

MINERAL PAINTS.

PAINT SHALES OF PENNSYLVANIA.¹

By BENJAMIN L. MILLER.

INTRODUCTION.

For certain purposes pigments of low tinting value, such as colored shales, have been found to be equal to those of more uniform composition and deeper color. In the manufacture of oilcloth and linoleum the mineral coating on which the color patterns are printed and also the under surface can be prepared as well from yellow and red shales containing only a small percentage of iron as from yellow and red ochers in which the iron content is much higher. Similarly the paint that is applied to a fresh surface of wood or metal primarily for the purpose of filling the pores and small cavities in order to make a smooth surface on which later coats of paint are spread can be manufactured from materials with low tinting value. Black, red, and yellow shales are utilized for these purposes and the materials when prepared for the market are known as paint fillers.

The mineral composition of the shales used as pigments is varied, but they are characterized by the absence of any minerals that readily decompose on exposure to atmospheric action. The minerals present must be inert and they must possess the desired color. The basis of all the shales is hydrated aluminum silicate (clay), together with considerable silica in the form of quartz, the whole colored by iron, either in the hydrated form (limonite) or in the anhydrous condition (hematite), by graphite or amorphous carbonaceous matter, by manganese oxide, or by some other colored constituents. Sericite is not uncommonly present and in many of the paint shales of Pennsylvania is a very prominent constituent.

Besides the mineral composition it is necessary to determine the amount of linseed oil required for each pigment, as in the cheaper paints the oil costs much more than the dry colors and the materials requiring the minimum amount of oil are preferred by the manufacturers of mixed paints. Many of the claims of superiority of one product over another are based on its lower absorption of oil.

¹ Published by permission of the State geologist of Pennsylvania. A more complete article on the "Mineral pigments of Pennsylvania" will shortly be published by the Pennsylvania Geological Survey.

The quarrying of the shales is a simple process and calls for no special description. The preparation of the materials for the market is simple in principle but demands considerable care, and several processes are utilized in the mills now operating in Pennsylvania. The excess of water must be eliminated by drying and the shales ground to extreme fineness. To a considerable extent the value of the pigment is determined by its fineness. In the descriptions of individual properties the methods will be briefly described.

The prices of the prepared pigments range from \$3 to \$50 a ton and depend on their adaptability for definite purposes and the supply available. As a rule the margin of profit is moderate and the market is limited, otherwise the annual production would be greatly increased. Each company in operation could readily increase its output with a minimum of expenditure and would undoubtedly do so if the demand were greater. Although most of the ground shale produced in Pennsylvania is utilized by local paint and linoleum manufacturers, a considerable portion is shipped to remote parts of the United States and even to foreign countries.

BLACK SHALES.

OCCURRENCE AND CHARACTER.

Black shales, ground and sold under the name "mineral black," are extensively used in the manufacture of paint in many places. "Mineral black is a pigment made by grinding a black form of slate. It contains a comparatively low percentage of carbon and consequently has low tinting value. It finds use as an inert pigment in compounded paints, especially for machine fillers. The pigment has a flocculent appearance, the particles showing a strong tendency to mass."¹ Black shales are widely distributed throughout Pennsylvania, occurring in a great many formations representing every Paleozoic period. In many places the material has been dug for use in paint and in some of the slate regions the refuse about the quarries has been shipped to paint factories. A small use has been made of the culm heaps about the anthracite coal mines and the disintegrated surface coal near the outcrop. There is a tendency for most of the black-shale material to settle out of the oil, as mentioned in the quotation above, but this is not a serious objection. The durability of the paint in which black shales have been used is vouched for by many persons who have tried it. Black shale is used to some extent in paint for buildings, but chiefly in the manufacture of a black filler for ironwork.

The descriptions of individual properties which follow probably include all the most important operations of the present time, but no doubt many localities where black shales were formerly quarried as pigments are omitted.

¹ The properties and structure of certain paint pigments: Bull. 29, Sci. Section, Paint Mfrs. Assoc. United States, p. 35.

PLANT OF KEYSTONE PAINT & FILLER CO.

The principal producer of black-shale pigments in Pennsylvania is the Keystone Paint & Filler Co., of Muncy, Lycoming County, which has been in continuous operation for more than 25 years.

At present the company is operating two quarries, both of which are located short distances south of Muncy. The older of the two quarries is situated very close to the left bank of Susquehanna River, about 1 mile south of the Muncy railroad station, and the other a short distance farther south.

The rock, which is of a dull dead-black color, although termed a shale, is intermediate between limestone and shale. Except on weathered surfaces the shaly lamination is not especially noticeable and the CaCO_3 present is sufficient to produce a feeble effervescence on the application of dilute hydrochloric acid. The black color is due to the presence of a considerable amount of vegetable matter. Pyrite, precipitated from descending waters by the reducing action of the carbon contained in the rock, occurs in the form of individual crystals and small nodules. In certain places the amount of pyrite is sufficient to render the rock useless. The shale occurs in the Helderberg formation, which consists mainly of limestone, locally interbedded with shales. At the old quarry black argillaceous limestones occur in association with the shales and must be rejected, as a high percentage of CaCO_3 is undesirable.

The following analysis of the finished product, furnished by Harrison Bros. & Co., paint manufacturers, represents the true character of the rock probably better than a single analysis of a picked specimen of rock taken directly from the quarry:

Analysis of Keystone black filler.

SiO_2	57.53
Al_2O_3	16.72
Fe_2O_3	4.52
FeS_2	3.76
CaCO_3	4.12
MgO	1.38
Na_2O	1.06
K_2O	2.12
Water.....	3.19
Organic matter (carbon).....	5.60

 100.00

The rock is hauled by wagon from the quarry to the mill at Muncy, where it is prepared for shipment. It is stored in sheds until needed, and remains there long enough for the excess moisture to evaporate. The first stage in the grinding process is crushing in an ordinary jaw crusher, whence the rock goes to a mill for fine grinding, and then to a

pulverizer, where the separation of the fine and coarse particles is effected by strong air currents. The coarser materials return to the mill for further grinding, while the finer portions, classified into three grades according to size of grains and depending on the distance they are carried by the air currents, are packed in kegs or barrels of 100 to 400 pounds. Most of the product is shipped in the dry form, although some is made into paint at the plant, as the company is also engaged in the manufacture of mixed paints.

The product is recommended by the company "as a filler or 'rough stuff' for automobiles, buggies, passenger cars, safes, and all similar work in which a filler is used to make a surface, including machinery, machine tools, farming implements, and all kinds of ironwork."

PLANT OF PENN KEYSTONE CO.

A black filler is also produced by the Penn Keystone Co., which has its offices at Williamsport and operates a mill about 1 mile southwest of Antes Fort post office, in the water gap produced by a stream cutting through Bald Eagle Mountain. The rock is obtained from the Nippenose Valley near Rauchtown. The quarry now in operation is located on the farm of R. H. Overdorf, about 1 mile west of Rauchtown. Until recently the rock utilized was quarried on the farm of J. S. Group, about one-fourth mile south of Rauchtown.

The rock is black carbonaceous argillaceous limestone occurring in the upper part of the Trenton limestone of the second geological survey of Pennsylvania. Fossils are rare in the rock best suited for the production of the black filler, but are abundant in the interbedded layers of purer limestones, especially in the quarry close to Rauchtown. The amount of carbonaceous matter present is large, and in the weathered portions, where much of the CaCO_3 has been removed by solution, the black matter rubs off readily and the rock has a general resemblance to lignite. Pyrite is present in certain portions in the form of tiny crystals, in nodules, and in small veins.

Mr. C. T. A. Mallalieu, general manager of the company, furnishes the following analysis of the finished product:

Analysis of Penn Keystone Co.'s black filler.

SiO_2	59.24
Al_2O_3	17.10
Fe_2O_3 and FeO	7.26
K_2O	3.34
CaO	1.70
Na_2O96
MgO22
MnO	Trace.
Volatile matter and combined water.....	9.86
	99.68

The rock is hauled to the mill, where it is first allowed to dry in a shed and then crushed, ground, and bolted. All the material passes through four or five bolts, the last of which is a 180-mesh wire screen. The mill is operated by water power. None of the material is manufactured into paint by the company, all being shipped in the dry form.

BLACK FILLER MATERIALS NEAR ALLENWOOD.

Along the right bank of Susquehanna River just below Fritz station, on the Philadelphia & Reading Railroad, some black shale of the Hamilton formation was quarried for use in paint during the summers of 1909 and 1910. Altogether about four carloads have been taken from this quarry, all of which was shipped to the mill of the J. Wilbur Co. in Philadelphia, where it was ground.

The rock is black in color and consists mainly of argillaceous and carbonaceous matter, with a small amount of CaCO_3 and pyrite. One thin layer of fossiliferous limestone interstratified with the shales was observed in the quarry.

A short distance south of this locality similar black shales were formerly mined for the same purpose. The strata were worked by an adit driven in the side of the hill, but at present no traces of the former workings can be seen. A description of this mine was published by the Second Geological Survey of Pennsylvania.¹

BLACK SLATES OF LEHIGH AND NORTHAMPTON COUNTIES.

The Martinsburg shale in Lehigh and Northampton counties contains two belts of slate that have long been worked for roofing slate, blackboards, billiard-table tops, etc. A considerable amount of the refuse slate from these quarries has been sold to paint mills throughout the State and some has been shipped as far as Chicago. The cost is little more than the freight charges, as the companies are glad to have the material removed.

H. D. Rogers² described some slate in the vicinity of Nazareth that was worked for use in paint many years ago. It seems that he probably referred to what is now known as the "cement rock," which directly underlies the Martinsburg shale.

BLACK SHALES AND COAL OF THE COAL REGIONS.

The black shales of the "Coal Measures" have also been used in the manufacture of paint to a minor extent. Culm has also been used, and a few years ago black paint was made from the outcrops of disintegrated coal in the Schuylkill region near Pottsville.

¹ Second Geol. Survey Pennsylvania, Rept. F3, 1891, pp. 87-88.

² Geology of Pennsylvania, vol. 1, 1858, p. 249.

YELLOW SHALES.**OCCURRENCE AND USE.**

Yellow shales occur in many places throughout the State and at several geologic horizons, but particularly in the Martinsburg and Mauch Chunk shales. In a number of places these shales have been utilized in the manufacture of paint, and when ground fine and mixed with oil they are very serviceable. Their principal use, however, is in the manufacture of oilcloth and linoleum. They are considerably lighter in color than the ochers and contain a much lower percentage of hydrous iron oxide, as a rule not more than 5 per cent. Yellow shales that are worked for paint are usually called ochers, but such usage is plainly not justified.

PLANT OF LUZERNE OCHER MANUFACTURING CO.

The most extensive and also the oldest company now engaged in the quarrying and grinding of yellow shales is the Luzerne Ocher Manufacturing Co. Its offices are located in White Haven; its quarry and mill are about 1 mile east of Moosehead station, on the Lehigh Valley Railroad.

The shales, which are light yellow in color, occur near the base of the Mauch Chunk shale. In the quarry the workable shales are about 15 feet in thickness and are almost horizontal in position.

Mr. S. S. Staples, the president of the company, has furnished the following analysis of the rock:

Analysis of yellow shale used by Luzerne Ocher Manufacturing Co.

SiO ₂	64.24
Al ₂ O ₃	22.40
Fe ₂ O ₃ and FeO.....	4.80
Combined water.....	5.70
Undetermined.....	2.86

100.00

From the quarry the shale is trammed to the mill, where it passes through two sets of crushers that reduce it to $\frac{3}{8}$ -inch size. It is then dried in a drier, after which it is ground in burrstone mills and bolted through 156-mesh silk screens. The finished product, called ocher, is used in the manufacture of oilcloth and linoleum. The annual output is about 2,500 tons. The supply of shale is practically unlimited, as it underlies the greater portion of a 3,000-acre tract owned by the company.¹

YELLOW SHALES OF CARBON COUNTY.

For several years M. L. Smith operated paint mills at Slatington, Lehigh Gap, and Hudsonale, using yellow Mauch Chunk shale obtained near the tunnel of the Central Railroad of New Jersey at Rockport and near Penn Haven Junction.

¹Additional information concerning this plant was published in Bull. U. S. Geol. Survey No. 430, 1910, pp. 436-438.

YELLOW SHALES OF WYOMING COUNTY.¹

Yellow shales of the Catskill formation of North Mountain, Wyoming County, have been tested by paint experts and pronounced valuable for paints. So far as known, however, they have never been utilized.

YELLOW SHALES OF BERKS COUNTY.

Yellow ocherous shale was dug about two years ago along the Pennsylvania Railroad tracks opposite Perry station of the Lehigh Valley Railroad, on the farm of J. K. Weidman, of Shoemakersville. The shale is light yellow or buff in color and contains little grit. It forms a part of the Martinsburg ("Hudson River") shale, which consists mainly of dark-colored shales, especially in Northampton and Lehigh counties, but farther westward contains interbedded red and yellow shales. Where worked the shale dips about 25° SE.

Two carloads only were dug at this locality, both of which were obtained by the J. Wilbur Co., of Providence, R. I., and Philadelphia. The shale was found to be of considerable value as a base for oilcloth and linoleum, but no more was dug because of the inability of the owner of the land and the operator to agree on the amount of royalty. The supply is undoubtedly very large and the deposit is so located that it can be easily and economically worked.

Similar material occurs at many other places in this formation, but so far as known little use has been made of it. The percentage of iron is low, yet for many purposes the shale is very serviceable. A mile north of Myerstown there is said to outcrop a deposit of yellow shale that has the appearance of being suitable for the manufacture of a coloring base for oilcloth, although none of it has yet been used in that way.

RED SHALES.**OCCURRENCE AND CHARACTER.**

Red shales have been employed in the manufacture of paint in many places in the State, but at present operations are being carried on in only three localities. The operations are not limited, however, by the distribution and amount of the shales but by the market for the product. Red shales occur in many of the geologic formations, but are especially well represented in the Martinsburg ("Hudson River"), Catskill, and Mauch Chunk of the Paleozoic era and the Brunswick shale of the Triassic.

The red coloring matter of these shales consists of ferric oxide, which forms a coating about the individual grains and was no doubt present when the shales were deposited. In some places the iron content has been changed somewhat since deposition by the precipitation of more iron oxide; in other places there has been subse-

¹ Eng. and Min. Jour., vol. 26, 1878, p. 439.

quent leaching by which some of the iron has been removed. However, as shales are relatively impervious to water, they are less apt to undergo subsequent changes in composition than more pervious rocks.

QUARRIES OF THE J. WILBUR CO.

In the vicinity of Greenawald, Berks County, the J. Wilbur Co., of Providence, R. I., has quarried red shales of Martinsburg age since 1895, and during the years 1890 to 1895 the same company worked similar material near Lenhartsville.

The quarry where the greatest amount of material has been obtained lies about three-eighths of a mile east by south of the station at Greenawald. At that locality the shale bed suitable for use as a pigment includes a thickness of about 75 feet of fine-grained dark brick-red shales. The beds are tilted to the south at an angle of about 55°. The quarry was extended to the boundary lines of the property and excavated to a depth of 55 to 60 feet on the uphill side of the opening.

The quarry now being operated lies near the top of a high hill about one-eighth mile east of Greenawald station and has only recently been opened. About 600 tons had been shipped from this quarry at the time of the writer's visit in September, 1910. The opening shows a thickness of 35 feet of good material and James S. Focht, the general manager of the company, says that explorations have shown a thickness of 250 feet of workable material farther back in the hill. A double inclined track runs from the level of the railroad up to the quarry and the ore is taken down by gravity; a loaded car in descending pulls an empty car up to the workings.

The shale worked near Greenawald contains enough fine-grained sericite to produce a soapy or talcose feeling when rubbed. On this account the material produced by the company is sold under the trade name "talckene." The shale, especially in the recently abandoned quarry, is further of interest on account of the concentric discoloration spots that are irregularly distributed throughout it.

The following analysis of "talckene" is furnished by Mr. H. W. Rice, president of the J. Wilbur Co.

Analysis of talckene.

Organic and volatile matter.....	4.297
Iron and aluminium oxides.....	14.546
Silica and silicates.....	81.157
	100.000

The shale is quarried and shipped over the Philadelphia & Reading Railroad to Philadelphia, where it is ground to a very fine powder. Its principal use is in the manufacture of oilcloth and linoleum. The amount of material obtainable is practically unlimited and the cost

of production low, so that the output could easily be greatly increased if the market demanded it.

In the same vicinity the J. Wilbur Co. is also quarrying a light-yellow sericite shale which is likewise ground and used for linoleum. This deposit has been worked less than the red shale.

QUARRY OF ATLAS MINERAL & MACHINERY CO.

About half a mile south of Albany the Atlas Mineral & Machinery Co., of Lincoln, N. J., has operated a quarry in the creek bluff, from which considerable red Martinsburg shale has been removed. The bluff is about 50 feet in height and the strata have a dip of about 60° E. Sericite is more abundant than in the shale at Greenawald, and the concentric discolorations are absent. Much of the red iron oxide, however, has been removed and the shales are blotched irregularly. Percolating water carrying organic acids has probably removed the coloring matter.

This quarry was last operated during the summer of 1908. The shale was shipped to the mill of the company at Lincoln, N. J., where it was ground.

QUARRY OF B. F. RUTH & CO.

A short distance from Greenawald B. F. Ruth & Co., of Reading, have also worked the red Martinsburg shale intermittently for several years. The general character and occurrence of the shales are similar to those in the quarry of the J. Wilbur Co.

HUDSONDALE OCHER WORKS.

The Hudsondale Ocher Works, of Weatherly, work a quarry in the red Mauch Chunk shale about 1½ miles west of the small village of Hudsondale and operate a mill for grinding the product about one-fourth mile west of the village.

The shale is brick-red in color and contains considerable sericite, causing it to feel soapy to the touch. As this property is possessed to a great degree by talc, the finished product at this plant is marketed under the trade name "talkene."

The section exposed in the quarry is as follows:

Section at quarry of Hudsondale Ocher Works.

	Feet.
Red shale, decomposed and mixed with surface soil.....	4
Red shale, rather soft.....	12
Buff sand.....	1-3
Red shale, hard and compact; does not break in thin laminae like ordinary shale.....	8-10
Lighter-colored shale exposed in bottom of quarry.	

The buff sand mentioned in the above section seems to occur in lenses, as the quarry face shows rapid thinning and thickening of the stratum, and it is said by the quarrymen to occur in pockets. The best material comes from the lower bed of red shale.

The dip of the beds varies considerably within short distances, but in general the strata are gently inclined to the west.

A short siding allows the cars to be brought close to the quarry and the shale is taken to them by means of wheelbarrows. At the mill the material passes first through a rock crusher which reduces it to about $\frac{3}{8}$ -inch size. Thence it goes through an improvised rotary drier about 15 feet in length. It is then ground in burr mills and bolted through four 6-sided reels. The coarse particles which do not pass through the fine meshes are taken back to the burr mills for regrinding. The finished product is sacked for shipment.

The entire output is utilized in the manufacture of linoleum and oilcloth.

PLANT OF RENO BROS. PAINT CO.

The Reno Bros. Paint Co., at Pulaski, Lawrence County, is one of the oldest operating companies in the State. The business was started by H. B. Reno in 1870. The mine furnishing the material is on the west side of the Shenango River valley about half a mile north of Pulaski, less than half a mile from the Mercer County line; the mill for grinding the shale is close to the Pulaski Station of the Pennsylvania Railroad.

The shale is brick-red in color and forms a part of the Pottsville formation. It was included in the Sharon shales of the Second Pennsylvania Geological Survey. The strata are practically horizontal and outcrop on the side of the valley a short distance from the top of the divide. The material used varies in thickness from 5 to 7 feet. It is underlain by blue shale and overlain by a bed of compact gray sandstone which forms an excellent roof. The shales are worked through a tunnel driven into the side of the hill.

The shale is hauled by wagon to the mill at Pulaski, where it is thrown on a platform and exposed to the weather for some weeks or months in order to permit it to partly disintegrate, thus facilitating its grinding. It is later taken into the mill where it is first ground in a vertical rock crusher and then elevated to a bin on the floor above, whence it is fed into a grinding mill. The product is again elevated to the second floor, where it is drawn by suction through an impact pulverizer, by which the finest particles are separated from the coarser. The air separator divides the material into about two equal portions, the finer going into a bin and the coarser returning to the grinder. If the product is to be shipped in the raw state, it is packed in barrels or sacks from the bin. A con-

siderable portion is calcined before being marketed and that portion is taken to a drier from the bin. During the calcining process it is continually stirred in order to have the burning uniform throughout. From the drier the product is passed through a flour bolting mill to remove any lumps that may have been formed during the burning.

The product of this plant is sold under the trade name "Reno's French umber filler." The following analysis of the raw material is furnished by Mr. Charles E. Hull, the general manager:

Analysis of shale used by Reno Bros. Paint Co.

Combined water.....	6.10
Silica.....	57.26
Oxide of iron.....	9.28
Alumina.....	21.34
Lime.....	.25
Magnesia.....	.16
Titanic acid.....	.94
Alkalies.....	3.29
Manganese.....	.00
Sulphuric anhydride.....	.02
Phosphoric acid.....	.10
	98.74

The product is used as a filler for many kinds of articles of both metal and wood. It is used as a base in many prepared fillers and is frequently mixed with white lead. Most of it is sold to steel and iron manufacturers, particularly locomotive, safe, and structural steel makers, and is shipped to many points throughout this country as well as to Canada, Mexico, and France.

PLANT OF PULASKI UMBER CO.

The Pulaski UMBER Co. operates a mine on property adjoining that of the Reno Bros. Paint Co. and is working the same bed of red shale. The mill where the shale is ground is located on the east side of Shenango River, within the town of Pulaski. This plant is not operated continuously, and the mill is at present in need of repairs.

The finishing process is somewhat different from that of the Reno plant. After being exposed to the rain and sun the shale is passed through a rock crusher and then goes to a ball mill where it is ground between steel balls. From the ball mill it goes to a reel fitted with 8-mesh wire screens and thence to flour reels with No. 17 silk bolting cloth. It is then bagged or sent to a drier, if the burned product is desired. The burned material is again bolted to eliminate any lumps. At each stage of screening and bolting the coarse material is returned to the ball mill.

PLANT OF PILMAS PAINT CO.

The Pilmas Paint Co., of Elmira, N. Y., has mined some red shale about 3 miles north of East Charleston, in Tioga County, and has ground it about 1 mile east of Crooked Creek post office (Holliday station, on the New York Central Railroad).

The rock is light-red shale lying near the base of the Cattaraugus formation. Only about 200 tons has been dug, most of which has been used for experiments, and none has been dug for several years.

Mr. W. E. Mandeville, president of the company, has furnished the following analysis of the material:

Analysis of shale used by Pilmas Paint Co.

Silica.....	75.52
Alumina.....	9.85
Iron oxide.....	4.95
Lime.....	1.27
Magnesia.....	1.29
Potassium oxide.....	2.02
Sodium oxide.....	2.22
Loss on ignition.....	3.14
	100.26

RED SHALES OF WYOMING COUNTY.

The Catskill formation, which has an extensive distribution in the northeastern portion of the State, contains many beds of red shales. At one time these were worked by the Scranton Paint Co. near Factoryville, Wyoming County. The ore was first roasted and then ground in oil. The product was satisfactory and the supply of shale ample, but the market for such material being limited and competition keen, operations were discontinued several years ago.

RED SHALES OF SOMERSET COUNTY.

Along Paint Creek, in the extreme northern portion of Somerset County, red shale and red clay of the "Coal Measures" were dug for use as a paint several years ago. The material was used only locally for painting barns and other buildings, and operations have long since ceased. The strata utilized are said to have been from 1 to 3 feet in thickness. That portion of the shales which had been disintegrated to form clay was used rather than the unaltered beds.

RED SHALES OF ARMSTRONG COUNTY.

In the geologic report on Armstrong County¹ W. G. Platt describes some red shales near Centerville (Meredith) and some red clay near Putneyville that were formerly worked for paint for local use. The shales occur in the Conemaugh and the clay in the Allegheny formation.

¹ Second Geol. Survey Pennsylvania, Rept. H5, 1880, pp. 154, 155, 164.

SURVEY PUBLICATIONS ON MINERAL PAINT.

The following publications, except those to which a price is affixed, can be obtained free by applying to the Director, United States Geological Survey, Washington, D. C. The priced publications may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C.

AGTHE, F. T., and DYNAN, J. L. Paint-ore deposits near Lehigh Gap, Pennsylvania. In Bulletin 430, pp. 440-454. 1910.

BURCHARD, E. F. Southern red hematite as an ingredient of metallic paint. In Bulletin 315, pp. 430-434. 1907.

——— Barytes and strontium. In Mineral Resources U. S. for 1909, pt. 2, pp. 697-700. 1911.

——— Mineral paints. In Mineral Resources U. S. for 1909, pt. 2, pp. 701-720. 1911.

ECKEL, E. C. The mineral-paint ores of Lehigh Gap, Pennsylvania. In Bulletin 315, pp. 435-437. 1907.

——— Metallic paints of the Lehigh Gap district, Pennsylvania. In Mineral Resources U. S. for 1906, pp. 1120-1122. 1907. 50c.

HAYES, C. W., and ECKEL, E. C. Occurrence and development of ocher deposits in the Cartersville district, Georgia. In Bulletin 213, pp. 427-432. 1903. 25c.

STODDARD, J. C., and CALLEN, A. C. Ocher deposits of eastern Pennsylvania. In Bulletin 430, pp. 424-439. 1910.

SALINES.

SURVEY PUBLICATIONS ON SALINES, INCLUDING SALT, BORAX, AND SODA.

The more important publications of the United States Geological Survey on the natural lime, sodium, and potassium salts included in this group are those listed below.

These publications, except those to which a price is affixed, may be obtained free by applying to the Director, United States Geological Survey, Washington, D. C. The priced publications may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C.

ARNOLD, RALPH, and JOHNSON, H. R. Sodium sulphate in Soda Lake, Carriso Plain, San Luis Obispo County, Cal. In Bulletin 380, pp. 369-371. 1909.

BREGER, C. L. The salt resources of the Idaho-Wyoming border, with notes on the geology. In Bulletin 430, pp. 555-569. 1910.

CAMPBELL, M. R. Reconnaissance of the borax deposits of Death Valley and Mohave Desert. Bulletin 200. 23 pp. 1902. 5c.

——— Borax deposits of eastern California. In Bulletin 213, pp. 401-405. 1903. 25c.

CHATARD, T. M. Salt-making processes in the United States. In Seventh Ann. Rept., pp. 491-535. 1888.

DARTON, N. H. Zufri salt deposits, New Mexico. In Bulletin 260, pp. 565-566. 1905. 40c.

ECKEL, E. C. Salt and gypsum deposits of southwestern Virginia. In Bulletin 213, pp. 406-416. 1903. 25c.

——— Salt industry of Utah and California. In Bulletin 225, pp. 488-495. 1904. 35c.

KINDLE, E. M. Salt resources of the Watkins Glen district, New York. In Bulletin 260, pp. 567-572. 1905. 40c.

PACKARD, R. L. Natural sodium salts. In Mineral Resources U. S. for 1893, pp. 728-738. 1894. 50c.

PHALEN, W. C. Salt and bromine. In Mineral Resources U. S. for 1909, pt. 2, pp. 661-684. 1911.

——— Potash salts, their uses and occurrence in the United States. In Mineral Resources U. S. for 1910.

RICHARDSON, G. B. Salt, gypsum, and petroleum in trans-Pecos Texas. In Bulletin 260, pp. 573-585. 1905. 40c.

SCHULTZ, A. R. Deposits of sodium salts in Wyoming. In Bulletin 430, pp. 570-588. 1910.

YALE, C. G. Borax. In Mineral Resources U. S. for 1909, pt. 2, pp. 631-632. 1911.