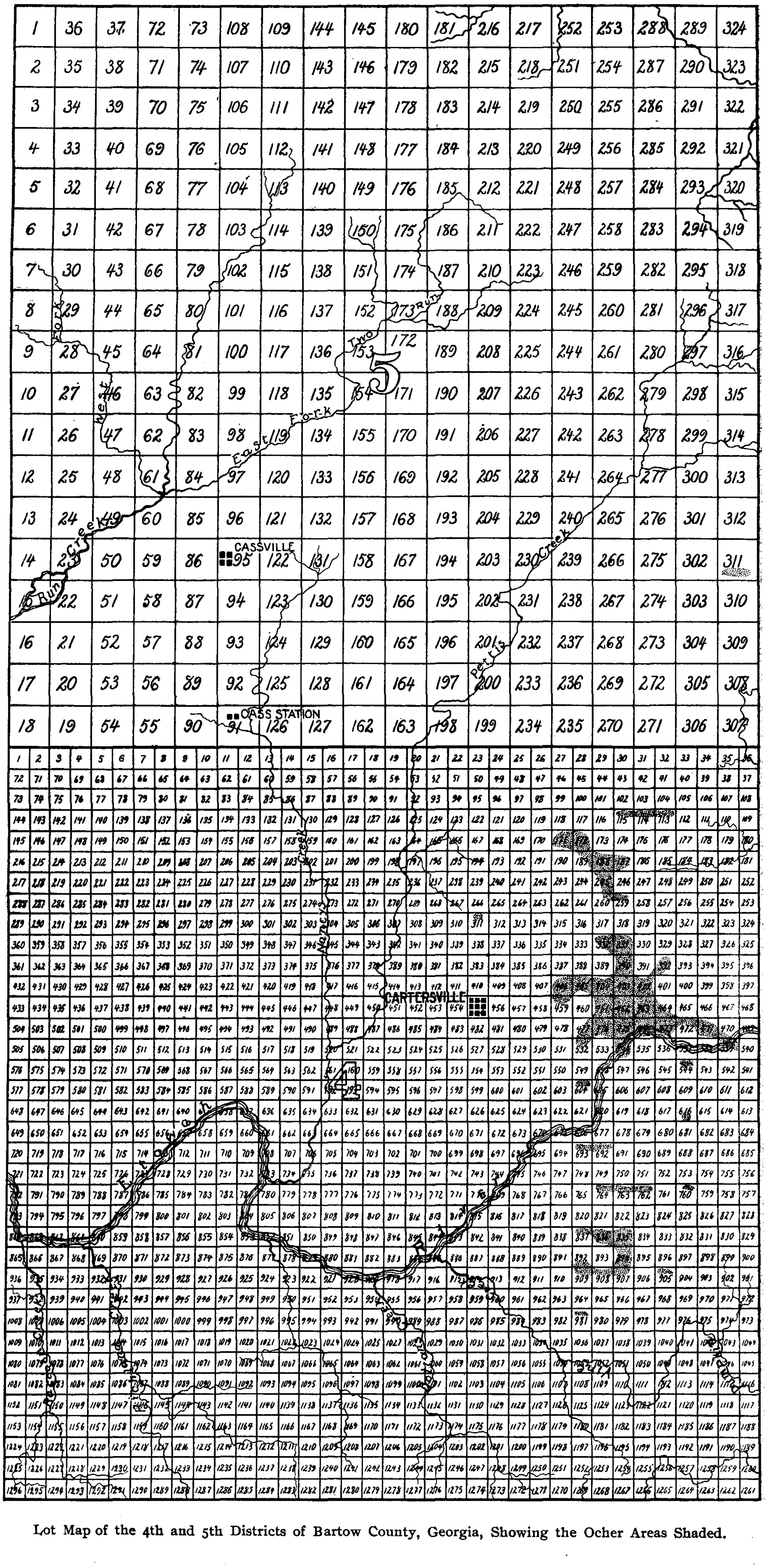
GEOGRAPHIC DISTRIBUTION OF THE OCHER DEPOSITS

The ocher belt, as shown on the distribution map,[1] has an approximate length of about eight miles in a nearly north-south direction. As indicated by natural outcrops and prospect pits, the belt is a very narrow one, not exceeding two miles at the widest point. It has its beginning at a point to the west of Emerson on the John P. Stegall property, about two miles south of the Etowah river, and is easily traced in a northward direction, about one mile east of Cartersville, to a point north and to the west of Rowland Springs. Beyond this point, surface indications disappear and no openings have been made; hence it cannot be traced, although diligent prospecting may possibly reveal a further northward extension of the belt. Less than two miles southeast of the town of Cartersville, the Etowah river cuts directly across the north-south axis of the belt. In cutting across the quartzite ridge at this point, an excellent natural exposure of the ocher beds in place is afforded. Here the ocher has been extensively mined and one of the largest and best equipped plants in the district is located.

Geologic Distribution and Position of the Ocher Deposits

The ocher is entirely limited to the Weisner (Cambrian) quartzite (Chilhowee standstone of Safford) as indicated on the map, and as stated above, it occurs along a somewhat continuous belt, extending from Emerson on the south side of the Etowah river, northward to Rowland Springs, a north-south distance of approximately eight miles. Exposures of the fresh rock indicate that the ocher occupies an extensively shattered zone in the quartzite. It

[1] Opposite page 24.



Lot Map of the 4th and 5th Districts of Bartow County, Georgia, Showing the Ocher Areas Shaded.

is found in place in the hard and fresh shattered quartzite, and in a similar position in the residual clays derived from the decay of the quartzite. Examples of both occurrences are abundant in the region. The theory, which most satisfactorily explains the formation of these deposits, would probably indicate ocher occurring at considerable depths below the surface which might or might not prove workable. At the river ocher plant, two miles southeast of Cartersville, tunnels have been driven for some distance into the quartzite ridge at or near water level in the river, and the same quality and quantity of the ocher are indicated as at higher levels. Mine openings for ocher elsewhere in the district are usually located at some distance above the drainage level of the surrounding region. No clue therefore as to depth of the ocher, or vertical range of the deposits, is furnished by any of the workings in the region. If the hypothesis, advanced and discussed in Chapter IV of this report for the genesis of the ocher deposits, proves to be the correct one, the vertical distribution of the material is entirely independent of the local water level of the area. On this hypothesis, the deposits may continue for considerable depths.

Chemical Composition of the Ocher

The chemical composition of both the crude and the refined ocher is shown in the following analyses made by the N. P. Pratt Laboratory in Atlanta, Georgia: —

Table of Chemical Analyses of the Ocher

	I	II	III	IV	V	VI	VII	VIII
Fe_2O_3	72.29	56.29	65.49	54.60	67.37	61.40	67.32	62.79
Al_2O_3	5.55	10.15	7.20	6.68	6.85	7.14	5.86	6 94
FeO	0.46	0.39	—	—	—	—	—	—
MnO_2	0 87	0 54	1.80	1.50	2.04	2.00	—	—
SiO_2 (Free, Sand)	6.65	8.94	7.76	17.42	6.54	11.89	9.14	6.20
SiO_2 (Combined as Silicates)	3.98	9.49	6.85	10.08	6.61	5.84	6.35	9.78
H_2O at 105° C.	0.55	2.08	0.40	0.48	0.96	0.46	0.78	0.50
H_2O above 105° C.	9.22	11.34	10.50	9.24	9.63	9.37	9.60	—
Total	99.57	99.22	100.00	100.00	100.00	98.10	99.05	

I Specimen of crude ocher collected by Thomas L. Watson from Mansfield Brothers' property, Lot No. 462, 4th District, 3rd

Section, Bartow County. Submitted, by the Geological Survey, to the N. P. Pratt Laboratory for analysis.

II Specimen of crude ocher collected by Thomas L. Watson from the John P. Stegall property, near Emerson, Bartow County. Submitted, by the Geological Survey, to the N. P. Pratt Laboratory for analysis.

III, IV, V and VI Analyses of the Blue Ridge Ocher Company's refined ocher. Lot No. 490, 4th District, 3rd Section, Bartow County. Furnished the Survey through the courtesy of the Manager, Capt. John Postell of Cartersville, Georgia. Analyzed by the N. P. Pratt Laboratory.

VII Analysis of the Cherokee Ocher and Barytes Company's refined ocher. One mile east of Cartersville. Furnished the Survey through the courtesy of the President, Mr. T. W. Baxter of Atlanta, Georgia. Analyzed by the N. P. Pratt Laboratory.

VIII Analysis of the American Ocher Company's refined ocher. Originally the N. P. Lanham property. Lots 475, 476 and 534, 4th District and 3rd Section, Bartow County. Furnished the Survey through the courtesy of the Manager, Mr. Waite of Cartersville, Georgia.

Assuming the ferric oxide[1] in the table of percentages to be combined with water according to the formula $2Fe_2O_3.3H_2O$ to form limonite, the percentage amount of limonite in each case has been calculated with the following results: —

		Per Cent. of Limonite			Per Cent. of Limonite
Column	I	84.49	Column	V	78.74
	II	65.79		VI	71.76
	III	76.54		VII	78.68
	IV	63.82		VIII	73.39

Average .... 74.15 per cent.

From the above figures, it is observed that the amount of hydrous oxide of iron calculated as limonite is approximately the same for the selected samples of the crude ocher and the refined product. The limit of variation is rather a wide one ranging from 68.68 per cent. minimum (refined ocher) to 90.90 per cent. maximum

[1] Only in one case, analysis II of the table, do the analyses show sufficient water to satisfy all the ferric oxide according to the formula $2Fe_2O\ .3H_2O$.

(crude ocher) with an average for the eight samples of 78.33 per cent. The figures further show that an average of 20.46 per cent. or nearly one-fourth of the entire product consists of other mineral matter, including some water or moisture, that cannot be separated from the hydrous iron oxide by the present method of cleansing. Field and laboratory studies show this admixed mineral matter to consist largely of clay and very finely divided quartz particles and grains with, in many cases, smaller amounts of manganese oxide. The sum total of these in the best grades of the ocher will average as low as 10 to 15 per cent. and, in the poorer grades, the average is as much as 30 per cent.

Proportioning the several ingredients shown in analysis II of the table after the usual method of calculating from analyses the probable mineral combination, we get —

Limonite	65.79	per cent.
Clay	25.27	" "
Quartz	8.94	" "
Total	100.00	" "

Referring again to the table of chemical analyses, the percentage of ferric oxide (Fe_2O_3) calculated to a water-free basis becomes for each analysis —

		Per Cent. Fe_2O_3
Column	I	80.11
	II	65.01
	III	73.50
	IV	60.47
	V	75.34
	VI	68.09
	VII	75.11

Physical Properties of the Ocher

The ocher as it appears in the Cartersville District presents but little diversity of appearance. The principal difference in appearance to be noted is that of color. In this area, the color of the ocher which varies from a dark to a light, bright yellow is conditioned principally, if not entirely by the amount of clay or argillaceous matter admixed with it, which in turn is dependent upon the character of the rock which the ocher replaces. Where the ocher replaces the pure quartz rock, it is invariably of the light, bright yellow color and it contains comparatively little admixed clay; while the ocher bodies found replacing the interbedded siliceous shales of the Weisner formation contain considerable clay, and the ocher is darker in color and is of inferior grade. On this basis, two grades of the ocher are distinguished: (a) bright yellow and (b) dark yellow containing much clay and of inferior quality.

The bodies of pure ocher consist of a yellow powder of extremely finely divided particles of hydrated ferric oxide, clay-like in character, in which the water content is high and the material soft enough to be spaded up. As the ocher grades from the soft clay-like bodies, through that bound together by a quartz skeleton, into the hard and firm quartz rock, the color gradually fades and finally disappears in the absence of the yellow powder from the rock.

Aside from the argillaceous matter or clay, the other impurities, silica and manganese oxide, exercise but little if any effect on the physical appearance of the pure ocher. Silica is constantly present; but it is rarely sufficiently coarse-grained in the purer beds of ocher to impart any perceptible gritty "feel." In the other phases of the ocher the harsh "feel" is apparent from the skeleton of silica binding the ocher powder together. Manganese oxide, usually present only in small trace, gives a slightly greenish tint to the refined ocher. The effect of calcining the ocher is described beyond.

SHADE VARIATIONS IN THE COLOR OF THE OCHER

The natural colors of ochers depend in general upon chemical composition. Thus the hematites usually give ochers of a deep-red color; while the limonites are colored some shade of yellow or brown. More directly the natural colors depend on the degree of hydration and oxidation of the material and the kind and amount of impurities.[1] This is forcibly illustrated in the shade variations in color of the Cartersville ocher. As elsewhere shown in this

[1] Merrill, G. P., The Non-Metallic Minerals U. S. National Museum, Washington, 1901. p. 240.

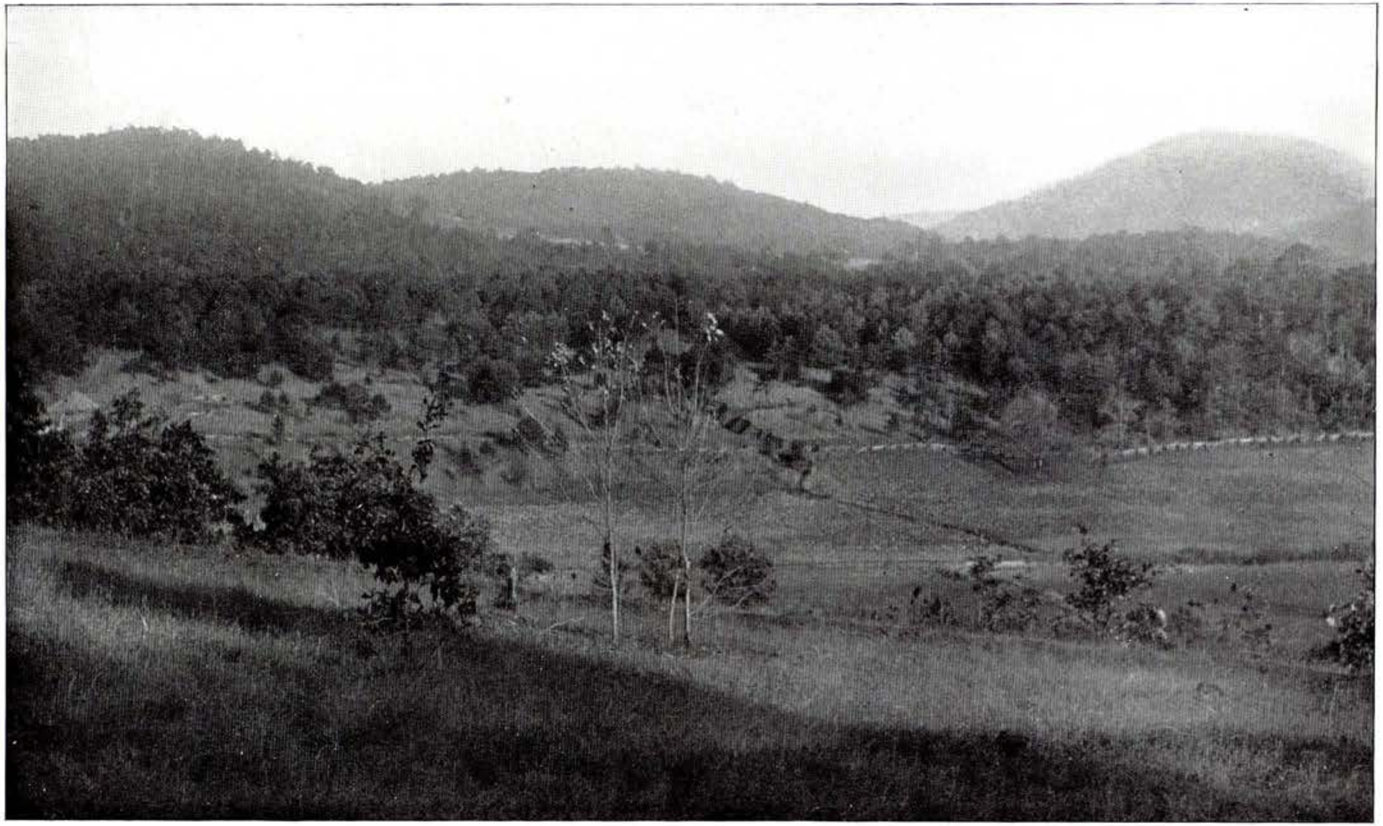


Photo. by Thomas L Watson

A VIEW SHOWING THE RIDGE-VALLEY TYPE OF TOPOGRAPHY IN THE CARTERSVILLE DISTRICT, GEORGIA.

report, portions of the Cambrian quartzite contain interbedded siliceous shales, the silica in which has been replaced in whole or in part by the hydrated ferric oxide, producing an ocher of much darker color and of inferior grade to that derived from the quartzite, by reason of the large proportion of admixed argillaceous matter (clay) contained in the original shale layers. On the other hand, the ocher derived from the quartzite in which the shale layers are absent is a bright golden yellow, contains only a small proportion of argillaceous matter, and makes the best grade of ocher mined in the region. Between these two extremes, nearly all intermediate shade variations in color are met with.

The demands are largely for the bright colored ocher, and a practice sometimes indulged in consists in mixing with the dark colored material, which contains a high percentage of clay, enough of the bright yellow ocher to produce an average grade of merchantable ocher.

Umber

No account is taken in this report of the occurrence of considerable quantities of umber in the district, consisting of admixtures of manganese oxides and clay, for the reason that no attempt has been made to mine it on account of lack of market.

Surface Indications of the Ocher

Over those portions of the region, where residual decay is the most complete and the mantle is the thickest, without partially decayed fragments and masses of the ocher-bearing quartzite exposed on the surface, the ocher makes little or no show at the surface. In such places, the presence of the ocher is indicated only by natural or artificial cuts and openings. Over much of the district, however, fragments and large masses of the quartzite, more or less highly impregnated with ocher and colored a distinct yellow, have been broken and dislodged from the ledges and reefs of the outcropping ocher-bearing quartzite, and scattered over the surface. These masses of ocher-charged quartzite are locally known as "ocher-bloom" and they furnish trustworthy evidence for tracing the ocher. At still other points, the exposed ledges and reefs of the ocher-impregnated quartzite project above the surface of the residual decay and reveal the presence of ocher.

Still another surface evidence of the presence of ocher, which serves in tracing it, is the occurrence of baryta. The intimate association of the ocher and barite has already been described. The residual decay covering the quartzite contains in many places barite, which affords an excellent means of tracing the ocher deposits. Wherever prospecting has been carried on in the localities containing barite, more or less extensive deposits of ocher have been revealed. This is practically true over parts of the area immediately to the north and south of the Etowah river.

CHAPTER III

DESCRIPTIONS OF INDIVIDUAL PROPERTIES

Below, are descriptions of the ocher properties that have been worked and are at present being worked, and of other known exposures of ocher in the district. The locations of all of the known exposures and outcrops of ocher in the area are recorded on the map showing distribution.[1]

At present, four plants, extensively equipped, are mining, manufacturing and shipping the refined ocher. These are all located within a short distance of the town of Cartersville on the Western and Atlantic railroad, which is the principal shipping point in Bartow county, and is one of the leading towns in northwest Georgia. The plants include: The Georgia Peruvian Ocher Company; The Cherokee Ocher and Barytes Company; The Blue Ridge Ocher Company; and The American Ocher Company. Each one of the companies has an office in Cartersville.

The Georgia Peruvian Ocher Company's Property.

The property of The Georgia Peruvian Ocher Company is located less than two miles southeast of the town of Cartersville at the south end of the wooden bridge across the Etowah river. At this point, the river has cut across the quartzite ridge whose elevation is 480 feet above the river level, making an excellent natural exposure of the quartzite beds and of the ocher in place. No section in the region affords better opportunity for studying the mode of occurrence of the ocher and its relationship to the inclosing quartzite. So completely has the quartzite at this point been shattered by compression that it is almost impossible to accurately determine at all times the original quartzite bedding. From top to

[1] Opposite page 24.

bottom the nearly vertical rock section is crossed and recrossed in all directions by closely intersecting irregular lines of fracture, which for the most part stand more or less open. Plate II shows how extensively crushed and intersected by numerous lines of fracture the quartzite formation is, and how greatly changed from its original condition. The ocher forms an extremely irregular network of veins which ramify and penetrate the crushed and shattered quartzite in all directions. Extreme irregularity both as to direction and size characterize the veins. They widen and narrow without uniformity, often expanding into bodies of large size which yield vast quantities of the ocher, connected by narrow winding passages. These pockets or expanded portions of the veins may be connected at close or at wide intervals. Extensive mining at this locality and the removal of large quantities of the ocher at different levels has left the ridge, as Hayes describes it, "completely honeycombed with these irregular passages and rooms."

Doctor C. W. Hayes, who formerly studied the ocher at this point in considerable detail, has so fully and adequately described it, that I quote at length from his description. He says:[1]

"The contact between the ocher and the inclosing quartzite is never sharp and distinct, but always shows a more or less gradual transition from the hard vitreous quartzite, to the soft ore which may be easily crushed between the fingers. The quartzite first becomes stained a light yellow, and loses its compact, close-grained texture. This phase passes into a second, in which the rock is perceptibly porous, having a rough fracture and a harsh "feel," and containing enough ocher to soil the fingers. In the next phase, the ocher preponderates, but is held together by a more or less continuous skeleton of silica, although it can be readily removed with a pick. The final stage in the transition is the soft yellow ocher, filling the veins, which crumbles on drying and contains only a small proportion of silica in the form of sand-grains.

"The intermediate zone between the pure ocher and the quartzite is usually a few inches in thickness, although it may be several feet between the extremes, and, on the other hand, sometimes only a fraction of an inch. When the transition-rock is examined un-

[1] Geological Relations of the Iron Ores in the Cartersville District, Georgia. Trans., Amer. Inst. Mining Engineers, 1901, Vol. 30, pp. 415-417.

ONE OF THE OPEN-CUTS OF THE LINDERMAN OCHER MINE, GEORGIA PERUVIAN OCHER COMPANY, NEAR CARTERSVILLE, GEORGIA der a microscope, the character of the transition can be seen even more clearly. The more compact portions, which are only slightly stained with iron, are seen to be composed of a transparent ground-mass, threaded with minute cavities, which penetrate the rock in all directions and contain a fine dendritic growth of iron oxide. The latter occurs only rarely in isolated grains, but generally in clusters of minute crystals or fibers, attached to each other and branching irregularly from a central stem. They have no trace of crystal form. Passing toward the ore-body, these minute passages become larger and increase in frequency, until only a finely branching siliceous skeleton remains, the greater part of the rock having been replaced by the iron oxide. Under polarized light, the transparent ground-mass is broken up into an aggregate of small quartz grains, penetrated in all directions by the iron oxide. The latter does not lie between the individual grains, but passes through them, as though the ground-mass were quite homogeneous. The process of replacement is never complete; for all the ocher contains more or less sand. When this is washed clean from the iron oxide, it is found to differ from ordinary sand-grains in having extremely irregular outlines. This sand, as might be anticipated from the microscopic structure of the slightly altered quartzite, is evidently composed, not of the original grains of the rock, but of detached portions of the irregular siliceous skeleton, which, in the intermediate stages of replacement holds the iron oxide in its cavities. Aside from the silica, the ocher as mined contains only hydrated ferric oxide, a small amount of alumina, and a trace of manganese oxide, the latter giving it a slightly greenish tint.

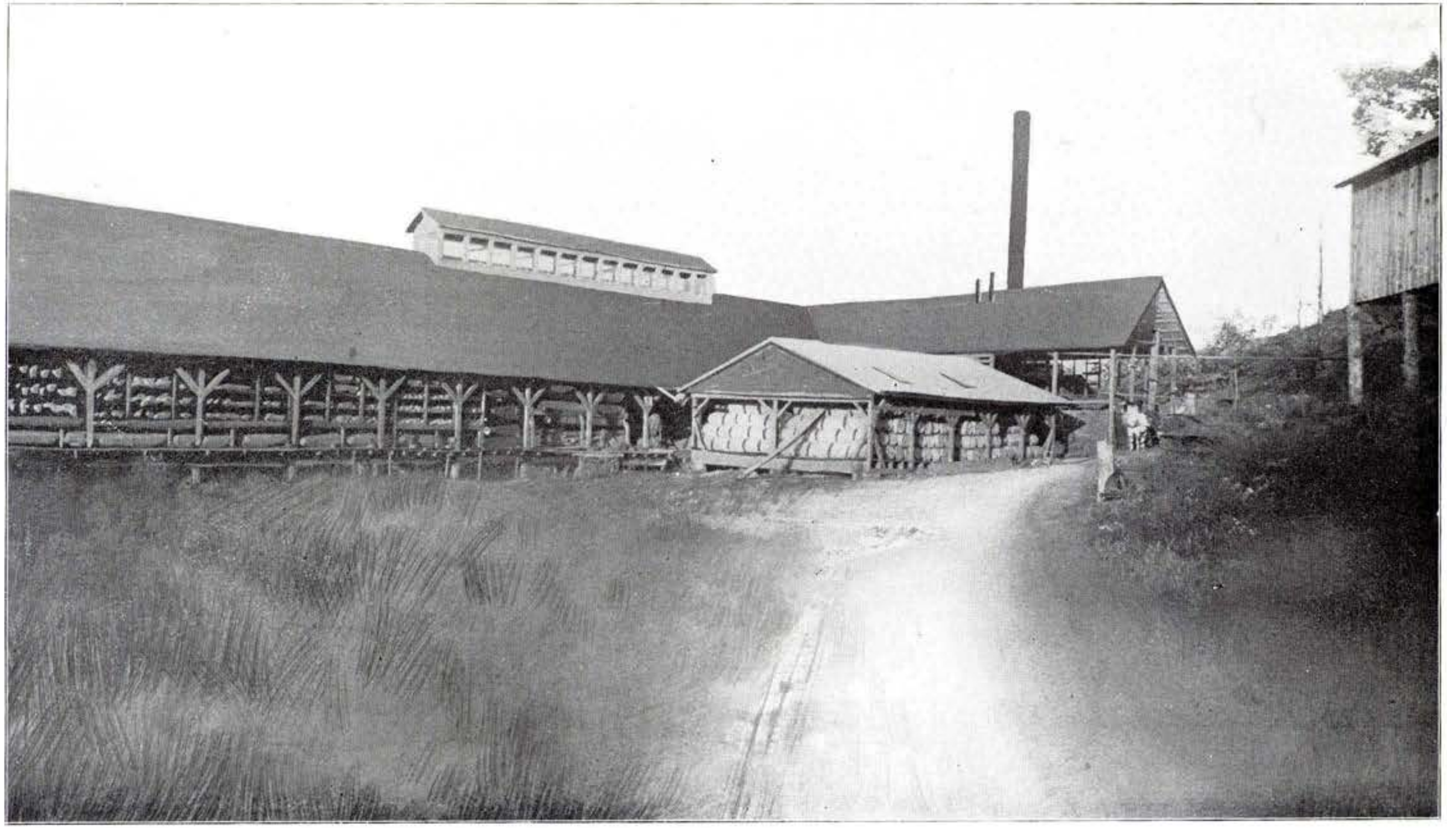
"Some portions of the Cambrian quartzite contain interbedded siliceous shales; and the silica in these has also been replaced to some extent by iron oxide, producing an ocher which is inferior to that derived from the quartzite, since it contains considerable clay — practically all the argillaceous matter originally contained in the shales. Imbedded in this ore are numerous small cubes of pyrite, or rather limonite pseudomorphs after pyrite. These were probably an original constituent of the shales, before the replacement occurred."

That portion of the quartzite formation nearest the river bridge is quite generally impregnated with the ocher, and the entire rock from top to bottom is either slightly or deeply colored yellow, according to the amount of iron oxide it contains. The rock is usually more or less porous or cellular though hard and firm from the large percentage of binding silica. The entire mass resembles a ferruginous breccia. It is mined by blasting, and in bulk will probably average ten to twenty per cent. of ocher. The iron oxide powder is not uniformly distributed through the rock, but is more localized in some portions than in others. As mined, it is crushed and the ocher floated and saved by the usual process, described elsewhere in this report. The proportion of over-burden is necessarily large in comparison with the amount of ocher saved for this part of the ridge.

In other parts of the ridge, the soft clay-like ocher is removed from the large irregular bodies or pockets by the pick and shovel, loaded on tram-cars drawn by mules, and conveyed from the mines through tunnels. During the summer of 1902, three levels were thus being worked, the lowest one of which was at or near the water level of the river. No work has yet gone below the river level, although from the nature and origin of the deposits it is evident that the ocher extends some depth lower.

The contact between the ocher of the large bodies and the quartzite is not entirely sharp; but the intermediate zone between the pure ocher and the quartzite is usually very slight in width. As mined from these pockets, the ocher is as nearly pure as it occurs at any place in the district, and it contains as impurities only small amounts of silica and clay with usually a trace of manganese oxide. It contains a large percentage of water when first mined, which makes it rather a heavy "mud." The bulk of the ocher mined on this property is from the large irregular bodies of the nearly pure material.

Both the quartzite and ocher bodies are penetrated by numerous fissures and cavities containing usually crystals of both barite and quartz. Large and small clusters and groups of beautiful crystals of barite, measuring in extreme cases several inches in length, are frequent. Grains of the white granular barite are less common. Much of the massive granular mineral in large and small



DRYING AND STORAGE SHEDS OF THE LINDERMAN OCHER MINE, GEORGIA PERUVIAN OCHER COMPANY, NEAR CARTERSVILLE, GEORGIA masses or lumps are found scattered somewhat abundantly over the surface and in the covering of residual decay over most of the property. The fragments and masses of this mineral are especially abundant on land lot 693. Dr. Hayes suggests that the barite filling and lining the cavities and fissures was "probably deposited after the conditions favorable for the solution of silica and the deposition of ocher had passed.[1] This mineral is known to the miners as "flowers of ocher."

A chemical analysis of the refined ocher manufactured by the Georgia Peruvian Ocher Company's plant, made by the N. P. Pratt Laboratory in Atlanta, is given below: —

Moisture	0.48
Water of Combination	9.24
Peroxide of Iron	54.60
Alumina	6.68
Silica, Free (Sand)	17.42
Silica Combined as Silicates	10.08
Manganese Dioxide	1.50
Total	100.00

The Georgia Peruvian Ocher Company's plant is the oldest one of the four plants operating at present in the district. Its production and capacity are likewise the largest. The equipment is complete and entirely modern and in all respects thoroughly efficient. Ample facilities are provided for drying the floated ocher (evaporation) either by artificial (steam) or by natural (sun) means. The two processes of drying the ocher, artificial and natural, are described in detail elsewhere in this volume, as they are used alike by all of the plants of the district and are the same in each case.

The writer is reliably informed that practically three-fourths of the prepared ocher of this plant is exported to numerous points in the British Isles and on the Continent, where it is used principally in the manufacture of linoleum and similar products. The remainder of the output is shipped to various northern points in the United States and is used in the manufacture of linoleum and

[1] *Op. Cit.*, p. 418.

to some extent in paint. Shipments are made in barrels and bags of uniform size whose capacities are 350 to 400 pounds and 210 pounds, respectively.

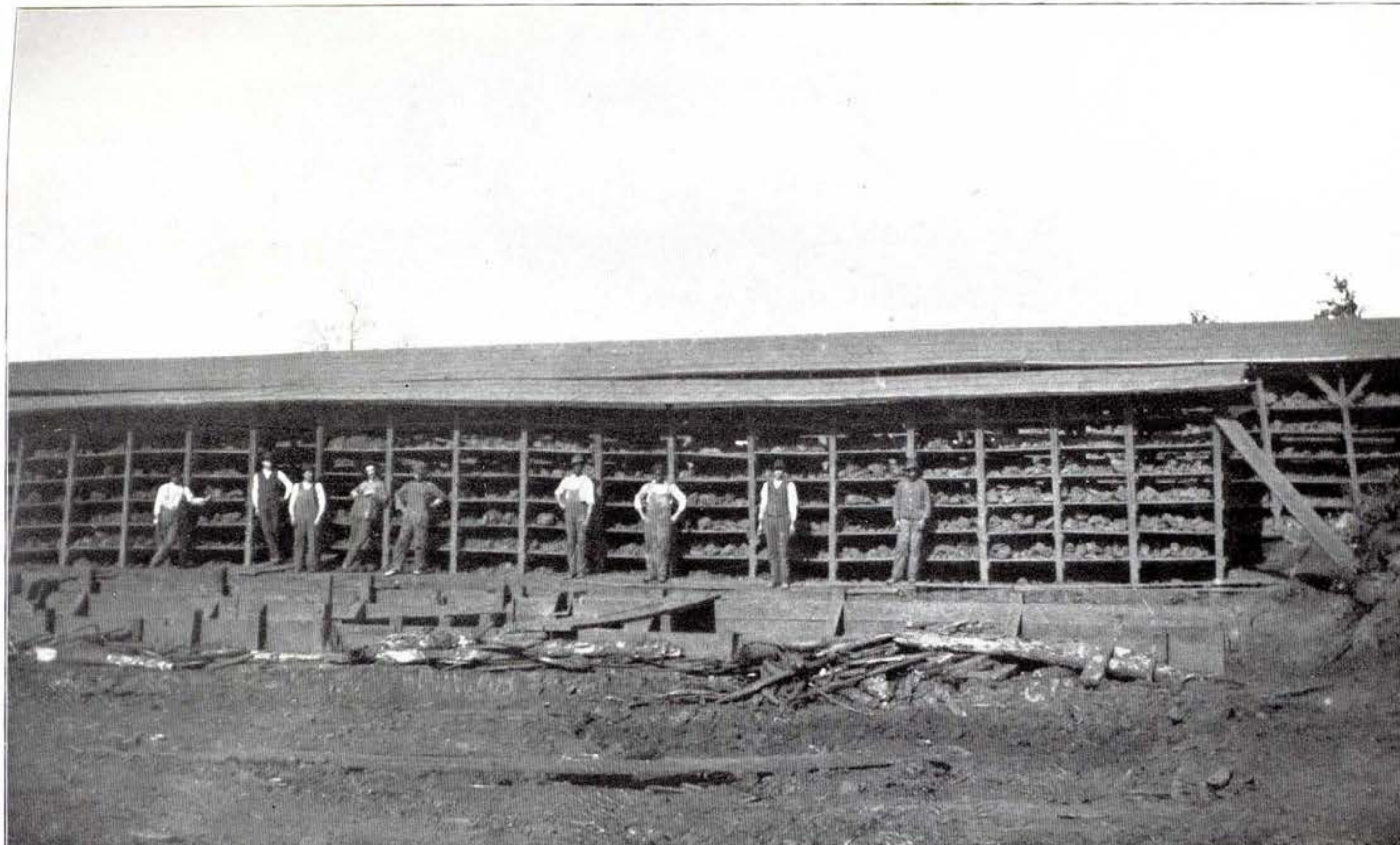
The map of this property, prepared by Hall Bros., Civil and Mining Engineers, of Atlanta, Georgia, shows the extent of the property, the location of the underground workings; and the locations of the different milling and manufacturing parts of the plant. A more recent map has been prepared of the property which indicates considerably more underground mining than the one accompanying this report, but a copy of the map could not be obtained. As shown on the map, the lots owned by the Company are Nos. 692, 693, 763, 764, in the 4th district and 3rd section of Bartow county.

The Cherokee Ocher and Barytes Company's Property

The Cherokee Ocher and Barytes Company's property is located one mile east of the town of Cartersville on lots Nos. 406 and 459, 4th district and 3rd section of Bartow county. Both lots have been worked to some extent, with the principal work confined to the north lot, number 406. Four different slopes have been worked on this lot, two of which were worked on two different levels at depths of 70 and 98 feet, respectively, below the surface. Work in the other two slopes has been confined to one level only. The openings are all very close to each other. The slopes or tunnels are worked on a considerable incline and the ocher is raised by cars operated by steam and cable.

The openings are near the western margin of the quartzite on a slightly elevated area overlooking the broad valley in which the town of Cartersville is located. When approached from the west side, or the town of Cartersville, the ridged character of the quartzite at this point is much less conspicuous than at the river ocher plant described above. Immediately to the east, however, the ridge-valley type of topography is strikingly shown, and within a few paces of the openings the surface lowers quite rapidly forming the west side of an adjacent valley.

The rocks at this point are deeply covered by residual decay and



ONE OF THE DRYING SHEDS OF THE CHEROKEE OCHER & BARYTES COMPANY, NEAR CARTERSVILLE, GEORGIA.

are seldom exposed at the surface. Unlike the deposits mined by the Georgia Peruvian Ocher Company, the ocher on this property is inclosed in the residual decay derived from the quartzite and is not surrounded by the fresh and hard quartzite in place as at the river. Reefs of the partially decayed, crushed and brecciated quartzite, varying in thickness, are cut through in places by the tunnels. The decay is composed principally of red, yellow and dark colored clays often containing abundant admixed fragments of the quartzite of all sizes and in all stages of decay. In the deeper levels, the ocher rests on decayed quartzite highly impregnated with the iron oxide powder. This decay marks a transition zone between the hard and fresh quartzite below, impregnated with the ocher powder, and the beds of soft nearly pure ocher. For several inches next to the ocher proper the quartzite decay is usually sufficiently loose and friable (sometimes incoherent) to be scooped up with the hand. Often, however, the rock next to the contact is less advanced in decay and crumbles only under pressure of the hammer or pick.

Two grades of the ocher are met with in the openings, a light and a dark-colored material. In the light colored ocher, the principal impurity is silica with a minimum quantity of argillaceous matter. The dark colored ocher contains a large proportion of clay derived from the original rock containing the ocher. Close examination of the sections along the tunnels shows the original rock to have been quartzite containing interbedded layers of shale; and according to which type of rock the ocher replaces depends the light or dark colored grade of material. The light colored ocher is found replacing the quartzite and the dark colored material replaces the shale; hence the large proportion of clay in the latter, rendering it of darker color and inferior quality to the bright ocher.

The following chemical analysis made by the N. P. Pratt Laboratory in Atlanta, June 29, 1899, and kindly furnished the Survey by the President of the Cherokee Ocher and Barytes Company, Mr. T. W. Baxter, will indicate the general character of the refined ocher manufactured by the Cherokee ocher plant: —

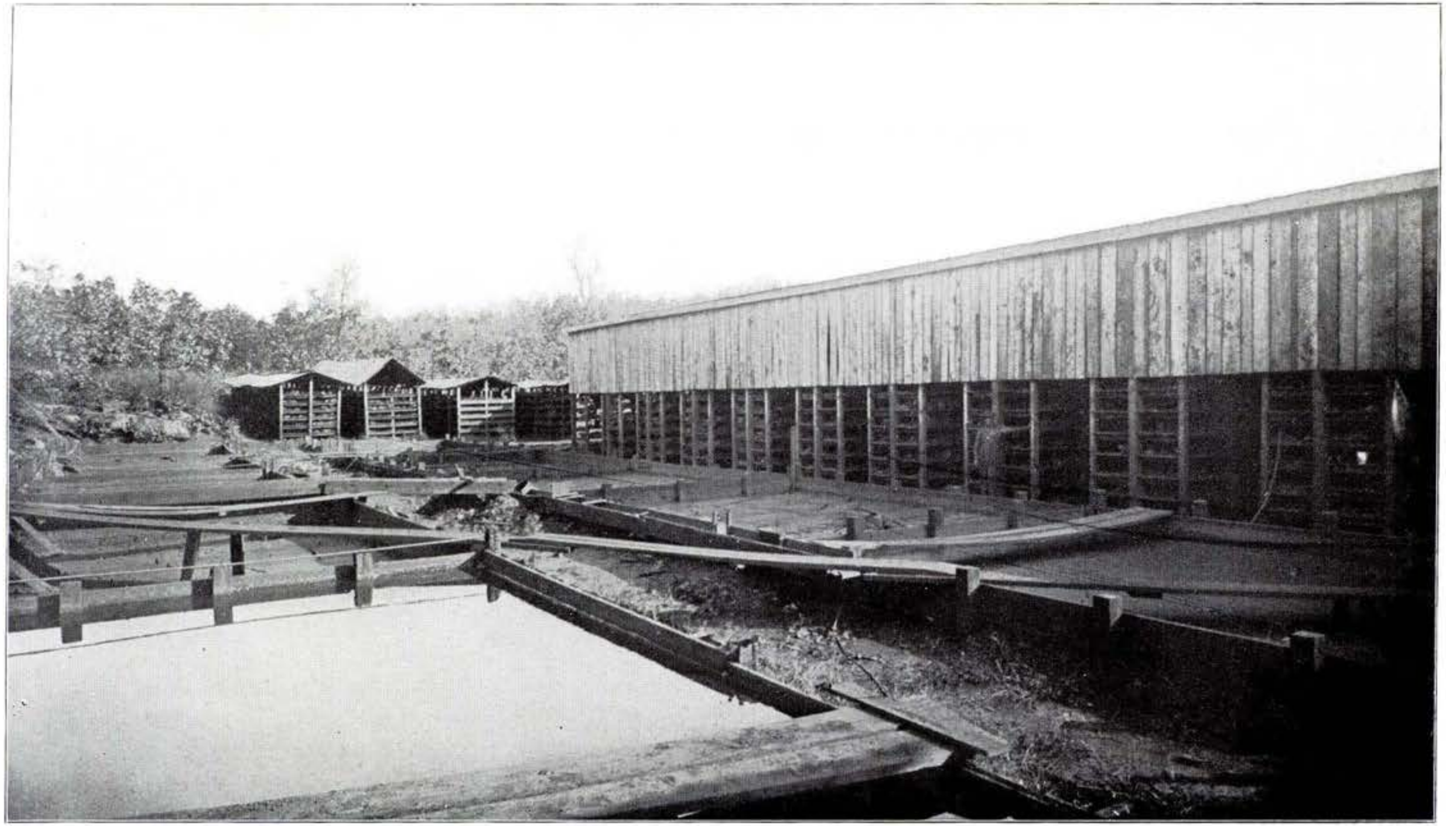
Moisture at 212° F.	0.78
Water of Combination	9.60
Peroxide of Iron	67.32
Alumina	5.86
Free Silica (Sand)	9.14
Silica Combined as Silicates	6.35
Total	99.05

The Cherokee ocher plant is a large and commodious one; is well equipped with modern machinery; and it contains ample facilities for the artificial and the natural drying of the ocher. The writer was informed that less than one-half of the yearly product was exported to England and Scotland and the remainder was marketed in different parts of the United States. Its principal use is in the manufacture of linoleum and to a less extent in paints.

The Blue Ridge Ocher Company's Property

The Blue Ridge Ocher Company's property includes lot 390, 4th district and 3rd section of Bartow county, located about two miles east of the town of Cartersville. This lot was worked many years ago for manganese when it yielded a large quantity of excellent ore. At that time, no attention was given to the excellent deposits of yellow ocher so intimately associated with the manganese. The two mineral products occurred side by side exposed often in the same openings, some of which are now used in mining the ocher, though originally made for removing the manganese.

The openings are made in the residual clays derived from the decay of the quartzite and are located about midway up the west side or slope of a quartzite ridge, whose trend is approximately north and south. The average slope of the ridge at this point is fairly steep, growing considerably steeper to the north and south of this lot. The tunnels are driven on a slight incline directly into the ridge. Near the top of the ridge, the covering of residual decay rapidly decreases in depth, and, on the ridge-crest, exposures of the hard and fresh quartzite are not uncommon. Low reefs and broken masses of the quartzite make up the character of the out-



GENERAL VIEW OF THE SETTLING VATS AND DRYING SHEDS OF THE CHEROKEE OCHER & BARYTES COMPANY, NEAR CARTERSVILLE, GEORGIA crops. The entire surface slope is littered with small and large fragments of the hard and angular rock.

The general character of the decayed rock is quite similar here to that of the residual decay described as enclosing the ocher occurring on the Cherokee Ocher and Barytes Company's property. Distinct evidence of interbedded shales with the massive quartzite appears. The decay is heavily charged with quartzite fragments varying in size, and in all stages of decay. The same vari-colored clays are cut through by the tunnels. In the fall of 1900, a section along the main tunnel was carefully measured. This will give a good general idea of the difference in the rock material passed through. Beginning at the surface the section showed —

	Ft.	In.
Red clay containing abundant fragments and masses of the quartzite in all stages of decay — usually well advanced and falling into loose sand under gentle pressure	62	6
Micaceous white clay dipping into the ridge at an angle of about 45°	37	0
Red clay heavily charged with friable quartzite fragments	32	0
Brecciated quartzite cemented with iron oxide, much decayed and cut by thin seams of plastic red clay along the lines of fracture	50	0
Nearly fresh massive quartzite, greatly crushed and fractured	14	6
Ocher containing thick seams or layers of dark colored clay, some manganese oxide, and hard lumps and nodules of spongy limonite	134	0
Total length	330	0

Here, as on the Cherokee ocher property, the contact between the pure ocher and the underlying rock is marked by a transition zone of decayed quartzite, variable in thickness, and highly impregnated with ocher. This zone is of about the same thickness and of the same general character as that described on the Cherokee property. On both properties, the contact wherever exposed is fairly well defined. At a depth of only several inches below the bed of soft ocher, the quartzite is broken with difficulty by the hammer, and at every point examined the hard rock contained ocher powder disseminated through it. During August of 1902, large quantities of hard and spongy lumps and masses of limonite were removed from the ocher beds. These are usually assembled at irregular intervals in the beds of ocher as stringers or seams, rarely as well defined nests or small pockets. They usually admit of easy separation.

The quality of the ocher on this property is not surpassed by that of any in the district. Through the kindess of the Manager, Captain John Postell, I am able to give the following analyses of the refined ocher manufactured by the Blue Ridge Ocher Company, made by the N. P. Pratt Laboratory, of Atlanta: —

	I	II	III
Moisture	0.40	0.48	0.96
Water of Combination	10.50	9.24	9.63
Free Silica (Sand)	7.76	17.42 [1]	6.54
Silica Combined as Silicates	6.85	10.08	6.61
Alumina	7.20	6.68	6.85
Peroxide of Iron	65.49	54.60 [1]	67.37
Manganese Dioxide	1.80	1.50	2.04

The form of washer used at this plant differs from that in operation at the other plants in the district. A detailed description of the washer used at the Blue Ridge Ocher plant is given on page 73 of this volume. The ocher is removed from the tunnels by means of tram-cars and mules. It is estimated that approximately 20 tons of the crude ocher will yield 10 tons of the finished or refined product. In other words, the crude ocher including impurities, loss in washing, handling, etc., yields 50 per cent. of the merchantable ocher. In the first grade crude ocher, the impurities, which include sand and clay, with some manganese and hard iron oxide, will average about 15 per cent. These will average not less than 25 per cent. in the lower grade ocher. Captain Postell informs the writer that 15 to 25 per cent. of the ocher is lost in handling.

[1] Not sufficiently cleansed.

THE OCHER PLANT OF THE BLUE RIDGE OCHER COMPANY, NEAR CARTERSVILLE, GEORGIA

The plant is not equipped for steam drying, and all evaporation is by the natural process, for which there is ample capacity in the way of vats and racks. More than 90 per cent. of the ocher produced at this plant is exported to England, Scotland and Germany, where it is said to be used entirely in the manufacture of linoleum. The remainder of the output from this plant is marketed at different points in the United States, and is used entirely in paint, both in the natural state and calcined. When calcined the ocher is converted into the red oxide of iron, making it when free from certain impurities a very desirable pigment.

The American Ocher Company's Property

This property was originally known as the N. P. Lanham tract; and it includes lot 475, the east half of lot 476 and all of lot 534 north of the Etowah river, in the 4th district and 3rd section of Bartow county. It is located approximately two and a half miles southeast of the town of Cartersville. Preparations were being made, during August 1902, at the time of my examination, for the erection of a large and commodious plant by the company on lot 475 near the line of lot 534. An abundant water supply is assured at all times from the Etowah river, which is full 600 feet from the plant and is the major or principal stream in Bartow county. The tract maintains a gentle slope toward the river.

On the crest of the ridge some distance back from the river, numerous exposures of the hard and fresh quartzite occur. Many of these exposures are large and in the form of broken reefs and masses of the rock, which rise usually only a few feet in elevation above the general surface. The rock is pyritiferous in places. At this point, the slope facing the river is not a smooth one; but the surface is dissected at intervals by irregular, wide valleys, which head well back near the ridge top in case of the larger ones, not occupied, as a rule, by permanent streams. To the north and south of this point, however, permanent streams tributary to the river occupy the transverse valleys. One of these valleys dissects lot 475, and the Lanham dwelling house is located on it. In this way, the ridge slope has been cut into spurs or subordinate ridges, which become more accentuated some distance back from the river.

The main lot, 475, has been prospected in a number of places for ocher, with good results in nearly every opening made. Not less than ten openings made in different portions of the lot expose an excellent grade of ocher. The largest opening is near the top of the ridge, and has a depth of about 30 feet. This opening shows a capping of several feet of red and darker colored clays, principally the former, admixed with fragments of decayed and partially decayed quartzite, overlying the ocher. The remaining depth, more than 20 feet, is ocher. Near the top of the ocher are found scattered nodules of small size and stringers of manganese oxide, and a few pieces here and there of gray specular iron ore. The bottom of the opening exposes the decayed quartzite highly charged and impregnated with ocher, immediately underlying the bed of pure ocher. The occurrence here is in every respect similar to that described on the properties of the Blue Ridge Ocher Company and the Cherokee Ocher and Barytes Company, and differs from that of the Georgia Peruvian Ocher Company at the river by the enclosing rock being residual clays derived from the decay of the quartzite and not the hard and fresh quartzite.

The remaining openings which expose ocher on this property are smaller and less deep than the one described above; but similar geological conditions of occurrence are indicated in all. So far as developments have been made, the ocher on this lot is of excellent quality and appears to be in large quantity.

Through the courtesy of the Manager, Mr. Waite, I give below a partial analysis of the refined ocher manufactured by the American Ocher Company, made by the N. P. Pratt Laboratory in Atlanta: —

	Per Cent.
Moisture	0.50
Iron Peroxide	62.79
Alumina	6.94
Silica (Combined)	9.78
Free Silica (Sand)	6.20

Surface indications of ocher appear in places on lot 534, and a single small test-pit has been opened along the public road exposing ocher.

The Blue Ridge Mining Company's Property

The following lots of land owned by The Blue Ridge Mining Company contain ocher. A majority of these lots have been tested with very favorable results and on many of them the deposits are very extensive. Upon further development, all of these may prove to contain valuable deposits of ocher.

Lot No.	District	Section	County
114	4	3	Bartow
260	"	"	"
392	"	"	"
404	"	"	"
464	"	"	"
473	"	"	"
532	"	"	"
539	"	"	"
544	"	"	"
616	"	"	"
311	5	"	"

On lots 114, 392 and 544, the occurrence of the ocher is similar to that described on the property of the Georgia Peruvian Ocher Company at the river. In each case, good vertical sections of the hard and shattered quartzite are exposed enclosing the ocher. Opportunity for studying the relations between the ocher and the enclosing hard rock is afforded in each section.

The Rowland Springs road passes through lot 114, which exposes on the north side a vertical section of the quartzite.[1] The rock shows evidence of crushing and is intersected by irregular fracture lines. The bedding planes are easily discernible and the dip is nearly vertical. When freshly broken, the rock shows much disseminated ocher and some manganese oxide, in places. Near the top of the section, a cut has been made for a short distance, from which several tons of ocher were reported to have been re-

[1] See Plate XI.

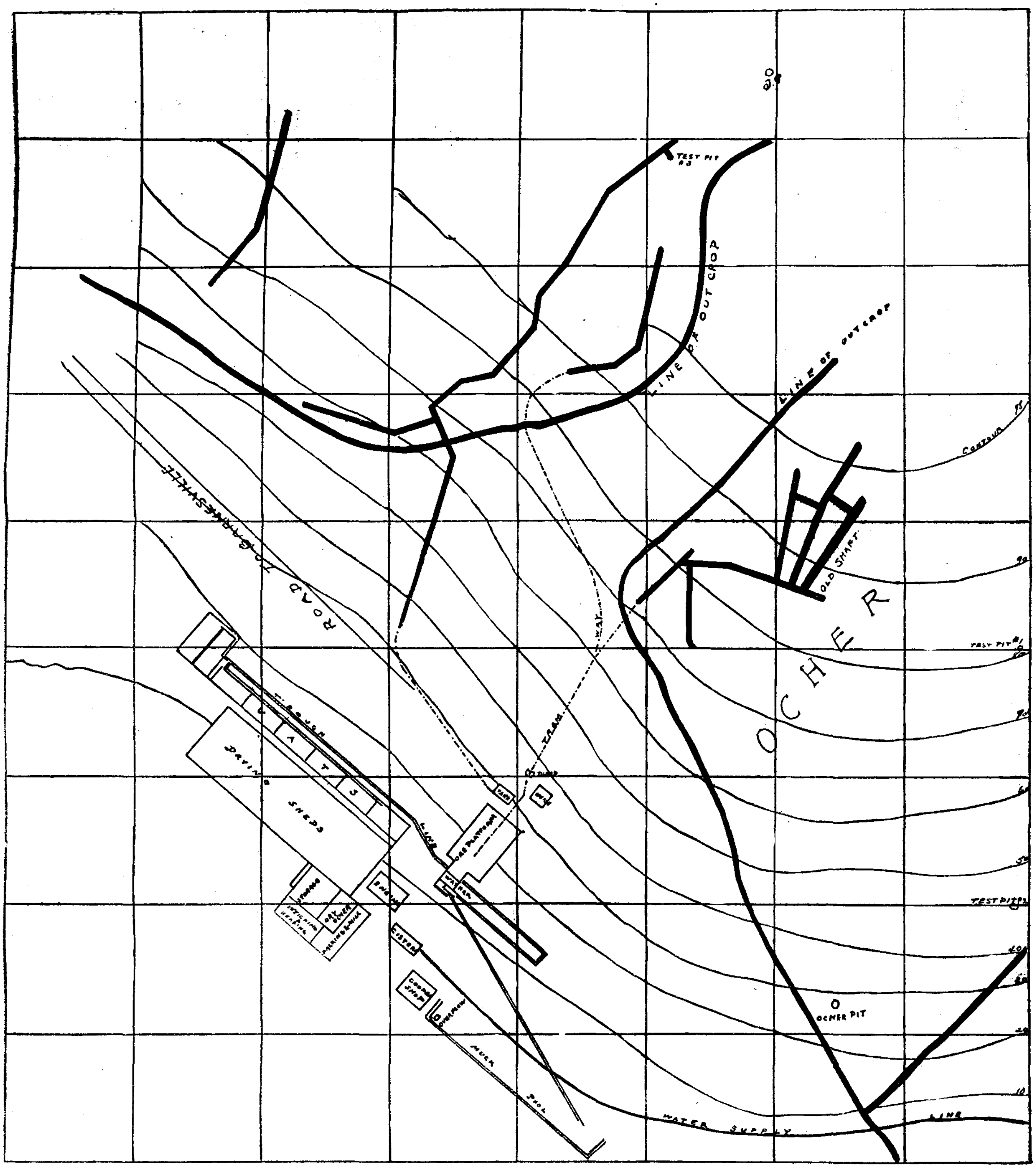
moved. At this point, the ocher is overlain by several feet of residual clay with the enclosing rock on the sides, of quartzite.

The section on lot 392 is quite similar to the one described on lot 114. The quartzite bears evidence of considerable crushing in places and its beds have an almost vertical dip. It varies from thin siliceous, shaly beds through thicker layers of hard, flinty quartzite, to that of a fine grained conglomerate in texture. The ocher is mostly inclosed by the quartzite; but near the top it is in close association with deposits of brown iron ore.

Lot 544, 4th district, affords several excellent exposures of the Weisner quartzite, in the low cut of the Western and Atlantic railroad and along the Etowah river. These sections occur on the Cartersville side where the river is crossed by the Western and Atlantic railroad, and are due in part to excavating for the road bed and the cutting of the river. In the railroad cut, the bedded quartzite is thrown into folds and is greatly crushed and shattered.[1] Impregnations of both ocher and pyrite are observed in places in the rock to some extent. Passing out of the railroad cut at the trestle and turning northward for a few rods, a second excellent exposure of the quartzite, showing the relationship between the inclosing quartzite and ocher, occurs near the top of the bluff facing the river. The section is 30 or more feet high. The rock is rather thin bedded, and is greatly folded, crushed and brecciated. A pocket of ocher some 40 to 50 feet wide is inclosed by the quartzite. Manganese is sparingly associated with the ocher and occurs elsewhere in the rock. A small quantity of the ocher has been removed.

On the remaining lots of the Blue Ridge Mining Company, Nos. 260, 404, 464, 473, 532, 539, 616, 4th district, and lot No. 311, 5th district, the occurrence of the ocher differs from that described above. So far as the openings indicate, the ocher on these lots is inclosed by the residual clays derived from the decay of the quartzite. In some instances, the openings are of sufficient depth to expose a zone of underlying partially decayed quartzite impregnated with the ocher powder, into which the pure ocher above grades. The general characteristics of the enclosing clays and of the underlying zone of

[1] See Plate II.



Topographic Map of the Blue Ridge Ocher Company's Property, with the Underground Workings Shown in the Heavy Black Lines. Contour Interval, 5 feet, with the Local Plant as Datum. From Blue Print Furnished by the Company in 1902.

partially decayed quartzite are the same as previously described on some of the above properties.

Owing to the meager prospecting on some of these lots, it is impossible to state or even predict how extensive the ocher deposits may be. Lots 464, 473 and 539 have been extensively worked for manganese. The openings are numerous and usually of large size exposing extensive bodies of ocher whose quality is unsurpassed in the district. Nearly midway up the western slope of a high quartzite ridge, a tunnel has been driven on lot 616, for a distance of 215 feet directly into the ridge. Beginning at the opening, the tunnel exposes —

	Feet
Clay	75
Ocher	10
Clay	(?)
Clay containing manganese	25
Partially decayed quartzite and clay	(?)
Gray specular iron ore (hematite)	3

The Georgia Manganese and Iron Company's Property

Lots 115, 187 and 188, 4th district, owned by the Georgia Manganese and Iron Company, are located on the Rowland Springs road two and a half miles northeast of Cartersville. These lots have been prospected to some extent indicating marketable deposits of a good grade of ocher. On these three lots and the adjoining ones, Nos. 175, 189 and 245, large quantities of manganese ores have been mined. The openings revealing ocher are not so intimately associated with those of manganese as often occurs elsewhere in the area. On the north side of the road, a short distance back, a deep valley has been carved by a small stream, exposing in places the hard and fresh underlying quartzite, manifesting the usual evidence of crushing. Good exposures of the ocher occur at several points along the stream, enclosed usually by the hard quartzite and overlain in places by the residual decay derived from the underlying rock. Stringers and scattered nodules of manganese oxide are embedded in the ocher near the top. Broken masses and low reefs of the quartzite outcrop on the surface, back from the stream, and near the ocher. Some of the hard rock masses are porous and yellow in color from much impregnated ocher thoroughly disseminated through them, locally known as ocher "bloom." The rock also contains some pyrite in places.

In other places on the property, so far as the test-pits show, the ocher in some of them is inclosed by the residual clays derived from the decay of quartzite. The property has been extensively worked in places for manganese; but no ocher has been mined on it. Judging from the few openings exposing the ocher, workable deposits of good quality may be expected.

The Stegall Property

Lots Nos. 835, 894, 905, 907, 908 and 909, 4th district, owned by Mr. John P. Stegall of Emerson, Georgia, are located near Emerson on the west side of the Western and Atlantic railroad, three and a half miles southeast of Cartersville. With one exception, lot 894, the lots have all been prospected for ocher with excellent results. The writer was informed by Mr. Stegall that several cars of ocher were shipped a good many years ago to an ocher mill then in operation at Rockmart, Georgia. The ocher is of the best grade found in the county, as is shown by the following analysis of a sample of the crude ocher collected by the writer and analyzed for the Geological Survey by the N. P. Pratt Laboratory in Atlanta: —

Moisture at 105° C.	2.08
Water of Combination	11.34
Free Silica (Sand)	8.94
Combined Silica	9.49
Iron Protoxide	0.39
Iron Peroxide	56.29
Alumina	10.15
Manganese Dioxide	0.54
Total	99.22

On lot 905, several test-pits have been dug along the public road near the depot at Emerson, exposing an excellent deposit of the ocher enclosed in the residual clays derived from the decay of the quartzite. Lots 908 and 909 occupy a portion of the west slope of a high and steep quartzite ridge. Several openings have been made a short distance up the slope in ocher bodies inclosed by the hard quartzite. At this point the exposures of the quartzite are often porous or spongy in texture and decidedly yellow in color from the presence of abundantly disseminated ocher. This phase is readily traced into a second one consisting largely of ocher bound together by a firm skeleton of silica, which in turn grades into beds or pockets of the soft, pure ocher. The occurrence of the ocher on these lots, 908 and 909, is, so far as could be made out from the exposures, in every respect similar to that described on the Georgia Peruvian Ocher Company's property at the river.

The Mansfield Brothers Property

The Mansfield Brothers property includes the following five lots of land on which ocher occurs: Nos. 402, 403, 462, 463 and 474, 4th district. The property joins the Blue Ridge Ocher Company's lot on the south, and is located approximately two miles east of Cartersville. Numerous test-pits have been dug on lots 403 and 462 exposing ocher in all of them. These lots occupy portions of the east and south slopes of the same quartzite ridge, respectively. The pits expose a capping of three to five feet of residual red clay containing abundantly admixed fragments of the quartzite in all stages of decay. The ocher is next below the red clay and is of uniform grade and color. The openings on lot 462 show some admixed gray specular iron ore (hematite) and manganese with ocher in places. The writer was informed by Mr. C. C. Mansfield that about two cars of the ocher were shipped some years ago from lot 462 to an ocher mill then in operation at Emerson, Georgia. One tunnel has been opened on this lot, having a length of about 100 feet.

A sample of the ocher collected by the writer from this opening and analyzed for the Survey by the N. P. Pratt Laboratory in Atlanta, indicates a very superior grade of ocher: —

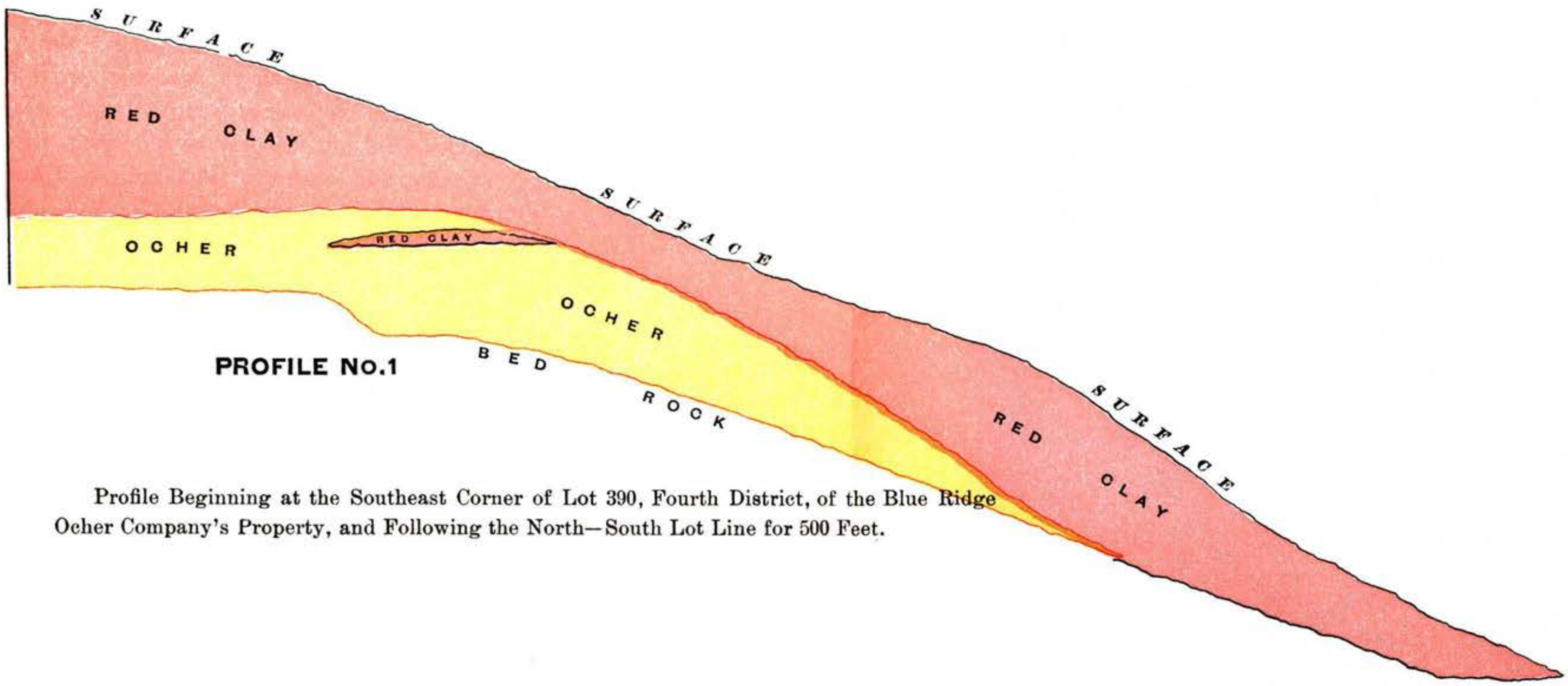
Moisture at 105° C.	0.55
Water of Combination	9.22
Free Silica (Sand)	6.65
Combined Silica	3.98
Iron Protoxide	0.46
Iron Peroxide	72.29
Alumina	5.55
Manganese Dioxide	0.87
Total	99.57

Only slight surface indications of ocher appear on lots Nos. 402, 463 and 474. No test openings have been dug, and no statements can be made concerning the ocher occurrence on any of the three lots.

The John A. Stephens Property

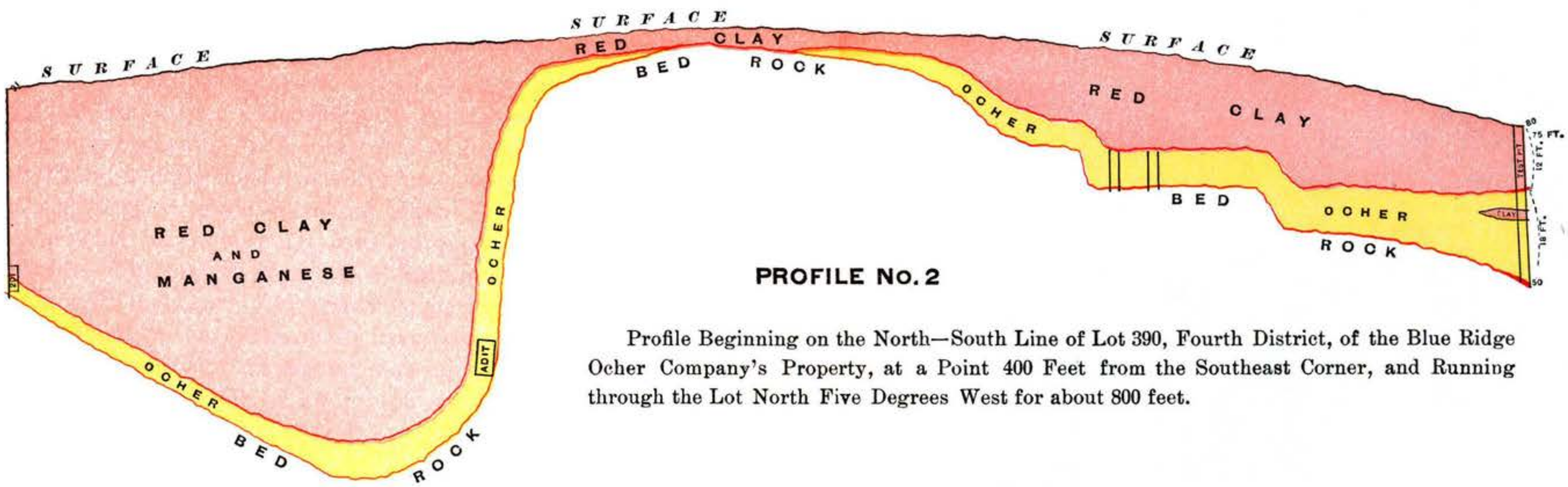
The John A. Stephens property includes the following lots of land on which ocher occurs: lots Nos. 836, 981 and the north half of lot 892, 4th district. These lots are located on a steep quartzite ridge several miles southeast of Cartersville and a short distance east of Emerson. No openings have been made for ocher on lots 892 and 981; but abundant surface indications in the nature of ocher "bloom" occur over parts of both lots. The ocher "bloom" consists of scattered rounded masses of the hard quartzite, porous and spongy in texture, and distinctly yellow in color from the large quantity of the ocher powder disseminated through them. Both manganese and brown iron ore (limonite) are exposed in openings on lot 981; and considerable barite is scattered over the surface and embedded in the residual clays on lot 892.

Lot 836 is the principal ocher lot of the property, and it has been rather thoroughly prospected. Eight openings of fair size, together with a number of small pits, are dug over all parts of the lot, and an excellent quality of ocher is exposed in all of them. The occurrence of the ocher here is in the partially decayed quartzite capped usually by two or three feet of residual red clay commingled with abundant fragments of quartzite in all stages of decay. In places, the usual occurrence of manganese oxide is noted in the ocher, but not in sufficient quantity to be hurtful. Groups of barite



PROFILE No.1

Profile Beginning at the Southeast Corner of Lot 390, Fourth District, of the Blue Ridge Ocher Company's Property, and Following the North—South Lot Line for 500 Feet.



PROFILE No. 2

Profile Beginning on the North—South Line of Lot 390, Fourth District, of the Blue Ridge Ocher Company's Property, at a Point 400 Feet from the Southeast Corner, and Running through the Lot North Five Degrees West for about 800 feet.

crystals are found in the ocher in some of the openings. The quartzite is spongy or porous in texture and yellow in color from disseminated ocher powder, and large masses are scattered quite freely over the surface of the lot — ocher-"bloom." Conditions point to a similar occurrence of the ocher on this lot as that at the river on the Georgia Peruvian Ocher Company's property.

The Elijah Field Estate

Similar surface indications (ocher-"bloom") as those described on lot 836 above, very favorably appear on the adjoining lot 837, 4th district, located about one mile and a half south of the ocher mill at the river. Considerable barite is scattered over the surface of the lot in places.

The Barron Lot

Lot 405, 4th district forms a part of the Parrot Springs property and adjoins that of the Cherokee Ocher and Barytes Company. A number of small test openings made in different places on the lot expose a good grade of ocher inclosed in the residual clays. Across the ravine from the openings the hard and fresh quartzite outcrops in large broken masses, much of which is impregnated with pyrite. Here the quartzite is very dense and flint-like in character.

The W. H. Lanham Property

The W. H. Lanham property includes lot 477 and the west half of lot 476, 4th district, which joins the American Ocher Company's property on the west. In the west half of lot 476 two openings, a shaft 28 feet in depth and an open cut have been made close together disclosing a good grade of yellow ocher. The surface red clays cap the ocher in the openings from an average depth of three to eight feet. The shaft is opened to a depth of 28 feet without passing through the ocher. Considerable barite is mixed with the ocher. About 30 tons of the ocher have been removed.

A large quantity of manganese was mined about 20 years ago in the southwest portion of lot 477 on top of the quartzite ridge.

The manganese openings exposed a body of yellow ocher in close association with the manganese ores. At the time of my examination the openings were nearly entirely filled in, leaving nothing in the shape of ore visible.

THE SATTERFIELD PROPERTY

On this property, only one lot of land, No. 259, 4th district, affords indications of ocher. The indications on this lot are very slight for ocher and they are entirely of a surface character, since no prospect-openings have been made.

THE JONES BROTHERS PROPERTY

Lot 331, 4th district, occupies a portion of the south slope of the quartzite ridge trending east and west, and it adjoins the Blue Ridge Ocher Company's lot 390. The surface of the lot is strewn with large and small fragments of the hard quartzite. A number of prospect openings have been made in different places on the lot, nearly all of which expose yellow ocher. The ocher is apparently inclosed by the residual clays derived from the decay of the quartzite.

THE SMITH AND PEACOCK LOT

This lot, 332, 4th district, joins the Jones Brothers lot 331, and it occupies the lower portion of the same ridge slope. Mr. James M. Smith owns the east half of the lot on which a large open cut near the lower part of the slope has been made, exposing a body of a good grade of ocher containing some manganese oxide in the form of nodules mixed with it. The occurrence of the ocher here is, so far as revealed by the opening, in the residual clays.

THE LARRAMORE PROPERTY

The Larramore property which includes lots Nos. 471 and 472, 4th district, is located two and one half miles east of the town of Cartersville. Quite an extensive body of yellow ocher crosses lots 471 and 472 in close association with manganese ores, which have been mined to some extent on these lots. A number of test-pits have been put down on the ocher at several places on the two lots with very favorable results as regards both quality and quantity of the ocher. The ocher bodies will average three to nine feet in thickness and are enclosed in the residual clays. The contact between the overlying surface red clays and the ocher is always sharp, while that between the ocher and the underlying clays and decayed quartzite is never sharp, but they grade into each other. The occurrence of the ocher here is quite similar to that previously described on many of the properties in the region.

The Franklin Lot

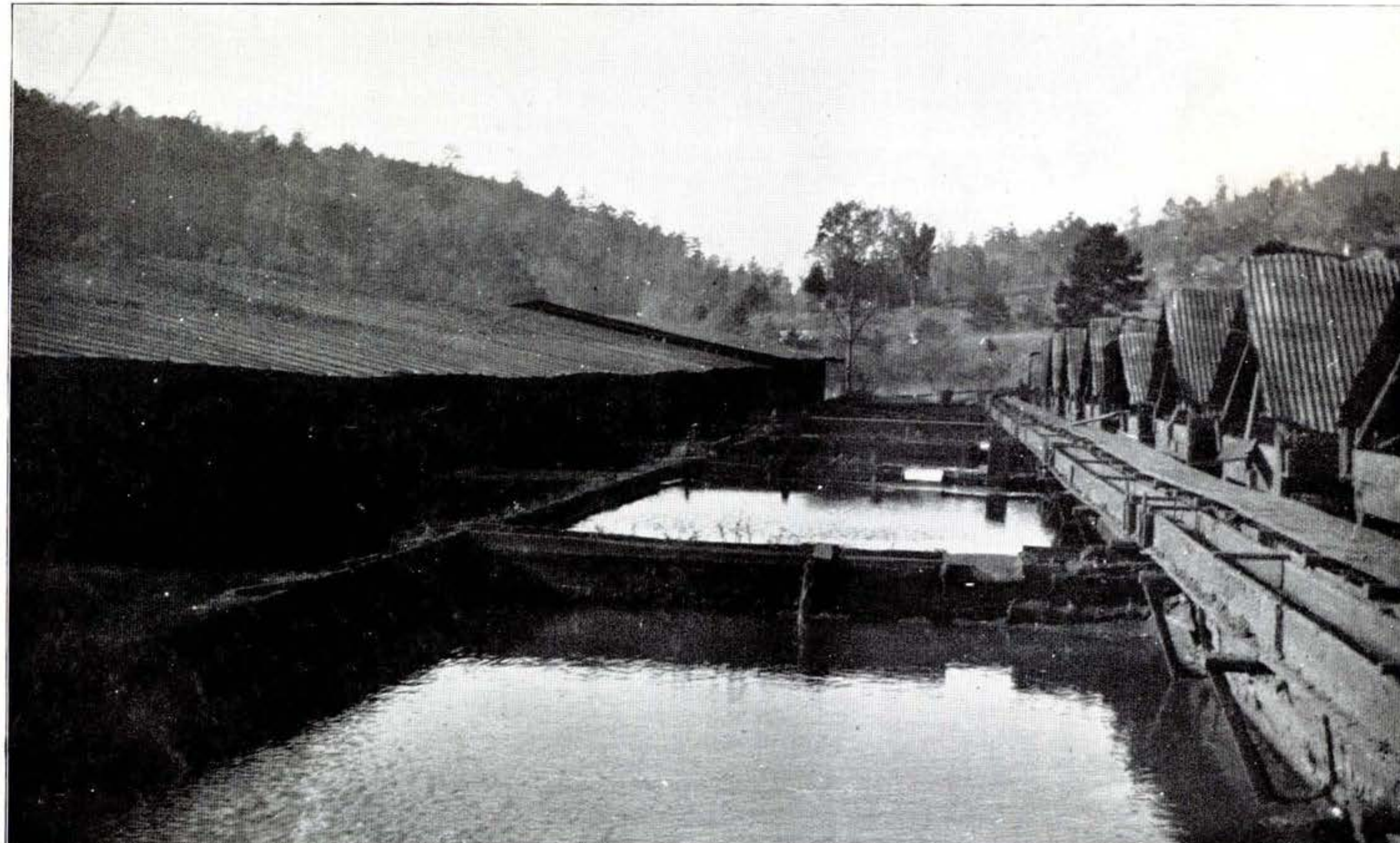
Lot 172, 4th district, known as the Franklin lot is owned by Larramore, Daniel and Stephens of Cartersville. It is located on a high quartzite peak within a short distance east of Cartersville. Numerous openings occur on the lot from which manganese ores were mined. Some of the openings expose a good grade of yellow ocher in close association with both manganese and some brown iron ore.

The John Dobbs Estate

Lot 760 of this estate is located on a high and steeply sloping quartzite ridge and was extensively worked for manganese ores some years ago. On the ridge top, surface indications of ocher in the nature of ocher-"bloom" are very favorable indeed. The porous or spongy textured quartzite, colored a distinct yellow from the abundance of contained ocher powder, covers the surface on top of the ridge in the form of loose, broken somewhat rounded masses of considerable size.

The Crenshaw Property

This property is located about two miles southeast of the town of Cartersville, on the opposite side of the Etowah river from the Georgia Peruvian Ocher Company. Two openings were made some years ago on lot 604, 4th district, from which some of the ocher was shipped to the ocher mill then in operation at Emerson, Georgia. A good exposure is seen along the public road where the ocher body is inclosed by the hard and nearly fresh quartzite. Surface indications of the ocher in the nature of ocher-"bloom" have been observed at other places on the Crenshaw property, the most noteworthy one of which is near the union of the two roads leading southeast from Cartersville at the Western and Atlantic railroad, about one mile southeast of the town.



SETTLING VATS AND DRYING SHEDS OF THE BLUE RIDGE OCHER COMPANY, NEAR CARTERSVILLE, GEORGIA

CHAPTER IV

GENESIS OF THE OCHER DEPOSITS IN THE CARTERSVILLE DISTRICT

Introductory Statement

The wide variation in the mode of occurrence of ocher in different localities indicates that its origin has not been the same in all cases. Deposits of the nature of ocher may result from the leaching action of percolating waters and subsequent deposition therefrom. They may result as residual products formed by the removal in solution of the soluble parts of the original rock leaving the insoluble portions, clay and iron oxide, to form the different ocherous colored clays. Decomposition of rocks rich in iron-bearing silicate minerals may form deposits of the ocher type, illustrated in the yellow ocher deposits of Little Catoctin Mountain in Virginia, which are said to represent residual accumulation from the decomposition of certain schists. The oxidation of beds of pyrite; the alteration or decomposition of beds of hematite; and the alteration of the more compact forms of limonite, may each result in the formation of ocher deposits.[1]

The mode of occurrence of the yellow ocher deposits in the vicinity of Cartersville, Bartow County, Georgia, points to still a different type of deposit in point of origin from that of any stated above. The occurrence of ocher in this locality proves, as shown below, that it has been formed by molecular replacement[2] of the original rock, quartzite. Subsequent weathering, in the re-

[1] Merrill, Geo. P., Guide to the Study of the Collections in the Section of Applied Geology. The Non-metallic Minerals. Report of the U. S. National Museum for 1899 (1901), p. 241.

[2] Lindgren, Waldemar, The Gold and Silver Veins of Silver City, DeLamar and other Mining Districts in Idaho. 20th Ann. Rept., U. S. Geol. Survey, 1898-'99 (1900), Part III, p. 207 *et seq.*

—— —— Metasomatic Processes in Fissure-Veins, Trans. Amer. Inst. Min. Engrs., 1901, Vol. 30, pp. 578-692.

gion since the formation of the ocher has resulted in the ocher bodies being inclosed in many cases by residual clays derived from the decay of the original rock, which apparently closely ally them to residual deposits, but that they are not, is made evident from the discussion which follows below.

Petrography of the Weisner Quartzite

Some portions of the Weisner quartzite, as previously stated, contain interbedded siliceous shales of dark color. In the quartzitic portions of the formation the rock varies from dense, nearly white, and vitreous massive beds without distinct evidence of its fragmental character visible to the unaided eye, to massive beds of distinct granular quartzite of light and dark gray colors. By far the majority of the beds are composed of the granular quartzite in which the fragmental character is plainly evident. In the beds of the granular type, the rock varies from an even-grained fine granular quartzite to a distinct conglomerate facies in which the quartz pebbles are usually of very small size.

Thin sections show it to be a rather pure quartz rock, consisting of quartz grains of somewhat variable size. In general the larger grains contain some inclusions of foreign mineral matter. Hardly a section examined failed to show in a number of the larger grains abundant hair-like needles of probable rutile which are often bent and curved and in many cases broken. Usually the grains are considerably clouded by very fine innumerable dust-like particles without definite arrangement and whose exact nature it was not possible to determine. Inclusions of slender prismatic crystals of apatite are not uncommon in some of the thin sections. The general shape of the larger grains is round. When examined in detail the outer margin of the grains invariably presents an irregular, angular outline formed by the interlocking or dove-tailing of individuals of a surrounding mozaic of much smaller quartz granules. The larger grains are rarely in juxtaposition but are usually surrounded by the mozaic of very fine-grained angular quartz granules. This mozaic of quartz granules fills the entire interspaces between the larger grains. It is explained as due to the peripheral shattering of the larger grains by intense pressure-metamorphism which is further greatly strengthened by the general undulous extinction of the larger grains, and by the greatly crushed condition of the formation made apparent in the field.

Besides quartz, occurs a slight sprinkling in some of the thin sections of feldspar grains including microcline and a striated plagioclase, some calcite and occasional grains of a titaniferous iron oxide. Next to quartz, pyrite is the most abundant mineral. It frequently occurs as fresh grains and crystals; more often as partially and entirely oxidized, in the form of iron oxide. In the latter case the original pyrite may be altered to a limonite pseudomorph, but generally the change has been rapid and a cavity preserving the original outline of the pyrite, only slightly stained or partially filled with the iron oxide, forms the only evidence of the former presence of the pyrite. The mineral both in the fresh and in the completely oxidized or altered condition is often present in the same thin section. The stain of yellow iron oxide derived from the oxidation of the pyrite discolors the section for some distance around and away from the position of the original sulphide mineral. The staining extends the farthest along the sutures between the quartz grains and the fracture lines which are present at times in the grains.

Microscopic study shows quite plainly the relations of the ocher to the quartzite and its mode of occurrence in the rock. After careful study of a number of thin sections under the microscope of the ocher-stained rock from different parts of the belt my results accord so closely with those of Hayes that I again use his description.

Doctor Hayes says:[1] "When the transition-rock is examined under a microscope, the character of the transition can be seen even more clearly. The more compact portions, which are only slightly stained with iron, are seen to be composed of a transparent groundmass, threaded with minute cavities, which penetrate the rock in all directions and contain a fine dendritic growth of iron oxide. The latter occurs only rarely in isolated grains, but generally in clusters of minute grains or fibers, attached to each

[1] Trans. Amer. Inst. Min. Engrs., 1901, Vol. 30, p. 416.

other and branching irregularly from a central stem. They have no trace of crystal form. Passing toward the ore-body, these minute passages become larger and increase in frequency, until only a finely branching siliceous skeleton remains, the greater part of the rock having been replaced by the iron oxide. Under polarized light, the transparent ground-mass is broken up into an aggregate of small quartz grains, penetrated in all directions by the iron oxide. The latter does not lie between the individual grains, but passes through them, as though the ground-mass were quite homogeneous. The process of replacement is never complete; for all the ocher contains more or less sand. When this is washed clean from the iron oxide, it is found to differ from ordinary sand-grains in having extremely irregular outlines. This sand, as might be anticipated from the microscopic structure of the slightly altered quartzite, is evidently composed, not of the original grains of the rock, but of detached portions of the irregular siliceous skeleton, which, in the intermediate stages of replacement, holds the iron oxide in its cavities."

A chemical analysis made, for the Geological Survey, by the N. P. Pratt Laboratory in Atlanta, of specimens of the quartzite collected by the writer is given on page 15.

Mode of Occurrence of the Ocher

As previousy defined the yellow ocher belt in Bartow county is entirely limited to the Weisner quartzite of lower Cambrian age. Field study of the area shows that the ocher occurs in both the hard and fresh quartzite and in the residual clays derived from the decay of the quartzite. So far as mining developments have been made in the area the ocher has nearly equal occurrence in the fresh and in the decayed quartzite. At every point examined its position in the residual clays is in all respects similar to that in the hard and fresh rock, indicating that since its formation some portions of the quartzite have favored decay more than others. With respect then to the character of the enclosing material (rock) the mode of the occurrence of the ocher is best described separately under (a) occurrence in the fresh rock, and (b) occurrence in the residual decay.

Occurrence in the Fresh Rock. — Abundant opportunity is afforded for studying the mode of occurrence of the ocher in the fresh rock over many parts of the area from the good natural and artificial exposures of the rock. The best section afforded for the study of the ocher in its relation to the fresh rocks is at the wooden bridge over the Etowah river, two miles southeast of Cartersville, where the river has cut across one of the quartzite ridges and where extensive mining has been done by the Georgia Peruvian Ocher Company. Here the quartzite has been extensively crushed and shattered from compression so that it is difficult to determine the original bedding of the rock. I quote in full Doctor Hayes' very adequate description of the mode of occurrence of the ocher at this point.

He says:[1] "The ocher forms a series of extremely irregular branching veins, which intersect this shattered quartzite without any apparent system. They frequently expand into bodies of considerable size; and when the ocher is removed, rooms 6 to 10 feet in diameter are sometimes left, connected by narrow winding passages. The mining of the ocher has left the point of the ridge completely honeycombed with these irregular passages and rooms.

"The contact between the ocher and inclosing quartzite is never sharp and distinct, but always shows a more or less gradual transition from the hard vitreous quartzite, to the soft ore which may be easily crushed between the fingers. The quartzite first becomes stained a light yellow, and loses its compact, close-grained texture. This phase passes into a second, in which the rock is perceptibly porous, having a rough fracture and a harsh "feel", and containing enough ocher to soil the fingers. In the next phase the ocher preponderates, but is held together by a more or less continuous skeleton of silica, although it can be readily removed with a pick. The final stage in the transition is the soft yellow ocher, filling the veins, which crumbles on drying, and contains only a small proportion of silica in the form of sand-grains.

"The intermediate zone between the pure ocher and the quartzite

[1] A very full and accurate description of the mode of occurrence of the ocher at this point has been given by Doctor C. W. Hayes in the Trans. Amer. Inst. Min. Engrs., 1901, Vol. 30, p. 415, *et seq.*

is usually a few inches in thickness, although it may be several feet between the extremes, and, on the other hand, sometimes only a fraction of an inch."

Microscopic study of a large number of thin sections of the ocher charged quartzite collected from all parts of the area discloses with but few exceptions, either the former or the existing presence of pyrite. In many of the sections at least a part of the pyrite is entirely fresh and unaltered, but in a majority of them the pyrite has been completely oxidized leaving the original space occupied by the mineral only partially filled, as a rule, by its alteration product, iron oxide. In such cases a complete outline of the original pyrite crystal is preserved in the cavity once filled by the mineral. In still other cases the change has resulted in limonite pseudomorphs after the pyrite. Between these two extremes of scant iron oxide partially lining the cavity and that of pseudomorphic limonite filling the entire cavity all gradations are traced. This presence of pyrite in the quartzite probably has some direct bearing on the origin of the ocher as discussed below.

The full and accurate description quoted above from Hayes of the ocher occurrence in the fresh quartzite in the section exposed at the wooden bridge over the Etowah river to the southeast of Cartersville, similarly applies to the remaining exposures over the region, studied by me, in which sections show the occurrence of ocher in the fresh rock.

Occurrence in the Residual Clays. — The area is one of profound atmospheric decay, and exposures of the fresh rock are rather seldom seen. The mantle of residual decay resulting from the action of the atmospheric agents attains considerable thickness. It is thicker over some of the sub-terranes than over others and it likewise varies in thickness over different parts of the same formation. Variation in depth of decay is especially true of the Weisner quartzite in the Cartersville district where the ridge-valley type of topography is so clearly defined. Accordingly the decay is deeper in the valley-bottoms and on the lowlands than on the ridge tops.

Again it has been shown in this volume that some portions of the Cambrian quartzite were interbedded with siliceous shales; that the shales, as the quartzite, have been replaced in part by the ocher; and that so far as developments extend the occurrence of the ocher in the shales is frequent.

The ocher cuts the inclosing clays in a very irregular manner, forming a series of irregular branching deposits which correspond to veins in the fresh rock. The ore-bodies narrow and widen, thin and thicken throughout their extent. Irregularity obtains both as to vertical and lateral distribution of the deposits. The contact between the ocher bodies and the surrounding clays is never entirely sharp, but a more or less gradual transition from the clays to the pure ocher is usually shown. The ocher-charged clays at the point of contact lessen considerably in the ocher content a short distance away and is entirely absent in the clays at some distance from the contact. As is the case with the ocher bodies in the fresh rock the transition zone between the clay and the pure ocher is quite variable, from a few inches or less to as many feet between the extremes.

The similarity in the mode of occurrence of the ocher in the fresh rock and in the residual clays is clearly brought out in the description of individual properties in Chapter III. The field conditions make it entirely plain that the position of the ocher in the clays is in all respects similar to that in the fresh rock. Evidence pointing to leaching or concentration of these bodies upon subsequent weathering of the original inclosing hard quartzite, forming the surrounding clays, is lacking. Somewhat extensive mining on the properties of the Blue Ridge Ocher Company, the Cherokee Ocher and Barytes Company and the American Ocher Company affords the best opportunity for studying the mode of occurrence of the ocher in the residual clays.

Statement of the Evidence and its Discussion

The mode of occurrence of the ocher when viewed in its relation to the character and structural conditions of the inclosing rock forms the strongest possible argument for the theory favoring its formation from solution. All evidence, both from field and laboratory study, goes to prove that the deposition of the ocher has taken place not by simple filling of cavities and fissures in the rock but by a molecular replacement of the original rock, by the process known as metasomatism.[1] The proof of this is found in the mode of occurrence of the ocher and its relations to the inclosing rock, the principal evidence for which may be summed up as follows: —

1 In nearly every instance of exposure of the fresh rock over the ocher belt, the rock is found to be extensively crushed and shattered and cut in all directions by lines of fracture, by compression. This mechanical action was probably accompanied by heat and the zone of crushed rock afforded a ready and natural passage-way for underground circulating waters, both of which were favorable to increased chemical action.

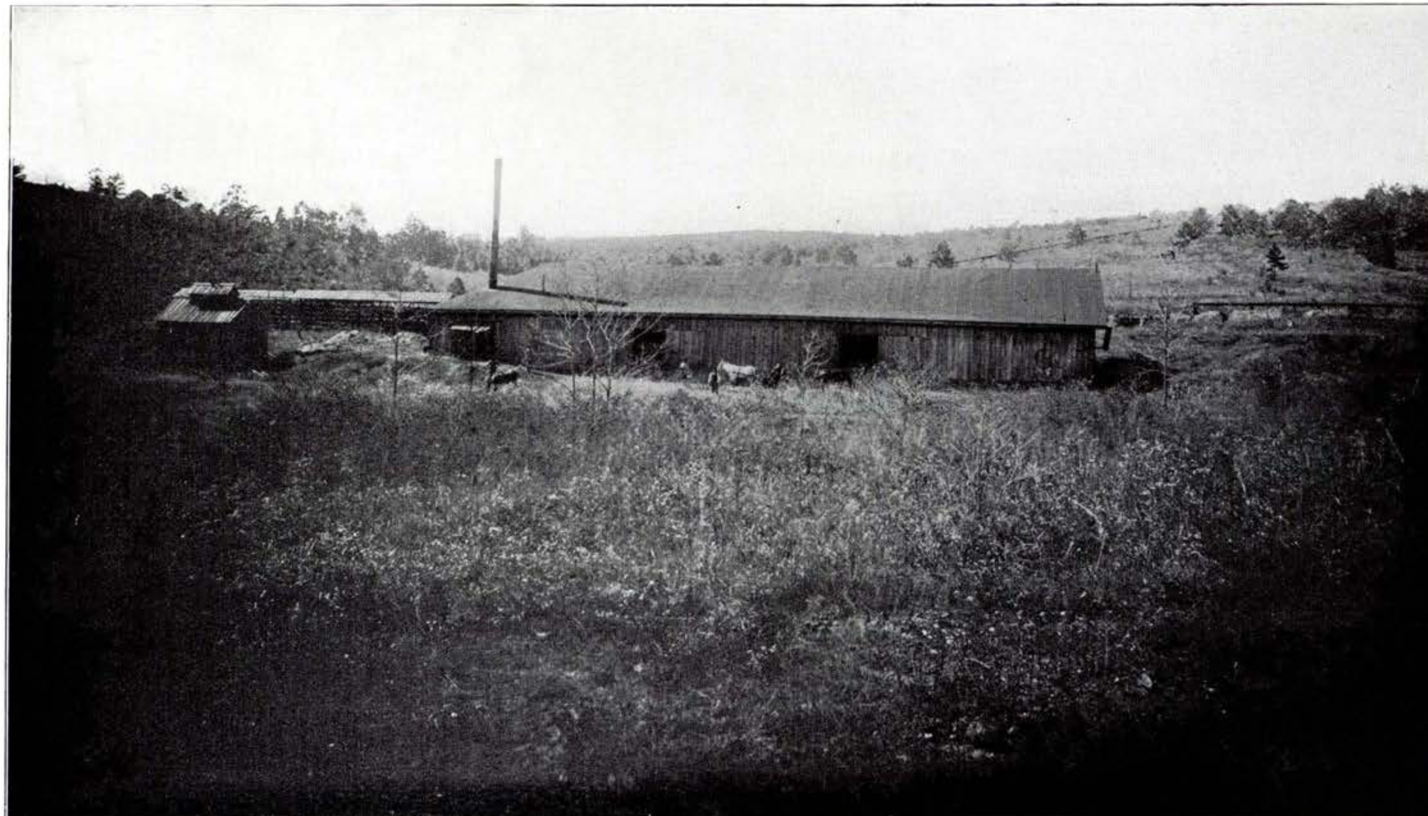
2 The contact between the ocher and the surrounding quartzite is never sharp and distinct, but is marked by a gradual transition from the hard quartzite to the soft ore. The transition zone between the hard quartzite and the soft ocher varies from a few inches to several feet in thickness between the two extremes. "The quartzite first becomes stained a light yellow, and loses its compact, close-grained texture. This phase passes into a second, in which the rock is perceptibly porous, having a rough fracture and a harsh "feel", and containing enough ocher to soil the fingers. In the next phase the ocher preponderates, but is held together by a more or less continuous skeleton of silica, although it can be readily removed with a pick. The final stage in the transition is the soft yellow ocher, filling the veins, which crumbles on drying, and contains only a small proportion of silica in the form of sand-grains."[2]

3 The exceedingly irregular character of the ore-bodies and their distribution in the enclosing rock. The shattered rock is cut in all directions by exceedingly irregular branching veins of the ocher, which narrow and widen, thin and thicken, indiscriminately without apparent regard to system or uniformity.

4 Microscopic study of the transition rock which makes plain the relations of the ocher to the quartz rock and its mode of occur-

[1] By metasomatism is here meant "the conversion of a rock or mineral aggregate into another of partly or wholly different chemical composition." The form, structure, and texture of the original mineral or rock may be totally or partly changed. Lindgren, W., 20th Ann. Rept., U. S. Geol. Survey, 1898-99 (1900), p. 217; Trans. Amer. Inst. Min. Engrs., 1901, Vol. 30, p. 580 *et seq.*

[2] Hayes, C. W., *Op. Cit.*, pp. 415-416.



A VIEW OF THE PLANT OF THE AMERICAN OCHER COMPANY, 2½ MILES EAST OF CARTERSVILLE, GEORGIA.

rence in the rock. The iron oxide usually cuts across the quartz grains instead of lying between them. This replacement process is never complete but all the ocher contains more or less free quartz grains distributed through it. The grains are very irregular in outline which distinguishes them from ordinary quartz or sand grains, and were evidently produced from solution.

5 Finally, the replacement hypothesis is strengthened by the general appearance of the rock in places affording evidence of solution and re-deposition of the silica. Small cavities penetrating the quartzite in places are frequently observed to be lined with very small crystals of quartz deposited from solution. Also the skeleton of silica binding the ocher together and from which the sand grains disseminated through the purer beds of soft ocher have been derived, indicate deposition from solution rather than composed of grains of the original rock.

The Source of the Iron Oxide

The iron oxide in the form of the yellow ocher deposits occurring in the Cartersville district was probably derived in part from two different sources. (a) That derived from the decay of surface rocks and carried downward by the percolating waters in the form of soluble ferrous salts; and (b) that derived from the pyrite contained in the quartzite.

How much of the iron oxide was derived from the first source and how much from the latter must necessarily be entirely conjectural. That both proved in part a source of supply of this ingredient in some places if not in all can hardly be doubted. Hayes states that the iron oxide was derived from the decay of surface rocks.[1] That pyrite has contributed in part at least to the supply is evidenced by the former and existing presence of this mineral in every thin section of the quartz rock examined by the writer, and by its frequent state of oxidation.

The Process of Replacement

Perhaps the most difficult part of the process to understand is the solution of the silica of the quartzite. What materials were

[1] Trans.. Amer. Inst. Min. Engrs., 1901, Vol. 30, p. 417.

present in the circulating waters that aided or affected solution of the silica can only be conjectured. The recent work of Van Hise and others, indicating that under conditions of great pressure and high temperature silica becomes readily soluble as a constituent of rocks, seems applicable to the region under discussion and likely exercised an important control. Of greater importance, however, is the principle that, "under certain conditions, a carbonic acid solution of iron carbonate, meeting an oxidizing solution, precipitates its iron as hydrated ferric oxide, and at the same time dissolves silica"[1] — a reaction which would entirely explain the formation of the ocher deposits in the Cartersville region, since all the necessary conditions were seemingly present. The broken and shattered quartzite afforded a ready and natural zone for the penetration to considerable depths of the downward percolating surface waters. The iron oxide derived from the source indicated above was held in solution in the form of some soluble ferrous salt, presumably as carbonate or as some organic salt. It seems more than likely that through the more open fissures in the rock atmospheric oxygen was dissolved and carried downward in solution by some of the descending waters. As Hayes says,[2] "The two solutions coming in contact, the iron carbonate was oxidized and precipitated as limonite, in the place of silica dissolved at the same time."

The theory of replacement or metasomatism for the type of ore deposit here discussed conforms closely to the facts obtained from both field and laboratory study. Field study makes it entirely plain from the mode of occurrence that the position of the ocher in the enclosing clays is in all respects similar to that in the fresh rock, and that subsequent weathering has reduced the fresh rock, quartzite originally enclosing the ocher-bodies, to that of residual clay.

[1] *Op. Cit.*, p. 417. [2] *Ibid.*, p. 417.

CHAPTER V

HISTORICAL SKETCH OF THE DEVELOPMENT OF THE OCHER INDUSTRY IN THE DISTRICT

The first authentic record of ocher mined in Bartow county, Georgia, dates back to the year 1877, when Mr. E. H. Woodward began mining ocher on a property located near the limits of the town of Cartersville. The crude ocher was hauled in wagons to Cartersville and prepared for market. At this time Mr. Woodward was also engaged in mining manganese on the Dobbins property, six miles northeast of Cartersville.

In the year 1878, Mr. A. P. Silva, who for several years had been engaged in the extensive mining of manganese in the district, mined some ocher on a small scale. In the same year Mr. M. F. Pritchett purchased the ocher interest of Woodward and Silva, and the ocher mined was hauled to Cartersville, where it was washed and dried preparatory to shipping. He used for drying the ocher a brick furnace about 30 feet long and four feet wide with thin sheet iron for the bottom and a fire box located at one end.

Pritchett sold his interest to Maltby and Jones in 1879. Mining was continued on the same properties, but under improved methods. Hauling of the crude material to Cartersville was also continued where it was prepared for market. The only mines worked were located on the Larey property near the wooden bridge across the Etowah river, two and a half miles southeast of Cartersville on the Emerson road.

In 1890 the property was again sold to the Georgia Peruvian Ocher Company, composed of Western capitalists. Improved methods in the preparation of the ocher for market were introduced by the company. For the reason that the wagon road was better to Emerson than to Cartersville, the plant was moved to the former place, two miles south of the mines. The first shipment of American ocher to Europe is reported to have been in December, 1890, from the mines of this company near Cartersville, Georgia. The shipment consisted of a consignment of 50 tons to England.[1]

Systematic mining and preparation of the ocher with the use of modern machinery and improved methods, properly dates perhaps from the year 1891, when J. C. Oram of Vermont and E. P. Earle of New York, both experienced ocher men, became interested in the company. Both of these men had handled ocher for years in the East and it was due to them that the ocher industry became firmly established in Bartow county, Georgia. Up to this time the ocher had been dried with steam in large vats fitted with steam pipes along the bottom of the vats. Mr. Oram first introduced the natural process of air-drying, in vats dug in the ground. The capacity of the vats was a car-load or more of the ocher when dry. The two last plants established in the district, namely, the Blue Ridge Ocher Company, and The American Ocher Company, have not put in equipment for steam drying, but use only the natural or air-drying process.

In 1893, Mr. W. B. Shaffer bought the property adjoining the Larey property, directly at the entrance to the wooden bridge across the Etowah river on the Emerson road, and established the Standard Peruvian Ocher Company. Mr. Garrett Linderman purchased in 1896 the Shaffer plant and property, becoming owner of both the Shaffer and Oram mines and mill and is operating at present as the Georgia Peruvian Ocher Company. All the machinery and other equipment were moved from Emerson to the present site at the bridge and a commodious modern plant installed at the mines for preparing the ocher for market.

In 1898 a second plant, known as the Cherokee Ocher and Barytes Company was installed for the purpose of mining and shipping ocher, by Messrs. Akin and Baxter, one mile east of the Western and Atlantic Depot in Cartersville.

In 1899 a third plant known as the Blue Ridge Ocher Company was added by Messrs. Hull and Postell, located about two and a half miles east of Cartersville. The last and fourth plant to be es-

[1] U. S. Geol. Surv.; Mineral Resources of the United States for 1889 and 1890, p. 509.

tablished in the district was the American Ocher Company in 1902, owned by a syndicate in Warrior's Mark, Pennsylvania. The plant is located two and a half miles nearly due east from Cartersville and like the others is in all respects an up to date plant.

Several unsuccessful attempts were early made to produce ocher at Rockmart in Polk county, Georgia, but each time the venture was abandoned.

PRODUCTION

For the purpose of comparison the production of ocher in Georgia from 1889 to 1901 inclusive is shown in the following table:—

PRODUCTION OF OCHER IN GEORGIA FROM 1889 TO 1901 INCLUSIVE[1]

Year	Quantity Short Tons	Value	Average Value per Ton
1889	2,512	$ 29,720	$ 11.83 +
1890	800	12,800	16.00
1891	600	9,000	15.00
1892	1,748	26,800	15.33 +
1893	2,000	39,000	19.50
1894	1,690	17,840	10.55
1895	2,105	31,080	14.76 +
1896	2,981	28,005	9.39 +
1897	2,608	36,600	14.03 +
1898	2,858	30,798	10.77 +
1899	3,212	39,505	12.29
1900[2]	6,828	73,172	10.71 +
1901[2]	5,077	49,176	9.68 +
1902[2]	3,688	38,423	10.42 —
1903[2]	5,212	47,908	9.19 +

The above table illustrates the noteworthy fact that, beginning with the year 1890 there has been with several exceptions a general increase from year to year in the output of this product from Georgia. The average value per short ton has ranged between $9.19 in 1903 and $19.50 in 1893.

Including Georgia, nine States contributed to the output in ocher in 1901. Of these only four, California, Georgia, Pennsylvania and Vermont, had more than two producers. Pennsylvania pro-

[1] 21st Ann. Rept., U. S. Geol. Survey, 1898-99 (1901), Part VI, pp. 572-574.

[2] Mineral Resources of the United States, U. S. Geol. Survey, Calendar year 1903, p. 1098

duced 45 per cent. of the total output in 1900, and 46 per cent., in 1901.

PRODUCTION OF OCHER IN 1896, 1897, 1898, 1899, 1900, 1901, 1902 AND 1903, BY STATES [1]

State	1896		1897		1898		1899	
	Quantity Short Tons	Value	Quantity Short Tons	Value	Quantity Short Tons	Value	Quantity Short Tons	Value
Georgia	2,981	$ 28,005	2,608	$ 36,600	2,858	$ 30,798	3,212	$ 39,505
Pennsylvania	2,926	26,818	6,825	81,325	5,986	61,500	7,285	57,245
Vermont	——	——	693	7,739	664	6,650	653	6,200
Other States	8,167	81,635	3,880	37,100	2,455	24,884	2,974	37,218
Total	14,074	136,458	14,006	162,764	11,963	123,832	14,124	140,168

State	1900 [2]		1901 [2]		1902		1903	
	Quantity Short Tons	Value	Quantity Short Tons	Value	Quantity Short Tons	Value	Quantity Short Tons	Value
Georgia	6,828	$ 73,172	5,077	$ 49,176	3,688	$ 38,423	5,212	$ 47,908
Pennsylvania	7,601	21,661	7,632	76,106	9,818	80,259	4,937	34,782
Vermont	401	3,856	370	3,493	441	4,544	—— [3]	—— [3]
Other States	2,185	25,018	3,632	49,024	2,618	22,482	2,375	28,935
Total	17,015	186,707	16,711	177,799	16,565	145,708	12,524	111,625

[1] 21st Ann. Rept., U. S. Geol. Survey, 1898-99 (1901), Part VI, p. 572.

[2] Mineral Resources of the United States for the Calendar Year 1903, p. 1098.

[3] Included in Other States.

Methods of Mining the Ocher

The ocher deposits to be mined in the Cartersville region form extremely irregular branching veins, which intersect the rock in almost every direction. The veins narrow and widen, thin and thicken at irregular intervals. Bodies of considerable size are frequently met with, which, after the ocher has been removed, leave chambers eight to ten and more feet in diameter, connected by irregular narrow passages. With respect to the enclosing rock two distinct types are to be considered. First the ore bodies may be entirely enclosed by the hard and fresh, shattered quartzite, the best illustration of which is on the property of the Georgia Peruvian Ocher Company, at the wooden bridge across the river to the southeast of Cartersville. Second, the ore bodies may be entirely enclosed by the residual clays derived from the decay of the quartzite, and is illustrated by the properties of the other three companies operating in the district. Mining of the ocher bodies enclosed by the hard and fresh quartzite necessitates frequent blasting, which is unnecessary in those bodies surrounded by the clays. The deposits are usually exposed along the slopes and summits of the quartzite hills and ridges. The bodies of pure ocher are soft and clay-like in character and the ore is easily mined with the pick and shovel.

Systematic mining is carried on on several properties in the Cartersville district, namely, the Georgia Peruvian Ocher Company; the Blue Ridge Ocher Company; the Cherokee Ocher and Barytes Company; and the American Ocher Company. The method of mining on these properties consists of tunnels driven into the ridge, with shorter drifts or tunnels worked from the main ones at suitable points. By this method a number of levels, one above the other, have been worked on several of the properties, but much more extensively on the Georgia Peruvian Ocher Company. On this property the natural section exposed by the river cutting across the quartzite ridge, has been worked back some distance from the river by blasting. At this point about half of the entire section from top to bottom is of the shattered rock almost entirely replaced by the ocher held together by the hard siliceous skeleton, which can be easily and profitably worked in this way.

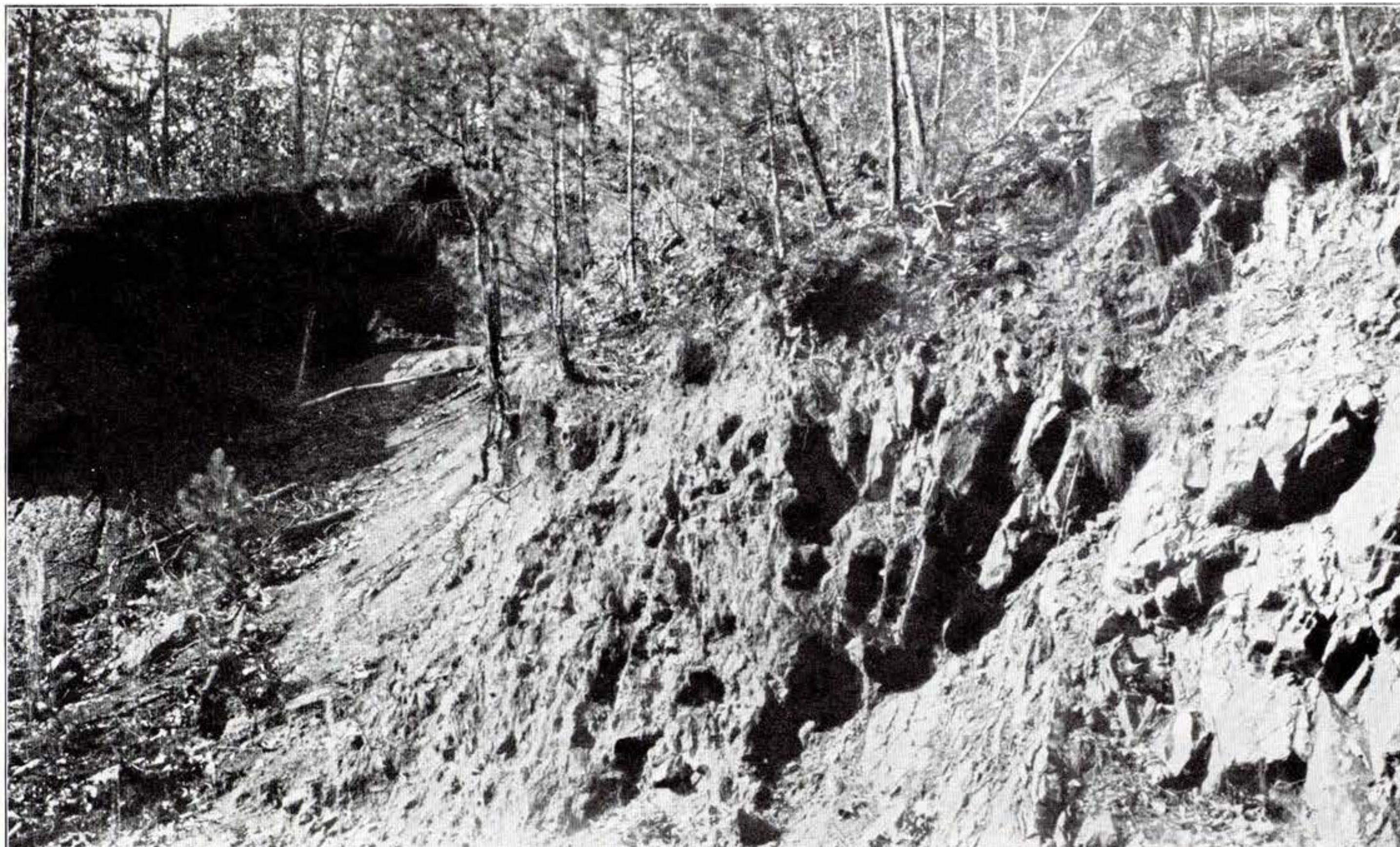
Timbering is necessary in tunneling, as both the clay and the crushed and shattered quartzite are apt to cave in. Also this method of underground mining is extensive enough here, to necessitate underground tramways and lights. The tram-cars are drawn in and out of the mines either by mules or by means of steam and cable. Both are in use at the Cartersville mines.

Preparation of the Ore

None of the ocher is marketed in the crude state. To obtain the merchantable product the only preparation necessary involves the separation of the ocher from its mechanically admixed impurities as mined. As previously described the principal impurities include clay, sand and manganese dioxide. The process employed in the Cartersville district for freeing the ocher from its impurities and otherwise preparing it for market includes washing, drying, pulverizing and packing, which can best be described separately under the several headings.

Washing. — The crude ocher as mined is separated from the heavier and coarser impurities by a process of washing in running water. The ocher existing in a finely divided state separates and floats suspended in the water while the coarser and heavier impurities settle rapidly to the bottom. With one exception the form of washer used at the different plants in the Cartersville district is of the kind used for washing the manganese and brown iron ores.

After the ocher has been mined it is carried on an inclined tramway from the mines to the washer and dumped into a long trough or box filled with running water. A central shaft, armed with iron blades arranged in the shape of a broken helix, revolves lengthwise in the box, and violently agitates the ore. The very finely divided particles of ocher remain suspended in and are floated by the water, which escapes through the openings near the top of the box into a race or flume which empties into a series of vats a short distance away where the ocher is allowed to settle. The water in the vats is disposed of by decantation and evaporation. The greater bulk



A VIEW OF THE WEISNER QUARTZITE, NEAR CARTERSVILLE, GEORGIA, WITH A SMALL OPEN-CUT AT THE LEFT, MADE IN PROSPECTING FOR OCHER.

of the impurities settles rapidly and escapes through an opening provided near the bottom and at one end of the trough, as waste. This form of washing necessarily involves considerable loss in the ocher, as much of it escapes with the waste, amounting to as much as 25 per cent. in some cases. Also, some of the lighter and more finely divided impurities are floated with the ocher but to some extent settle along the bottom of the race in transit from the washer to the vats. The remainder of these impurities, which includes mostly clay and finely divided silica as sand passes into the vats and there settles in intimate admixture with the ocher. That the refined ocher is never free from these impurities is clearly shown in the table of chemical analyses on page 29.

The form of washer in use at the Blue Ridge Ocher Company's plant was planned with the view to diminish the grinding and rubbing action in the log washer, and thereby decrease proportionately the resulting percentage of finely divided impurities, sand and manganese oxide principally, which would be floated with the ocher. As designed and operated by Captain Postell, manager of the company, the washer consists of a V-shaped box about 7 feet long, 5 feet high, and 3 feet wide at the top. In the bottom of the box is fastened a 3-inch pipe with one-eighth inch perforations along the top at intervals of about one and one-quarter inches. The water is introduced into this pipe and issues into the box through the perforations in the pipe. Over this pipe revolves a shaft set with 1-inch pins so arranged that those of one row fall just half way between those of the next row, giving a spacing between pins, if they were aligned in the same row, of two inches.

By this arrangement the ocher is sufficiently disintegrated without being subjected to the grinding and rubbing action of the log washer. The water containing the suspended particles of ocher overflows at the top of the washer-box into a line of troughs through which it passes into the settling vats. The ocher is further purified by settling of a portion of the impurities along the bottom of the troughs. After the overflow becomes thin showing that the ocher in the charge is about exhausted, a long narrow door at the bottom of the washer is raised and the sand, clay, etc., mixed with some ocher are washed through and carried off in a trough as waste.

Captain Postell states that the washer of the size here given easily handles 25 to 30 tons of the ocher per day of ten hours, and that all the necessary work including cleaning of the troughs, etc., is readily performed by three ordinary laborers.

Drying. — The water is in large part syphoned from the vats by means of rubber hose. After the ocher has settled and as much of the water syphoned off by the hose as possible, further expulsion of the water is by means of evaporation. Evaporation is either by natural means, exposure to the heat of the sun, or by artificial means promoted by steam heating. Several of the plants in the district are fully equipped for both processes of drying, but for reasons stated below most of it is accomplished by the heat of the sun. The ocher is removed from the vats just as soon as it is stiff enough to handle. It is then placed on drying racks under the shed where the drying process is completed. The time required for evaporation sufficient to admit of handling the ocher, after syphoning off the water from the vats to transferring to the racks under the shed, will average about ten days in clear summer weather. It requires from eight to twelve days of similar weather to complete the drying on the racks before removing the ocher to the pulverizer.

Artificial drying is in vats or tanks arranged in series, and in which iron pipes are run at close intervals along the sides and bottoms for steam heating. Drying by this method requires usually not longer than one or two days, when the ocher is ready to be removed to the racks and the drying continued for the usual time, eight to twelve days, before the ocher is dry enough to pulverize. While the time is considerably shortened by the steam drying over the natural evaporation by the sun, the ocher is less desirable than the sun dried material. The reason for this is that, near the pipes the heat is strong enough to partially dehydrate or calcine the ocher changing its color from yellow to dark red according to the following reaction: —

Yellow Ocher (Hydrous Iron Sesquioxide)		Red Ocher (Anhydrous Iron Sesquioxide)	
$2Fe_2O_3 \cdot 3H_2O$	$+$ Heat $=$	$2Fe_2O_3$	$+3H_2O$

For this reason some of the plants in the district have not included equipment for artificial drying.

The drying sheds are of the usual kind, consisting of parallel tiers of racks, one above the other, spaced at regular intervals to admit of the free circulation of air, open on all sides but roofed over to protect the ocher against rain. Plates V to IX inclusive are views of several of these sheds. The capacity of the sheds will vary of course, but they may be built of any size. The average shed in the Cartersville district will contain not less than 20,000 square feet of rack space. Likewise the settling vats may show considerable variation in size with perhaps the average size having a capacity of about 50 tons of ocher.

Pulverizing and Packing. — After being thoroughly dried on the racks, the ocher is removed to a room where it is pulverized and packed under steam pressure. Packing is in barrels and bags of uniform size. Capacity of the barrels is from 350 to 400 pounds, and that of the bags 210 to 250 pounds. The Georgia Peruvian Ocher Company export their product in barrels lined with a form of elastic bag to protect the ocher.

Transportation

The Western and Atlantic railroad connecting Atlanta, Georgia, and Chattanooga, Tennessee, passes directly through the ocher belt, and affords a ready outlet to all points north, south and west. The town of Cartersville, from which the area derives its name, is the county-seat of Bartow county and is one of the principal towns of northwest Georgia. It is located directly on the Western and Atlantic railroad and the four ocher plants operating at present are located within a radius of less than three miles of the town.

The country roads connecting with this point on the railroad are good and teams can be hired at from $2.00 to $3.00 per day. Hauling in this section can be done, however, much more cheaply by contract than by day work.

Fuel

A large part of the area is heavily timbered with second growth forests, which insures an abundance of fuel in the nature of cord wood and charcoal. Labor is usually cheap and the timber can be secured at very reasonable figures. Large supplies of coal are mined a short distance to the northwest in Alabama and in the extreme northwest corner of Georgia.

WATER

The area has a plentiful water supply in the numerous large and small streams. The Etowah river, one of the major streams in northwest Georgia, flows directly across the belt a short distance to the south and east of Cartersville, and is fed by numerous smaller streams over the area which enter as north and south tributaries. The water-power along the Etowah river in the vicinity of Cartersville is one of the principal water powers in the State.

THE CALCINED OCHER

On account of the invariable presence of traces of manganese oxide, and of larger amounts of other impurities, it is claimed by some producers in the district that the ocher does not yield a desirable product on calcining. Some laboratory tests made by the writer on both the raw and refined ocher of the best bright yellow grade entirely disproves the claim. In order to test the claim that manganese oxide was the injurious impurity present in the ocher I powdered a lump of pyrolusite (MnO_2) obtained from the mines in the Cartersville district and thoroughly mixed this with the powdered yellow ocher to the amount of 20 per cent of the manganese oxide. The powdered mixture of ocher and manganese oxide was then subjected to the heat of a bunsen burner until the iron oxide (ocher) had been completely dehydrated. The calcined powder was of a rich, uniformly dark blood red color and when compared with the color of the similarly calcined ocher of the best grade no appreciable difference in color could be discerned. Both powders were then separately ground in hard linseed oil and several coatings of each applied with a brush on smooth fresh surfaces of wood blocks. The results were highly satisfactory and the difference in color was hardly appreciable. The color was entirely uniform and homogeneous both before and after grinding in oil.

The results obtained from the tests made on the best grade of ocher indicate that a desirable red pigment is produced from the yellow ocher by calcining. In fact I am reliably informed that a small amount of the ocher produced by one of the companies in the district is calcined and used in the paint trade as a red pigment. Undoubtedly the demand in this direction will be increased in the future. The dark grade of ocher which is inferior to the bright yellow product, because of the large amount of admixed argillaceous or clayey material, would probably not yield so satisfactory a pigment on calcining. The claim that the traces of manganese oxide usually present in the refined ocher prevents burning to a uniform color is entirely unfounded. This is based on the tests made of a prepared sample to which eighteen to twenty times more manganese oxide was added than is present in any of the better grades of yellow ocher produced in the Cartersville district, and yet the results as shown above were entirely satisfactory.

USES

The principal use made of the yellow ocher mined in Bartow county, up to the present time, is in the manufacture of linoleums and oil cloths. For this consumption the important markets are in England and Scotland, to which the bulk of the Cartersville product is exported. Some of the ocher is used for a similar purpose in the plants in the United States manufacturing linoleums and oil cloths. It is used to a limited extent in the manufacture of paints.

Until recently the American ochers have been considered inferior to the imported ochers from other countries for the manufacture of paints. Gradually, however, the excellent qualities of the Cartersville ocher for paint purposes are beginning to be recognized and it may be confidently predicted that in the future an increasing demand will be made for this product in paint manufacture. By reason of its high grade character, containing, proportionately a smaller amount of impurities and a larger amount of iron oxide, than most of the yellow ochers produced in the United States, the Cartersville ocher yields on calcining a rather desirable red pigment, which must eventually make its way into the markets.

The Cartersville ocher is further used in a variety of minor ways the demand for which is very limited.

Markets

The principal markets at present for the Georgia product are foreign, and they include points in England, Scotland, Ireland, and to some extent Germany. It is also shipped for use to many of the larger towns both in the north and in the south.

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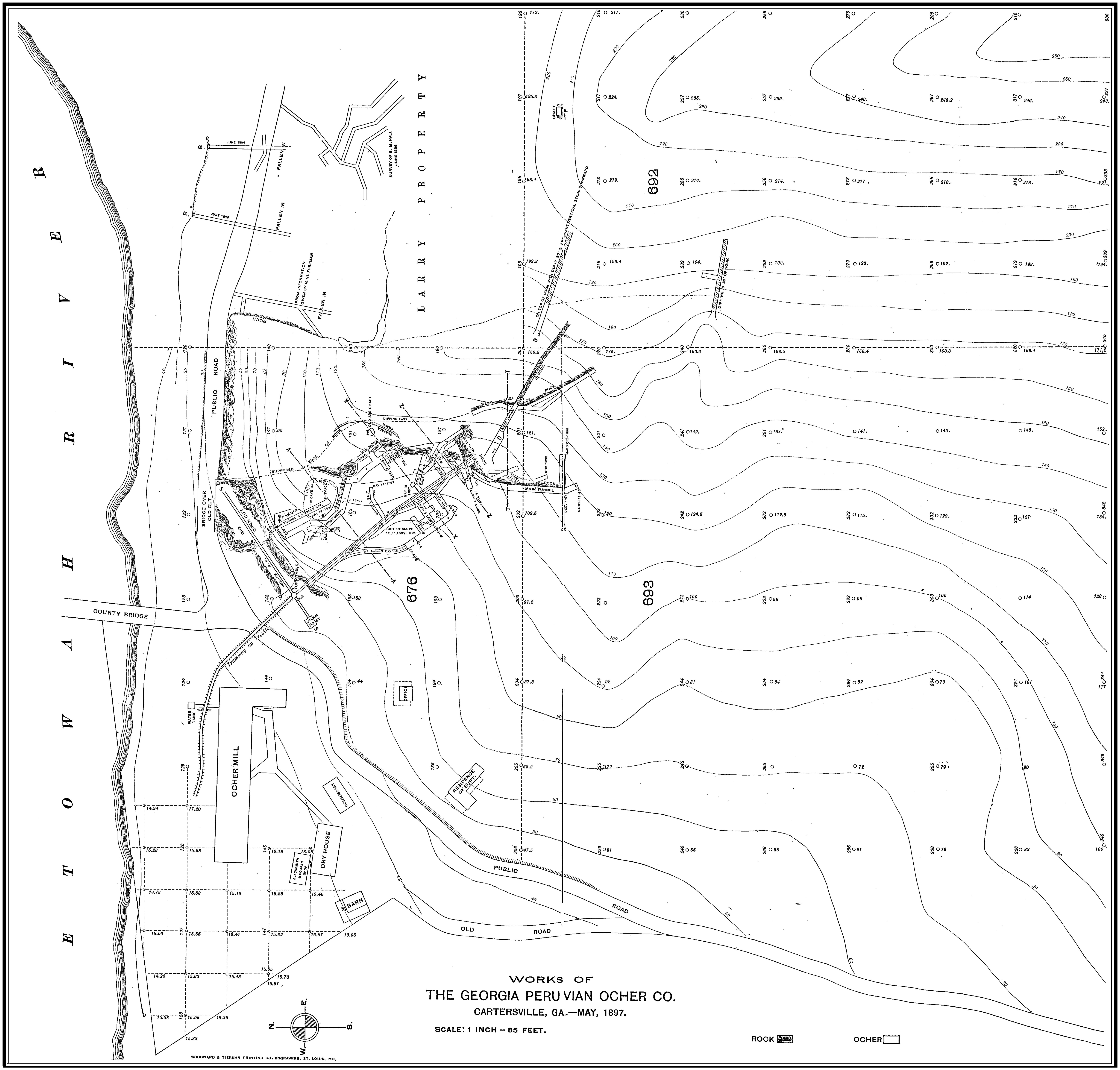

WORKS OF

THE GEORGIA PERUVIAN OCHER CO.

CARTERSVILLE, GA.—MAY, 1897.

SCALE: 1 INCH = 85 FEET.