1934

Fuller's earth in Southeast Missouri

Willard Farrar

FULLER'S EARTH

IN

SOUTHEAST MISSOURI

by

Willard Farrar

A

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Approved by C. L. Dake

Professor of Geology.

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INTRODUCTION

The geology of Southeastern Missouri has not been studied in detail, and only the general features of the structure and stratigraphy were known until recently. In June, 1932, Francois E.Matthes[1] of the United States Geological Survey was

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1. Matthes, F.E., Cretaceous sediments in Crowleys Ridge, Southeastern Missouri; Bull.Amer. Assoc.Petrol.Geol., vol.17, No.8, August, 1933, pp.1003-1009.

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engaged in geomorphologic studies in this general area, and in the course of field work collected specimens of a fossiliferous clay on Crowleys Ridge, near the town of Ardeola, Stoddard County. This material was studied by Dr.L.W. Stephenson of the United States Geological Survey, who identified certain fossils of Cretaceous age. As this was the first time that sediments referable to the Cretaceous had been found in Missouri, Dr.Stephenson took the first opportunity that presented itself to examine the outcrop.

In March, 1933, Dr.Stephenson, H.S.McQueen, and the writer collected Cretaceous fossils from two localities

on Crowleys Ridge in Stoddard County, and McQueen took several samples of a gray-green clay which Dr.Stephenson identified as the Porters Creek clay of Eocene, Midway age. The samples were given to Dr.Victor T.Allen of St.Louis University, who reported that a microscopic examination showed the principal mineral present was montmorillonite, $(Mg, Ca)O. Al_2O_3.5SiO_2.(5-8) H_2O$. As this is the essential mineral constituent of all known fuller's earth, the possibility of developing a new mineral resource was presented. This paper covers the results of this investigation to which the writer was assigned by Dr.H.A.Buehler, State Geologist of Missouri.

ACKNOWLEDGMENTS.

The writer is pleased to acknowledge his indebtedness for the helpful assistance of Dr.H.A.Buehler, Director, Missouri Geological Survey, who pointed out the problem and made this work possible. His enthusiasm has been an aid and a stimulus. H.S.McQueen took all but one of the photographs, and offered valuable suggestions in regard to the field work. Dr.W.T.Schrenk and Mr.D.S.Grenfell, chemists of the Missouri School of Mines and the Missouri Geological Survey respectively, gave considerable guidance in connection with testing the clay for its bleaching power. Mr.Laurence Bax assisted in collecting auger samples for testing purposes.

The Department of Geology of the Missouri School of Mines and Metallurgy has been of great assistance. Dr.C.L.Dake critically reviewed the manuscript and offered many suggestions. Drs.G.A.Muilenburg and O.R.Grawe checked the identification of certain minerals, and Professor J.S. Cullison examined and identified micro-fossils from wells in the area.

Professor J.H.Steinmesch of the Mining Department offered suggestions on mining and milling practice, and obtained considerable cost data which would not otherwise have been available. He has shown great interest throughout the investigation.

Dr.Victor T.Allen,of St.Louis University, spent several days in Southeast Missouri with the writer, in connection with his summer work for the Missouri Geological Survey, and made available his unpublished mineralogical determinations. His assistance has been very valuable.

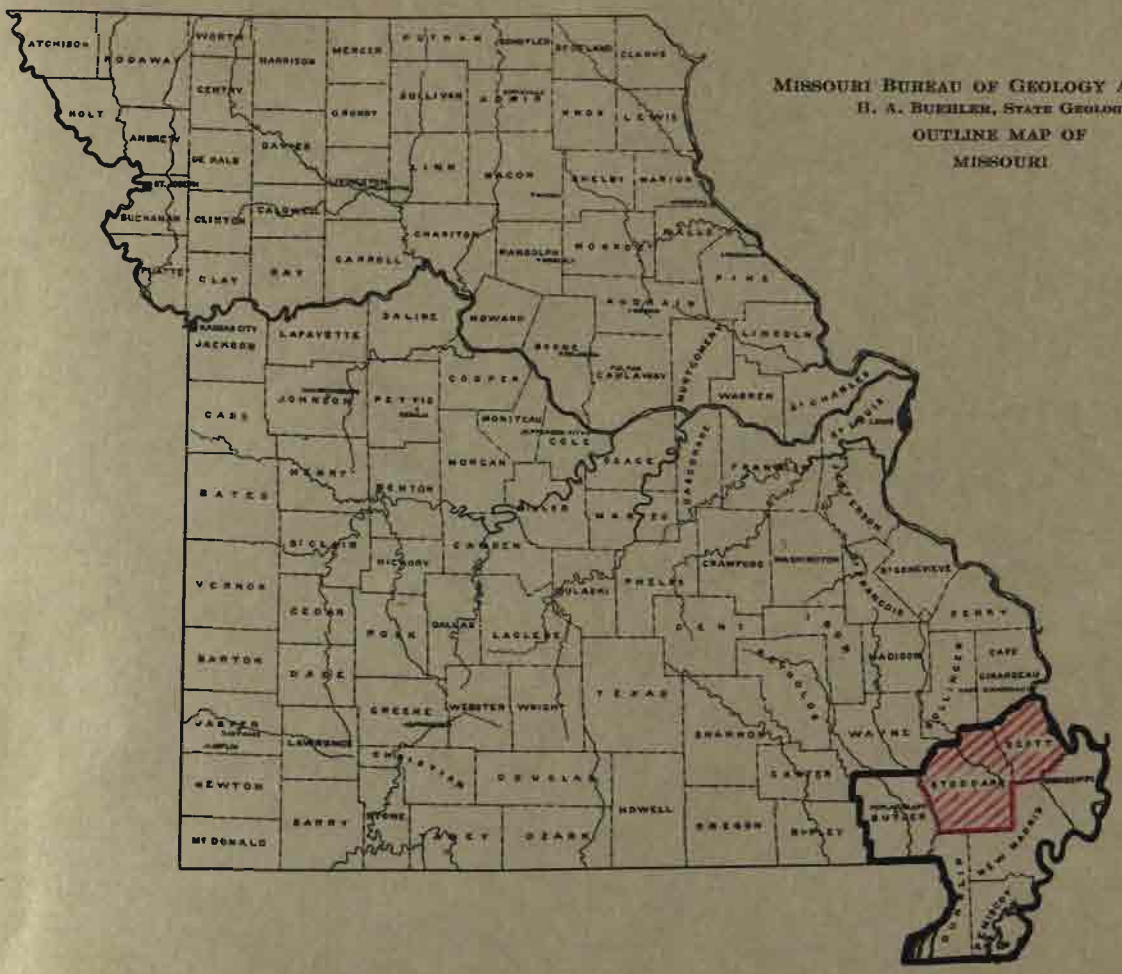
Dr.L.W.Stephenson, Chief, Section of Coastal Plain Investigations, United States Geological Survey, spent two days in Southeast Missouri in field studies with the writer. He has been kind enough to identify fossils from many parts of the area, and has shown a great interest in new discoveries. His assistance and counsel in matters pertaining to the stratigraphy have been invaluable.

ABSTRACT.

Recent work,(1933-34) in southeastern Missouri by the Missouri Geological Survey has shown that deposits of bleaching clay occur in the Porters Creek formation of Tertiary age. Various localities in Scott and Stoddard counties are described, in which favorable conditions for development exist. The method of testing the clay for bleaching power is treated briefly. Suggestions are offered in regard to prospecting, mining and milling.

A bibliography of two hundred and one references is given.

FIG. I

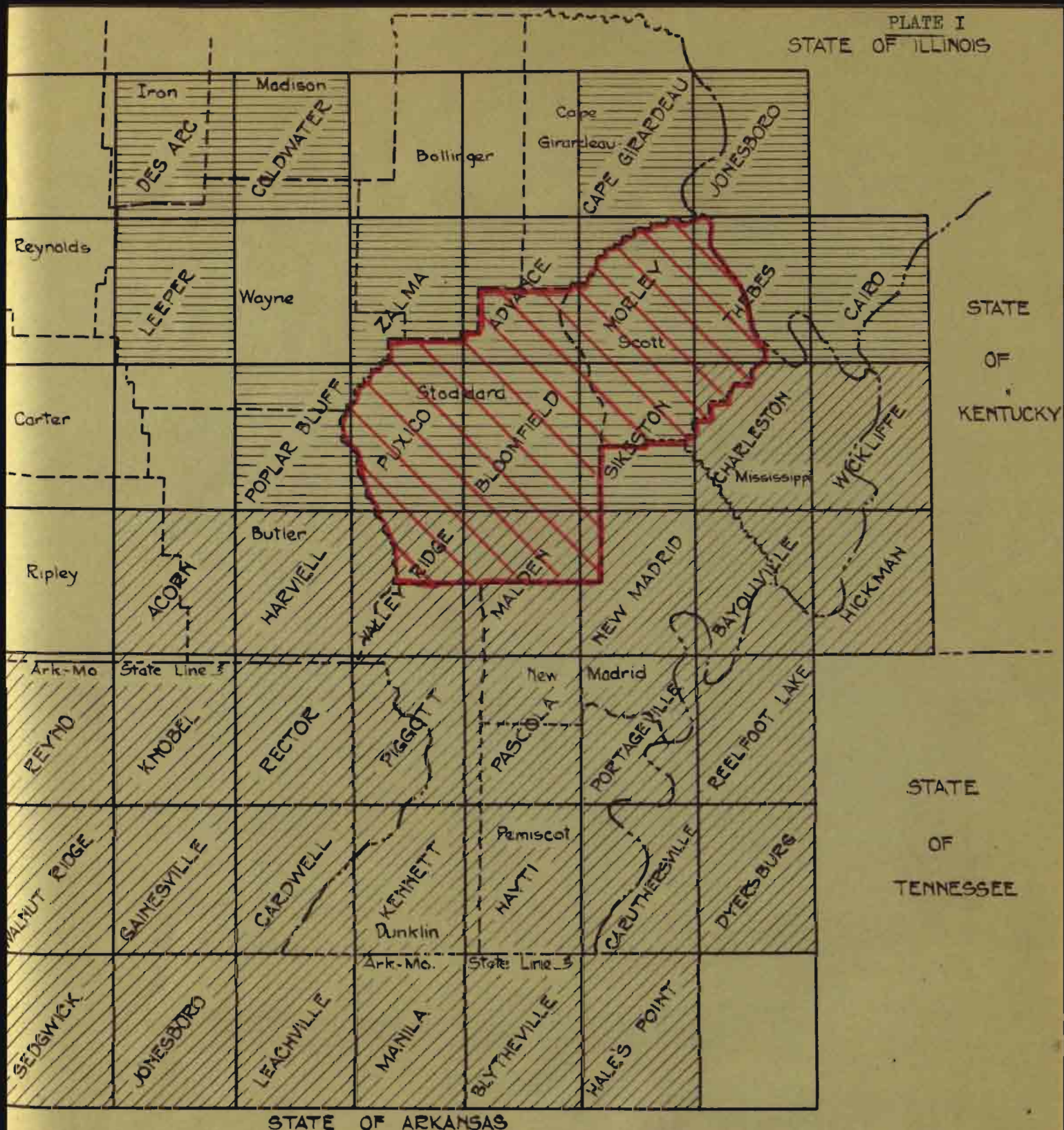


Southeastern Missouri counties wholly or partially underlain by coastal plain deposits outlined thus.

Counties in which deposits of fuller's earth occur.

Location. - The extreme southeastern portion of Missouri, generally called the Southeast Lowlands, comprising Butler, Dunklin, Mississippi, New Madrid, Pemiscot, Scott and Stoddard counties, is wholly or partly underlain by sediments which are a part of the Gulf Coastal Embayment. Its location is shown in Fig.1. In the last two counties named, the northernmost of the group, are deposits of clay, sand and gravel of economic importance. In this paper only fuller's earth will be discussed, and the stratigraphy and economic geology of the entire region will be taken up in a later paper.

Maps. - Various maps of the area under consideration have been published. The Corps of Engineers, U.S.Army, in cooperation with the United States Geological Survey, and the Missouri Geological Survey, have recently (1931-1932) made accurate topographic maps of the entire region on the 1:62,500 scale. On the lowland portion the contour interval is five feet, and on the adjacent upland the contour interval is twenty feet for eight quadrangles in the northern portion of the area and twenty-five feet for the remainder. These quadrangles are shown in Plate I. In addition to the topographic maps, soil survey maps of Dunklin, Mississippi, Pemiscot and Stoddard counties have been prepared by the U.S. Department of Agriculture, Bureau of Soils. The Missouri Geological Survey has published a State Geologic Map, a State Base Map, and a State Drainage Map.



PUBLISHED MAPS OF SOUTHEAST MISSOURI & VICINITY

PLATE I

GENERAL GEOLOGY.

Many of the details of the geology of Southeast Missouri and much of the published data pertaining to the stratigraphy has been revised during the investigation of fuller's earth possibilities. Previous field work has been of a reconnaissance character, and many important points, obtained in more detailed mapping, have been missed. It is now definitely established that sediments of Cretaceous age, heretofore not recognized, outcrop in Missouri. The occurrence has been described by Matthes.[2]

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2. Matthes, F.E., op.cit.

The preparation of the stratigraphic section of the Cretaceous and Tertiary and the nomenclature thereof has been based on faunal reports furnished by the Coastal Plain Section of the United States Geological Survey[3] from

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3. Stephenson, L.W., personal communications.

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collections made in the field.

The following section, compiled from outcrop data, is given to show the general characteristics of the sediments in Scott and Stoddard counties:

GENERALIZED SECTION IN SCOTT AND STODDARD COUNTIES.

Quaternary system:
- Recent:
  - Gravel, clay, silt, sand and loam in the flood plains of the present streams.
- Pleistocene:
  - Loess,
  - Gravel, chiefly brown, black pebbles locally, reddish sand at base.

Tertiary system:
Eocene:
*Wilcox group:
Sand, red, white and orange; clay, gray,brown, and white, with a little orchid.
Midway group:
Porters Creek clay:
Clay, dark gray to black when wet, light gray to pale yellowish green when dry, hard, non-plastic, with conchoidal fracture, Muscovite, angular quartz sand, and glauconite occur as impurities along the bedding planes. The fuller's earth horizon of the area.
Clayton formation:
Clay, sandy, green on fresh surface, due to presence of a large amount of glauconite, weathers reddish brown and indurates at the surface. Some Midway fossils and a few reworked Cretaceous forms are present.[4]

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4. Matthes,F.E., op.cit.

Cretaceous system:
Gulf series:
**Ripley formation:
Sand, white to yellow, generally rather fine grained, very micaceous, locally cemented by limonite, and frequently becoming quartzitic upon weathering; clay, brownish and greenish yellow, gray and brown, with interbedded sand; thin beds of lignite and some lignitiferous sand.

*- Fossil leaves obtained during the field work indicate the presence of sediments of Wilcox age. It is recognized that more detailed work may show the presence of later Eocene or younger sediments of Tertiary age.

**- The upper portion of the Ripley has been referred to the Owl Creek tongue and the beds in the lower portion of the hill at Ardeola to the McNairy sand member, by Stephenson.

Previous work.- In the Nineties the clay resources of Missouri were studied by H.A.Wheeler, who mentions some shale beds in Scott County as being of Tertiary age.[5]

5. Wheeler, H.A., Clay deposits of Missouri: Mo.Geol.Survey, 1st series, vol.11.

Some of the localities described by him are now known to be outcrops of the Porters Creek clay. The Idalia shale of Marbut[6] seems to correspond in part to the Porters Creek, but the

6. Marbut, C.F., The evolution of the northern portion of the lowlands of southeastern Missouri: Univ.of Mo.Studies, vol.1, No.3, July, 1902, pp.21-23.

locations given by him do not in all cases agree with present known outcrops of the clay. He states that the lower sixty or eighty feet of the bluffs at Ardeola are made up of the shale. The lower one hundred and ten feet of this section has been shown by Matthes[7] to be of Ripley (Cretaceous) age,

7. Matthes,F.E.,op.cit.

and the upper forty-seven feet of the hill is composed of the Porters Creek (Eocene) clay. Marbut mentions the outcrop at Idalia, and it is thought that the dark-colored to black clay outcropping along the east line of the SE.1/4 NE.1/4 sec.28, T.26 N.,R.11 E.(Bloomfield Quadrangle) is the clay to which he referred. If so, this is probably the Porters Creek, although this correlation is based only on the lithologic characteristics of the clay, since due to structural conditions, this outcrop cannot be traced into known Porters Creek. Other parts of Marbut's description indicate that

he confused clays of the Midway and Wilcox groups, lumping them all under the term "Idalia shale". It has previously been suggested that the gray clay at Idalia is Porters Creek.[8]

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8. Lamar, J.E., and Sutton, A.H., Cretaceous and Tertiary sediments of Illinois, Kentucky and Missouri: Bull. Amer.Assoc.Petrol.Geol., vol.14, No.7, p.853,July,1930.

Lithologic character.- The Porters Creek clay is a very persistant horizon stratigraphically, and the lithologic character of the formation does not vary greatly, although mineralogically as shown by optical data the uppermost portion in certain areas has different characteristics.[9]

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9. Allen, Victor T., personal communication.

To date, however, no satisfactory criteria have been developed, for differentiating the various beds of the Porters Creek on the outcrop. The clay is quite lean and plasticity is developed only where thoroughly saturated. Generally the only effect of water is to darken the clay and make it very slippery. This tendency to become "slick" has caused the inhabitants of the lowlands to refer to it as "soapstone".

In general the clay is black or very dark gray when thoroughly saturated, and changes to lighter shades of gray to gray-green on losing this mechanically held water. Usually it is more massively bedded in the basal portion,

and this feature is shown in the exposures in Stoddard County, but is not apparent in Scott County. In many cases there appears to be a large amount of included sand, but examination shows the sand to be concentrated along parting planes,together with a considerable amount of muscovite. A condition such as this frequently produces a slightly banded appearance on the outcrop, with the darker material next to the sand layer. A very prominent feature of the Pfgters Creek is its nodular structure, and weathered slopes are generally covered with conchoidal or "hickory nut hull" shaped fragments. Jointing, which is vertical or nearly so, is a noticeable feature locally, and most of these joints are filled or stained with iron oxide. Large nodules of cherty iron carbonate occur at various horizons, some of them forming definite beds, and in addition, bands of brownish yellow clay are sometimes observed.

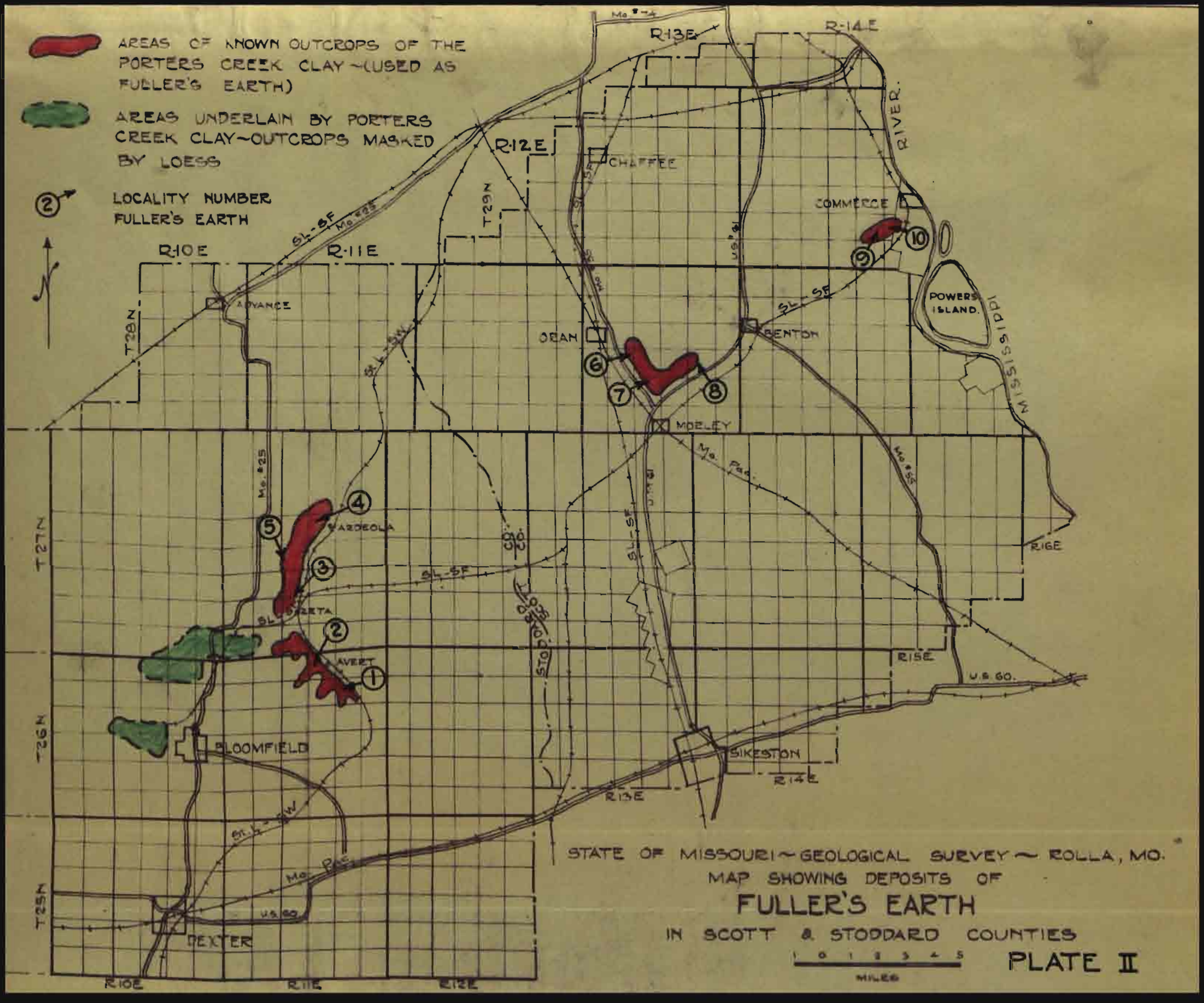
Thickness.- At a point about one-half mile north of Zeta the clay is over sixty feet thick, but this does not represent the total thickness as the base of the clay is not exposed. This section however represents the greatest thickness known at present. The amount of clay exposed above the level of the lowlands in Stoddard County decreases from this point to the south, and in the un-named brook at the road bridge approximately at the center of the north line of the NE.1/4 sec.14, T.26 N., R.11 E., there is about ten feet exposed, most of the formation being below lowland level.

The log of the Bloomfield city well (located in the NE.1/4 SE-1/4 ~~SE~~ NE.1/4 sec.23, T.26 N., R.10 E., elevation 458 feet above sea level, Bloomfield Quadrangle) shows blue shale between the depths of forty and one hundred and seventy feet, and this is tentatively referred to the Porters Creek. This probably includes the Clayton formation and the Owl Creek tongue of the Ripley which total about sixty-five feet in the Ardeola section; and if this is deducted from the total thickness given in the log, the Porters Creek is probably about sixty-five feet thick. This figure agrees much more nearly with the known thicknesses in both Stoddard and Scott counties.

In Scott County, on the farm of Mrs.May Fullenwider southeast of Oran, the clay is twenty-four feet thick, being exposed in a gully to the northeast of the house in the SW.1/4 NE.1/4 sec.20, T.28 N.,R.13 E., (Morley Quadrangle). Here it is underlain by the Clayton formation and overlain by beds provisionally referred to the Wilcox group. South of this exposure, and approximately at the center of the east line of sec. 29, T.28 N., R.13 E., a combination of outcrop data and borings indicates a thickness of forty feet. On Jackson Hill, west of Commerce, there is thirty feet exposed along the road, underlain by the Clayton and overlain by gravel. This is in the W.1/2 NE.1/4 SE.1/4 sec.26, T.29 N.,R.14 E. (Thebes Quadrangle), and is probably the thickest section in the

immediate vicinity, as the clay thins both east and west from this point. On the old Joe Ellis farm in the NW.1/4 SW.1/4 sec.25, T.29 N., R.14 E., borings show a thickness of twenty-five feet.

Areal distribution.- The known distribution of the Porters Creek is shown in a general way on the map, Plate II. Underneath the bridge on Cane Creek about the center of the east line of the NE.1/4, NE.1/4 sec.1, T. 24 N., R 9 E. (Puxico Quadrangle) there is a small outcrop which has been referred to the Porters Creek solely on lithologic grounds. Detailed field work in T.25 N., R.10 E., and T.24 N., R.9 E., would undoubtedly discover additional exposures. Two areas are shown and described as masked by loess, and in this area the clay is very poorly exposed. Small outcrops may be seen as follows: on the road crossing the northern part of sec.21, T.26 N., R.10 E., just east of the house on the 460 contour (Bloomfield Quadrangle); on the hillside both east and west of the cemetery in the center of the SW.1/4 sec.21, T.26 N., R.10 E.; in the gully heads in the SE.1/4 of the same section; and in the stream bed about the center of the east line of sec. 15, T.26 N., R.10 E. South of this last mentioned point, the clay has not been found, although more detailed field work in this area may show its presence. It is believed, from the general field relations that borings in the area between sec.15, T. 26 N., R.10 E. and sec.1, T.24 N., R. 9 E., will find the Porters Creek



STATE OF MISSOURI ~ GEOLOGICAL SURVEY ~ ROLLA, MO.

MAP SHOWING DEPOSITS OF

FULLER'S EARTH

IN SCOTT & STODDARD COUNTIES

PLATE II

beneath the loess without the Wilcox intervening.

Descriptions of outcrops.- In Stoddard County the best exposures are on the east side of Crowleys Ridge from sec.14, T.26 N., R.11 E., northward to sec.10, T.27 N, R.11 E., or approximately from Guam to Ardeola, via Avert and Zeta. Between these two villages, the Porters Creek clay shows in all the valleys, forming the valley floor at Guam and rising about one hundred and ten feet above the level of the lowlands at Ardeola. The outcrops are divided into two units by the water gap of the Castor River.

SECTION EXPOSED ON WILSON CREEK
(in the SE.1/4 SE.1/4 NW/1/4 sec.10,T.26 N. R.11 E.
Plate II, Locality 1)

	Thickness Feet	Inches
Tertiary system:		
Wilcox group:		
Sand, white, coarse, angular very loose - approximate thickness....	80	
Midway group:		
Porters Creek clay:		
Clay, dark gray to black with a yellow tracery of iron oxide. The clay fractures into relatively small lumps in comparison with the clay at creek level.....	25	
Iron concretions, siderite in part, quite cherty, the surface oxidized to limonite in most cases.The maximum size of these bodies is four by eight feet,and the clay that is associated with this zone is very sandy.....	1	6
Clay, slate gray,without iron oxide tracery,fracturing into large nodules which are stained with iron oxide.....	5	
Creek level		

This is an interesting exposure and merits further study. The clay above the zone of concretions is somewhat different from the lower clay in its general appearance. Microscopic examination has shown that the chief constituent mineral has higher indices of refraction than the typical montmorillionite, and it has been suggested that the clay mineral present is beidellite.[10] Laboratory tests have shown it to be a poor bleaching agent in comparison with the material below the zone of the concretions. From the standpoint of utilization, the exposure described above is worthless as only five feet of the exposed clay has good bleaching qualities and the amount of overburden is large.

10. Allen, Victor T., personal communication.

On Beech Grove Branch in sections 10 and 11, T.26 N., R.11 E., there are a number of exposures of the Porters Creek. Outcrops can be seen as far upstream as the NE.1/4 NW.1/4,SW 1/4, sec.10, but the best exposure is in the NW.1/4 SE.1/4 NE.1/4 of section 10 on the south (right) bank of the stream. Here twenty-five feet of the Porters Creek is exposed above stream level, overlain by 7 - 10 feet of loess. The total thickness of the formation at this point was not determined, and the location is poor for mining purposes, as there is a haul of about one and three-quarter miles to the railroad at Avert, and three-eighths of a mile of this is over a very bad road which would need a large amount of maintenance.

On Poplar Branch in sections 3 and 9, T.26 N., R.11 E., the Porters Creek is well developed, outcrops extending to the center of the west line of the NW.1/4 sec. 9, where there is a zone of brilliant yellow clay overlying the dark gray bed which outcrops at stream level. The yellow color is caused by the large amount of iron which has been precipitated by downward moving ground water, the iron bearing sands of the Wilcox group being the original source. It is believed that this yellow zone, which becomes quite plastic under conditions of thorough saturation, is the same horizon which was mined for ochre in Scott County (NE.1/4 sec.29, T.28 N., R.13 E., Morley Quadrangle) during the last decade of the nineteenth century.

SECTION OF PORTERS CREEK CLAY NEAR AVERT.

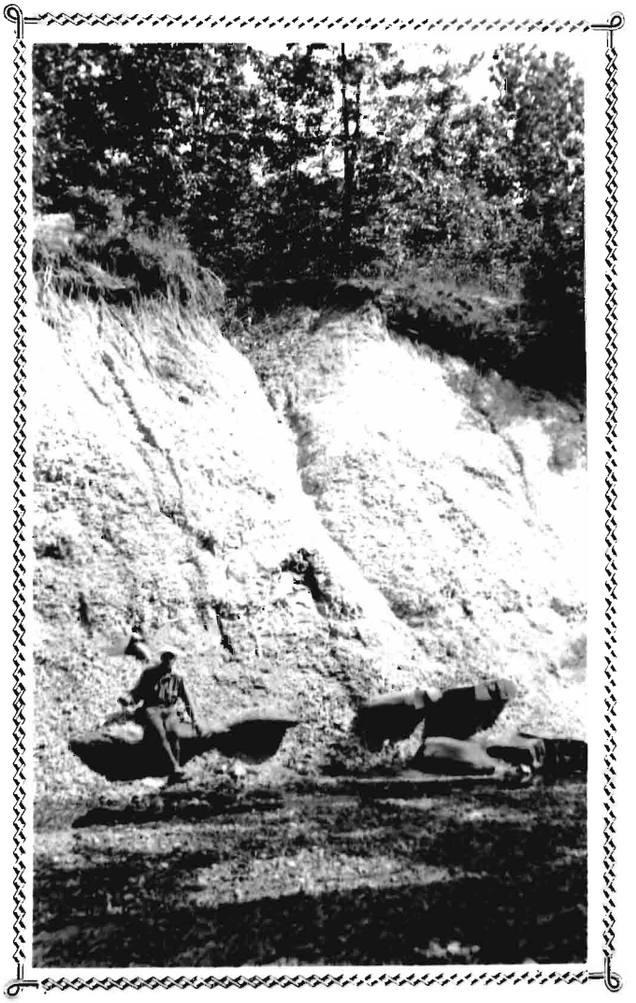
(This section is exposed on Poplar Branch in the NW.1/4 NW.1/4 SE.1/4 sec.3, T.26 N., R.11 E.,on the south (right) bank of the stream.)
Plate II, Locality 2.

	Thickness Feet	Inches
Residual soil.....	2	
Clay, yellow green, nodular, nodules surrounded by clay of the same color which is considerably more plastic.....	4	
Clay, dark green to gray-green when damp, drying to a light gray, very nodular.....	21	
Iron concretions, siderite in part, quite cherty, the surface oxidized to limonite in most cases.....	1	6
Clay, dark green to black, nodular.....	2	6
Creek level		

The clay is exposed in the bank for a distance of one hundred and fifty feet, and the maximum height of the

PORTERS CREEK CLAY ON POPLAR BRANCH NEAR AVERT

NW.1/4 NW.1/4 SE.1/4 sec.3,T.26 N.,R.11 E.
Plate II, Locality 2
Photograph by H.S.McQueen.



DETAIL OF FACE

NW.1/4 NW.1/4 SE.1/4, sec.3,T.26 N.,R.11 E.
Plate II, Locality 2
Photograph by H.S.McQueen.

outcrop is twenty-eight feet. Plate III, A and B, shows the character of the exposure, and the size and type of vegetation. It is approximately three-eighths of a mile to Avert, and two thirds of this distance is a good gravel road.

Between Poplar Branch and the Castor River, there are a number of outcrops of the Porters Creek, but none of them are well located with respect to present transportation facilities. Near the river, alluvial deposits mask the older formations. North of the river the clay is found in the lower portion of the ridge, and along the road on the north line of sec. 28, T.27 N., R.11 E., the following section is exposed.

SECTION ON EAST FACE OF CROWLEYS RIDGE

(about one half mile north of Zeta, Stoddard County)
Plate II, Locality 3.

	Thickness Feet	Inches
Quaternary system:		
Pleistocene:		
Loess, yellow brown clay.....	16	
Pliocene: (?)		
*Gravel, white, red, brown and black pebbles, poorly sorted and with considerable sand.....	3 -5	
Tertiary system:		
Midway group:		
Porters Creek clay:		
Clay, light green, rather plastic..	1	6
Clay, medium light green, hard, with characteristic conchoidal fracture..	3	6
Clay, medium gray green, sand and mica along parting planes, one-half inch streak of iron oxide at top of this bed.....	8	
Clay, dark gray-green, sand, mica and iron oxide along parting planes.	6	

	Thickness Feet	Inches
Clay, light to medium gray-green, large amount of sand and considerable muscovite along parting planes. The sand is generally white and fine grained, subordinate amounts are stained with iron. On weathering clay is a light gray to cream.....	5	
Covered interval.....	25	
Lowland level		

* A fault,with five feet of displacement, downthrown to the west, strikes due north in the banks on both sides of the road.

Eight soil augur holes were drilled in the field south of the road in an effort to determine the total thickness of the Porters Creek at this point. The clay is at least sixty feet thick, and the base of the formation was not reached, the hole bottoming at an elevation of 326 feet above sea level. The top of the Porters Creek in the ridge to the west is at an elevation of 386 feet.

This exposure is within one-quarter of a mile of the St.Louis-Southwestern tracks; a good gravel road,with favorable grades,connects this locality with the railroad. Zeta, which is the junction of the main line of the St.Louis-Southwestern Railroad with a branch line of the St.Louis-San Francisco Railroad, is three-quarters of a mile distant, over a good road.

Between the outcrop described above and Ardeola, about three miles to the northeast, the Porters Creek

gradually rises in the hills until at Ardeola its base is about one hundred and ten feet above the level of the lowlands, or at an elevation of 430 feet above sea level. Outcrops occur in many gullies on the east face of the ridge, and in no case are these exposures more than one-half mile from the St.Louis-Southwestern Railroad. The country however is heavily wooded and there are no roads in this area. In the ridge northwest of the village of Ardeola the Porters Creek clay is well exposed, and the section given below was originally mentioned by Matthes,[11] but was not measured in detail by him.

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11. Matthes, F.E., op.cit., p.1005.

SECTION ON SOUTHEAST FACE OF CROWLEYS RIDGE AT ARDEOLA

(Exposed along road from Ardeola store to Ardeola school in the south half of the NW.1/4 NW.1/4 sec.10, T.27 N., R.11 E., Advance Quadrangle.)

Plate II, Locality 4.

	Thickness Feet	Inches
Quaternary system:		
Pleistocene:		
Loess, yellow-brown clay.....	5	
Pliocene (?)		
Gravel, chiefly brown pebbles, poorly sorted.....	6	
Tertiary system:		
Eocene:		
Midway group:		
Porters Creek clay (exposed thickness 47 feet):		
Clay, light gray-green, considerable sand locally along parting planes, some limonite staining..	14	
Clay, dark gray-green on fresh surface, weathers into chips and thin flakes of a light gray color, containing thin beds (6 inches to 1 foot) of clay which		

	Thickness Feet	Inches
has a high iron content. These beds are a prominent feature of the fresh surface, but become obscured by weathering.....	33	
Clayton formation (total thickness 4 feet,6 inches):		
Clay, green, very glauconitic, glauconite present as thin flakes of a very dark green. Weathers to a reddish brown ironstone flecked with green.....	2	
Clay, green, highly glauconitic, glauconite in pellet form;sand, clear, very angular. The lower portion of this bed is fossiliferous.....	2	
Ironstone, reddish brown, sandy, containing many poorly preserved fossils which include both Cretaceous and Tertiary forms; the Cretaceous derived from the underlying Owl Creek tongue of the Ripley formation.....		6
Cretaceous system:		
Gulf series:		
Ripley formation(total exposure 72 feet):		
Owl Creek tongue(total thickness 61 feet 8 inches):		
Clay, yellow-brown, very sandy,fossiliferous.....	5	
Clay, dominately gray-green, weathering to light gray and frequently marked by pale yellow blotches, quite sandy, sparingly fossilferous.....	6	
Clay, warm to drab brown, considerable mica along partings, sand lenses locally indurated.....	11	
Sand, white to bright orange, angular grains. The entire bed is lignitic, and much of it is cross bedded. The basal portion of this member is well indurated, making a ledge in the road. The cementing material is iron oxide..	11	
Clay, gray, weathers to thin flakes of a light gray shade; thin seams of iron oxide throughout the entire thickness of the bed;some white sand along the parting planes.....	10	

	Thickness Feet	Inches
Sand, vivid orange, cemented with iron oxide; makes ledge in ditch....		9
Clay, drab brown, iron oxide particles throughout, becomes sandy in upper portion of bed.....	2	7
Clay, black or nearly so, nodular on fresh surface, weathers light gray with parting planes prominent.....	2	6
Clay, brown, flour-fine in texture, few small flakes of muscovite.....	1	0
Clay, dark gray to black, hackly-weathering, iron oxide along joints.....	1	6
Clay, brown with slight drab gray cast, finely divided, considerable amount of muscovite.....	1	6
Clay, gray, banded on weathered surface, fine sand and limonite along parting planes.....	2	4
Clay, gray, weathers white, few hard seams of iron oxide.....	1	3
Clay, drab gray, flour-fine in texture, mica flakes along parting planes.....	4	2
Lignite, some ironstone pipes.....	1	1
McNairy sand member (exposed thickness 10 feet 3 inches):		
Sand, white, fine angular grains, some clay lenses, upper portion of bed shows greater induration.....	2	9
Sand, white, angular grains, sugary texture.....	2	0
Sand, lignitic, highly iron stained, indurated locally.....	1	0
Sand, white, fine angular grains, small amount of lignite and iron oxide.....	2	0
Sand, white, fine angular grains, highly lignitic, some iron oxide, exposed thickness.....	2	6
Lowland level.		

This section was formerly considered to be of Wilcox age.[12]

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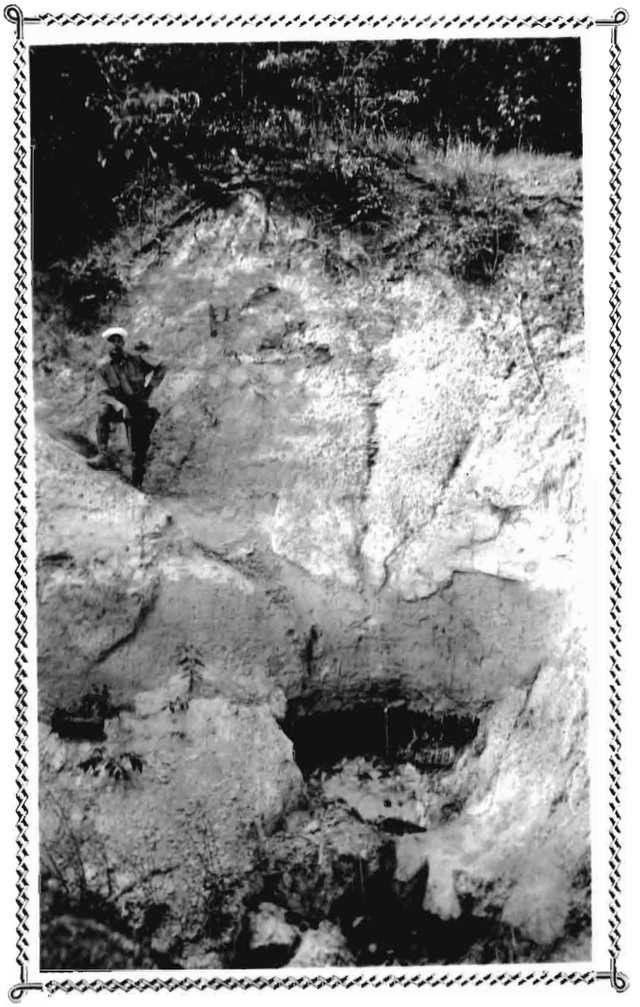
12. Wilson, M.E., The oil and gas resources of Missouri; Mo.Bur.Geol.and Mines, vol.XVI, 2nd ser., 1922, p.264.

GENERAL VIEW OF HILLSIDE AT ARDEOLA

NW.1/4 NW.1/4 sec.10,T.27 N.,R.11 E.
Plate II, Locality 4
Cretaceous-Eocene contact marked by pick.
Photograph by L.W. Stephenson.

DETAIL OF CRETACEOUS-EOCENE CONTACT

NW.1/4 NW.1/4 sec.10, T.27 N.,R.11 E.
Plate II, Locality 4
Clayton formation shown between picks.
Photograph by H. S. McQueen.



LIGNITE BED BETWEEN OWL CREEK TONGUE AND MCNAIRY SAND MEMBER
OF THE RIPLEY FORMATION
NW.1/4 NW.1/4 sec.10,T.27 N., R.11 E.
Plate II, Locality 4
Lignite marked by pick
Photograph by H.S.McQueen.

The upper portion of the Porters Creek in this section has little value as a bleaching clay. The lower thirty-three feet of the clay has bleaching powers which are comparable to those of the clay at other localities in Southeast Missouri. None of the beds below the top of the Clayton formation have any bleaching power, but clays referable to the Owl Creek tongue have been used for pottery and stoneware in both Scott and Stoddard counties.

One exposure in the main body of the ridge merits description. This is the outcrop along the road in the SW. 1/4 SE.1/4 sec.17, T.27 N.,R.11 E., about one and one-quarter miles airline distance from the St.Louis-Southwestern tracks, and about three miles by road from Zeta.

SECTION EXPOSED ALONG GRAVEL HILL SCHOOL ROAD

(SW.1/4 SE.1/4 sec.17, T.27 N.,R.11 E.,Bloomfield Quadrangle)

Plate II, Locality 5.

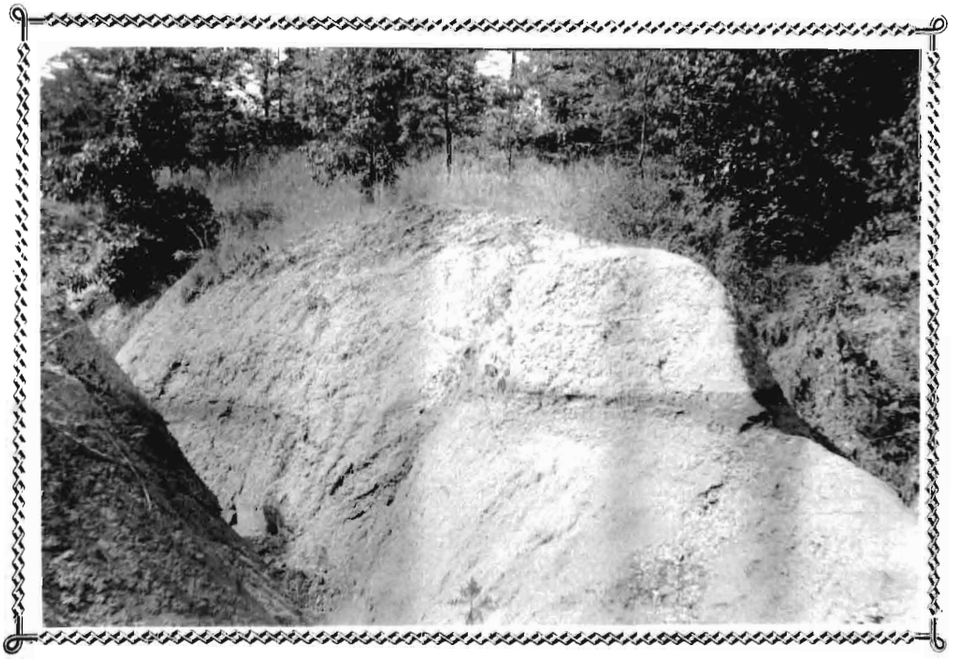
	Thickness Feet	Inches
Quaternary system:		
Pleistocene:		
Loess, small amount of gravel at base.....	16	6
Tertiary system:		
Eocene:		
Midway group:		
Porters Creek clay(thickness, 39 feet,4 inches)		
Clay,yellow-green on fresh face, streaked with darker green, some sand and mica along parting planes. The characteristic nodular fracture of the Porters Creek is dominated by a tendency to break into rectangular blocks,		

	Thickness Feet	Inches
joint planes filled with iron oxide.....	16	6
Clay,reddish-brown, very high iron content,sandy. This bed shows 28 inches of displacement, and is downthrown to the southeast;see Plate 5A.....	1	0
Clay, dark green ground mass, streaks of lighter material, together with some yellow-brown iron oxide, the fresh surface presenting a markedly striped appearance. Upon considerable weathering this bed forms thin flakes of light gray clay. Parting planes are filled with sand,iron oxide and mica, and the joints contain abundant iron oxide.....	10	6
Clay, dark green on fresh surface, yellow streaks, weathered surface yellow-brown.....	1	6
Clay,dark green on fresh surface,streaked with yellow clay along parting planes.Fine white sand and a small amount of mica along parting planes. Joints in bed filled with iron oxide, clay more sandy toward the top.....	7	4
Clay, dark green,weathering to light gray-green, very nodular, the nodules having a maximum thickness of 4 inches and a length of 8 inches.....	1	0
Clay, dark green,weathering to light gray-green, thin flat flakes, very hard when dry,but slightly plastic when wet.....	1	6
Clayton formation(thickness 4 feet,3 inches):		
Clay, brown, large amount of irregularly distributed glauconite.....	1	5
Clay, black.....	0	1
Clay,yellow,considerable glauconite.....	0	8

	Thickness Feet	Inches
Clay, black.....	0	1
Clay,green, very glauconitic, resting with irregular contact on underlying clay.....	0	4
Clay, yellow, limonitic.....	0	1
Clay, yellow-brown, glauconitic, very sandy, highly fossiliferous.....	1	6
Cretaceous system:		
Gulf Series:		
Ripley formation: (exposed,2 feet):		
Owl Creek tongue:		
Clay, yellowish brown, very sandy, very fossiliferous....	2	0
Creek level.		

This section is not nearly as advantageously situated as those on the east slope of Crowleys Ridge because of the relatively long haul to the railroad, one mile of which is up a fairly steep hill, which, at the time the section was examined, would have required considerable work to make it fit for travel in bad weather.

In Scott County, in the southern portion of the Benton Hills, there is a considerable area which is underlain by the Porters Creek clay, although it is nowhere as thick as it is in Stoddard County. In the SW.1/4, NE.1/4, sec.20, T.28 N., R.13 E., on State Highway No.55 southeast of Oran, there is twenty-four feet of the Porters Creek exposed, the base of the formation being approximately fifty feet above the level of the highway. Its relations are shown in the following section:



SMALL FAULT IN PORTERS CREEK CLAY

SW.1/4 SE.1/4 sec.17, T.27 N.,R.11 E.
Plate II,Locality 5
Photograph by H.S.McQueen

CRETACEOUS-EOCENE CONTACT

SW.1/4 SE.1/4 sec.17,T.27 N.,R.11 E.
Plate II, Locality 5
Base of shovel to uppermost pick is in the Clayton formation.
Photograph by H.S.McQueen.

SECTION ON THE FARM OF MRS. MAY FULLENWIDER,

(Exposed in gully northeast of farmhouse in the NW.1/4, SW.1/4 NE.1/4, sec.20, T.28 N., R.13 E., Morley Quadrangle, Scott County)
Plate II, Locality 6.

	Thickness Feet	Inches
Quaternary system:		
Pleistocene:		
Loess:		
Yellow-brown clay, making vertical face in gully head, estimated thickness.....	35	
Tertiary system:		
Eocene:		
Wilcox group (?) (thickness, 3 feet 6 inches):		
Clay, gray-white with yellow staining.....	1	6
Covered interval.....	1	0
Clay, grayish brown, sandy, few small leaf prints.....	1	0
Midway group:		
Porters Creek clay:		
Clay, dark gray to nearly black, some gray-green very nodular clay, hackly fracture throughout, thin seam of iron oxide at top of bed, some penetration of glauconite at base.....	24	0
Clayton formation (thickness 2 feet, 8 inches):		
Clay, dark green, thin-bedded, with flaky glauconite, sandy partings..	1	8
Clay, dark green, considerable pyrite.....	0	8
Iron oxide and pyrite.....	0	4
Cretaceous system:		
Gulf series:		
Ripley formation:		
Owl Creek tongue:		
Clay, gray with yellow staining, very sandy, some disseminated glauconite.....	4	10
Clay, dove colored, well-bedded, members about one-half inch in thickness with white, angular-grained, micaceous sand, somewhat iron stained along the partings..	3	10

	Thickness Feet	Inches
Covered interval.....	14	0
Sand, white, fine angular grains, micaceous, with partings of dove-colored clay.....	1	0
Covered interval.....	3	10
Sand, white, fine grained, micaceous, some yellow and brown staining, a little gray plastic clay in small lenses.....	0	7
Interbedded sand and clay lithologically similar to the overlying bed, but approximately equal amounts of sand and clay are present.....	0	6
Clay, light gray with slight brown shade; white, interbedded sand.....	0	7
Interbedded clay and sand, stained with iron.....	0	4
Interbedded clay and sand, clay is orchid to red, sand is vermillion..	1	4
Sand, white, angular medium sized grains.....	0	8
Sand, yellow, brown and white, angular medium sized grains.....	1	0
*Covered interval, approximately.... Level of old road in front of house.	20	

*Limonite occurs persistently as float at this horizon.

It would be very difficult to develop the Porters Creek clay at this point as the base of the clay is high above the road and the overburden is quite thick, although the Porters Creek in this section shows good bleaching power. The section is included to show the general relations and thicknesses of the sediments.

In the SW.1/4, NW.1/4, sec.28, T.28 N.,R.13 E.(Plate II,Locality 7) the clay shows a considerable increase in thickness, reaching a maximum of forty feet. This is a much more attractive location, as far as mining problems are concerned,

as the base of the Porters Creek is about thirteen feet below road level at this point. The clay is overlain by gravel and the upper portion is highly impregnated with iron, and was mined as ochre about 1890. Much of the clay could be mined without a large amount of stripping, but as the working face moved eastward into the hill, the loess and gravel would greatly increase in thickness.

The southern tip of the Benton Hills is underlain by the Porters Creek, but exposures are rare due to masking by talus from the overlying sediments. An outcrop may be seen along U.S.Highway No.61 about two miles southwest of Benton at approximately the center of sec. 23, T.28 N., R.13 E., (Plate II, Locality 8) where the Porters Creek is about twenty-five feet thick, the base being about twelve feet below the level of the concrete highway. The clay is underlain by the Clayton formation and overlain by loess, the latter being from two to ten feet thick. This outcrop is very well located with respect to the transportation lines, but the thickness is not as favorable as that of the exposure previously described in the southwestern point of the hills.

Near Commerce, at Jackson Hill, in the NE.1/4 SE. 1/4 sec. 26, T.29 N., R.14.E. (Plate II, Locality 9) thirty feet of the Porters Creek shows on the hillside, being underlain by the Clayton and overlain by gravel. In general, the overburden in this area is quite thick, and while some of the gravel is of saleable quality, there is a large admixture of

reddish sand, together with a small amount of clay of various colors. This outcrop is the thickest in the immediate vicinity, as the clay thins both east and west from this point. A combination of data from borings and outcrops shows a thickness of about twenty-five feet in the NW.1/4 SW.1/4 sec. 25, T.29 N., R.14 E. East of this area the clay thins, and is completely absent at a point about one half mile west of Commerce. The Porters Creek in this vicinity is well located with respect to the present transportation facilities, a good gravel road connecting with Commerce. Cheap freight rates are available by the use of the Mississippi River.

PROSPECTING

Possibilities exist for the immediate development of one or more deposits of fuller's earth in the Porters Creek clay of southeastern Missouri. However, prospective operators should investigate the above described areas in a much more thorough manner than was possible in this investigation. A large auger, or possibly a small core drill capable of furnishing three inch cores to a depth of about seventy-five to one hundred feet would be a very valuable aid in prospecting. Drilling options should be obtained and the various areas described thoroughly sampled. It would probably be advisable to drill the holes on 600 foot squares and follow this with additional drilling on closer spacing if the first holes show up favorably.

If this procedure is followed it should be possible to accurately outline any marked variations in the bleaching value of the deposit either horizontally or vertically. If the laboratory tests prove that the clay is satisfactory for bleaching mineral oils it would be advisable to take representative samples of such size that they could be tested under commercial conditions. Too much emphasis cannot be placed on the necessity of thoroughly testing the earth to determine its value.

TESTING.

Sampling.- Samples taken for testing purposes were of two types, outcrop and auger. Auger samples should be used if possible as they are more representative of the depost. The ordinary type of clay auger did not prove satisfactory in this work as the amount of the sample obtained was not large and it was difficult to pull the auger. A 4 inch post hole auger, Iwan's pattern, proved to be quite satisfactory as a large sample was obtained by this means, although the drilling speed averaged only four feet an hour. About 2 - 3 pounds of sample was retained for each foot of hole, and a portion of this was prepared for testing in the laboratory.

Laboratory procedure.- An untreated neutral oil of 300 Saybolt Universal Viscosity was used in making the tests. To prepare this oil for bleaching with the clay under test, it was necessary to treat the oil with

acid in the proportion of 30 pounds of 93% sulfuric acid to 48 gallons of oil. After the oil was heated to a temperature of 100°F., the acid was added. The source of heat was then removed, and the mixture thoroughly agitated for one hour, using a stirring rod attached to a small motor, the speed of which was controlled by the use of a rheostat. The mixture, after settling for twenty-four hours to separate the sludge, was decanted.

The sour oil was then treated with the clay under test, using clay in an amount equal to 10% of the oil by weight. In all cases the clay was ground to minus 200 mesh. The clay-oil mixture was heated to a temperature of 290-300°F., for thirty minutes, being stirred as rapidly as possible throughout this time with a motor-driven stirring rod. The speed of stirring was determined by the tendency of the mixture to spatter, and was approximately 200-250 RPM. After this treatment the hot clay-oil mixture was decanted through a Buechner funnel on which a filter paper moistened with oil, had been placed. A suction vacuum was applied with a water aspirator before the mixture was poured onto the filter paper, as unfiltered oil will pass beneath the edges of the paper if this precaution is not observed. It is necessary to use oil to moisten the paper as the use of water will form an emulsion which will cloud the color of the bleached oil. The Missouri earth from the various

localities was compared with earth from California, Florida and Illinois, and it was found that the Missouri earth gave about the same degree of bleach as that from Pulaski County, Illinois. The Florida and California earths gave a slightly better bleach, but the exact difference in the amount of bleach is hard to determine accurately as the colors can all be classed as "orange pale". Color stabilities are the same as those of the Olmstead earth.

A bleaching clay should be tested by percolation methods as well as by the tests outline. When this work was carried on, neither time nor equipment were available to make percolation tests, but it is realized that this should be done in order to furnish accurate data on the bleaching power of the clay.

Other tests, which have some predictive value but are not as satisfactory as bleaching tests for evaluating the clay, are those for specific volume and for apparent acidity. The specific volume of a sample of clay is the weight of a unit volume of clay that has been finely ground expressed as pounds per cubic foot. It is essential, in making this test, to compact the clay as much as possible to reduce the voids. In making this test a sample of the clay is placed in a small Erlenmeyer flask of known weight and volume, and the flask tapped gently until it will hold no more earth. This test, of course, should be run only with earth which is thoroughly dry. The value of specific

volume determinations has been discussed by Parsons,[12] who says, "the volume occupied by a definite weight of fuller's earth is of importance as affecting the number of times a filter press must be opened for a given quantity of earth, and also in determining the size of measure to use in adding the earth to the oil".

12. Parsons,C.L., Fuller's Earth; U.S.Bur.Mines,Bull.71, p.30, 1913.

Shearer[13] says that, roughly, the absorption of oil by an earth varies inversely as the density.

13. Shearer,H.K., The bauxite and fuller's earth of the coastal plain of Georgia: Geol.Survey of Georgia, Bull.31, p.157, 1917.

The "apparent acidity" of bleaching clay is determined by titrating two grams of clay in suspension in 100 cc. of distilled water with N/10 sodiun hydroxide, using phenophthalein as an indicator. The result of this test is generally reported as the number of cubic centimeters of sodium hydroxide solution required to produce a neutral condition in the suspension of 100 grams of the clay in water. The test is not conclusive as many highly efficient bleaching agents do not show acidity.[14] The fuller's

14. Perry, John H., Chemical Engineers' Handbook; Mantell, C.L., Section 11, Adsorption, p.1062,1934.

earths from Georgia and Florida, however, require from 10 to 150 cc. of N/10 sodium hydroxide to neutralize the apparent acidity.

Fuller's earths are frequently analyzed chemically, but the ratios of the constituents vary considerably. There appears to be no relation between the adsorptive power of fuller's earth and clays and their chemical analysis.[15]

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15. Mantell, C.L., op.cit., p.1061.

Sometimes the rise in temperature is noted when the clay is mixed with pinene, acetone, or even with the oil itself. Occasionally these tests give useful data, but the results of such indirect tests are always less reliable than those made directly on oils.[16]

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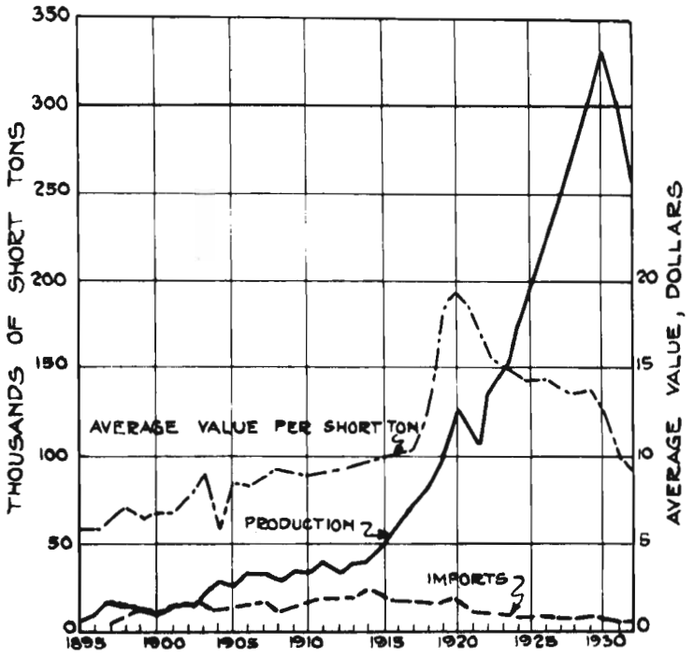
16. Kalichevsky, Vladimir, A., and Stagner, B.A., Chemical refining of petroleum; American Chemical Society, Monograph Series, 1933.

DEVELOPMENT.

Production of fuller's earth has increased annually, except during the depression of 1921; and again during the years 1931 and 1932, when it was affected by the present depression. Production for the United States is shown on Plate VI. With the increasing use of petroleum, it appears that Southeastern Missouri offers a good field for the development of a fuller's earth industry. It is thought that mill sites in the vicinity of Commerce in Scott County, and



PRODUCTION, IMPORTS & AVERAGE VALUE
OF FULLER'S EARTH~ 1895-1932

PLATE VI

near the towns of Avert or Zeta in Stoddard County, offer the best possibilities. If the mill site is near Commerce, the advantages of river transportation are available. There is a nine foot channel on the Ohio to Cincinnati, on the Illinois to Chicago; and on the Missouri from its mouth to Kansas City there is a six foot channel. The St.Louis-San Francisco Railroad is within one-fourth to one-half mile of the hills in this vicinity. The river port is Commerce, about two miles distant, with a good gravel road connecting the proposed site with the town. The other deposits in Scott County have good roads connecting them with the proposed mill site, but the haul is too great to make their development without a separate mill very attractive. In Stoddard County the villages of Avert and Zeta are served by the St.Louis-Southwestern Railroad, and Zeta is also on a branch line of the St.Louis-San Francisco Railroad.

The mining and milling of the clay for use as fuller's earth is not particularly difficult or expensive. It is said to cost less than $5 a ton to mine, dry and mill a clay in a modern plant.[17]

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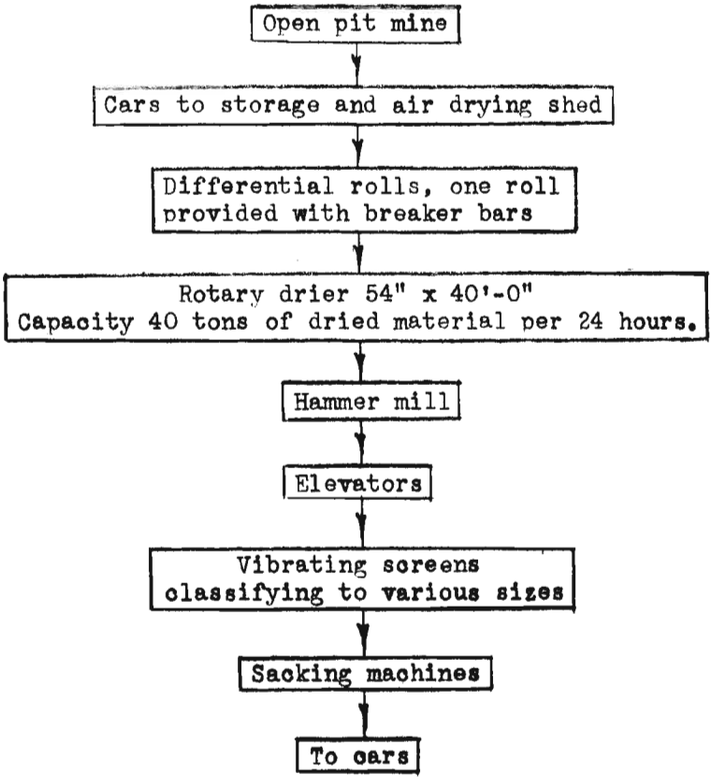
17. Nutting, P.G., Wide variety of bleaching clays in the United States to satisfy the needs of petroleum refiners; Oil and Gas Jour.,vol.31,No.6,p.14,Jan.26,1933.

A mill for this purpose would have approximately the following flow sheet:

SUGGESTED FLOW SHEET OF FULLER'S EARTH PLANT



A mill of this type does not represent a very large investment. The most expensive item of equipment is the rotary drier which would cost approximately $7,500 installed. The drier would burn either coal or oil, and could be arranged to use wood. If coal were used, 400 pounds per hour with a calorific value of 9000 B.t.u. per pound would be required; if it were fired with oil, 25 gallons per hour of 138,000 B.t.u. per gallon fuel oil would be used. The amount of wood used would, of course, be subject to considerable variation, depending on

the character of the wood furnished. Cord wood costs $2.00 a cord in Stoddard County, and could probably be bought for slightly less in large quantities. Wood is very plentiful on Crowleys Ridge, and if used, would provide a small local industry. The freight rate on Illinois coal to Commerce is $1.65 per net ton; on Kentucky coal the rate to Commerce is $1.90, and to Zeta $2.00 per net ton. (Rates as of Jan.1934). The total cost of the coal would, of course, vary with the ability of the purchasing agent to secure advantageous prices from the various producers.

The total cost of the mill would depend on the type of power used. If steam were used, from $3,000 to $5,000 would be necessary to set up a boiler and arrange the equipment for steam power. In general, electric power would be more satisfactory and arrangements could probably be made for power with the utility company supplying the district. Cost of power is a matter that would have to be taken up by the operating company, and no estimates of costs can be given here. If the mill were located at Avert or Zeta, the municipal plant at Sikeston might be a source of power provided transmission facilities were constructed.

It is believed that the total cost of the mill and equipment would not exceed $15,000, and it might be even less than this amount if second hand material were used. Local labor is very cheap; a large number of men is not required

for the operation of the mill and mine, and it would appear that the Porters Creek clay could well be developed as a source of fuller's earth in certain areas of southeast Missouri.

A bibliography on fuller's earth and related subjects is appended. It is not thought to be complete, but it is given to afford a useful set of references for anyone considering the development of these deposits.

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