ABRASIVE MATERIALS.

TRIPOLI DEPOSITS NEAR SENECA, MO.

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INTRODUCTION.

A very light, porous variety of decomposed siliceous rock, resembling the weathered chert popularly known in the region as "cotton rock," is rather extensively quarried in the vicinity of Seneca, Mo., and marketed under the commercial name tripoli stone. Production began in 1888 with the manufacture of scouring bricks and tripoli powder or flour. The product came into competition with similar articles made from tripoli (kieselguhr, kieselmehl, bergmehl) and tripoli slates (kieselschiefer)—infusorial deposits—and, though of entirely different origin, resembled those articles so much both in appearance and use that it was sold under the same name.

LOCATION.

As indicated on the sketch map (fig. 25), about 2 square miles of land in the neighborhood of Seneca and Racine is owned in fee or under lease by the various companies interested in the tripoli industry. Tripoli is likewise known from the vicinity of Fairland, Wyandotte, and Grove, Okla., and Neosho, Mo. There are doubtless other deposits in the territory between these localities, as well as elsewhere over the area underlain by the cherts and limestones of the Boone formation, though probably not all are suitable for use as filters or scouring powder.

GEOLOGY.

The tripoli deposits occur in the Boone formation, which in this region consists of a series of alternating limestones and cherts, with an average thickness of probably 350 feet. The only stratum which can be readily recognized is a bed of oolitic limestone 6 to 9 feet in thickness, which in the region to the north has been called the Short Creek member of the Boone formation. The deposits of tripoli are mostly found above the horizon of this limestone, though some are below it, in particular those south of Grove.

Some of the deposits occur in the steeper bluffs of the hills, but in such locations, by reason of the fact that tripoli is formed by weathering processes, they are not likely to be of workable extent. Most of the deposits now being exploited are on the tops of the hills, owing to the greater economy of operation and the greater likelihood of extensive deposits in such a situation. The bodies of tripoli range from 4 to 12 feet or more in thickness, and are overlain by chert, gravel,

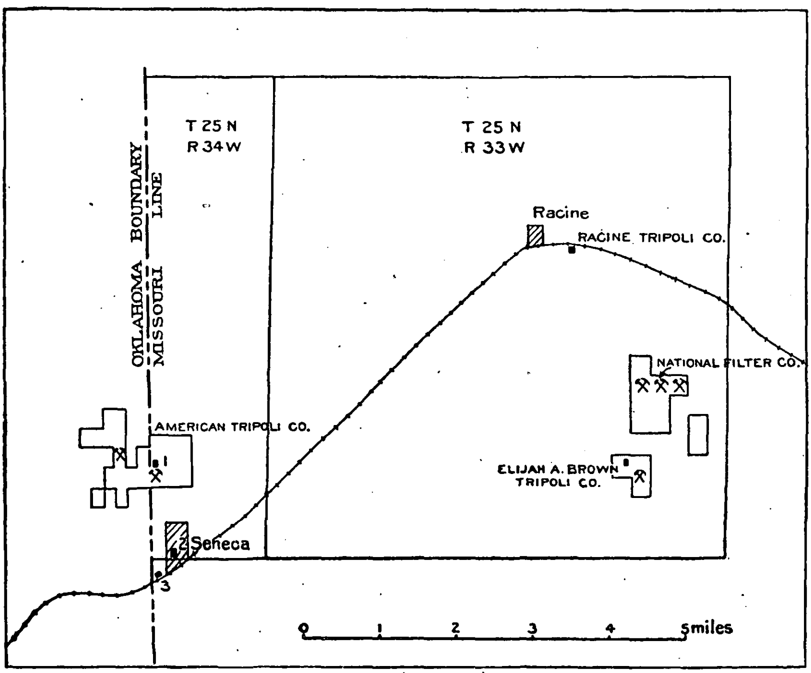

FIG. 25.—Sketch map showing location of tripoli deposits near Seneca, Mo. 1, 2, 3, Plants of American Tripoli Company.

and red clay, such as are common to the region. Some of the deposits rest upon impure spotted or discolored tripoli; in others the bed rock is a stratum of solid chert. In the spotted tripoli below the regular quarry bed in the American Tripoli Company's quarry in Oklahoma, the dark spots occur in a horizontal band and strongly suggest the dark material that is deposited in the pits of stylolites.

In the quarries north of Seneca the tripoli is massive, with scarcely a trace of stratification, but divided into irregular blocks by vertical, horizontal, and variously inclined and curved seams or joints. Chert occurs in lenses or more commonly in " balls " through the body of the tripoli itself, locally in such quantity as to force the abandonment of the quarry. Chert is also present in a streak of varying thickness on both sides of the slickensides which occur here and there in the tripoli. Such a cherty "slickenside" may form the limiting wall of a quarry. In one of the quarries there are several pronounced and characteristic slickensides in the north wall, each with its cherty faces. These extend downward for 2 or 3 feet and then die out, leaving no trace in the tripoli below. Another one, a foot in length from top to bottom, dies out at both ends. It is conceivable, of course, though not probable, that the slickensiding beyond that now evident was destroyed in the alteration to tripoli. Otherwise the conditions here seem to indicate that slickensides require very little displacement for their production.

In the quarries south of Racine the tripoli bed is itself massive and shows no lamination, but is overlain by horizontally banded and flaggy rotten cherts. Similar material occurs below the tripoli bed where the underlying beds were seen. In an abandoned portion of the quarry of the National Filter Company there is a sink hole which permits a view of the underlying formation and shows to some extent how effective the leaching surface waters have been in this region. A section here is as follows:

Section at National Filter Company's quarry near Racine, Mo.

	Thickness.	Depth.
	Feet.	*Feet.*
Soil, waterworn gravel, and waxy red clay	3	3
White and red streaked shelly tripoli	2	5
White tripoli	5	10
Banded red and white soft chert	3	13
Red and white rotten chert	5	18
Soft white rotten chert rock resembling tripoli	8	26

The tripoli at this place is very free from the irregular and curved jointing which was noted in the Seneca district, there being a few vertical crevices bearing due northwest and one seam of waxy red clay 2 inches wide reaching to the bottom of the quarry.

CHARACTER.

Tripoli is a light, even-textured, minutely porous rock, crumbling easily to the touch in the green state, but preserving its form very well when air dried. Owing to its extreme porosity, it is highly absorbent. This porosity is thought to be due, as shown later, to the solution of the limy portion of a calcareous chert, the siliceous skeleton of chert grains being left behind. According to Hovey,[a] the

[a] Sci. Am. Suppl., July 28, 1894, p. 15487. There are numerous references to the occurrence and nature of the Seneca tripoli deposits in various text-books, State reports, and the statistical annuals, but they are all apparently based on the observations of Dr. Hovey, as reported in the above citation.

tripoli grains "are very minute, by far the most of them being not over 0.01 mm. (0.0004 inch) in diameter, though occasional grains measure 0.03 mm. across. These particles are double refracting and are probably chalcedony."

In the quarries the more open seams are filled with red clay, which in many places stains the contiguous rock to a uniform brownish or reddish tint. Here and there occurs a beautiful regular banding perfectly independent of the original bedding planes, but showing more or less relation to the jointing and resembling the banded iron stains sometimes observed in weathered sandstone. The color thus varies from white to cream and light red. No traces of diatoms, radiolaria, or other fossils have been observed in the deposits. They either were absent in the original rock or have been removed in the process of the alteration which produced the tripoli.

The composition of the tripoli in these deposits is shown in the following analyses:

Analyses of tripoli from deposits near Seneca, Mo.

	1.	2.	3.
Silica (SiO_2)	98.28	98.100	98.10
Alumina (Al_2O_3)	.17	.240	.24
Iron oxide (FeO and Fe_2O_3)	.53	.270	.27
Lime (CaO)	Trace.	.184	.33
Potash (K_2O)	.17	----------	----------
Soda (Na_2O)	.27	.230	.23
Ignition	.50	1.160	1.17
Organic matter	----------	.008	----------
	99.92	100.192	100.34

1. By R. N. Brackett, Rept. Arkansas Geol. Survey for 1892, vol. 5, p. 267.
2. By W. H. Seamon, Sci. Am. Suppl., July 28, 1894, p. 15487.
3. Missouri Geol. Survey, vol. 7, 1894, p. 731.

ORIGIN.

The commonly accepted explanation of the origin of the tripoli is that it results from the decomposition of chert. The analyses show that it is practically pure silica. In the quarries lenses and solid or hollow balls of more or less decomposed chert are found, and slickensided crevices are usually faced with solid undecomposed chert. In none of the quarries or natural exposures is it possible to trace the tripoli laterally into unaltered rock. The massive, jointed character of the rock, the absence of bedding, and the lack of fossils would indicate that a profound alteration must have taken place if the tripoli is derived from the ordinary fossiliferous cherts of the region, which occur in beds rarely over 1 or 2 feet thick. "Cotton rock," the ordinary weathered and decomposed surface rock, is quite as fossiliferous as the unaltered chert from which it is derived, though some of it is almost as light as tripoli. It is difficult to see how further weathering alone could completely obliterate the bedding and fossils. On the whole, it is practically inconceivable that the usual chert of this region could weather into such an even-tinted, homogeneous rock as the tripoli actually is.

Locally there are beds of massive white to gray dull-looking rock ranging up to 10 or 15 feet in thickness. This rock is fine granular and unfossiliferous, and breaks with the subconchoidal fracture of a dense, fine-grained limestone. Immersed in acid it effervesces freely, but preserves its original volume after treatment, showing it to be a siliceous limestone or highly calcareous chert. The siliceous residue, after being washed and dried, is a porous granular rock closely resembling a poor grade of tripoli. It seems most likely that the tripoli deposits were formed by the leaching of the lime from some such bed as this. If so, this would explain the massive character and the localization of the tripoli, as well as the absence of fossils. Such a rock would be subject to the same concretionary processes as other limestones, and chert lenses and nodules, once formed, would show a much greater resistance to solution or leaching than the body of the rock, and apparently would remain much as they are now found in the tripoli. The cherty slickensides likewise afford corroboration of this view. Thus the original calcareous chert adjacent to the slickensides might readily be silicified by water entering along the crevice, and this cherty seam would persist when the body of the rock was altered to tripoli. On the other hand, if we assume that the original rock was chert, it seems unlikely that the area which would be entirely unaffected by the decomposition and weathering would lie along openings that permitted free access to the circulating water.

QUARRYING.

In quarrying these deposits, after the mantle of 2 or 3 feet or more of clay, gravel, and residual chert is stripped from the tripoli, vertical channels 12 inches wide are cut to the bottom of the deposit, or to such depth as is desired. These channels are easily made with a light pick of ordinary shape. Where the rock is much cut up by fissures and clay seams, the channels are cut along the most prominent of these joints, to lose as little as possible of the dimension stone. Two such channels, several feet apart, are run into the quarry face as far as it is desired to loosen the stone. A 2-inch hole is then drilled between the ends of the channels, filled with unslacked lime, and tamped. By absorption of quarry sap the lime is slacked, swells, and lifts the stone, the steadily increasing pressure having a tendency to loosen up the blocks along the already existing joints rather than to make new fractures. The shape and size of the blocks thus obtained depend on the number and attitude of the joints. The larger blocks of good quality are sent directly to the filter shop. Spalls and pieces unsuitable for filters are sent to the dry sheds, to be later ground into tripoli flour. When rock for grinding only is desired, that is to say, when it is too much jointed or for some other reason is unsuitable for filter stones, powder is used instead of lime in raising the rock, as it gives blocks of smaller size and saves some hand breaking before crushing.

Where the rock is not so closely beset with joints and fractures, narrow 2-inch cross channels are cut the length of the handle with a narrow-eyed pick, the eye being no wider than the cutting edge of the pick. In this way pieces of regular dimensions are obtained. Blocks 2 by 2 by 5 feet are as large as are ordinarily desired.

It seems that channeling machines, such as are used in quarrying massive limestones, might be advantageously employed in those quarries where there is not so much jointing. Special care would need to be taken to keep the channel clear of the muck formed of the comminuted tripoli.

MANUFACTURE.

FILTER STONES.

The rough blocks from the quarry are taken direct to the mill, where they are sawed up into blocks of the proper dimensions to be turned into filter stones of various shapes and sizes. In practice it was found that the "set" of an ordinary circular saw soon wore down to the thickness of the body of the saw, when it would cramp. With a saw set with diamond teeth, the setting of the diamonds soon wore loose under the abrasion of the stone. A wire saw was likewise tried without success. A special form of saw, which is thoroughly satisfactory, consists of a simple disk in the margin of which, at intervals of 2 or 3 inches, slots slightly narrowing toward the bottom are cut to a depth of three-eighths of an inch. A steel "tooth," five-sixteenths of an inch in width, about five-eighths of an inch in length, and just thick enough to stick tightly, is driven in each slot. This saw cuts the stone rapidly and does not clog up. The teeth are occasionally dislodged, and at intervals those missing have to be supplied. The stone as sawed is usually so full of sap that water oozes out just in front of the saw. The sawed blocks are air dried before the next step, which in the case of cylindrical and tubular filter stones is to make them round. For this purpose a vertical sandpaper disk is employed. The ends of the block are squared to the proper length, and the block is placed lengthwise between two centers, which allow it to revolve on a vertical axis parallel to the face of the disk. The operator presses the corner edges successively against the sandpaper, revolving the block with a motion opposite to that of the disk, until it is roughly cylindrical. Then the block is allowed to rotate freely on its axis, the motion being communicated by the disk, and the diagonal attrition rapidly produces a perfect cylinder. Filter stones of special shapes are produced on regular turning lathes and special boring machines. Defective blocks and trimmings, as well as lathe dust picked up by the dust collector, go to the tripoli flour mill.

TRIPOLI FLOUR.

Spalls and small or waste blocks from the quarry, together with waste from the filter mill, after having been thoroughly dried for two or three weeks, are crushed, ground on buhrs, and bolted by machinery of simple flouring-mill type. Two grades are marketed, depending on the degree of fineness. The grade O. G. (once ground) will pass through a No. 60 wire mesh, and the grade D. G. (double ground) passes through a No. 140 mesh or a No. 14 silk bolting cloth. Three colors of the flour are made—" white," " cream," and " rose." These colors are obtained by hand sorting the blocks in the dry sheds, those blocks with the most iron stain making the " rose " flour, and the mixed and spotted blocks making the cream colored. The bolted product is sacked or barreled and shipped just as ordinary flour.

PRODUCTION.

According to published reports from various sources, the production has increased from less than 200 tons of tripoli flour in 1888 to 1,000 tons in 1893, 1,375 tons in 1894, and 4,000 to 5,000 tons in recent years. Figures are not available for the tonnage of rough tripoli blocks worked up into filter stones in previous years, but for 1906 it was approximately 600 tons. The present price of tripoli flour f. o. b. cars at Seneca is from $6 to $7 per ton. It is impossible to put a unit price on the finished filter stone, the price of the individual pieces varying with the size and the amount of work done on each. The value of the combined production of tripoli flour and filter stones was, in 1893, $25,000; in 1894, $35,500; in 1905, $50,000; in 1906, approximately $60,000. According to report, about 40 per cent of the flour is exported to foreign countries.

USES.

Tripoli stone has a moderate sale for blotter blocks and scouring bricks, but the important use is for filter purposes. The local mills turn out the filter stones in shapes and quantities to suit the manufacturers of filters. The size ranges from the ordinary house filter to single filters with a capacity of 400 gallons per hour, or batteries of such filters with any desired capacity. For such purposes ocular evidence proves that tripoli stone will remove much of the matter mechanically suspended. As pathogenic germs infesting waters are largely attached to such suspended matter, it follows that they would be likewise removed. Bacteriological examination of water before and after its passage through tripoli filters, it is claimed, demonstrates the sterilizing efficiency of the stone.

Tripoli flour is used as an abrasive, for general polishing, burnishing, and buffing. It is used also as an ingredient of various scouring soaps. Unsuccessful attempts have been made to mold filter stones from tripoli flour to which a binder has been added, but in all experiments so far the binding agent has fatally impaired the porosity of the filter.

Formerly diatomaceous earth (kieselguhr) was used as the absorbent base in the manufacture of dynamite. In recent years this inert base has been superseded by a compound of sodium nitrate, wood pulp, marble dust, and various other substances, which has the advantage of entering into the combustion of the explosive. A rough estimate of the additional force thus gained places it at 5 per cent. The cost of diatomaceous earth is from \$25 to \$30 or more per ton, depending on the shipping distance. Wood pulp costs \$30 per ton, or more, and is constantly advancing in price. The price of tripoli flour, finely bolted, sacked, and hauled to the railway, as shown above, is between \$6 and \$7 per ton. Merely ground, unbolted, hauled in bulk from the mill, the flour could be laid down at the two powder plants in the vicinity of Joplin for approximately half that sum. It is believed that tripoli flour might be substituted for the wood pulp, either in whole or in part, without materially impairing the explosive value of the compound, at a possible saving of \$3 or \$4 per ton in the cost of the powder. If experience should show a serious impairment, it is believed that this could be remedied by the addition of more nitroglycerine and that there would still be a notable saving. As the Joplin plants have a combined daily production of about 30 tons of dynamite, it seems that the point is one worthy of consideration.

FIRMS ENGAGED IN THE INDUSTRY.

The American Tripoli Company is the largest as well as the pioneer company in the industry, having erected a grinding mill in 1887, to which was soon added machinery for the manufacture of filter stones. This grinding mill, variously enlarged and remodeled, is in use today, and has a daily capacity of 15 tons of tripoli flour. It is situated on the highland just east of the Missouri-Oklahoma State line, a mile north of Seneca, and the quarries are near by on each side of the line. In 1905 the Seneca Filter Works, established in 1894, were absorbed by this company, which thenceforward carried on the filter business at the new plant. In 1907 the company built in Seneca, adjacent to the Frisco Railroad, a new and much larger mill, though of the same type as the original mill. The new mill is equipped with two crushers, five runs of vertical buhrs, 20 sieve reels, flour packers, etc., and has a capacity of 30 tons per ten-hour day, power being furnished by a 150-horsepower boiler and a 100-horsepower engine. In this plant the attempt is made by the installation of large dust collectors and by hidden journals to lessen as far as possible the friction and wear due to flying tripoli dust. It is planned to double the capacity of the filter works and consolidate them with the mill. The company also owns 80 acres of land with tripoli quarries in the Racine district just south of the National Filter Company's quarry.

Filter works at Racine, Mo., have been operated in connection with the tripoli quarries 2 miles south of that place for a number of years. The National Tripoline Company built a tripoli mill at Kirkwood, Mo., in 1904, to operate the same quarry, but it was shut down after a few months. A reorganization under the name Racine Tripoli Company was effected in 1907. Water power was secured just south of Racine station, and it is planned to start a tripoli flour mill shortly.

The Elijah A. Brown Tripoli Company during 1907 completed a small new mill 3 miles due south of Racine. It is equipped with a crusher, run of buhrstones, sieve reel, saw, sandpaper disk, and boring machine. Though small it is complete and will turn out both filter stones and tripoli flour. The company owns 120 acres of land on which are good deposits of fine-grained tripoli.

The National Filter Company owns 80 acres in the Racine tripoli district. It quarries out the tripoli stone in large blocks, 2 by 2 by 4 or 5 feet in size, which are shipped to the firm's manufacturing plant in Chicago, Ill. Only the drying sheds and quarry machinery are located at the quarries. Owing to the practical absence of joints and clay seams, no blasting is done at this quarry, the rock being wholly quarried out with hand picks.

C. C. Martin & Son own a quarry in the Racine district, and make odd lots of filter stones to order on an ordinary turning lathe.

Other tracts of land near the quarries above described are known to be underlain by tripoli stone of good quality, but the quarries mentioned comprise all that are now in operation.

SURVEY PUBLICATIONS ON ABRASIVE MATERIALS, QUARTZ, FELDSPAR, ETC.

The following list includes a number of papers, published by the United States Geological Survey or by members of its staff, dealing with various abrasive materials:

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