CIRCULAR 6132

MAY, 1929

INFORMATION CIRCULAR

DEPARTMENT OF COMMERCE -- BUREAU OF MINES

OCHER AND OCHERY EARTHS

BY

R. M. SANTMYERS

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By R. M. Santmyers[2]

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1 - The Bureau of Mines will welcome reprinting of this article, but requests that the following footnote acknowledgment be made: "Printed by permission of the Director, U. S. Bureau of Mines. (Not subject to copyright.)"

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GENERAL DESCRIPTION

Ocher or ochery earth is a natural mineral pigment composed largely of clay permeated with hydrated iron (ferric oxide).[3] Its color ranges from yellow through orange to reddish brown, depending largely on the amount of iron present. Ocher grades into sienna, which differs from ocher chemically in that it generally contains more ferric iron than it does clay, and physically in that when finely ground it is more of a stain than a pigment. Good grades of ocher should contain 20 or more per cent iron oxide, but the iron content and hence of the material marketed varies widely. Ocher has a specific gravity of about 3.5.

COLOR VARIATIONS

Cream ocher contains as low as 5 per cent iron hydroxide. It is used to some extent as a primer on wood, but has little value as a pigment.

Gray ocher is silica, clay, and carbonaceous matter. Sometimes it is colored slightly green by a trace of ferrous hydroxide. It is used as a filler for cheap paint.

White ocher is nothing but ordinary clay, and has no value in paint, although it is occasionally used as an adulterant.

Golden ocher is ocher which has been toned up with some chrome yellow. Various shades of it are on the market. Perfect orange-colored shades contain as much as 12 to 15 per cent chrome yellow. The base may be either French or domestic ocher.

Green ocher is similar in composition to gray ocher except that it contains a larger proportion of ferrous hydroxide. It is found principally in Bohemia (Czechoslovakia), and goes by the name of "terre verte." It has no hiding power when used alone in paints, but as it has a high absorbent capacity for certain aniline colors, it is largely used as a base for cheap lakes. Verona green, Veronese earth, green earth, etc., are similar products.

Red ocher is obtained by calcining raw ocher at a low heat so as to drive off a part of the combined water. The shade depends upon the time of heating and the iron content - the longer the calcination the more purple the product. Burnt ochers are sold as Indian red, Venetian red, light red, etc. As a rule, however, these ochers are much richer in iron than the ordinary ocher, which almost never contains more than 30 per cent iron oxide.

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3 - United States Tariff Commission, Tariff Information Survey, Par. 55, Act of 1913, A-15.

USES AND SPECIFICATIONS

There are two principal uses for ocher - in paints and as a filler for linoleum and oil cloth. Ocher is also used to a limited extent as a pigment in coloring cement stuccos and mortars, for producing desired colors in earthenware when mixed with manganese oxide, and in very limited quantities for other minor uses. It does not seem to follow that the best ocher for color pigments in paints is necessarily the most desirable as a filler in linoleum.

Domestic ochers of the best quality make excellent pigments, work well with all vehicles and with other pigments, and are permanent in color. When mixed with white, fine cream or buff tints are obtained. Chrome yellow is sometimes added to ocher of inferior color to impart a brighter tint than the natural color, but the chrome yellow fades after a time and leaves only the natural ocher effect.

Color would seem to be less important in ocher for use in linoleum and oil cloth, and this perhaps accounts for the fact that a large quantity of domestic ocher has been exported for use as a filler, giving as good service as the better colored but more expensive French ocher.

Georgia ocher has been used chiefly as a filler in the manufacture of linoleum and oil cloth, and much of it has been exported to England and Scotland for that purpose. Some of it is used for the same purpose in this country. It is also employed in the manufacture of paints, and in a variety of minor ways. This ocher when calcined yields a red pigment which is becoming of importance, especially as a mortar color, and is finding its way into the markets in growing quantities.

Pennsylvania ocher has been used principally in the manufacture of paints.

The United States Army states in its paint specifications that yellow ocher must be equal in color and quality to the best French ocher, must be free from chromate of lead or any foreign coloring matter, and must contain at least 20 per cent oxide of iron and not more than 5 per cent lime.

Other specifications prepared and recommended by the United States Interdepartmental Committee on Paint Specification Standardization, published in Circular 91 of the Bureau of Standards, states that the dry pigment shall be a hydrated oxide of iron permeating a siliceous base, and shall be free from added impurities. It must all pass a 200-mesh screen, contain no less than 17 per cent iron oxide, not more than 5 per cent lime, - no lead chromate or organic colors, and must equal the sample mutually agreed on by buyer and seller in color, color strength, and tone.

Ocher in paste form shall contain not more than 71 or less than 69 per cent pigment, not more than 31 or less than 29 per cent linseed oil, not more than 0.5 per cent moisture, or more than 0.5 per cent coarse particles and skins (total residue on No. 200 screen).

SUBSTITUTES

Ocher has no substitutes in the sense of similar cheaper products, since it is the cheapest of the common yellow pigments and competes, especially in the golden grades, with more expensive products like chrome and zinc yellows. Artificial ochers, of composition somewhat similar to that of natural ocher, and yellow clay mixed with more or less ocher, are used to a limited extent in the cheaper grades of linoleum. Powdered slate and ground shale are now actually preferred by certain linoleum and oil cloth manufacturers who in past years were heavy consumers of ocher.

ARTIFICIAL OCHER

Since ocher consists essentially of hydrated oxide of iron, similar material can be prepared by precipitating iron salts. Artificial ochers have been made from copperas ($FeSO_4.7H_2O$) by pouring a solution of this salt into milk of lime and thereby forming a precipitate of calcium sulphate and iron (ferrous) hydroxide. This material is shoveled onto boards, allowed slowly to oxidize, and dried promptly when the proper shade of color is reached. An artificial ocher prepared in this way is likely to contain an excess of lime, which is detrimental for many purposes. Artificial ocher suitable for calcining to form red ochers and various iron paints is prepared by chemical precipitation, often using very pure materials. Alum sludge and various metallurgical by-products containing iron salts are likewise worked up into ocher.

MINING

As a general rule, ocher is a decomposed product or iron-bearing mineral which has been transported by water (often in admixture with clay) and finally deposited in seams, pockets, or what at one time were shallow pools. Occasionally, as in Georgia, it is found just above bedrock and beneath a residual capping -- sometimes even it extends downward into cracks and fissures of the bedrock; more often, however, it forms irregular masses or lenses in residual or transported clays.

Most of the ocher deposits in the United States can not be mined systematically because of their irregular and pockety nature. Wherever possible, the overburden is stripped off, but when it is too thick, either tunnels are driven into the hillside or shafts are sunk, depending upon the topography. Shorter drifts or tunnels are driven from the main openings at suitable points, and the ocher is mined wherever it is found. A number of levels, one above the other, have been opened at several localities.

Even when the deposits are quite dry, timber ordinarily has to be used in the main drifts. Moreover, either the ocher or the overburden is at all wet, timbering must be kept close to the face, and it will be necessary to mine out a given block of ground as rapidly as possible before too much weight comes on the timbers or before the wet clay or ocher oozes excessively into the workings. In Pennsylvania, where the deposits are erratic and the pockets of ore are

relatively small, operations are at present all open-cut, although shafts are at times employed wherever the beds lie more than 10 to 15 feet below the surface. The ocher, since it is more or less mixed with clay, must be removed very carefully; otherwise, since the clay can not be removed by washing and settling, the product becomes too low-grade.

The mining methods employed in Georgia, since they are conducted on a more extensive scale and are adapted peculiarly to local conditions, are described separately, as are also the methods used in France.

BENEFICIATION

The preparation of ocher for market is ordinarily quite simple, involving merely a rough separation of the ocher from impurities that may be mixed with it. The sequence of processes is essentially similar in all districts and includes washing, drying, pulverizing, and packing. The purpose of washing is primarily to rid the product of sand, small stones, and other foreign matter which may be associated with the ocher in nature or which has been mixed with it in mining. The washing process, however, since it thoroughly mixes the ocher, enables a more uniform product to be prepared. Sometimes it is also possible to improve the color or to produce minor modifications in the shade.

In Georgia, due to the fact that several of the deposits are large enough to justify the requisite expense, the plants are permanent and relatively more elaborate than in Pennsylvania, for example, where the deposits are small. As delivered to the washer, the Georgia ore contains 30 to 40 per cent ocher, mixed with quartzite fragments, clay, sand, and a little barite. Large rock fragments are rejected on a grizzly, and water under pressure is used to disintegrate the material and wash off ocher adhering to coarse rock. The ore then passes to a single 26-foot log washer. The logs are of yellow-pine, 18 inches in diameter, with chilled iron flights attached with lag screws. They are given a slope of 1 inch per foot, and are rotated at the rate of 20 revolutions per minute. As the coarse discharge leaves the log it is raked over a fine (about 12 mesh) screen and passes under water sprays to remove the last of the ocher before it is sent to waste. The fines through this screen, after being roughly classified in settling boxes, join the overflow from the log. The ocher, largely in suspension, can then be passed slowly through about 150 feet of wooden launders approximately 10 inches square and with a slope of one-quarter inch in 16 feet. The sand not eliminated in the log settles out in these troughs and is continuously shoveled out by hand and thrown away. In place of the launders, a classifier may be used. The washer has a capacity of 2 to 3 tons per hour.

The operation of the plants differs considerably in detail from this point on. The Georgia Peruvian Co., realizing that it was losing a large quantity of ocher by the old method of separating the sand in settling troughs, installed three James slime separators or classifiers in a plant located midway between the washer and the finishing plant.[4]

4 - Hubbell, A. H., An Improved Way of Washing Ocher. Eng. and Min. Jour.-Press, vol. 118, No. 9, Aug. 30, 1924, p. 336.

The entire mine output except the coarse discharge of the washer passes through the separators which recover 96 to 98 per cent of the ocher, separating all sand and other material over 300-mesh. Each of the three machines will successfully discharge (as overflow) from two to three tons per hour of minus - 300 - mesh ocher. At times, as high as four tons per hour has been discharged.

These separators, which were designed especially for this particular operation, consist of cones 14 feet in diameter. Material coming from the log washer is fed into the center of the cone by means of a launder. The ocher and slime overflow into a peripheral launder 12 inches wide. The coarser sand settles against a rising current of water that enters the cone at the bottom and is supplied from an overhead tank. The velocity of this upward current is carefully adjusted so as to effect the proper separation of sand and slime. The sand discharges through the spigot at the bottom into a small horizontal cylinder containing a flight conveyor which is operated by a 3-hp. motor mounted on top of the cylinder. This cylinder is an integral part of the cone. The flight conveyor stirs and scrubs the sand, releasing the particles of ocher that may be held between the coarser material; the ocher thus freed is pumped back into the top of the cone by a small centrifugal pump mounted on andintegral with the conveyor-cylinder. The sand tailings receive a very thorough scrubbing in fresh water, which is introduced into the discharge end of the cylinder through a second pipe line from an overhead supply tank. The flight conveyor rotates at 18 r.p.m. and has a double set of flights, so that the sand is moved very rapidly through the cylinder and is finally discharged as waste.

Before the slime separators were installed, the ore pulp after passing through the settling troughs to get rid of the sand was delivered to a 10 by 26 foot Dorr thickener preparatory to going to the drier. A very much larger volume of water, however, is now required to effect the thorough scrubbing given the sand in the separators, so that it has become necessary to install another and larger thickener. The small thickener can handle a monthly tonnage equivalent to a little over 500 tons of finished ocher. The capacity of the new thickener, which measures 8 by 34 feet, is roughly estimated at 600 to 700 tons of finished ocher monthly. The pulp entering the thickeners contain about 30 per cent solids, and the spigot discharge contains about 60 per cent. The pulp is pumped to the thickeners from the separators by a centrifugal pump driven by a 25-hp. motor.

The thickened product of the Dorr tanks is pumped by a 5-hp. motor Dorrco pump to two agitator tanks, 8 by 10 feet and 6 by 10 feet, respectively, which are homemade. From these the thickened ocher passes through $1\frac{1}{2}$ inch pipe to a so-called sprayer box at each drum drier, 10 by 12 inches in cross section, through which box a 3-inch shaft, studded radially with 3-inch pins or bolts, runs longitudinally. The shaft rotates at 200 r.p.m. in the pulp, and the pins spatter the ocher on to the slowly revolving surface of the drum. The drum is 10 feet long and 4 feet in diameter. Live steam at 80 pounds pressure is introduced into the center of one end of the drum, and the condensed water falls to the bottom where the pressure within the drum expels it via a stationary pipe bent to form a siphon which passes out of the drum through the center of one

end and thence to the boiler via an ordinary steam trap. These driers have been developed in the Cartersville district and are surprisingly efficient in view of the amount of water evaporated per pound of steam.

The ocher is in contact with the hot surface of the drum only long enough to be thoroughly dried. It is scraped off at another point before it has a chance to darken through the loss of any of its water crystallization. Darkening is to be avoided, as it spoils the color and thus lowers the grade and value for marketing. There are five of these driers, each of which has a capacity for 24 hours' continuous operation of about 11 short tons.

At another plant the ocher-laden water from the washer and settling launder is run into a series of settling tanks. After standing, the excess water is siphoned off and the thickened ocher is shoveled into wheelbarrows and transferred to two long rows of drying vats, arranged along each side of a horizontal belt conveyor. The bottoms of these vats, which are 12 to 15 feet square by 3 feet deep, are covered with coils made of 1-inch pipe through which live steam is passed when the vat is filled with ocher sludge. When the ocher is thoroughly dry it is shoveled by hand into the conveyor. A disintegrator breaks up the large lumps, and after going through a pulverizer, the ocher is taken by screw conveyor and elevator to a sheet-steel bin over the packing floor.

In Pennsylvania, the ore as it goes to the washer is mixed with clay and with nodules and fragments of limonite and chert. The clay, of course, accompanies the ocher in the overflow from the log washers. The better part of the iron ore is separated from the chert by hand, and when enough of it accumulates it is shipped to some nearby furnace.

The ocher and clay are washed into a series of settling troughs that are slightly inclined so that the water passes through them rather slowly. The current is further retarded by baffle boards, behind which the coarser particles settle. At one mine there are 28 of these troughs each 14 to 16 feet long and 13 inches wide. The coarse sand settles mostly in the first two or three troughs, and by the time the last one is reached even the extremely fine sand has been practically eliminated. From the sand troughs the ocher-bearing water flows to settling ponds formed by digging into the ground a few feet and placing the excavated material as an embankment around the sides. These ponds which are roughly rectangular in shape, vary in size, but they average probably about 40 feet in length, 25 feet in width, and 3 to 4 feet in depth. Frequently they are arranged in series so that the finest material will pass from the one pond into the next; the overflow from the last pond is carried off through a pipe. It is also possible to grade the material as it comes from the mine and then to turn the best grade of ocher into one pond and to send that having a large admixture of clay into another. When a pond is full, the surplus water is allowed to evaporate. This may require from a few weeks to several months, depending upon the weather. When the ocher finally reaches a condition where it can be readily shoveled, it is dug and hauled in wheelbarrows to the drying sheds and placed on long open shelves for final drying. In a few places steam drying sheds are used, but most of the ocher is air-dried. Some of the plants which have steam dryers use them only in winter when air-drying is impossible.

After drying, the material either is hauled at once to the railroad for shipment or else is ground in buhr mills and then packed in bags or barrels.

At the old iron mines ocher was deposited behind the mud dams constructed to impound and clarify the muddy waters from the mines and washeries. Much of this ocher is mined with sand, but some of it even without washing is almost as good as that which has been carefully washed from natural deposits. As a rule the ocher from these old mud dam deposits is apt to contain a fairly large proportion of clay and sand and must be washed, but in the extensive deposits that accumulated about the larger mines that were worked for many years it is usually possible to find several layers of fairly clean ocher.

DOMESTIC DEPOSITS

Ocher is produced more or less regularly in the following States named in order of importance: Georgia, Pennsylvania, Virginia, Alabama, California, Iowa, and Vermont. Deposits have been found in other States, but are not known to have maintained any important production. In the Pacific Northwest, however, certain deposits, notably in western Washington, are of considerable potential importance commercially.

Georgia[5]

Georgia is by far the leading producing State. There are no official figures of production, but according to estimates of several producers, the annual output is in the neighborhood of 15,000 tons, practically all of which comes from the Cartersville district, in Bartow County.

Early Developments

In 1877 E. H. Woodward began mining ocher on a property located near the limits of the town of Cartersville.[6] The crude ocher was hauled in wagons to Cartersville where it was prepared for market. At the same time Mr. Woodward was engaged in mining manganese on the Dobbins property some miles away. In 1878 A. P. Silva, another manganese producer, commenced to mine ocher in a small way. In the same year M. F. Pritchett purchased the ocher interests of both Woodward and Silva. For drying the ocher he employed a brick furnace about 30 feet long and 4 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. Improved methods of mining were introduced, but the crude material was still hauled to Cartersville to be prepared for market. The only mines worked were located on the Larey property near the bridge across the Etowah River, 2½ miles southeast of Cartersville.

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5 - Weigel, W. M., Barite and Ocher in the Cartersville, Ga., District. Repts. of Investigations, Serial 2477, 1923, 11 pp.

6 - Watson, T. L., A Preliminary Report of the Ocher Deposits of Georgia, Geol. Survey of Ga., 1906, p. 67.

In 1880 this property was again sold to the Georgia Peruvian Ocher Co., which is still operating. Better methods were devised for preparing the ocher for market, and since the road was better to Emerson than to Cartersville, the plant was moved to the former place, 2 miles south of the mines. This company is credited with having sent a consignment of 50 tons of its ocher to England in December, 1890. This is believed to have been the first shipment of American ocher to Europe.[7]

Systematic mining and the use of modern machinery for preparing the material seem to date from the year 1891, when J. C. Oram of Vermont and E. P. Earle of New York became interested in the company. Both of these men had handled ocher for years in the North, and as a result of their efforts the ocher industry became firmly established in Bartow County, Ga. Instead of drying the ocher in large vats with steam pipes at the bottom, Mr. Oram simply led the material into pits dug in the ground, and allowed it to dry naturally. One of these pits would contain a carload or more of ocher when dry.

In 1893 W. B. Shaffer bought an adjoining property situated on the Emerson road, directly at the bridge across the Etowah River, and organized the Standard Peruvian Ocher Co. Three years later G. Linderman purchased the Shaffer plant and property, becoming owner of both the Shaffer and Oram mines and mill. These properties are operated at present under the name of the Georgia Peruvian Ocher Co. All the machinery and other equipment were moved from Emerson to the present site at the bridge, and a modern plant was installed at the mines for preparing the ocher for market.

A second ocher plant was erected in 1898 by the Cherokee Ocher and Barite Co., 1 mile east of the railroad station at Cartersville. This plant is in operation to-day under the same name.

In 1899 a third plant known as the Blue Ridge Ocher Co. was located about 2½ miles east of Cartersville. The last and fourth plant established in the district was that of the American Ocher Co., in 1902. The plant is located 2½ miles nearly due east from Cartersville, and like the others is in all respects an up-to-date plant.

Mining Practice

The ocher occurs along a belt extending for 6 or 8 miles in a nearly north and south direction and lying within about 1¼ miles east of Cartersville; the occurrences begin at a point about 2 miles south of the Etowah River where this stream cuts across the belt of Weisner quartzite.

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7 - U. S. Geological Survey, Mineral Resources of the United States, 1889-1890, p. 509.

The ocher in general forms an irregular network of veins in the quartzite, though many of these are neither rich enough nor large enough to work. Formerly the ocher was mined largely from open cuts near the base of the hill, but these had to be abandoned when the overburden became excessive, and now all mining is carried on underground. The vein or bed being worked strikes approximately northeast and southwest, parallelling the hillside, and as far as developed the dip (to the northwest) conforms to some extent to the slope of the hill. Toward the top of the hill the ore body flattens, follows the slope approximately down the hill, and flattens again at the foot, apparently dipping under the river in a northwesterly direction. The greatest dip on the hillside is about 40°. That part of the vein good enough to work is 12 to 40 feet thick; it is locally called sandstone, but is altered to some extent; the overburden consists almost entirely of decomposed quartzite and clay. The vein is reached by tunnels driven through the overburden at vertical intervals of 50 feet. On reaching the ore, drifts are carried along the foot wall and raises are put up about every 50 feet. The ore is stoped underhand, beginning at the top of a raise and working down the dip. At the bottom of each raise a loading chute is provided for the mine cars. The raise is never quite filled with ore. All available waste is stowed in the square sets to help hold the ground, which is very heavy and requires timbering close up to the face. Tunnels and drifts are timbered with sets 4 feet apart. Round timbers 8 to 10 inches in diameter, hand flattened, are used. As the timbers last only two to three years, all ore recoverable from one tunnel and set of drifts is removed if possible within this period in order to avoid re-timbering. On account of the short distance from the surface to the ore, it is cheaper to work different parts of the vein through a number of openings than to keep a fewer number of main haulageways and permanent tunnels in repair. One-ton ore cars on 18-inch gauge track are used, and trammed by hand and mules.

The other mines in the district are worked in much the same manner.

Production

The quantity and value of the ocher produced in Georgia during the period 1889 to 1914 is shown in the following table:

Production of Ocher in Georgia, 1889 - 1914[1]

Year	Quantity, short tons	Value	Year	Quantity, short tons	Value
1889	2,512	$29,720	1902	3,688	$38,423
1890	800	12,800	1903	5,212	47,908
1891	600	9,000	1904	4,752	44,142
1892	1,743	26,800	1905	4,209	43,481
1893	2,000	39,000	1906	5,550	58,350
1894	1,690	17,840	1907	5,600	57,100
1895	2,105	31,080	1908	6,035	63,851
1896	2,981	28,005	1909	5,838	60,971
1897	2,608	36,600	1910	7,011	70,388
1898	2,858	30,798	1911	7,395	69,447
1899	3,212	39,505	1912	10,107	101,790
1900	6,828	73,172	1913	11,420	123,090
1901	5,077	49,176	1914	8,607	84,193

1/ Later figures not available, although estimates place present output at about 15,000 tons annually.

Source: 1889-1902 Watson, T. L., Ocher Deposits of Georgia. Geol. Sur. of Ga. Bull. 13, pp. 69, 1906, 1902-1914 "Mineral Paints" Mineral Resources of the U. S. Annual U.S. Geol. Survey.

Pennsylvania[8]

Pennsylvania's annual output is estimated at about 4,500 tons. Yellow ocher occurs at many places in the State, though it has been worked mainly in the eastern part. Its distribution is practically coextensive with the brown (limonite) iron ores, which occur mostly in the limestone that crosses the State in broad or narrow bands in a general northeast-southwest direction. In recent years these iron ores have been largely neglected, but at one time they were extensively utilized.

The most important ocher district in Pennsylvania at present lies within a comparatively narrow belt of limestone and quartzite which extends from Easton to Reading, and which lies between the gneiss ridges of South Mountain on one side and the slates of the Hudson River Series on the other. It comprises the Easton, Allentown, Slatington, Boyertown, and Reading quadrangles of the United States Geological Survey, and lies in the counties of Northampton, Lehigh, and Berks.

8 - Miller, B. L., The Mineral Pigments of Pennsylvania. Rept. Topo. and Geol. Survey Com. Pa., 4th ser., 1911.

The ocher and the brown iron ores of the region occur either in pockets irregularly distributed throughout clays, or in rather definite layers, perhaps representing the strata of the original rocks that have been wholly replaced. Some of the pockets of ocher are several feet in diameter, and it is possible to remove the material without taking out much clay. In other cases, however, the ocher is in such small masses that much clay must be removed, and the mixture forms a low-grade ocher. The clay ranges in color from white to yellow, to red, to black, and since it can not be removed from the ocher by washing and settling, the best grades of ocher can be obtained only from large pockets or from thick layers.

The ochers and associated clays lie upon the older rocks, in the main, and represent the residual insoluble material or replacements that have occurred along fractures or faulted zones.

The origin of the limonite and ocher deposits of Pennsylvania has been discussed by many writers and many different explanations have been advanced. H. D. Rogers[9] believed that the iron came from the overlying slates in which the iron existed in the form of pyrite. Prime[10] says they have been formed in place by the decomposition of ferrous silicates or ferrous carbonate originally present in the limestones. The assertion is made by d'Invilliers[11] that they are produced by the decomposition of pyrite originally present in the shaly strata intercalcated with the limestone. Hopkins[12] says "the original source of the iron is primarily the Cambro-Ordovician limestone and slates, with smaller quantities from the overlying Ordovician and possibly Silurian strata and the underlying slates and quartzites. The iron occurs in these strata as carbonate, sulphide and silicate, the first being probably the most common."

The deposits lie mostly between Easton and Allentown and the mines are served by the Lehigh Valley Railroad Co. and Central of New Jersey, those mines lying between Allentown and Reading are served by the East Pennsylvania branch of the Philadelphia and Reading Railway Co. which follows closely the line of ocher working. Throughout the belt most of the ocher mines are within 3 miles of the railroad, so that the cost of haulage to the shipping points is not excessive as the roads are generally good. Steam power is commonly used.

Production

The quantity and value of the ocher produced in Pennsylvania from 1889 to 1914 is shown in the following table:

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9 - Geology of Pennsylvania, vol. 1, 1858, pg. 183.
10 - Second Geological Survey of Pennsylvania, Rept. D., 1874, pp. 53 and 59.
11 - Second Geological Survey of Pennsylvania, Rept. I, p. 36.
12 - Bull. Geol. Soc. Amer., Cambro Silurian Limonite Ores of Pennsylvania. Vol. 11, 1900, pp. 475-502.

Production of Ocher in Pennsylvania[1]

Year	Quantity, short tons	Value	Year	Quantity, short tons	Value
1889	7,922	$103,797	1902	9,818	$80,259
1890	4,173	61,458	1903	4,937	34,782
1891	4,535	56,588	1904	4,077	29,355
1892	7,055	90,755	1905	7,789	72,360
1893	5,375	71,575	1906	8,597	79,244
1894	4,975	47,830	1907	8,047	76,816
1895	6,800	74,300	1908	9,286	78,956
1896	2,926	26,818	1909	4,137	45,472
1897	6,825	81,325	1910	3,642	32,254
1898	5,986	61,500	1911	3,013	28,101
1899	7,285	57,245	1912	3,300	28,950
1900	7,601	21,661	1913	3,935	32,175
1901	7,632	76,106	1914	3,799	34,223

1/ Official figures after 1914 are not available.

Source: "Mineral Paints," Mineral Resources of the U. S. Annual, U. S. Geological Survey.

Virginia

Little ocher has been produced in Virginia in recent years, although a few tons may have been shipped without finding their way into the recorded figures of mineral production of the State.

Ocher of more or less purity is found and has been produced to some extent in each of the principal geologic divisions of the State, namely, the Coastal Plain, the Piedmont Plateau, and the Valley region. At one time or another it has been mined in the following localities: Near Bermuda Hundred, on the Appomattox River, in the extreme eastern part of Chesterfield County; in the Little Catoctin Mountain, near Leesburg in Loudoun County; near Bedford City in Bedford County; near Keezletown in Rockingham County; from the western base of the Southwest Massanutten Mountain; at Stanley in Page County; and near Shenandoah in Page and Rockingham Counties. Other ocher deposits are found rather widely distributed over the Valley and Piedmont provinces and to some extent over the Coastal Plain, but they have not been worked. Deposits of ocher varying in color from red to yellow and brown, some of them apparently quite promising, are found in Campbell and Bedford Counties; near Bon Air in Chesterfield County; near Fairfield in Rockbridge County; near Waynesboro in Augusta County; and near Roaring Run in Craig County. In the Valley and Piedmont areas, the ocher beds are usually associated more or less with beds of iron ore.

The writer has received several fine specimens of yellow ocher from the vicinity of Bluemont, in Loudoun County, and W. P. Miller, of Lynchburg, Campbell County, has sent in a specimen of bronze ocher which no doubt might be used for a paint pigment.

Other States

In Vermont, ocher mining is one of the oldest minor industries. Beds at Brandon in northern Rutland County and at Shraftsbury and Bennington, in Bennington County, have been worked in a small way for many years, but is is not known whether at present the ocher mines of the State are producing or not.

In Alabama, ocher is mined in Clarke County, and in the past has been produced in Autauga and Elmore Counties.

In California, ocher deposits have been worked in Calaveras, Napa, and Riverside Counties.

STATUS OF THE DOMESTIC INDUSTRY

The ocher industry in the United States comprises mostly small intermittent operations, although some permanence is in evidence in the Georgia field. Owing partly to the pockety nature of the occurrence and partly to the difficulty and uncertainty of finding a continuous market, domestic ocher suffers severely in competition with the well-established French products which are considered superior to the domestic product. Imported ochers, as a class, have a better permanent color than those produced in this country, but their leading advantages are the result of more uniform deliveries and standardized grading. In the linoleum and oilcloth industries, into which the domestic product enters in large quantity, exact shades of color are of less significance than other properties.

No actual production figures have been published since 1914. In that year 14,387 tons were produced, having a value of $136,185, which were divided as follows: Georgia, 8,607 tons, valued at $84,193; Pennsylvania, 3,799 tons, valued at $34,223; and other States 1,981 tons, valued at $17,769.

In the reports of the Bureau of the Census, the production of ocher is included with that of other iron oxides, both natural (sienna, umber, etc.) and synthetic (precipitated). For this larger group the output was reported as 54,180 tons valued at $3,357,895 in 1927, a large increase as compared with 33,895 tons, valued at $2,151,445, reported for 1925. For other alone, unofficial estimates place production at approximately 22,000 tons, proportioned as follows: Georgia, 15,000 tons; Pennsylvania, 5,000 tons; and all other States, 2,000 tons. There is no doubt, however, that some yellow clay is included in these estimates, especially in Pennsylvania.

IMPORTS AND EXPORTS

The imports of ochers and siennas into the United States in recent years have shown a gradual increase, as will be noted from the tables following. The tonnage from France, which furnishes the bulk of the imports into the United States, has shown practically no increase, but the value of the ocher imported from that country has more than doubled during the past four years.

Ochers and Siennas Imported Into the United States, 1924 - 1927

Country	1924		1925		1926		1927	
	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value
France	16,360,765	$161,461	17,151,162	$191,182	16,148,144	$266,176	16,658,319	$323,601
Germany	363,849	6,952	161,819	2,772	336,871	6,611	254,114	5,531
United Kingdom	190,913	5,779	245,298	9,293	219,552	7,388	321,469	15,230
All Other	2,741,760	75,497	2,580,535	71,773	4,141,129	109,976	3,638,467	104,132
TOTAL	19,657,287	249,689	20,138,814	275,020	20,845,696	390,151	20,872,369	448,494

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Ochers and Siennas, Unground Crude, Imported for Consumption

Year	Ochers		Siennas	
	Pounds	Value	Pounds	Value
1924	328,912	$5,088	1,501,490	$42,473
1925	134,775	2,214	1,385,608	34,809
1926	122,697	2,717	2,018,289	49,472
1927	466,752	13,107	1,668,065	42,831

Ochers and Siennas, Washed or Ground, Imported for Consumption

Year	Pounds	Value
1924	17,994,225	$204,237
1925	18,651,893	238,258
1926	18,251,763	334,693
1927	18,920,745	395,684

THE FRENCH INDUSTRY

General Statement

The principal ocher deposits of France are located at two main centers: At Apt, in the Department of Vaucluse, and at Auxerre, in the Department of Yonne.[13]

The ocher deposits of the Department of Vaucluse are located in two valleys of the Provence Alps; that of Calavon Torrent between the Luberon and Vaucluse Mountain ranges, and that of the Auzon River between the Vaucluse and Ventoux ranges.

The physical properties of the ore in this district are favorable to low production costs and high quality of product; the material is reported as being superior to that of any other country in the world. The ocher content of the ore extracted at present ranges from 5 to 20 per cent; a good average is said to be 10 to 15 per cent. A full color range exists - from light "canary yellow" to the deepest reds. The product is also characterized by impalpable fineness, without appreciable loss of color in grinding.

The Gargas (Vaucluse) field is known to be the world's greatest producer of "canary" and "lemon" (citron) yellow ochers, of "French satin" grade. Its product is in great demand and established factories compete in buying it. The exploitation in this field is carried on by farmers and by two of the leading

13 - Cameron, A. E., Ocher Industry in the Marseille Consular District, France, 1923, pg. 1.

members of the "Comptoir," subsequently described. These two companies own their own land and also the mills for treating the product. The farmers, on the other hand, sell their ore to the highest bidders. Those possessing good ore and sufficient water, however, find it to their advantage to wash the ore themselves and haul only the washed product to the Apt market.

For the farmers in this region, mining is a seasonal occupation; each farmer, to some extent, suits his own convenience as to the season for digging, storing the ore, and washing it, if he is a producer of washed ore.

The ore is usually dug during the fall and early winter and stored in separate lots according to color. It is generally washed during the rainy season, January to April, and dried in covered sheds from April to July. Further manufacture then continues during the rest of the year.

An interesting method of quarrying is that developed by the Eugene Dagan & Cie. of Apt, at a deposit at Roussilon. Here approximately horizontal adits are driven into the hillside and are well timbered. They follow particularly rich veins and pockets to a considerable depth, and permit the choice of good quality ore before extraction. The extension of these tunnels into other privately owned land is practically impossible, as the royalties demanded exceed what the companies can afford to offer under present conditions.

In preparing the material for market, ore of as nearly uniform color as possible is selected, dumped into a basin, flooded, and allowed to settle for several months. These basins are from 9 to 15 feet square and are made by damming small streams. After the mud cake is formed the water is drained off, and the cake is taken out in sections and placed in covered sheds to dry. It is then pulverized by hand with a large pestle, and put through fine mesh screens. This product is the "washed" ocher of commerce, marked with the letter "L" (lavee or washed), as distinguished from the washed, ground, and screened ocher of the factories. Opinions in the trade differ as to the relative merits of the old-fashioned farm product and the newer factory product.

If water is not available, the owner of the ore sells it to the factory offering the best price, and often delivers it to the plant himself.

In preparing ocher for the market in plants, the time-honored methods and routine of the farmers are employed, but with several improvements. The vats, or basins, are built of concrete and are larger and deeper, averaging 45 by 60 feet. Several basins are in operation at each plant, permitting several colors to be worked at the same time and a finer assortment to be obtained in each color. Grinding, cleaning, bolting, sorting, and grading are carried out mechanically. Centrifugal tables revolving at high speed sort out impurities with great accuracy and economy.

Day labor at the plants is employed at current rates, from 15 to 18 francs (60 to 75 cents) per day for unskilled labor. The labor supply is abundant, and accommodates itself remarkably well to seasonable migration between the varied industries of the region; farming, canning, preserving, and the

mining and preparation of ocher. High labor costs are kept down by gradually increasing the percentage of unskilled laborers as the division of labor becomes possible. The feeding of the grinding machinery and the packing of the product in barrels are now unskilled tasks.

The plant motive power in general use is steam, but electricity is being used more and more, as it is more economical. Narrow-gauge track exists in most plants, permitting the change from horse to electric locomotives.

Production

The production of ground and washed ochers in the Department of Vaucluse in recent years has been in the neighborhood of 23,000 metric tons, about two-thirds of the production of the pre-war years. The United States imports about one-third of this amount annually, or 8,000 tons of washed ocher.

Production of Ocher in France by Departments
(Metric tons)

Department	1913	1921	1922	1923	1924	1925
Ardeche	120	- -	650		- -	- -
Ardennes	1,000	- -	- -		- -	- -
Drome	120	1,000	1,000		1,000	850
Gard	- -	- -	- -		- -	- -
Pas-de-Calais	- -	500	150		- -	- -
Pyrenees (Hautes)	- -	- -	- -		500	600
Vaucluse	35,000	10,000	14,000		22,000	23,530
Yonne	20,000	7,000	11,960		13,000	- -
Nievre	- -	200	- -		- -	- -
Total	56,240	18,700	27,760	26,700	36,500	24,980

Organization of the French Industry

In an industry whose market is world-wide and whose most efficient producing region is extremely small, it is not surprising to find evidence of various attempts to control production and distribution by means of private combination.

The earliest manifestation of the natural tendency toward combination was the formation of a selling cartel known as the Chambre Syndicale des Fabricants d'Ocres, an all-embracing and powerful syndicate with many individual members, each of whom produced or traded on a small scale. Embracing both sellers and buyers, it formed a clearing house and a place for the discussion of costs, prices, and selling policies. Its weakness was twofold - inability to hold its membership in line during the lean war years, and the gradual ascendancy of one of its members, the Societe des Ocres de France, long the leading single ocher producer of France. After the formation of the Comptoir, which took over some of the Syndicate's most prominent local members, the need for the Syndicate was at an end. No evidence of its existence has been found since 1922.

The next step in the progress of the industry in Vaucluse was the entry into the Vaucluse district, as a producer and manufacturer, of the Societe des Ocre de France. This company, organized more than 60 years ago at Lyon, had operated very successfully in the Auxerre (Yonne) region, and had always enjoyed an excellent reputation for the color, texture, and purity which it extracted from the comparatively lean ore of the Yonne fields.

This concern, after entering the Apt district and operating as buyer and seller of ochers, built a modern plant at Apt. As it is located on the banks of the Calavon Torrent, it has ample water supply for its large washing pits or basins. Its steam-powered grinding mill treats mainly ore sold to it by many of the smaller land owners of the district. When opportunity arises it uses ore from its own extensive properties.

The remarkable success attained by the Societe, based on improved production methods and by large scale operations at more than one point, was felt by many of its competitors as a constant menace. This feeling was accentuated by the knowledge that the Societe, even before establishing its factory at Apt, was already the largest single factor in the French ocher industry. The smaller plants and dealers either had to combine or resign themselves to selling to or through the Societe.

A new combination was inevitable, and was made up of a few of the independents. It took the form of a centralized selling organization, and was called the "Comptoir des Ocres Francaises," a company with varying membership and capital, each member having one share -- a convenient form of cooperation open to both individuals and corporations under the French law. Each member retains actual ownership of his own ocher deposit and grinding mill, and thus continues to represent an integral production unit whose internal organization and production policies are not interferred with. Sales, on the other hand, are absolutely in the hands of the Comptoir and no member is permitted to sell even to another member of the cartel. Each member has a representative on the board of directors, and all members sit in the board meetings.

The present membership of the Comptoir includes:

Eugene Dagan & Cie.,	Apt.
Faustin Caste,	Apt.
Leopold Anseline,	Apt.
Julian Freres,	Apt.
Francis Barthelemy,	Apt.
Ad. Jean & Cie.,	Apt.
Tamisier Freres, Gargas	Vaucluse.
Aug. Malavard Fils,	Villes-sur-Auzon.

The determination of a selling policy was the principal difficulty in the launching of the Comptoir. So many of its members had exclusive agents in certain foreign countries that it was impossible to confine representation of the Comptoir to any one agent in any country. The policy of exclusive agents

was therefore abandoned by common consent. However, the former agents of each of the individual producers are now the favored customers of the Comptoir, and have protected distribution in the countries in which they operate.

Production, sales, and exports of French ocher are almost entirely in the hands of the Societe des Ocres de France and the Comptoir des Ocres Francaises. They compete on equal and friendly terms and so successfully as to control the market for French satin ocher both in France and abroad.

Grades of Ocher

The basic grades of commercial ocher on the French market are marked as follows:

J. L. - Washed yellow.
J. C. L. - Washed light yellow.
J. F. L. - Washed dark yellow.
CITRON - Lemon yellow.
R. L. - Washed red.
R. F. L. - Washed dark red.

If the texture of the product justifies the name, the letter S (satin) is added, representing a considerably increased value. Similarly, finely distinguished colors are designated by appropriate letters. All letters are branded or stamped on the heads of the barrels.

Six-letter satin ocher usually commands from four to six times the price of two-letter basic grades, when furnished by a reputable producer or dealer. Formerly many farmers were adept in producing the six-letter grades of remarkably uniform texture and color, and the trade was handed down from father to son. Now most of the finer grades can be made in plants under supervision of experts, and the plants also dominate in the production of light colors - canary, lemon and light red - with which iron oxides and other substitutes can not compete.

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