The Porters Creek Clay of Tennessee As a Bleaching Agent for Oils

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IN 1934 the Tennessee Division of Geology, in connection with its State-wide survey of clay resources now in progress, began a systematic study of the bleaching properties of certain types of clays, including kaolin, bentonite, and clays of the Porters Creek formation (Eocene age). The results of this preliminary study[1] were very encouraging. The sole objective of the preliminary work was, however, comparison of the bleaching activities of the various clays on mineral and vegetable oils.

During the past winter this study has been continued, principally on the Porters Creek formation, both because its abundance at a number of easily accessible points and because of the marked bleaching activity exhibited by its clays on both vegetable and mineral oils. Work on deposits suitable for bleaching edible oils has been particularly stressed.

A potential market for earths suitable for bleaching edible oil exists at Memphis in the four cottonseed oil refineries operating there. In addition to this market, refineries for peanut, soya bean, corn and other vegetable oils are located in Louisville, Ky., Cincinnati, O., Atlanta, Macon, Savannah, and Athens, Ga., Jacksonville, Fla., Chickasha and Oklahoma City, Okla., and Dallas, Fort Worth and Houston, Tex., and individually or in the aggregate these refineries offer potential markets that are worthy of serious consideration.

In addition to the research on vegetable oil with the Porters Creek, these clays have been studied for their bleaching activity with mineral oil and a few bentonites have been tested with both types of oil.

Earths Suitable for Oil Bleaching

Bleaching earth is any mineral substance, either natural or processed, that has a marked ability for removing certain basic colors from animal, vegetable, or mineral oils. "Fuller's earth" has long been applied indiscriminately to any clay-like substance having a decolorizing activity, but the tendency is to substitute "bleaching earth" or "bleaching clays" for the agents used in oil refining.

Practically all earths have some capacity for bleaching. The principal earths used are certain active clays and bentonites. Many clays are naturally active and require no other processing than that of grinding and sizing. Approximately 95 per cent of the natural earths produced in the United States are used in refining petroleum oils. Bentonites are usually not strongly active and require chemical or heat treatment to increase their activity. These so-called "activated earths" have found growing favor with the edible oil industry in recent years because of their superior activity and neutral effect on the fatty acid content of the oil. Such domestic earths have largely supplanted imported earths, as English XL, which was long a favorite with refiners of edible oils. Natural earths for petroleum refining are mined in Texas, Florida, Georgia, Illinois and a few other states. Bentonites and other earths that are activated for use in refining edible oils are produced in Utah, Colorado, Arizona, California and Wyoming.

Any earth used for bleaching edible oils must meet the following specific needs:

(1) the earth must not oxidize the oil or otherwise cause *any* increase in the free fatty acid content;
(2) clayey taste or odor must not be imparted to the oil;
(3) no more than 35 per cent of oil may be retained by the earth and a much lower retention is preferable;
(4) the oil must bleach to a color satisfactory for the product being made; and
(5) the earth must permit a fair rate of filtration.

In illustration of the above factors, the needs of cottonseed oil bleaching may be considered here. Of the five essentials, the most important is that regarding fatty acid. "Prime summer yellow cottonseed oil" as refined from the crude oil has a free fatty acid content of 0.05 per cent or less calculated as oleic acid and should not exceed 0.10 per cent. Any increase in the fatty acid content of an oil during bleaching will be sufficient to condemn the earth. The wide acceptance of activated bentonites is due largely to their neutral effect on the acidity of vegetable oil.

The bleaching activity and oil retention of an earth are two major requirements of an edible oil earth that are more or less interdependent. The greater bleaching activity, the less earth required, and consequently, the less retention. All plants desire to avoid loss of oil and seek earths with low retention values. Commercial practice indicates a retention range of 20 to 35 per cent where filter presses are steamed to as low as 8 per cent with water-washing of presses. Free and fairly rapid movement of oil through the filter presses is essential. Any earth that filters slowly or clogs the presses would delay plant operations unduly.

A bleachable oil is an oil that will bleach to 20 yellow, 2.5 red color, Lovibond scale, by American Oil Chemists' Society method. A bleached oil is an oil that has been bleached to 20 yellow, 2.5 red.

The requirements of an earth for bleaching mineral oils are not as specific as those demanded for edible oil. The chief interest of most refiners of petroleum oils is the ultimate cost of the earth. Low activity can be offset by the use of a greater quantity of earth, provided the earth of lower activity decreases cost. Petroleum oil, unlike edible oil, is not so valuable as to make retention a major controlling factor. Both activated and natural earths are used in the industry, but natural earths are in greater demand. Natural earths are considered here.

In the use of natural earths two fundamental processes are employed. First, the percolation method in which the oil is filtered through a relatively coarse earth, as 30 to 60-mesh; and second, the contact process in which bleaching is effected by heating intimately mixed

[1] Whitlatch, G. I., Bleaching earth prospects in Tennessee: Ceramic Age, vol. 24, No. 2, pp. 37, Aug., 1934.

oil and finely divided earth of 100-mesh or less sizes and then separating them in filter presses. The percolation method is practically always used for decolorizing purposes, but the contact method is used for either decolorization or neutralization of acid and acid-treatment products retained in lubricating oil after acid treatment. A combination of results of the two may be effected by the use of more earth than necessary solely for neutralization.

Geology of the Porters Creek

Western Tennessee, comprising the area lying west of the Tennessee River, is composed largely of unconsolidated sands, gravels, clays, and a single local thin limestone. To these sediments the geologic names Cretaceous, Tertiary, and Quaternary systems have been applied. The Porters Creek formation is near the base of the Tertiary system (as exposed in Tennessee), being underlain by the comparatively thin Clayton formation of the same system.

The Porters Creek formation extends across West Tennessee in a south-southwest trending belt that has a maximum outcrop width of about 8 miles, but locally the belt may thin to less than a mile in width. Outcrops of the clays of this formation are to be found in Henry, Carroll, Hadison, Henderson, Chester, and Hardeman counties. On the outcrop, the greatest known thickness of the formation is 85 feet at "Pinson Hill" in southeast Madison County, but well logs have recorded as much as 175 feet for the Porters Creek.

Clay composes the greater part of the Porters Creek formation in Tennessee, though beds of sand, often glauconitic, are not uncommon, particularly near the top of the formation. The sandy phases do not appear to be very persistent over long distances or to represent any particular stratigraphic horizon. They are, in effect, suggestive of the conditions described by Lowe[2] for his Tippah sandstone. Further the writer has noted at several points in the extreme upper part of the Porters Creek conditions that are very suggestive of the Ackerman formation, a member of the overlying Wilcox group of Mississippi that is, at present, unrecognized in Tennessee.

Lithologically, the clays of the Porters Creek are distinctively uniform and easily recognized by their color and habit of weathering. The dry, comparatively fresh clay is lead to dove-gray in color, but assumes whitish-gray to buff tones on dry, weathered surfaces. The wet clay ranges from dark grays to grayish-blacks. It is fine-textured and has a soapy feel when wet, hence the local appellation of "soapstone."

An outstanding character of the Porters Creek, observed in outcrops, is its intersecting system of vertical joints and attendant conchoidal fracture and weathering of the blocks formed by this jointing. As a result of this jointing and peculiar conchoidal or nodular fracturing, talus slopes developed on an outcrop are composed typically of irregular to shell-like fragments, and the outcrop has a hackly appearance. Another feature that aids in recognition of the Porters Creek is its low apparent specific gravity. The clay is normally porous and dry fragments of it are appreciably lighter in weight than similar size pieces of other types of clay. The clay, further, is decidedly resistant to weathering and does not slake readily.

The Porters Creek clay tends to be massive with rather inconspicuous bedding planes along which frequently occur thin layers of fine-grained white sand. Dikes of fine sand, varying from a few inches to as much as 22 feet in width, often cut the formation; they show no systematic orientation and frequently intersect one another. Occasional thin limonitic layers are formed along joints in the clay, but as a whole, the formation is not distinctly ferruginous.

Laboratory Technique

The needs of the oil industries have been constantly in mind throughout the research upon which this paper is based, and data interpretable by these industries have been sought. Many parts of the laboratory technique were suggested by commercial practices.

All clays used in the tests were ground and screened to 40-60, 60-100, 100-200, 200-325, and 325-minus sizes and each portion then blended by weight into mixes of the following compositions:

This blending of sized material obviates any effect of indiscriminate sizing and insures comparable results. The blended earths were dried to essentially constant weight at 100 degrees C.

All tests for bleaching edible oil were made with cottonseed oil, refined to the grade known commercially as "prime summer yellow." The standard bleach test of the American Oil Chemists' Society[5] was followed, but the recommended test-weight of 300 grams was reduced to 175 grams. The methods of this society were also followed in making the fatty acid tests, using, however, only 28.2 grams of oil instead of the standard test-weight of 56.4 grams.

Filtration was by gravity through filter paper. Comparison of the resultant oil of each test, as soon as cool, was made in a home-made light-diffuser with a sample of similar oil previously bleached with official fuller's earth. In these preliminary comparisons the quality of the bleach was recorded by letters as follows: AA, bleach test excels standard color; A, apparently equal colors; B, C, D, indicate relative inferiority of bleach test to that of standard. Later, certain earths of exceptional activity were re-run with the oil and color determined on a standard Lovibond colorimeter.

The per cent of free fatty acid in the test oil was compared with that obtained on similar oil bleached with official fuller's earth. As more than one lot of oil was used in the series of tests, the standard of comparison varied slightly due to original differences of free fatty acid content of the oils.

Retention tests followed the methods of Gardner and Coleman[6], mixing oil with a definite amount of clay until the mixture smeared the mixing dish, the oil being added drop by drop from a burette. No satisfactory method, under prevailing laboratory facilities, was developed for determining filtration speed, and the few results expressed here are only estimates.

Vegetable Oil Mix[3]	
60 — 100 mesh	25.0%
100 — 200 mesh	20.0
200 — 325 mesh	35.0
Through 325 mesh	20.0

Mineral Oil Mix[4]	
40 — 60 mesh	1.0%
60 — 100 mesh	4.0
100 — 200 mesh	20.0
200 — 325 mesh	25.0
Through 325 mesh	25.0

[2]Lowe, E. N., Coastal plain stratigraphy of Mississippi, Pt. I, Midway and Wilcox groups: Miss. Geol. Surv., Bull. 25, pp. 22-23, 1933.

[3]Screen analysis by author of official fuller's earth.

[4]Screen analysis of a commercial bleaching earth, supplied by Continental Oil Co., Ponca City, Okla.

[5]American Oil Chemists' Society, Official methods, Revised to Aug., 1934, p. 18.

[6]Gardner and Coleman, Paint Mfrs. Assocn. U. S., Tech. Circ. 85.

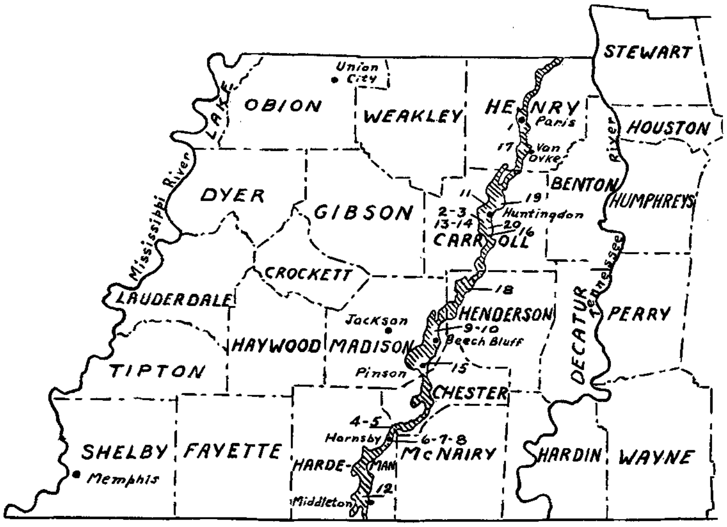
In addition to the above standard tests, some preliminary tests, suggested by the possibility of processing the Porters Creek clay to reduce its action on free fatty acids, were made. The test consisted of boiling a test-weight of clay in distilled water for 30 minutes, filtering, drying, re-pulverizing, and using in the standard bleach test. The filtrate water, to which was added a few drops of phenolpthalein indicator, was titrated with N/.1 solution of NaOH for soluble acid in the hope that some relation between this factor and the fatty acid increase might be established.

"No standard methods of evaluating decolorizing clays (used on mineral oil) have been developed due to the fact that every refiner's problem is so different that each refiner has attempted to develop laboratory procedure that will most closely duplicate his commercial practice."[7] In the absence of standard methods for testing the bleaching activity of an earth on mineral oil, the contact filtration method was adopted as it appears to permit a fair evaluation of relative efficiencies of the earths. If one earth bleaches to a degree greater than another, provided all elements of the test are equal, there can be no doubt as to the superior earth.

A relatively dark, steam-refined petroleum oil of moderately low viscosity with a Tag Robinson color of ½ was used for all mineral oil tests. Seventy-five grams of this oil, while cold, were mixed with 7.5 grams of earth (10 per cent of oil weight) and then heated carefully to 177 degrees C., where it was held for a period of 15 minutes. The mixture was stirred manually at a fair rate of speed during the heating. (Heating from 116 to 177 degrees C. should be with super-heated steam and stirring with a high speed agitator, but this was not possible in the present study.) Filtration was by gravity through filter paper.

Comparisons for color were made with a finished filtered stock oil with a Tag Robinson color of 1¼. Direct daylight supplied satisfactory illumination, and as the grading was done as group readings by two observers, fairly close distinction of color differences was possible. Comparison values were recorded by the letter system.

[7]Personal communication from Continental Oil Co., Ponca City, Okla.



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Ov. Official fuller's earth, obtained through J. C. P. Helm, Sec'y, American Oil Chemists' Society, New Orleans, La. 1. Paris, N. C. & St. L. R. R. cut at Fairview, ⅛ mi. N. of Russell Pottery Co., (1) and (10) groove over 35-ft. section on east side of railway, north of small branch; (12a and 12b) grab sample from near base of section noted under (1) and (10)—weathered material; (26) groove of 20-ft. section on west side of railway. 2. Outcrop along old Purdy road, 2.5 mi. southwest of Huntingdon, groove over 10-ft. exposed section. 3. Outcrop along old Purdy road, 2.6 mi. southwest of Huntingdon, composite sample over 35 ft. of exposed section. 4. G. M. & N. R. R. cut, Pinetop, groove over lowermost 20 ft. of section exposed at north end of cut. 5. Same as Locality 4, groove of more sandy and shaly type of Porters Creek clay exposed in north end of cut. 6. East of Hornsby, 1.3 mi., first major cut along St. Rd. 15, groove over 6 ft. of topmost part of section. 7. Milstead Farm, ¾ mi. NW. of Hornsby, 10-ft. groove of outcrop near base of ridge. 8. Same as Locality 7, groove from third test pit south of ridge. 9. West side of Beech Bluff—Jackson road, 1.0 mi. north of Beech Bluff, groove over 8-ft. exposed section; (9) grab sample of weathered clay. 10. Seven-tenths of a mile northwest of Locality 9 along same road, grab sample of weathered material. 11. Northeast of Huntingdon, 0.7 mi., 75 yds. east of county road, composite over lower 10 ft. of section. 12. North of Middleton, 2.3 mi., on Middleton-Bolivar road, groove of 15-ft. exposed section. 13. Purdy road, 1.8 mi. southwest of Huntingdon, just north of Lay Cook place, groove over 7 ft. of exposed section. 14. South bank of Brier Creek, 1.6 mi. southwest of Huntingdon on Purdy road, (16) uppermost 10 ft. of section; (27) lower 16 ft. of section. 15. Pinson Hill, 0.8 mi. E. of Pinson, composite of samples from middle and lower half of hill. 16. Seven miles south of Huntingdon along St. Rd. 22, composite of grooves from top and base of exposed section. 17. D. W. Dowdy Farm, 1.1 mi. W. of Van Dyke, (22) composite over 40-ft. section; (24) grab sample of weathered material. 18. E. E. Wilkins, 2.6 mi. SE. of Law, groove over 15 ft. of section beginning 10 ft. above creek. 19. West of Rosser, 1.5 mi. along U. S. 70, groove over 25 ft. of exposed section. 20. West side of St. Rd. 22 opposite Davis Chapel, 4.8 mi. south of Huntingdon, on W. A. Weaver farm.

Bentonites: 21. Approximately ¼ mi. W. of Southern RR. station at Pennine, groove of 1½ ft. 22. Parks Farm, 1.9 mi. S.E. of Wartrace, grab sample of slightly weathered material. 23. North of Wartrace, 3.6 mi. along St. Rd. 64, composite of 5 ft. bed. 24. Former Dixie Mineral Products Co. mine, Kelly Farm, 2.5 mi. N.W. of Evensville, groove over 3 ft. 25. Sample from near Lewisburg, furnished by J. W. Young, Fayetteville, Tenn., exact location not furnished, grab sample probably.

Non-Tennessee Clays: 26. Porters Creek clay from Olmstead, Ill. 27. Florida fullers earth, untreated. 28. Treated bentonite from plant in California. 29. Treated bentonite from California plant. 30. Georgia fullers earth, untreated.

An attempt to secure data on the approximate retention of mineral oil by the various earths was unsuccessful due to the viscosity of the oil.

The effect of heat treatment on the activity of the Porters Creek was tried in a preliminary way by heating a test-weight of earth to near red heat for several hours and then using it in the mineral oil bleach test. Apparently negative results were secured in all of these tests.

Discussion of Laboratory Results

As indicated on the accompanying map, this study is based on samples of Porters Creek clays from 20 localities in Tennessee and represents a fair cross-section of this formation as exposed across the State. A total of 25 samples was taken from these localities as, in a few instances, weathered samples were taken in addition to the fresh material, or strata in a deposit were sampled individually because of apparent lithic variations.

Five samples of bentonites were included in the study largely because of the present lack of data on this Tennessee material. The Tennessee bentonite, however, does not appear to offer a very attractive source for development due, as pointed out in our previous study[8], to thinness of the bed between limestones with high cost of mining.

Samples of commercial bleaching earths from Illinois, Georgia, Florida, and California producers were included in the mineral oil tests for sake of comparative efficiencies.

Vegetable Oil Tests

In evaluating the commercial possibilities of the Porters Creek for bleaching edible oils, any sample that caused 50 per cent or less of free fatty acid increase has been considered a fair prospect; other samples with greater increases but satisfactory bleaching activity would be suitable for bleaching soap or other non-edible vegetable oil product. Several factors complicate the selection of earths suitable for edible oil bleaching, chief of which is our present lack of data on the effects of treating Porters Creek clays. Boiling, heating, acidizing, or some other type of treatment may result in distinct improvement of decolorizing activity and in complete neutralization of fat splitting tendencies, especially in those that cause a minimum of free fatty acid increase in their natural conditions. Selective mining also may prove beneficial. Further, the fatty acid test is susceptible to slight variation in results in the hands of different operators; this is illustrated by check tests made by two persons on samples Nos. 2a and 2b, locality 2. (See Table 1.)

Other samples that caused 50 per cent or less increase of free fatty acid but showed a lesser degree of decolorization are those from near Paris, Pinetop, Beech Bluff, Middleton, and Van Dyke (locality Nos. 1 (12a), 4, 10, 12, and 17, respectively). All are, with the exception of the Pinetop (No. 4) sample, weathered materials, and the effect of weathering may have been beneficial to their activity. Weathering has been considered by some workers to aid the activity of an earth (8a) and present results add confirmatory evidence to this belief. Weathering also apparently has a favorable effect toward reduction of fat splitting tendencies of an earth. Unweathered samples of clays from the Paris deposit (locality No. 1) caused 100 to 200 per cent increases of free fatty acid content, while weathered clay of the same deposit caused only 35 to 50 per cent increases. Similar decrease is to be noted in the Van Dyke (locality No. 17) clays. Reverse results obtained in samples from Beech Bluff (locality 9) show that weathering may affect some earths adversely. Commercial workers are of the opinion that

TABLE NO. 1
Tests on Vegetable Oil.

Locality No.	Lab. No.	Type of Sample	COLOR Estimated	COLOR Lovibond Scale	FATTY ACID CONTENT Official Earth Pct.	FATTY ACID CONTENT Porters Creek Pct.	Approximate percent of increase	Retention (percent of dry earth)
0	0v	Official earth	Standard	20y—2.15r	0.030	....	...	39.0
1	1	Groove	B		"	0.090	200	70.0
	10	Groove	B		"	0.060	100	75.5
	12a	Grab, weathered	A		"	0.045	50	89.0
	12b	Grab, weathered		20y—2.15r	"	0.040	33	....
	26	Groove	B		0.025	0.060	117	63.5
2	2a	Groove	AA		0.030	0.055	83	69.0
	2b	Groove		20y—2.20r	"	0.045	50	....
3	31a	Composite	B		0.025	0.040	60	92.0
	31b	Composite		20y—2.20r	0.030	0.055	83	....
4	3	Groove	B		"	0.045	50	48.0
5	21	Groove	C		0.025	0.040	60	37.5
6	4	Groove	AA		0.030	0.030	00	73.0
7	5	Groove	B		"	0.055	83	73.0
8	25a	Groove	B		0.025	0.045	80	59.0
	25b	Groove		20y—2.75r	0.030	0.055	83	....
9	6	Groove	C		"	0.105	250	82.0
	9	Grab, weathered	B		"	0.150	400	80.0
10	18	Grab, weathered	B		0.025	0.030	20	90.0
11	7	Composite	B		0.030	0.060	100	79.5
12	8	Grab, weathered	B		"	0.045	50	85.0
13	13	Groove	B		"	0.050	67	77.0
14	16a	Groove	AA		"	0.040	33	83.0
	16b	Groove		20y—2.19r	"	0.040	33	....
	27	Groove	B		0.025	0.060	140	70.0
15	19a	Composite	AA		0.030	0.050	67	91.0
	19b	Composite		20y—2.00r	"	0.050	67	....
16	20	Groove	C		0.025	0.260	940	73.0
17	22	Composite	B		"	0.070	180	77.0
	24a	Grab, weathered	AA		"	0.045	80	93.0
	24b	Grab, weathered		20y—2.30r	0.030	0.045	50	....
18	23	Composite	A		0.025	0.120	380	89.0
19	33a	Composite	A		"	0.025	00	86.0
	33b	Composite		20y—1.90r	0.030	0.030	00	....
20	36	Composite	AA		0.040	0.045	12	89.0
		BENTONITES						
21	11	Groove	C		0.030	0.060	100	32.5
22	14	Grab	D		0.030	0.030	00	41.0
23	15	Composite	D		0.025	0.040	60	36.0
24	34a	Groove	C		0.030	0.040	33	30.0
	34b	Groove		20y—2.30r	"	0.040	33	....
25	35a	Grab	D		"	0.050	66	33.0
	35b	Grab		35y—2.90r	"	0.050	66	....

The good possibilities of the Porters Creek as a source of bleaching earths suitable for vegetable oil bleaching are well illustrated by the results of this study. Ten out of 25 samples gave favorable results. The area within an approximate radius of 5 miles of Huntingdon, Carroll County, is indicated as being distinctly favorable to prospecting for edible oil bleaching earths. Samples from locality Nos. 2, 6, 14 (16a) on the Purdy road southwest of Huntingdon, No. 19 from near Rosser, and No. 20 at Davis Chapel, each had bleaching activity near that of official fuller's earth and showed 50 per cent or less increase in free fatty acid content on the test oil. The "Rosser" earth, by virtue of its neutral effect on acidity and strong bleaching activity, is an outstanding prospect. The economic value of the Rosser occurrence is further enhanced by its proximity to shipping facilities and favorable conditions for mining relatively large tonnages. The only other sample showing neutral acid effect (locality No. 6) is from a deposit of limited size and probably not of economic importance.

[8] Whitlatch, Op. cit.

8a—See Miss. Geol. Survey Bull. 29, pp. 16-17, 1935.

organic matter is often the impurity of an earth that causes free fatty acid increase, and if this is true, weathering in those cases would improve the earth by leaching out the organic substances.

The fairest comparison that may be made of retention values obtained in this study is with that of a commercial earth used by the vegetable oil industry. The earth selected for this comparison had a retention value of 83.5 per cent. The average of the Porters Creek clays is 76.7 per cent. On a unit for unit basis, the average retention of the Porters Creek clays is better than a commercial standard earth, but the earth cited here is an activated earth with greater bleaching activity, hence less retention in plant practice. Such comparison of natural earth with treated earth does not give an absolute value, but the comparison is of interest in view of possible activation of Porers Creek clays. A number of the Porters Creek samples gave retention values below the average as in the cases of those from locality Nos. 1 and 2 with 63.5 and 69.0 per cent, respectively; a non-typical sandy sample from near Pinetop retained only 37.0 per cent of oil. The maximum retention of 93.0 per cent was on a weathered sample from Van Dyke.

The results of preliminary experiments to reduce the fat splitting effect of Porters Creek clays by boiling in water are shown in Table No. 3. Favorable results were obtained on all samples thus treated, and in three instances, very substantial reductions were effected. This type of treatment appears to have merit, and further study as to the effect of boiling over longer periods of time may produce even more favorable results. As indicated in the table, apparently no relationship exists between the soluble acids of a clay and free fatty acid increases.

TABLE No. 3

Lab. No.	Soluble Acids in the Clay (Per Cent)	Fatty Acid Increase with Raw Clay (Per Cent)	Fatty Acid Increase with Boiled Clay (Per Cent)	Difference, in Per Cent. of Reduction Effected by Treatment
9	5.0	400	20	380
17	0.75	500	60	440
20	10.0	940	240	700
22	8.0	140	10	130
23	1.0	380	270	110

The bentonites included in this study do not have as marked bleaching activity in the natural condition as the Porters Creek, though their tendency to cause fat splitting during bleaching is somewhat less than the clays. Retention of oil by bentonite is approximately half of that obtained with Porters Creek clays.

Mineral Oil Tests

The preliminary testing of Tennessee clays[9] clearly indicated that the decolorizing activity of a clay is, in some cases, greater with vegetable oil than with mineral oil, and vice versa, while other clays have approximately equal activity with either type of oil. This conclusion is reaffirmed by results shown in Table No. 2. Further, the tests demonstrate the general suitability of the Porters Creek clay for bleaching mineral oil. Seven samples from the 18 localities investigated had bleaching activities equivalent to a Tag Robinson color of 1½; one sample bleached the oil to a color in excess of the standard.

TABLE No. 2

Tests on Mineral Oil

Locality No.	Lab. No.	Estimated Grade	Locality No.	Lab. No.	Estimated Grade
1	1	B	15	19	B
..	10	B	16	20	B
..	12	A	17	22	C
..	26	B	..	24	B
2	2	A	18	23	AA
3	31	B	19	33	C
4	3	D	20	36	C
5	21	C			
6	4	B		**Bentonites**	
7	5	B	21	11	C
8	25	C	22	14	C
9	6	A	23	15	C
10	18	C		**Non-Tennessee Earths**	
11	7	A	26	A	C
12	8	A	27	B	B
13	13	A	28	C	AAA
14	16	A	29	D	AA
15	27	B	30	E	B

It is interesting to note that the Huntingdon area again predominates with three of the favorable localities (Nos. 2, 13, and 14) being on the Purdy road southwest of that city and a fourth locality of promise being a short distance northeast of the city. The sample from the Wilkins farm near Law, Henderson County (locality No. 18), had the best activity on mineral oil. Three other good prospects are the Beech Bluff, Middleton, and Paris (locality Nos. 12, 9, and 1) occurrences.

The general good bleaching activity of Porters Creek clays with mineral oil is more clearly demonstrated by comparison of the test-results with those obtained with various commercial earths. Two non-Tennessee earths, from Florida and Illinois sources, had only B ratings. If these earths were used as standards of comparison, only 5 of the Porter Creek clays would be inferior to them, and in several instances, superior in activity.

The bentonites, used as natural earths, exhibited only fair activity with mineral oil. All three samples included in these tests had C ratings.

The effect of heat treatment on the decolorizing activity of Porters Creek clays was tried in a preliminary manner with mineral oil, but no favorable results were obtained. Of six samples thus treated, four gave neutral results, and bleaching activity of the other two was impaired to an appreciable degree.

Geologic and Economic Data on Localities

The value of a clay property is in proportion to the tonnage available at an economical cost of mining and to the accessibility of the deposit to transportation. If a clay cannot be removed from a deposit and transported to its market with a reasonable expenditure of money, then the deposit ceases to have value from a commercial standpoint.

In Table No. 4 data relating to the most favorable localities in respect to transportation facilities, geological conditions, and estimated mining area and conditions are very briefly summarized. Only the most favorable sites for commercial exploration are included in the table, and localities mentioned under bleach tests that are not listed in the table are considered, for one reason or another, to be non-commercial in character.

The Future of the Porters Creek As a Bleaching Earth

The Porters Creek formation seems to offer the best source of

[9] Whitlatch, Idem.

TABLE No. 4
Geologic and Economic Data on Most Favorable Localities

County	Locality No.	Owner or Local Identification	Shipping Point, Distance, Direction and Railroad	Exposed Thickness	Overburden average	Estimated Mining Area and Conditions
Henry	17	D. W. Dowdy	Van Dyke, 1.1 mi. E., N. C. & St. L. RR.	40 ft.+	5 ft.	4 to 5 acres; good
Henry	1	N. C. & St. L. RR. cut	Fairview Sta., 1/8 mi. S., N. C. & St. L. RR.	20-35 ft.	5-8 ft.	10 acres; fine
Carroll	19	Outcrop	Rosser, 1.5 mi. E., N. C. & St. L. RR.	35 ft.+	5-10 ft.	6 to 10 acres; good
Carroll	14	Brier Creek	Huntingdon, 1.6 mi. NE., N. C. & St. L. RR.	26 ft.+	0-6 ft.	Probably several acres; good
Carroll	2; 3	Road Outcrop	Huntingdon, 2.5 mi. NE., N. C. & St. L. RR.	35-45 ft.	10 ft.	5 to 10 acres; good
Madison	9	Judge Everett	Beech Bluff, 1.0 mi. S., N. C. & St. L. RR.	15 ft.+	5-10 ft.	3 or more acres; fair
Madison	15	Walter Luster	Pinson, 0.8 mi. W., M. & O. RR.	85 ft.	Generally shallow	Possible large acreage; good
Henderson	18	E. E. Wilkins	Jackson, 12.0 mi. SW., I. C., G. M. & N. and other RRs.	33 ft.+	Apparently shallow	Probably several acres; good
Hardeman	8	Milstead Farm	Hornsby, 3/4 mi. SE., G. M & N. RR.	15 ft.	Practically none	1½ acres; good
Hardeman	7	Milstead Farm	Hornsby, 3/4 mi. SE., G. M & N. RR.	25-30 ft.+	Apparently heavy	Fair tonnages along base of ridge—80-acre tract; fair

bleaching earths in Tennessee. The State, it is true, contains other sources of bleaching media, as kaolin and bentonite, but the Porters Creek on points of accessibility, quantity, and general bleaching activity is the most logical source for future development. The kaolins and bentonites may not be entirely condemned, but either limited occurrence with attendant high cost of mining or remoteness from transportation serves to discourage commercial exploitation.

The Porters Creek clays, on the basis of decolorizing activity, can compete with commercial earths now employed in the mineral oil industries. This type of bleaching does not require a clay with a number of specific qualities as is the case in vegetable oil bleaching. The major factor in bleaching mineral oils is activity of the earth. The prospects of commercial development of Porters Creek clays for vegetable oil bleaching are less conclusively demonstrated by the present study. Clays from only two localities fulfill the majority of the requirements of edible oil earths, and of these, only one is capable of producing commercial tonnages. Consequently, a superficial conclusion would be that marketing of these clays to mineral oil refineries would afford the best opportunity. This, however, is not the case.

"Good bleaching earths suitable for bleaching mineral oils are abundant, producers are numerous, and each producer has ample reserves mapped ready for development. The clay beds (of bleaching character) already located are sufficient to supply even a largely increased demand for many years, and there is every reason to believe that the enormous deposits of the Southwest and the far West are practically inexhaustible."[10] The markets for bleaching earths used in petroleum refining are principally in the East and Southwest as Pennsylvania, Texas, and Oklahoma, and these markets are adequately supplied by well-established producers in Texas, Georgia, Florida, and Illinois. These favorably situated producers, mining under conditions favorable to low-cost production and shipping their product at equally favorable freight rates, present a serious form of competition to any interests that might contemplate development of a petroleum bleaching agent from the Porters Creek formation of West Tennessee. Such development is not impossible. but the handicaps are great. Production and marketing of superior clays at delivered prices below present established producers are the essential elements for success.

The production of Porters Creek clay as a bleaching agent for vegetable and animal oils offhand seems less attractive commercially than similar production for the mineral oil industries, but the writer is inclined to believe that the best potential markets for Porters Creek bleaching earths are in the vegetable and animal oil refineries. As has been pointed out by Nutting,[11] "The chief advancements to be looked for in the bleaching-earth industry lie not in the discovery of new beds or more powerful earths, nor in the development of new methods of treating clays, nor yet in the creation of synthetic products, but rather in the preparation at low cost for special purposes of special clays having a minimum cracking power and minimum retention, with maximum decolorizing or deodorizing power, together with the property of leaving a stable filtrate." The Porters Creek seems to offer possibilities in respect to several of the above points, especially for vegetable and animal oil bleaching.

The raw, untreated clays of the Porters Creek are naturally active, and the most serious obstacles to their development for vegetable oil bleaching are moderately high retention values and fat splitting tendencies. The latter of these defects, however, may yield to treatment by heat or acid, or more simply and economically, to boiling in water. Further, retention is interdependent upon activity, and if the natural activity of these clays was improved by acid or heat treatment, resulting in an earth of superior activity, the retention factor would be reduced in proportion to the increase of activity.

The writer recognizes the lack of experimental data bearing on the effects of treating Porters Creek clays. They might not respond to acid or other treatment. Such treatment might even be detrimental to their activity. Solution of the free fatty acid problem might not be possible by any type of low-cost treatment. But there still remains the possibility of producing a natural earth of satisfactory decolorizing activity with neutral effect on the acidity of vegetable oils. Laboratory data have shown at least one locality capable of producing this type of earth in commercial quantities; detailed prospecting should reveal other deposits of similar quality. And finally, if the Porters Creek cannot be activated or otherwise adapted to bleaching edible oils, manufacturers of white soaps and similar users of earths for bleaching vegetable and animal oils in non-edible products could be approached.

Petrographically and physically the Porters Creek clays possess several features that recommend them

[10]Nutting, P. G. Bleaching clays: U. S. Geol. Surv. Circ. 3, p. 7, 1933.

[11]Op. cit., p. 52.

for treatment. They are, as shown by Allen,[12] a bentonitic type of clay and it has been bentonite or bentonitic types of earth that have been most susceptible to activation and have proved most satisfactory in bleaching edible oils.[12a] In acid treatment of earths a non-slaking clay is preferable to one that slakes readily; the Porters Creek clay fulfills this requirement as it is essentially non-slaking. Finally, in milling an earth the production of a minimum of fines is desirable, and in this respect the Porters Creek is lithologically suitable as it is fairly hard and does not crush readily. An average of about 10 per cent of fines, less than 325-mesh in size, was produced in laboratory grinding of the samples for the present study.

In the edible oil branch of the vegetable oil industry the use of imported English earths has been gradually supplanted by domestic earths, usually activated bentonites. These activated earths, often shipped from distant points at a high cost per ton, are used at numerous plants in the South where animal oils and such vegetable oils as soya bean, cottonseed, peanut, and corn are bleached for manufacture into edible products. Nonedible products made of animal and vegetable oils, as soaps and cosmetics, and to a lesser extent, certain petroleum products, as medicinal oil, are similarly bleached with these activated earths. The competition for these markets is strong, it is true, but the advantage in freight differential an activated Tennessee earth would have over similar earths that are processed, for instance, in California and then shipped to southern refineries is not to be overlooked. The Tennessee earth, even though it required special treatment at slightly increased unit cost, could compete for its share of these markets through a decidedly lower delivered price. The most serious competitors of activated earths from Tennessee would be those at Macon, Ga., and Ocala, Fla., where clays are processed for use, chiefly in refining cottonseed oil. The West Tennessee clays, nevertheless, have potential markets at Memphis where four cottonseed oil refineries are in operation, and at other nearby cities, as Louisville, Ky., and Cincinnati, O., in which operate several plants that use bleaching earths on vegetable and animal oils.

Commercial development of the Porters Creek clays for bleaching any type of oil is not going to be sudden or rapid. Sound development must be preceded by thorough and extensive prospecting in the field and detailed laboratory testing of boring samples from any deposit that may be considered for exploitation. This is particularly applicable if the marketing of an earth for edible oil bleaching is contemplated. Much experimenting and prospecting is ahead of anyone that undertakes the production of this type of bleaching earth. The development of a commercially feasible process for the activation of the earth and neutralization of its fat splitting tendencies alone will require much time and expenditure of money.

At this writing experiments and tests by commercial interests are being made on the Porters Creek clay of West Kentucky, just across the line from similar Tennessee occurrences, and the writer is reliably informed that these independent commercial investigations have proved satisfactory and that plans are being made to process and ship these clays as bleaching earths to vegetable or animal product plants in the near future. Similar opportunities with equal chances of success exist in West Tennessee. Certainly the proximity to potential markets, the fair prospects of successfully competing for a part of these markets, and the abundance of naturally active clays are sufficient to justify commercial attempts to develop a bleaching earth industry in West Tennessee.

[12] Allen, V. T. Petrography and origin of the fuller's (bleaching) earth of southeastern Missouri: Mo. Geol. Surv., 58th Biennial Rpt., Appendix I, Pt. 3, p. 78, 1935.

[12a] Porters Creek clays of Mississippi, in tests of their bleaching activity on mineral oils, showed varying degrees of improved activity due to acid treatment in 75 per cent of the tests made in a recent report on the bleaching earths of that State. (Miss. Geol. Survey Bull. 29, by H. X. Bay—tests by P. G. Nutting, 1935.) Similar results were obtained by acid treatment of the Porters Creek clays of Missouri. (Mo. Geol. Survey Biennial Report, 58th; Appendix I, p. 71, 1935.)

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