Mississippi
State Geological Survey

William Clifford Morse
Director

Bulletin No. 22-A

A SUPPLEMENTARY REPORT ON BENTONITE IN MISSISSIPPI

By Hugh McD. Morse

University, Mississippi
1934

Corrections:

Page 6 - 13th line from bottom, for one & half miles, read one & one-half miles

Page 8 - In analysis for Feric and Ferous, read Ferric and Ferrous

Page 9 - 6th, 24th, 32nd lines from the top, for concoidal read conchoidal

Page 16 - 18 th line from top, read have for has

Page 20 - 10th line for concoidal, read conchoidal

Page 23 - Plate 1, 3rd from top, for Pliestocene, read Pleistocene

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ABSTRACT

A BRIEF DISCUSSION OF THE CRETACEOUS AND ITS SUBDIVISIONS, THE EOCENE AND A PORTION OF ITS SUBDIVISIONS, THE OLIGOCENE AND ITS SUBDIVISIONS AS THE BENTONITE BEDS ARE RELATED TO THEM. DETAILED SECTIONS SHOWING THICKNESS OF BENTONITE AND AMOUNT OF OVERBURDEN. A BRIEF DISCUSSION OF THE MIOCENE AND PLIOCENE FORMATIONS. A COMPARATIVE CHEMICAL ANALYSIS, CONCLUSIONS AND A SERIES OF MAPS AND DRAWINGS SHOWING BENTONITE DEPOSITS IN MISSISSIPPI.

INTRODUCTION

This publication is one of a series of brief reports designed by the late Dr. E. N. Lowe, former Director of the State Geological Survey, to cover recent developments in investigation of the various metallic and non-metallic minerals of Mississippi. Of these brief reports Bulletin No.22, "Bentonite in Mississippi", by Ralph E. Grim, issued in 1928, was the first, and was merely a preliminary report, the investigations into the deposits of bentonite in the State not having been completed at that time. Therefore, in 1932, the writer was instructed by Dr. Lowe to carry on further study of the bentonite deposits of the State and compile a short report giving the results of his findings. A full exhaustive and detailed report was desired, but lack of funds for the field work prevented the carrying out of this plan, and only recently has it been found possible to carry on some further study of these deposits, with the results set forth in this brief report, to which has been added some slight description of occurrences of bentonite in other states, with geologic and geographic features of these occurrences; also a list of known and suggested uses for bentonite, with a bibliography of the subject.

Bentonite, as defined by Ladoo, 1/ is a clay-like mineral or group of minerals consisting essentially of hydrous aluminum silicates, usually containing from 5% to 10% of alkalies or alkaline earth oxides. It is usually characterized by fine grain, high water content, high absorptive properties, and high plasticity. Some investigators speak of bentonite as "montmorillonite of beidellite" 2/. Within the past few years interest in bentonite has greatly increased, largely because of the various investigations and experiments which have developed new and important uses for this mineral in industry.

The name "Bentonite" was given to this type of clay from its occurrence in the Fort Benton formation of the Rock Creek district of Wyoming 3/. The uses of bentonite are principally governed by the physical rather than by the chemical properties of the material. The earlier uses and production of bentonite were small. From 1888 to 1898 production in this country averaged about 60 tons per year, valued at about $25 per ton f.o.b. cars. The price was soon reduced about $5 per ton, as production increased. In September, 1926, the R.T.Vanderbilt Co.4/, in a

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1/ Ladoo, Raymond B., Non-Metallic Minerals, p. 91

2/ Ross, C. S., and Shannon, E. V., The Minerals of Bentonite and related Clays, and their physical properties; Jour. of Am. Ceramic Soc., Vol.9, pp. 77-79. 1926

3/ Knight, W. C., Mineral Soap, Engr.& Min. Jour., Vol.63, p. 600. 1897

4/ Davis, C. W., and Vacher, H. C., Bentonite: Its properties, mining, &c. Technical Paper 438, Bureau of Mines, p. 2. 1928 report stated that bentonite ground to minus 100-mesh was offered f.o.b. cars in bags at Chicago for prices ranging between $40 and $50 per ton, and that crude bentonite with 12 to 30 per cent of moisture content was offered f.o.b. cars at point of origin for $4.50 to $10.00 per ton.

Acknowledgements

The writer wishes to acknowledge with deep sincerity the kindness shown and the aid and inspiration given him by the late Dr. Ephraim Noble Lowe, who was for more than 24 years State Geologist of Mississippi and Director of the Survey, and who though frail of body during the last year was mentally alert, and deeply interested in the possibilities and plans for the future development of Mississippi's metallic and non-metallic minerals.

Appreciation is also expressed to Mr. Ralph E. Grim for the use of his notes and other material used in the preparation of his "Preliminary Report on Bentonite in Mississippi", published in 1928 as Bulletin No.22 of the Mississippi Geological Survey; a pioneer work on that subject.

Other assistance is acknowledged in foot notes.

General Geology

Bentonite deposits occur mainly in the Tertiary and to a lesser degree in the Mesozoic and Paleozoic rocks. Deposits have been reported in many localities in the United States, and also in Mexico, Canada, France and China.

Some geologists regard bentonite as an alteration of volcanic ash; but this view is not universally accepted. The general theory is that bentonite is formed during explosion of volcanoes and is distributed by air currents in contact with corrosive gases 5/, causing a rapid disintegration of the particles as the ash fell into shallow water.

Wyoming. The bentonite of Wyoming occurs in the Benton formation of Cretaceous age, and it is from this formation that it takes its name. The Wyoming bentonite is considered the standard type for the study of all other bentonites. The most important beds are found in the Laramie and Big Horn basins. The beds vary in thickness from a few inches to more than 5 feet, usually overlain and underlain by a dark colored shale. The commercial deposits usually have only a foot or so of overburdening weathered material and very scanty vegetation, so that little stripping

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5/ Alexander, J., Bentonite; Colloid Symposium Monograph, Vol. 2, pp. 99-105, 1925.

is required. Open pit mining is used, with the clays loaded into wagons either by hand or with shovel, and hauled to the railroad, where it is dumped into box cars.

Other States. - Deposits of bentonite have been reported from California, South Dakota, Montana, Utah, Arizona, Nevada, New Mexico, Idaho, Tennessee, Kentucky, Arkansas, Alabama, Oklahoma, Texas, and Alaska

BENTONITE IN MISSISSIPPI

Occurrence, Extent, and Classification. - Bulletin No.22, a report on "Bentonite in Mississippi", by Ralph E. Grim, was issued in 1928 by the Mississippi Geological Survey as a preliminary report on the investigations which had been made at that time. This bulletin is now entirely out of print, only one copy remaining in the files of the Survey. The essential parts of this report will be used, however, in the preparation of this later bulletin on the same subject, with the addition of more recent findings, as a supplementary report.

Bentonite occurs in several counties of Mississippi, but so far, is mined only in Prentiss County, in the northeastern part of the state. Other deposits have been found in Monroe, Tippah, Itawamba, Rankin, Smith, Jasper and Wayne counties.

Geology of Prentiss County

Location. - Prentiss County is in the northeastern part of the state, with the seat of government at Booneville. About five miles southeast of Booneville lies the bentonite pit, on a graveled highway leading to Belmont in Tishomingo County. The Mobile and Ohio Railroad runs through Booneville, where the bentonite from the mine is loaded into box cars from a platform. Good highways make this pit accessible in all weathers throughout the year.

Topography and Geology. - The area for the most part is a flat-lying region, with the bentonite deposits in the low hills to the east of the flat region. These hills are principally erosional remnants of higher land masses. The streams of the region are small, and the drainage is to the south into the East Fork of Tombigbee River. Booneville has an elevation at the Mobile and Ohio Railroad station of 509 feet. The hills to the east have a maximum relief of 570 feet (barometer).

The Cretaceous formation in Prentiss County. - The beds of the Cretaceous are all present in Prentiss County. The following information as to these beds is taken from Lowe 6/. These beds are:

6/ Lowe, E. N., Geology and Mineral Resources of Mississippi; Miss.Geol. Survey Bull. No.20, pp. 47-55. 1925.

Tuscaloosa formation
Eutaw formation
Selma Chalk formation
Ripley formation

<u>The Tuscaloosa Formation</u>. This formation receives its name from Tuscaloosa, in Alabama, which is the type locality. It rests unconformably on top of the eroded hard Paleozoic rocks and is in turn overlain conformably by the Eutaw. The beds of the Tuscaloosa consist in their lower part of dark gray and brown lignitic clays and lignite. Above the clay beds are found interstratified beds of loosely consolidated sands of variegated colors, loose, coarse, and sometimes cross-bedded. With these sands are found clay lenses and frequently irregular clay beds. Associated with the sands of the Tuscaloosa are immense deposits of chert gravel, which are characteristic of the Tuscaloosa. The thickness of the beds of this formation varies from 270 feet at Corinth, in Alcorn County, to 1000 feet in Alabama.

<u>The Eutaw Formation</u>. The Eutaw overlies the Tuscaloosa conformably, and it is overlain conformably by the Selma Chalk. The name is derived from the typelocality in Alabama. The basal portion of the Eutaw is made up of variegated micaceous sands of red, yellow, blue, and other colors. The beds are loosely consolidated, cross-bedded and lenticular. The upper beds are characterized by green glauconitic sand and marl, highly fossiliferous, the large <u>exogyra ponderosa</u>, and the coiled shells of the Ammonite group being the most commonly found in these beds.

<u>The Selma Chalk Formation</u>. These beds receive their name from the type locality at Selma, Alabama. This formation is of marine origin, and is the most extensive of the Cretaceous formations in this State; it is underlain conformably by the Eutaw, and overlain conformably by the Ripley. The basal portion of the formation is made up of calcareous sands which grade into a chalky white limestone, very massive, with a thickness varying from 350 feet near the Tennessee line to at least 1000 feet farther south in Mississippi. The upper portion is characterized by a sandy limestone containing many fossils, as <u>ostrea</u>, <u>exogyra</u>, <u>gryphea</u>, <u>radiolites</u>, shark teeth, and bones of other animals.

<u>The Ripley Formation</u>. This is the upper division of the Upper Cretaceous in Mississippi, and receives its name from the type locality at Ripley, in Tippah County, Mississippi. The formation is made up principally of sandstone, limestone, green glauconitic sands and marls. The Owl Creek marl, a blue sandy marl, highly fossiliferous, is the most characteristic member of the Ripley. The most abundant fossils are the shells, the <u>ostrea</u>, <u>exogyra</u>, baculites, <u>scaphites</u>, and shark teeth. The Owl Creek beds are 3 miles northeast of Ripley, and are noted collecting grounds.

The above is not an exact quotation, but is merely a brief summary of Dr. Lowe's discussion of the Cretaceous formations in Mississippi, as given in his bulletin mentioned in Note 6.

Bentonite in Prentiss County

Location. The bentonite pit opened by Mr. W. A. Williams several years ago is five miles southeast of Booneville, on the gravelled highway leading to Belmont, Tishomingo County, placing it within easy reach of the Mobile and Ohio Railroad, which passes through Booneville. Test pits made in the area show about 10 acres underlain by bentonite with an average thickness of 36 inches. Mr. Williams states that the overburden averages about 12 feet. This deposit has been found mostly on land of Mr. S. M. Wroten. The bed occurs in the upper Eutaw formation which caps the surrounding hills in sections 36 - 5 - 7S, and 31 - 5 - 8S.

A detailed section of the Eutaw formation in Bentonite pit 200 yards southeast of drying shed in Prentiss County.

	Feet	Inches
Soil, covering	2	0
Sand, micaceous, blue, gray, fossiliferous...	10	0
Bentonite, yellow, iron-stain streaks	3	0
Shale, blue, sandy	00	6
Shale, brown, nonfossiliferous	4	0
	19	6

The overburdening soil is removed by steam shovel and is dumped down into the gullies. The mining of the beds was started on the outside so there was no reworking of the overburdening soil, as it is always behind the shovel. After the steam shovel has stripped off about an acre of soil the shovel is used in filling the wagons which carry the wet bentonite to the drying sheds where it is dumped out onto a latticed floor. As the bentonite dries it is dropped to a lower floor, where it is shoveled into trucks by hand, hauled 5 miles to the platform along the tracks of the Mobile and Ohio Railroad, and dumped into box cars. Several methods of drying have been tried, but none has proved very successful for cheap and rapid drying.

Plates showing pictures of bentonite pit, drying shed, dried bentonite, and pit after bentonite has been removed, are given at the back of this report.

Other deposits of bentonite are found in Prentiss County in the following sections. Their thickness, however, has not yet been determined:

	Section	Twp.	Range
$W\frac{1}{2}$, $NW\frac{1}{4}$	22	8S	4E
$E\frac{1}{2}$, $NE\frac{1}{4}$	21	8S	9E
	11	7S	6E

Structural. The strike of the beds is approximately north and south, with a west dip of about 30 feet to the mile. The Cretaceous beds overlie the Paleozoic formation unconformably; however, there does not appear to be on the surface any folding or faulting which would reflect structural conditions in these beds.

Bentonite in Monroe County

This area is entirely made up of Upper Cretaceous formations, such as previously described in Prentiss County. Two distinct beds of bentonite are found in this section with thickness of from 4 to 7 feet. 7/

A detailed section showing relation of the two bentonite beds in $NE\frac{1}{4}$ Sec.26, Twp.15S, R7E.

	Feet	Inches
Soil	5	0
Bentonite	5	1
Sand, gray, limy, micaceous...	35	0
Bentonite	9	0
	59	1

Chemical Analysis of Monroe County bentonite. By W. F. Hand, State Chemist, State College, Miss.

Silica (SiO_2)	60.51%
Alumina (Al_2O_3)	16.56%
Ferric oxide (Fe_2O_3)	7.74%
Volatile matter	14.34%
	99.15%

Bentonite in Itawamba County

The Upper Cretaceous formations are all represented in this county. Bentonite deposits have, however, been found only in small thin beds, but a more thorough search may reveal commercial deposits having only a small amount of overburden.

A bed of bentonite is known to exist about six miles north and one & half miles west of the Smithville-Fulton road in this county near White Springs, in Sec. 8 - 11 - 9, and also in Section 9.

A detailed section showing relation of two bentonite beds in Itawamba County measured from the base of cliff to the top of hill in Sec.8, Twp.11S, R9E.

	Feet	Inches
Soil	4	6
Sand, red, with thin layers of clay	40	0
Bentonite	3	0
Sand, buff-colored	0	6
Bentonite, yellow	2	0
Shale, gray, nonfossiliferous..	5	0
	55	0

7/ Grim, R. E., Bentonite in Mississippi, Miss.Geol.Survey Bull. No.22, p.2, 1928.

Other deposits have been reported in this area, but were not examined. The general characteristics of this area will be discussed later in this report.

Bentonitic Material in the Porters Creek clay in Tippah County

The formations in Tippah County consist of the Upper Cretaceous and the Upper Tertiary. The Upper Cretaceous formations having been described elsewhere in this report will not be discussed here.

Tertiary Formations:

A full description of the Tertiary formations in Mississippi will not be given in this connection, only those beds that occur in Tippah County will be mentioned.

The Midway Group. This group represents the oldest Tertiary formations, which overlie the Upper Cretaceous formations unconformably. The following are the divisions of the Midway Group:

Clayton formation
Porters Creek formation
Tippah Sandstone

Clayton formation. The beds of this formation take their name from the type locality at Clayton, Alabama. The Clayton formation overlies the Ripley unconformably, and is overlain by the Porters Creek. In the basal portion is a semi-crystalline limestone yellowish in color, which weathers into irregular slabs and rough surface. It contains abundant fossils, the most common of which is Turritella mortoni, a conical spiral univalve. The thickness of this limestone varies from 15 to 25 feet. The upper beds of the formation consist of greenish-gray, glauconitic marl containing many fossils, which weathers to a yellowish-red samd. The total thickness of the Clayton is about 60 feet.

Porters Creek Formation. These beds take their name from the type locality at Porters Creek, Hardeman County, Tennessee. "Flatwoods" was the name given it by Hilgard, and which is still used to some extent. This formation consists principally of dark gray clay; weathers to yellowish white; shows no distinct stratification; is nonfossiliferous; on breaking shows rounded nodular masses; peels like an onion; holds moisture, and forms a dense cold, wet, clay soil, difficult to cultivate in wet seasons. The topography, as the name suggests, is in general level, low and flat, though hills of considerable elevation occur in its area. The total thickness is about 150 feet.

Tippah Sandstone. These beds take their name from the type locality in Tippah County, where they make prominent hills west of the Flatwoods. They overlie the Porters Creek, and are in turn, overlain by the Wilcox. The beds consist of a series of fossiliferous sands separated by thin clay members. The total thickness is about 100 feet.

Tippah County Bentonite. The Porters Creek formation of Tippah County contains beds of clay which have the general characteristics of bentonite such as that from the type locality in Wyoming. The following analyses are given by Burchard: 8/

Analyses of Porters Creek Clay from Mississippi, and of Bentonite in Wyoming

	A	B
Silica (SiO_2)	60.68	63.25
Alumina (Al_2O_3)	15.66	12.63
Feric Oxide (Fe_2O_3)	6.40	3.70
Ferous Oxide (FeO)	None	.....
Titanium Dioxide (TiO_2)	1.00	.....
Manganous Oxide (MnO)	Trace	.....
Magnesium Oxide (MgO)	1.75	3.97
Calcium Oxide (CaO)	0.29	4.12
Sodium Oxide (Na_2O)	....	....
Potassium Oxide (K_2O)	....	3.55
Sulphur Trioxide (SO_3)	....	1.58
Moisture (H_2O--)	5.56	....
Water (H_2O -)	6.18	6.91
Carbon Dioxide (CO_2)	None	None
	97.52	99.71

A. Porters Creek clay, Blue Mountain, Miss. J.G.Fairchild, U.S.Geol.Survey, analyst.

B. Bentonite from Newcastle, Wyo. U.S.Geol.Survey Bull.285, p.446, 1906.

The writer found the location from which the above mentioned specimen was taken in Tippah County to be one mile northwest of Blue Mountain, Sec. 36 - 3 - 2, near an abandoned graveyard. The bottom of the ravine was filled to some extent by slump; 2 feet of a seam could be measured.

On the old road between Ripley and New Albany, about 3 miles south of Ripley, is a clay bed having conchoidal fracture, fine texture, thickness of 2 feet, nonfossiliferous, unstratified.

West of Ripley about four miles is located a bleaching clay mine from which the clay is taken by the open pit method, the clay being

8/ Burchard, E. F., Bauxite in Northeastern Miss., U.S.Geol.Survey Bull. 750-G, p.109, 1925.

located in the side of a hill above the surrounding lowland makes it very accessible.

The clay is of steel-gray color, very fine texture, nodular, the nodules being about 8 inches in length, 3 to 5 inches in thickness, and 6 inches in width, iron stain making up the outline of the nodules. (See Plate No. 7). The clay has a concoidal fracture on drying, with traces of mica on the inside. On placing pieces in water no discoloration is noted, and it will not stay suspended in water for any length of time. The material seems to have all the properties necessary for clarifying oils. An analysis of this clay has been made, but the writer does not have it at hand at the present time. The silica content is known to be very high.

There have been three openings made at about 150 feet apart along the side of a cliff with an angle of about 65 degrees. This cliff extends up a branch for about one-fourth of a mile, and the clay is exposed all the way; it has also been traced for one-half of a mile in the opposite direction. The cliff has a northeast-southwest trend.

<u>A detailed section of 1st opening in bleaching clay mine, 4 miles west of Ripley, measured from road to top of hill in Tippah County.</u>

	Feet
Soil	1
Clay, yellowish in color, nodular	5
Clay, steel-gray, fine texture, nodular, concoidal fracture	10
Sand, yellowish in color, contains some clay, a considerable amount of iron	2
	18

<u>A detailed section of the 2nd opening of the same mine</u>

	Feet
Soil	1
Clay, yellowish in color, nodular	5
Clay, steel-gray, fine texture, nonfossiliferous, nodular, concoidal fracture	50
Sand, yellowish in color, iron stain, contains some clay	3
	59

The 3rd opening has about the same detailed section as shown in the 2nd opening.

Smith, Jasper, and Wayne Counties

<u>Location:</u> - Smith and Jasper counties lie in the southeast-central part of the state. Wayne County makes up a part of the eastern border between Mississippi and Alabama. These three counties are underlain by rocks whose age ranges from Claiborne-Eocene to Pliocene. Alluvial

deposits are found along the stream courses. Good exposures of these formations are to be seen along the major streams in this area, such as: the Chickasawhay River, *Bucatunna Creek, Patton Creek, Horton Creek, Oakahay Creek, Tallahala Creek and East Tallahala Creek.

Topography: - These counties for the most part are flat-lying. The hills and valleys have been made in this section mainly by stream erosion. Gravel and sand clay roads are found in all parts of the area. The gravel roads are excellent all-weather roads. The Mobile and Ohio, Gulf and Ship Island, Gulf, Mobile and Northern, and the New Orleans and North Eastern, railroads are the common carriers of this section.

Claiborne-Eocene Group

Lisbon Formation; Wautubbee Marls: - Only the uppermost member of the Lisbon formation of Claiborne age is represented in this area. This member is the Wautubbee Marl, which takes its name from the type locality near Wautubbee station on the Northeastern Railroad, in a deep cut beneath the highway bridge on Highway No.11, in Clarke County. A large part of this formation is made up of grayish glauconitic fossiliferous marl. One characteristic fossil is the large saddle-shaped oyster, *Ostrea sallaeformis*. Thickness of this formation is approximately 40 to 50 feet.

Cockfield Formation: - The Cockfield formation takes its name from Cockfield Ferry, in Louisiana, where it is well developed, and where it is characterized by lignitic clays and sands. This formation thins to the east and thickens to the west. The average thickness in the eastern part of the state varies from 60 to 100 feet, while in the western part the variation is from 350 to 500 feet. Lignite seams, disseminated carbonaceous material and plant remains, and the absence of marine fossils, characterize this formation.

Jackson-Eocene Group

The Jackson formation was so named by Conrad from the type locality at Jackson, Mississippi, where it is well developed. The material of the Jackson is made up of clay, lignite, and interbedded fossiliferous sands, and marl beds toward the base. Total thickness of the Jackson formation is about 150 feet. Two formations are recognized:

Yazoo Clay
Moody's Branch Marl

Moody's Branch Marl: - This formation takes its name from the type locality at Moody's Branch, a small tributary of Pearl River within the city limits of Jackson, Mississippi, the stream having cut deeply into the formation. This formation is characterized by highly fossiliferous greenish glauconitic sandy marl. This is filled with numerous species of well preserved fossils, notable among which are *Ostrea trigonalis*, *Pecten spillmani*, etc. The thickness averages from 5 to 25 feet. Quoting from a statement made by Dr. Lowe in his report on the Geology and Mineral Resources of Mississippi, we note that: "An outcrop which is almost a duplicate of that at Moody's Branch, is exposed in a deep gorge on Garland Creek, four

*Buckatunna

miles northeast of Shubuta, Clarke County. At this locality the fossiliferous sandy member is 35 feet thick, while at Moody's Branch it has a thickness of 25 feet. Shell marls of this member outcrop at a number of points throughout Scott, Jasper, Smith and Clarke counties." 9/

Yazoo Clay: - The type section of the Yazoo clay is near Yazoo City, Mississippi, in the bluffs along Yazoo River. It consists of thin lignite beds, and buff-colored calcareous clays, showing heavy bedding and distinct jointing; frequently the clays have shell impressions; large oyster shells are common; smaller fossils are not so well preserved. The largest fossil found in these beds is the zeuglodon (*Basilosaurus cetoides*). This animal sometimes attained a length of from 70 to 80 feet, and weighed as much as several tons. Dr. Sullivan, of Millsaps College, Jackson, has collected in this State enough bones of this animal (including some of the ear bones, which are very rare), to make an almost perfect skeleton. 10/ The average thickness of this formation is about 150 feet.

Oligocene Formation

The Oligocene formation was given the name of Vicksburg by T. A. Conrad in 1846, from the exposed limestones and marls outcropping in the eastern bluffs of Mississippi River, and also along Yazoo River, being especially conspicuous near the city of Vicksburg, Warren County, Mississippi. The typical Vicksburg beds are made up principally of marine fossiliferous sandy marls and limestones, occuring in alternating beds of from one to three feet in thickness. The marls are sandy, yellowish to greenish in color, highly fossiliferous, the fossils being well preserved. The limestone is grey to bluish in color, and usually weathers to a buff color. These limestones are usually thin bedded.

Cooke 11/ correlated the Vicksburg group of Mississippi, Alabama, and Florida, and recognizes four divisions. Later he revised this and raised the Glendon to a formation, with the divisions in the following order:

		Byram Marl
		Glendon Limestone
Oligocene	Vicksburg Group	Marianna Limestone
		Forest Hill member
		Red Bluff member

Red Bluff Member: - The Red Bluff member was so named by Hilgard in 1860 from a fossiliferous bed between the Jackson and Vicksburg groups,

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9/Lowe, E.N., Geol.& Mineral Resc. of Miss.,Miss.Geol.Survey,Bull.No.20, 1925, p.71.

10/Sullivan, J.M., Millsaps College, Jackson, Mississippi, personal communication.

11/Cooke, C.W.,Correlation of the Jackson, Vicksburg Ages in Miss.,and Ala.,Journal Wash.,Academy of Sciences, Vol.8, No.7, 1918 which outcrops at Red Bluff on Chickasawhay River, about one and one-half miles south of Shubuta, Clarke County. Thickness varies from 10 - 20 feet.

Forest Hill Member: - This member takes its name from the type locality at Forest Hill, about six miles southwest of Jackson, on the Jackson to Natchez highway. It is made up of variegated gray to yellow and white clays and sands, and lignitic clays; few fossils. Thickness varies from the east to the west about 0 to 130 feet.

Marianna Limestone: - The Marianna Limestone was so named by Cooke from the good exposures of this formation found near Marianna, Florida, where it is seen in cuts between Marianna and Chipola River. The material is a soft, cream to grayish-colored, fossiliferous limestone. The thickness of this bed varies from five to 40 feet.

Glendon Limestone and Byram Marl: - The Glendon Limestone was so named from its type locality at Glendon, Clarke County, Alabama, by Cooke. It is a massive, fossiliferous, semi-crystalline and siliceous limestone, having a bluish-gray color. The thickness varies from five to 10 feet. The name Byram Marl was given this division from the marls that are so prominent along the banks of Pearl River at Byram, Hinds County, where it is typically exposed. It overlies the Glendon Limestone, and is a sandy glauconitic marl, very fossiliferous, made up of impure limestones and green shales. The thickness varies from 40 to 70 feet, and it is characterized by an abundance of Pectens.

Miocene Series

The Miocene series is divided into three members by Matson: 12/

Pascagoula Clay
Hattiesburg Clay
Catahoula Sandstone

Catahoula Sandstone: - The type locality of the Catahoula sandstone is found in Catahoula Parish, Louisiana. It is made up of sandstones, sands, and clays. The most prominent material is a gray sandstone and varies in hardness. It ranges in texture from a very fine sand, so fine as to resemble clay, to a very coarse quartz sand. Four miles south of Byram, on Pearl River, this sandstone is noticeably exposed; also at Star, on the Gulf and Ship Island Railroad. Here it is almost pure white and of uniform texture, and is associated with clays and lignite. This formation has no characteristic fossils, except remains of vegetation. Marcasite occurs very commonly in the lignitic clays of this formation, but less commonly in the sandstones. Gypsum and salt are not uncommon, though they have not been found in commercial quantities. The thickness of this formation is estimated at approximately 400 feet.

12/ Matson, G.C. and Berry, E.W., Prof. Paper 98-M, (U.S.G.S.), The Catahoula Sandstone and its Flora. 1916.

Hattiesburg Clay: - This formation takes its name from a locality near Hattiesburg, Forrest County, where it is represented by a great thickness of massive blue and gray clays. These clays are exposed along the banks of Leaf River, and other excellent exposures are found along the highways in cuts between Hattiesburg and Ellisville. Occasional beds of lignite are to be found in these clays. The clays near Hattiesburg show purple mottling on weathering. The thickness of the Hattiesburg is approximately 450 feet in central and western Mississippi.

Pascagoula Clay: - This name is derived from the clays along the Pascagoula River in the extreme southeastern part of the state, where the Pascagoula River enters Mississippi Sound at Pascagoula, Jackson County. Fossiliferous green clays outcrop along this river, and also along Leaf and Chickasawhay rivers. Similar bluish and greenish clays are exposed in the bluffs along Pearl River below Columbia. A good exposure is also to be seen about 15 miles west of Poplarville, in Pearl River County.

The fossils of these beds are principally oysters, gnathodons, and some others of salt water estuarine habit. This fact, taken together with the calcareous and glauconitic material of the formation, would indicate a marine or estuarine origin of the deposits. The Pascagoula formation rests unconformably upon the Hattiesburg clay, and is in turn overlain unconformably by the Citronelle formation. The Pascagoula has a probable thickness in this state of about 400 feet, and dips southward about 20 feet to the mile.

Pliocene - Citronelle Formation

The Citronelle formation takes its name from the type locality at Citronelle, Mobile County, Alabama. The name was given to these sediments by Matson 13/, which for the most part are non-marine. They extend from west Florida across Mississippi and Louisiana, and into Texas. Good exposures of the Citronelle, which are made up principally of gravel, sand, and motley colored clays, can be seen throughout Wayne County.

13/ Matson, G. C., The Pliocene Citronelle Formation of the Gulf Coastal Plain; U.S.G.S. Prof.Paper 98-L, p.168. 1916

Smith County - The bentonitic clays of Smith County are found outcropping in the northern part of the county (See Plate No.), and overlie the Vicksburg group. These clays lie unconformably on the Byram marl and overlap the Glendon limestone and the Marianna limestone, and in some instances rest upon the Forest Hill member. These bentonitic clays contain echinoids, mollusca, starfish, amd fragments of other fossils; which evidence points to marine deposition. The bed is massive, being from a few inches to 6 feet in thickness; color varying from an almost white to a very dark brown, with iron stain streaks running thru the bed; has a waxy feel, and is friable. Good exposures are hard to find, as the material weathers rapidly and is covered by slump. The bed is found only on the highest hills, where the elevation is between 450 to 500 feet above sea level (barometer).

Bentonite samples taken from the property of Mr. A. James, in Sec. 36, T6E., R4N., in road about 200 feet north of his house, were subjected to the Brownian movement test, and by this test the bentonite was shown to be possessed of this movement. Other samples taken from Mr. L. J. Husband's property one-half mile south of Lorena on the road to Raleigh, were also proved to have the Brownian movement; power of magnification used was 152. Some of the individual particles noted were flat with sharp, angular edges. Examination of the emulsion was made at intervals of 24, 48, and 72 hours respectively, after mixing the bentonite with water, an arc lamp being used for light. After 72 hours the emulsion showed that the particles were smaller, but the movement was much more pronounced. Samples taken from other properties in this area showed the same movement.

Several samples ground and passed through a 200-mesh screen were placed in an open graduated tube, and distilled water added; they showed a swelling property of from 30 to 40 per cent by volume.

Good exposures can be found on Mr. James' property, mentioned above, where a section measured from top to bottom of a ditch gives the following:

Sandy clay	3 feet
Clay	2 "
Bentonite	3 "
Lime	1 foot

In a gully $\frac{1}{4}$ mile west of Mr. James' house, another section is found, which measured from top to bottom of gully shows:

Clay	1 foot
Bentonite	4 feet
Lime	1 foOt

Mr. James' place is south of Polkville and east of Puckett, in Smith County. He has about 65*acres underlain with bentonite, the thickness varying from 2 feet to 6 feet, and overburden varying from one to 18 feet. Others in this area having bentonite on their properties are

*Estimated

Mr. C. Hughes and Mr. L. J. McNeece. All three of these property owners mentioned receive their mail at Polkville, R.F.D.

In sections 26 and 35, T7E.,R4N, on Mr. Higwood's property, bentonite was found on the top of a hill, with but a small amount of overburden covering it.

In sections 19 and 20, T8E.,R4N.,on Mr. Husband's property, ½ mile south of Lorena, the bentonite deposit has a thickness of from 2 to 6 feet, with overburden varying from 5 to 23 feet. The bentonite here is of fine texture, waxy and friable. A detailed section 300 yards west of Mr.Husband's place, in a gully, the material measured from top to bottom showed the following:

Sandy clay	.... 1 foot
Clay	.... 2 feet
Bentonite	.... 5 feet

Jasper County. - The bentonite of Jasper County has not been studied in as much detail as that of Smith County, but the conditions under which the bentonite occurs are about the same in both counties.

Approximately one-half mile south of Heidelberg, Jasper County, in Sec. 32, T1N.,R13E.,one outcrop is found. Other deposits probably occur to the northwest running into Smith County along the outcrop of the Vicksburg formation.

Wayne County. - The bentonitic clays of Wayne County, where they have been observed, are very much inferior to the bentonite of Jasper County, and especially so to that of Smith County, chiefly in that the bentonite of Wayne County is of a dark brown color, is waxy, and contains a great deal of detrital material. The beds however,are much more massive, reaching a total thickness in places of 14 to 16 feet. Good exposures can be seen in the northern and eastern parts of the county, along Buckatunna Creek. The deposits of bentonite here also overlie the Vicksburg, as in the case of the Smith County beds. Good deposits may possibly be found on the outcrop of these formations by coring, as good exposures are hard to find , as the material weathers badly, and becomes covered with slump.

Uses and Suggested uses of Bentonite

The commercial value of deposits of bentonite depends a great deal upon the physical condition of the material, as well as upon the chemical make up. Davis and Vacher have this to say: 14/

> The direct imbibing of water and various solutions by bentonite is undoubtedly a combination of adsorption, absorption, and chemical reaction.

Absorption of Gases. - The writer has worked on a number of experiments with bentonite as an absorbent of odors from vegetables in ice boxes or electric refrigerators. He has used both crude bentonite and refined or washed bentonite. These experiments have shown that bentonite will absorb the odors before they are taken up by ice cubes, milk, or butter. The experiments were carried on for over a year with cut onions, cantaloupe, and other vegetables that give off strong odors. One piece of bentonite was kept in a refrigerator for six months without losing the absorption property. Other experiments are planned with the view of fully testing the uses of bentonite as an absorbent of gases.

Bentonite as a Filler. - High grade paper requires a clay entirely free from grit and white in color, as a filler. Most of the paper manufacturers recognize the advantages of bentonite for use as a filler, but the high cost of the material and long distance hauling has prevented its wide use in this industry. The locating of more paper mills in the South should prove a stimulus to the development of Mississippi's bentonite deposits, especially to those deposits in Smith, Jasper, and Wayne counties, as these counties are situated in the pine belt of the state, pine products being so largely used in paper making.

Bentonite could easily be used to replace the clay filler in the manufacture of oil cloth and linoleum. Quoting again from Davis and Vacher above quoted, "Although there are no standard tests for evaluating clay fillers for oilcloth, curtain cloth, linoleum, or cordage, specifications usually include freedom from grit, ready slaking to a smooth soapy feeling, comparatively low oil absorption, and in some cases a pure white color. Bentonites are not known to have been used to replace clay in these industries, but their physical properties indicate that they should be of value for this. A laboratory test showed that less linseed oil is required to produce a certain consistence with alkali bentonite than with kaolinite." * * * * "A Denver paper company is reported to have used a large quantity of Wyoming bentonite as a filler or loader."15/

14/ Davis, C.W., and Vacher, H.C.; Bentonite: Its properties, mining, Preparation, and utilization; U.S.Bureau of Mines Tech.Pa.438.1928

15/ Op. cit.

Ceramics: - As a suspending agent in the field of ceramics, bentonite gives a better suspension of enamels than clay, one part of bentonite having the same suspension quality as 2½ parts of clay 16/. Bentonite has also suggested uses as a binder in the manufacture of chemical porcelain ware, and of graphite crucibles, but its high shrinkage would seem to detract from its value in this use.

Cements and Plasters: - Spence 17/ experimenting with bentonite showed that by adding one per cent bentonite the mechanical strength was increased and the time of setting decreased. The addition of a small amount of bentonite to plasters acts as a retarder.

Putty: - The writer has made several tests of bentonite for use as putty, and has found that the nearly white bentonite mixed with linseed oil that had been run through fuller's earth produced a very light colored putty, as good as any other.

Lubricating Greases: - Bentonite free from grit has been suggested as an absorbing agent for grease and graphite because of its selective adsorption for oil, and its aid in the retention of a protecting film on the metal surfaces.

Foundry Work: - As a bonding agent for molding sands in iron and steel works bentonite has been experimented with to some extent; it has also been used as an ingredient in core washes, for the reason that it keeps the carbonaceous matter in suspension. Its use in making cores is also noted, because of the fact that only about one-half the usual amount of linseed oil is required.

Dictophone and Phonograph Records: - Purified bentonite passing through a 200 mesh screen, free frpm grit, could be used as a binder in the making of records by this industry.

Stove, Shoe, and other Polishes: - Bentonite free from grit, could be used as a bonding agent in this industry. Its use also in the making of tooth paste might be an advantage, in that it absorbs grease, and prevents staining.

Dye Industry: - The absorptive power of bentonite for chemical salts and compounds suggests its possible use in the dye industry, as it aids in producing a better grade of coloring in textiles.

Pharmaceuticals and Cosmetics: - Bentonite is the original base for antiphlogistine, which is recorded as one of its earliest uses. Moistened with glycerine or water and heated it was applied as a dressing to relieve inflamation and soreness; also for rheumatic and pulmonary disorders, because of its long retention of heat. Massage creams

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16/ Manson, M.E., The use of Bentonite for suspending enamels: Jour. Am. Ceram. Soc., Vol.6, 1923.

17/ Spence, H.S., Bentonite: Canada Dept. of Mines, Rept. 626, 1924.

and facial beauty clays consist principally of bentonite as a base, and probably give some foundation for the statement that they will remove dirt, blackheads, pimples, and excess oil from the skin.

Refining Oil and Fats: - It is probable that the greatest use of bentonite at the present time is in the refining of petroleum products. In practically all cases bentonite has to be treated with sulphuric acid to be effective in clarifying oils. Its absorptive power is useful in de-watering in oil refining. The residue would make an excellent road topping.

Pencils, Crayons, Inks: - Purified bentonite free from grit could very easily take the place of clay in the manufacture of pencils, and because of its absorptive properties could be used as a base in crayons and certain inks.

Water Softeners: - Bentonite, given a special treatment for the removal of sliming properties, and then treated with a solution of a sodium salt and with a water wash, has proved excellent for the softening of water where the hardness is due to the presence of calcium and magnesium salts.

Drilling Mud: - Bentonite containing grit and other detergent properties could probably be used to mix in with barite to make a heavy drilling fluid for casing off water and lining the holes in well-drilling, and also to keep down heavy pressure of gas.

Horticultural Sprays, Animal Dips, etc.: - Bentonite's property of suspension and its inert character have given rise to its use in the manufacture of insecticides and tree sprays, and its spreading qualities to its use in the making of animal dips.

Deinking Printed Papers: - Experiments with bentonite have proved its value in removal of ink from old newspapers and other printed matter, by which process, not only demand for bentonite will be stimulated and an industry be expanded, but it will help to reduce the amount of timber used in paper making. A significant statement is made by Davis and Vacher 18/, that "several factors of importance indicate that bentonite will be used more and more for the deinking of newspapers. The practicability of its use has been proved. A mill operating at the rate of 40 tons of deinked paper stock per day made an average yearly saving of $15 per ton over the cost of using ground wood pulp."

Many other uses for which this valuable material is suited could be mentioned, such as its use in the manufacture of dynamite, wood dips, glue or sizing, and as a dusting agent, besides numerous others.

18/ Davis, C. W., and Vacher, H. C., Bentonite: Its Properties, Mining, Preparation, and Utilization; Tech. Paper 438, U.S. Bureau of Mines, 1928.

Chemical Composition

The following is a comparative analysis of Mississippi bentonite with bentonite from other localities:

	1	2	3	4	5	6	7	8
SiO_2	60.51	60.68	59.89	60.43	60.18	60.64	61.50	45.52
Al_2O_3	16.56	15.66	21.11	22.18	26.58	23.26	21.20	27.52
Fe2)O3	7.74	6.40	5.86	3.86	.....	3.92	0.10	2.80
TiO_2	.....	.1.00	.....	.....	.....	0.12	.....	.....
CaO	.....	.....	.....	.....	0.23	0.59	0.40	0.52
MgO	.....	1.79	.....	1.02	1.01	2.19	1.10	3.00
K_2O	.....	.....	.....	....	1.23	0.37	0.20	.....
Na_2O	.....	.....	.....	.....	.....	4.33	1.80	.....
H_2O	14.34	11.74	11.98	12.64	10.26	2.83	8.61	19.60
	99.15	97.52	99.86	99.11	99.49	98.25	94.91	98.96

1. Bentonite: Monroe Co., Miss.-Analyst, W.F.Hand, Miss.State Chemist
2. Bentonite: Tippah Co., Miss.-Burchard, E.F., U.S.G.S. Bull.750-G
3. Bentonite, Yellow: Smith Co., Miss., Analyst, H.McD.Morse, Miss.Geol.
4. Bentonite, White; " " " Analyst, H.McD.Morse " "
5. Type Material: Rock Creek, Laramie Basin, Wyo., Analyst T.T.Reed, Cassa Mining Co.
6. Bentonite: Belle Fouche, S.D.Ladoo, R.B., op.cit.
7. Bentonite Tallon, Nev., Davis and Vacher, op.cit.
8. Bentonite: Mine Creek, Ark., Ross and Shannon, op.cit.

Conclusions

Character of Bentonite.

The bentonite of Mississippi occurs in massive beds which are devoid of stratification. There are three distinct areas of deposition, two of which are in the northern part of the state - one in the Cretaceous formation, the other in the Tertiary about 20 miles apart - while the third area is in the south central part of the state about 200 miles from either of the other two.

Yet on the whole, all of these deposits are very similar:

Absence of grit (except in that of Wayne County)
Fineness of grain, as shown by the Brownian movement
Possessing concoidal fracture
Color varying from dark brown to white
Becoming very hard on drying
Thin sections being translucent, and distinctly waxy

Spence, Ries, Ross, Wherry, and others are of the opinion that bentonite is derived from volcanic ash, for thin sections examined by them show the ash structure well preserved, i.e.; bubbles, devitrified glass, segments of hollow spheres, and pumice fragments with fibrous habit.

The bentonites of Mississippi conform to these general characteristics, and physical and chemical properties, as set forth in the writings of the above named authorities on bentonite. These have been freely quoted throughout this report, and their writings cited in the notes.

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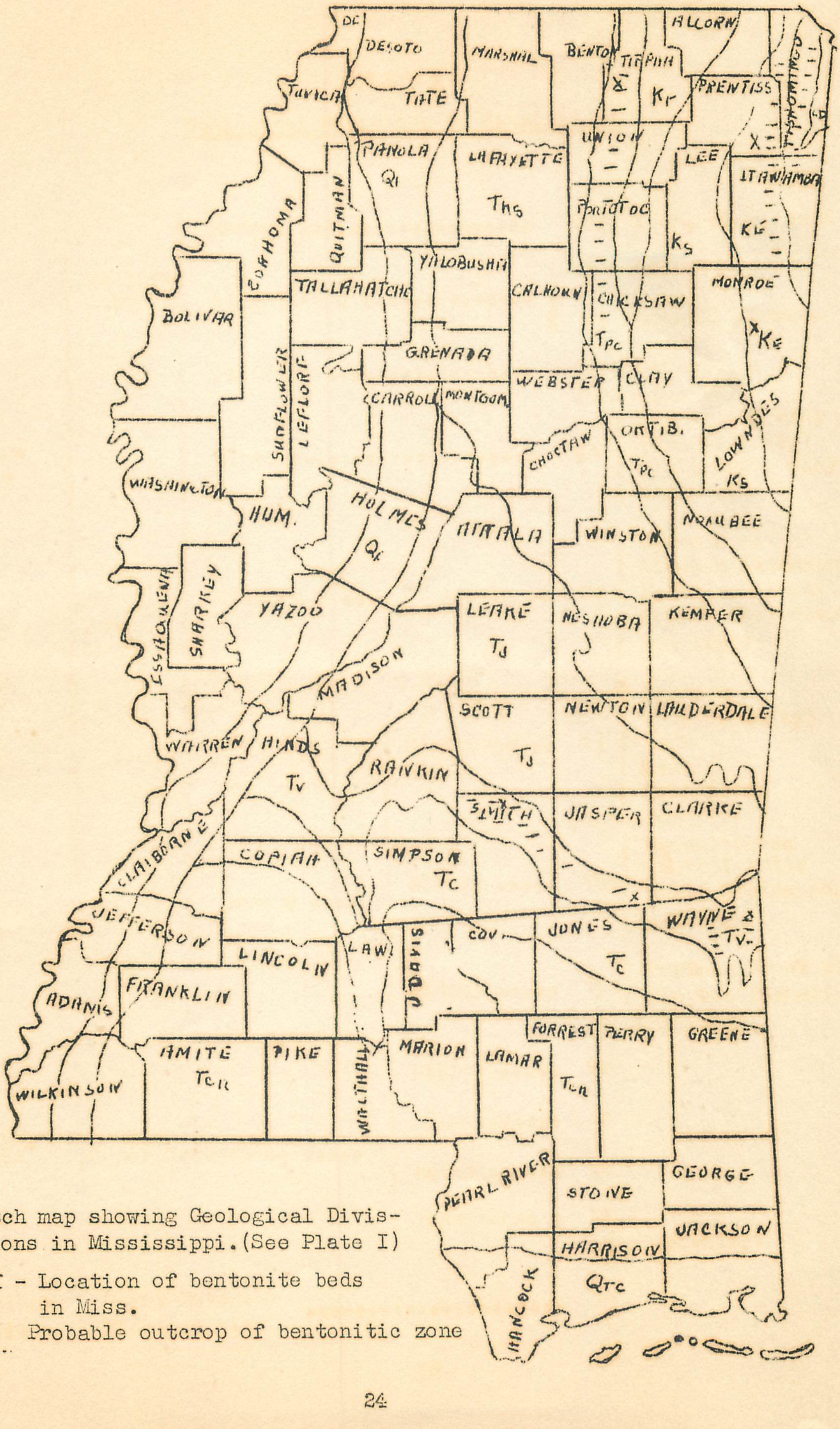
PLATE 1

Geological Divisions in Mississippi

Era	Period	Epoch	Group	Symbol	Formation
Cenozoic	Quaternary	Recent		Qsg	Loam, clay, sand
		Pliestocene		Ql	Loess
				Qct	Coastal Terrace
	Tertiary	Pliocene		Tcn	Citronelle
					(Unconformity)
		Miocene		Tc	Pascagoula clay
					(Unconformity)
					Hattiesburg clay
					Catahoula
		Oligocene	Vicksburg	Tv	Byram Marl
					Glendon limestone
					Marianna limestone
					Forest Hill clays
					Red Bluff
		Eocene	Claiborne	Tj	Jackson
					(Unconformity)
					Yegua
					Lisbon
					Tallahatta
					(Unconformity)
			Wilcox	Ths	Hatchitigbee
					(Unconformity
					Holly Spring sand
					Ackerman
			Midway	Tpc	Porters Creek clay
					Clayton formation
					(Unconformity)
Mesozoic	Upper Cretaceous		Ripley	Kr	
			Selma	Ks	
			Eutaw	Ke	
			Tuscaloosa	Kt	
					(Unconformity)
Paleozoic	Upper Devonian Mississippian			CD	

PLATE II

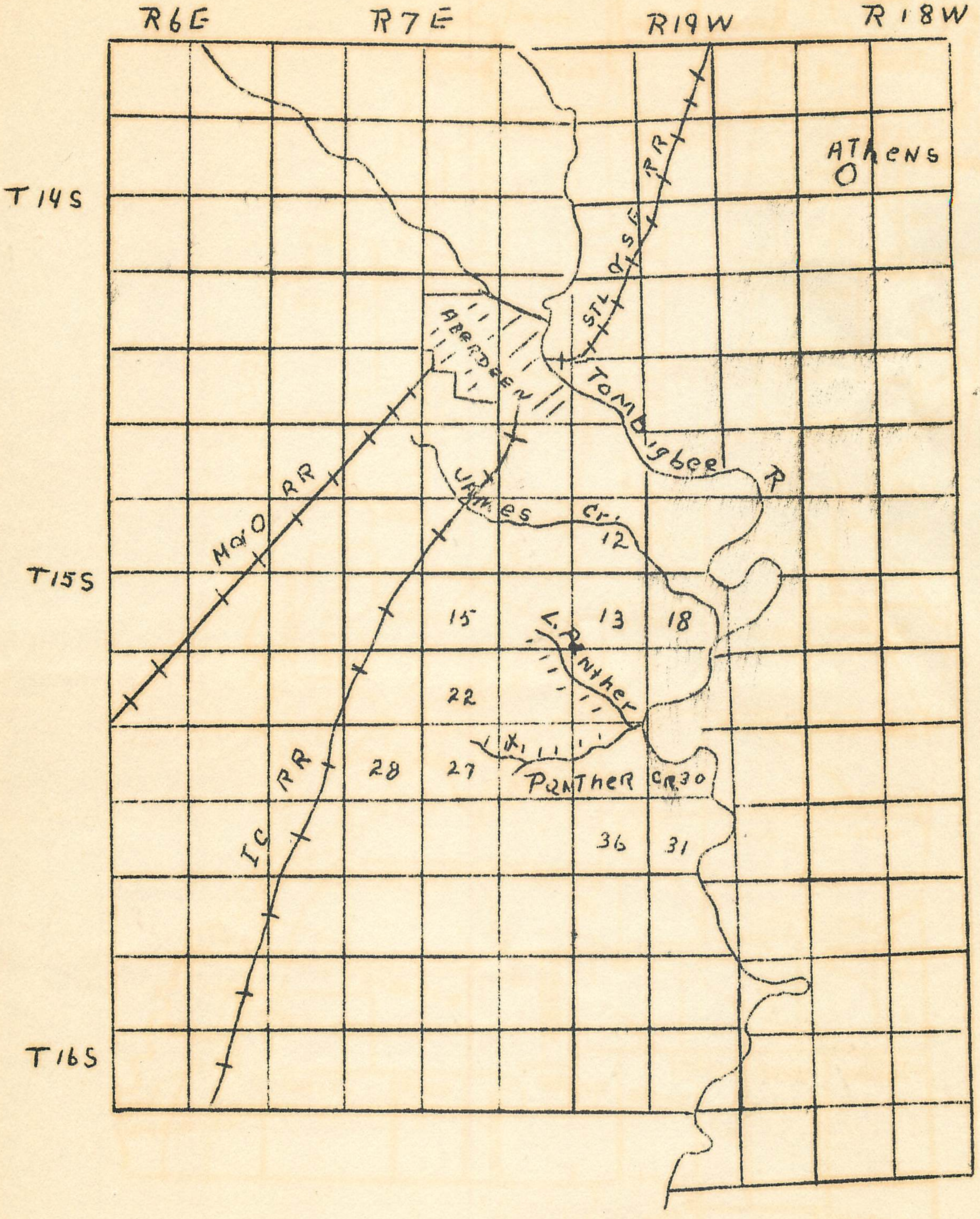


Sketch map showing Geological Divisions in Mississippi. (See Plate I)

X - Location of bentonite beds in Miss.

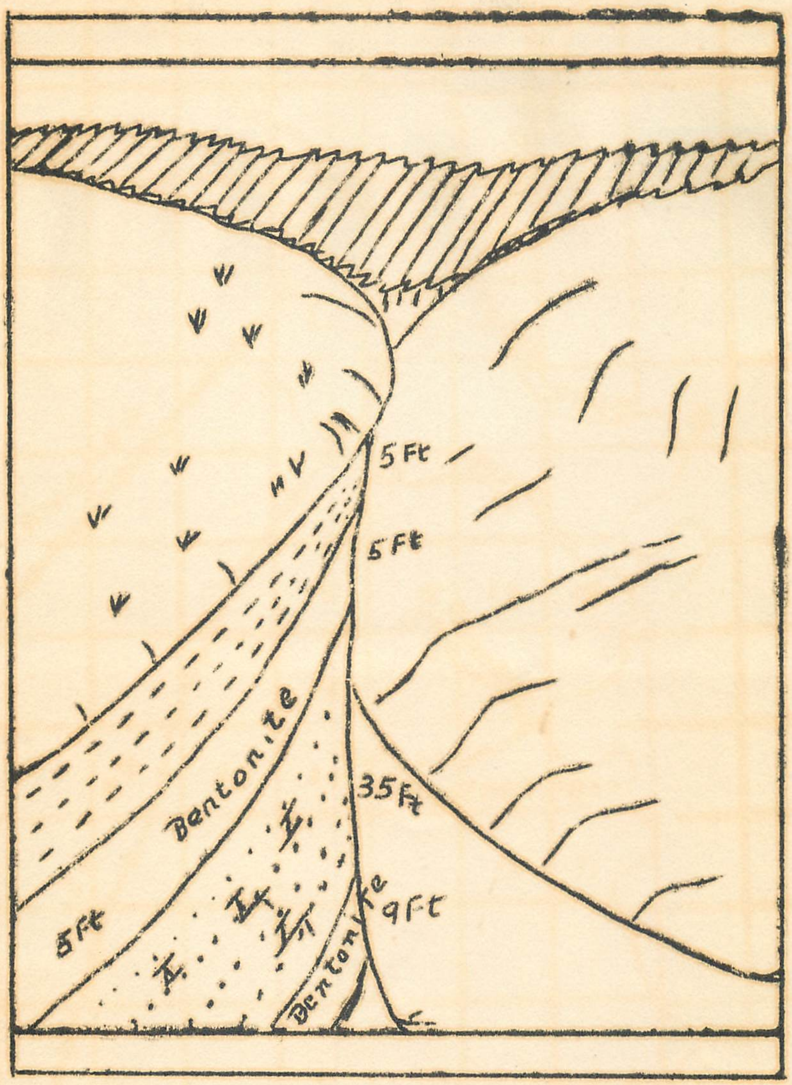
⁞ Probable outcrop of bentonitic zone

PLATE III



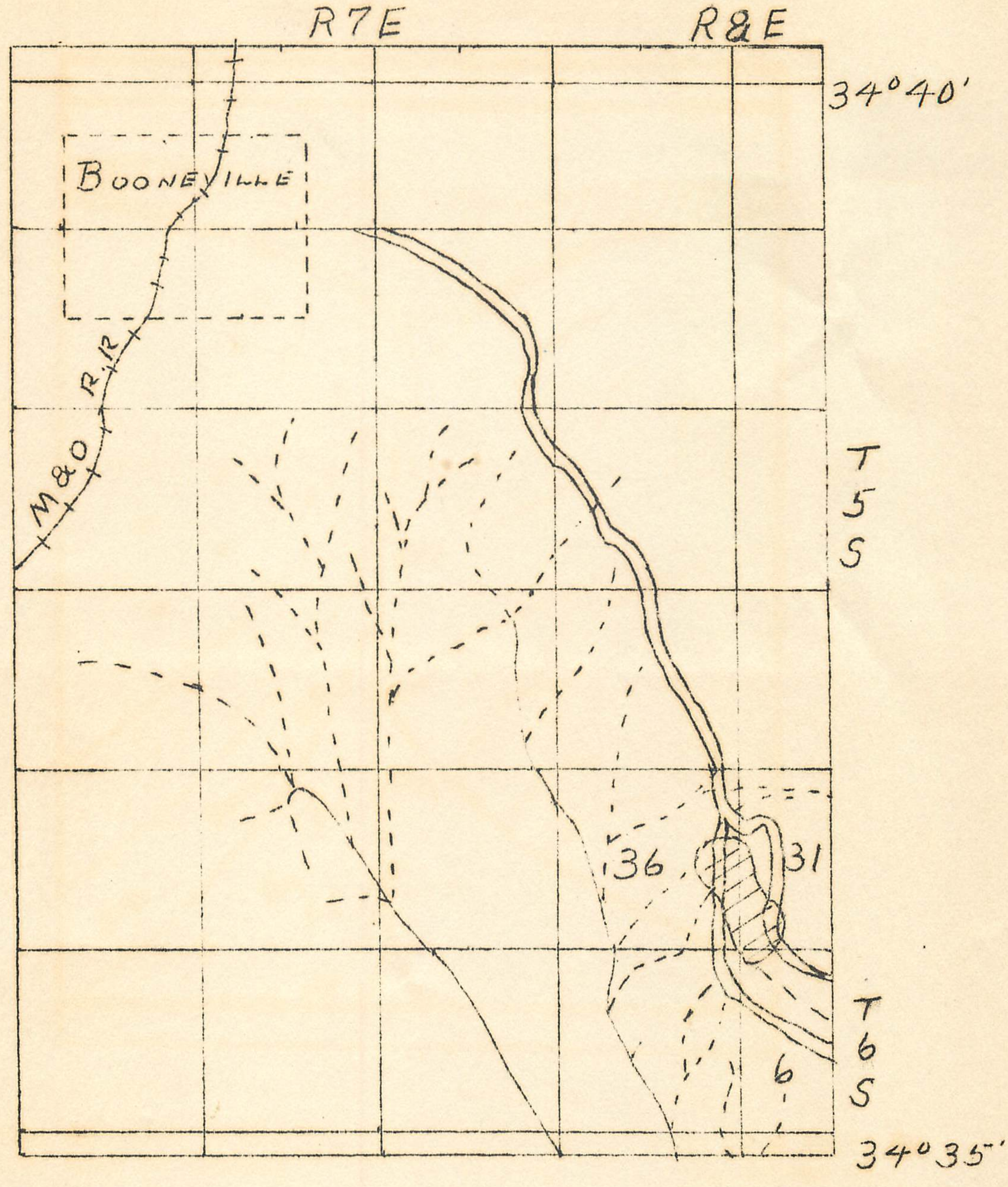
Bentonite deposits along Panther Creek, Monroe Co.,Miss.
See Plate IV

PLATE IV



Showing relation of two bentonitic beds in the side of a cliff 55 feet high on Panther Creek, in Sec.26, T15S, R7E, Monroe Co.

PLATE V

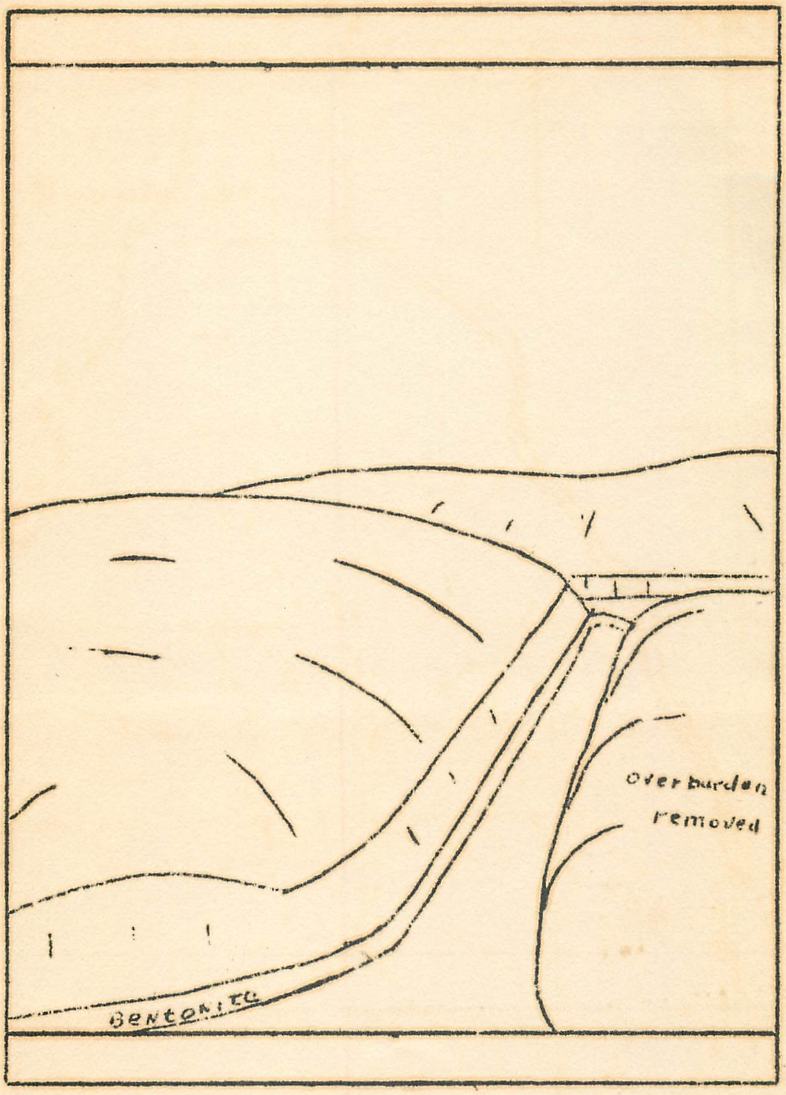


Sketch Map, showing the approximate location of the Bentonite near Booneville, Prentiss County, Mississippi.

(See Plate 6)

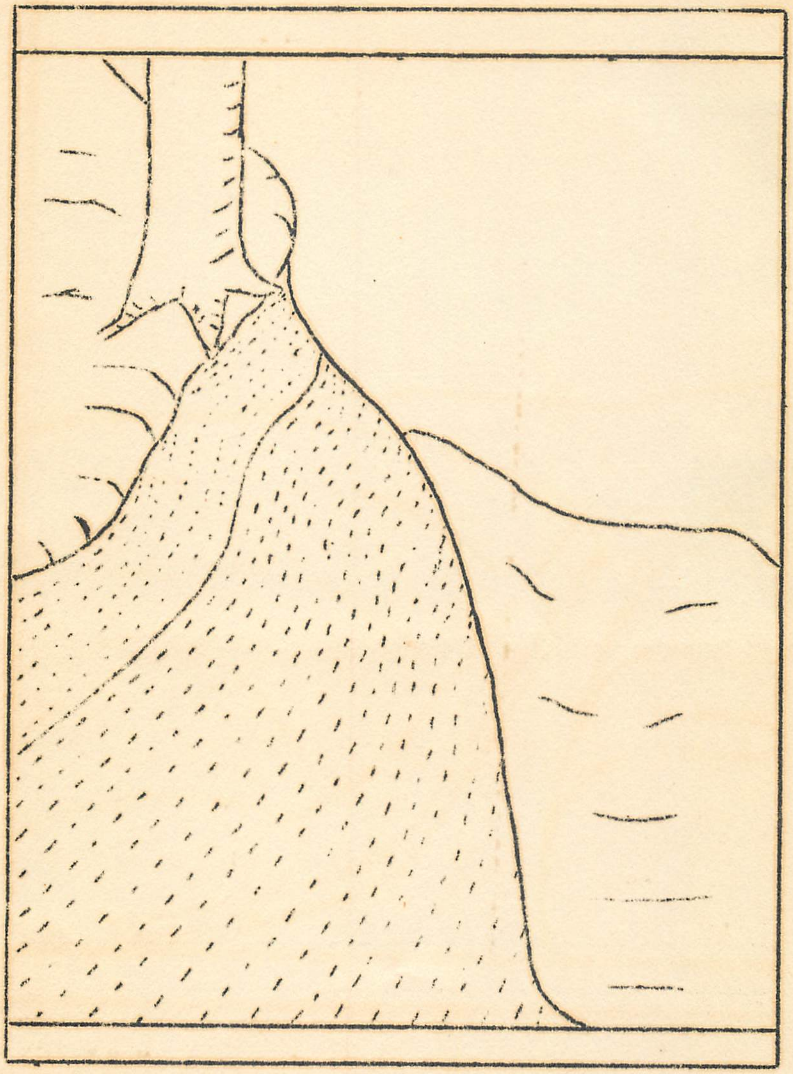
Approximate location of Bentonite.

PLATE VI



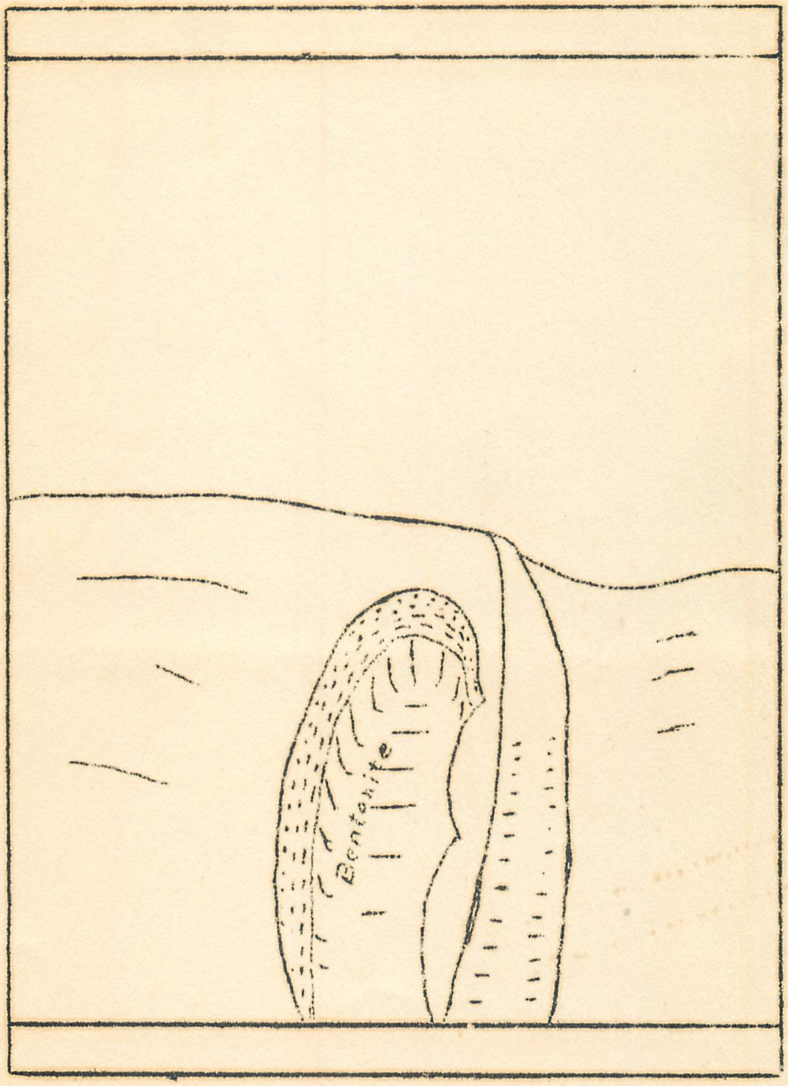
Showing relation of bentonite to overburden in bentonite mine
5½ miles S.E. of Booneville; Sec.31, T5S, R8E.

PLATE VII



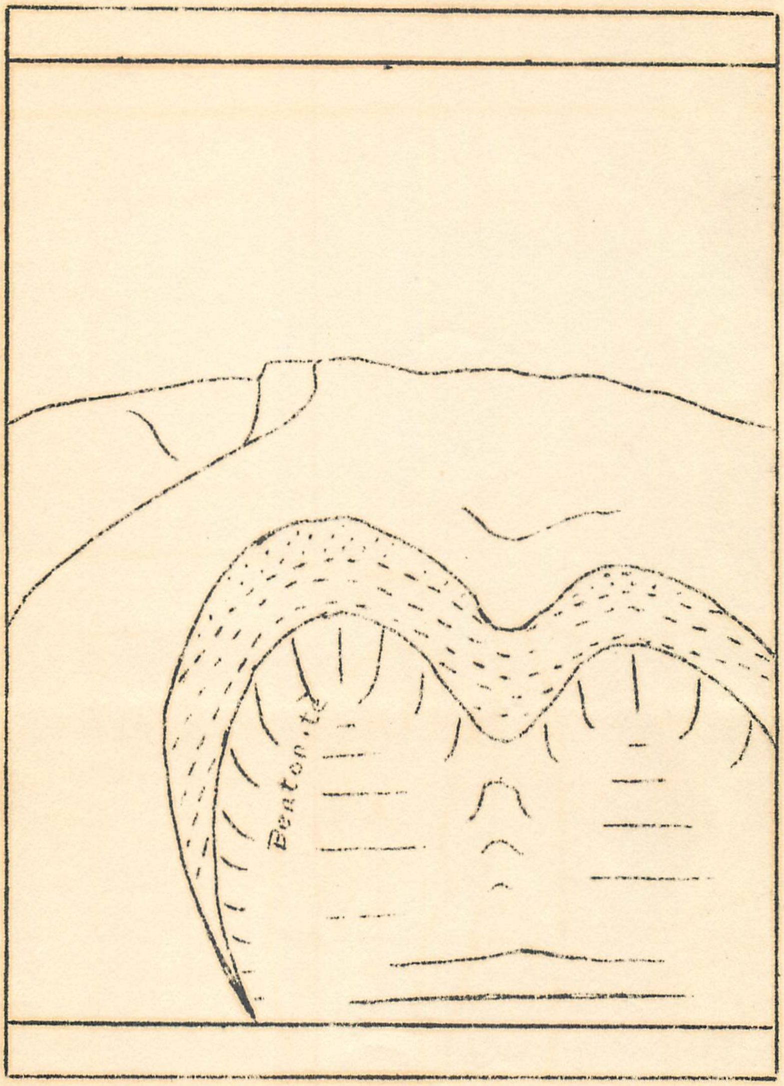
Showing relation of overburden to a 50 foot deposit of bleaching clay, about 4 miles west of Ripley, Miss.

PLATE IX



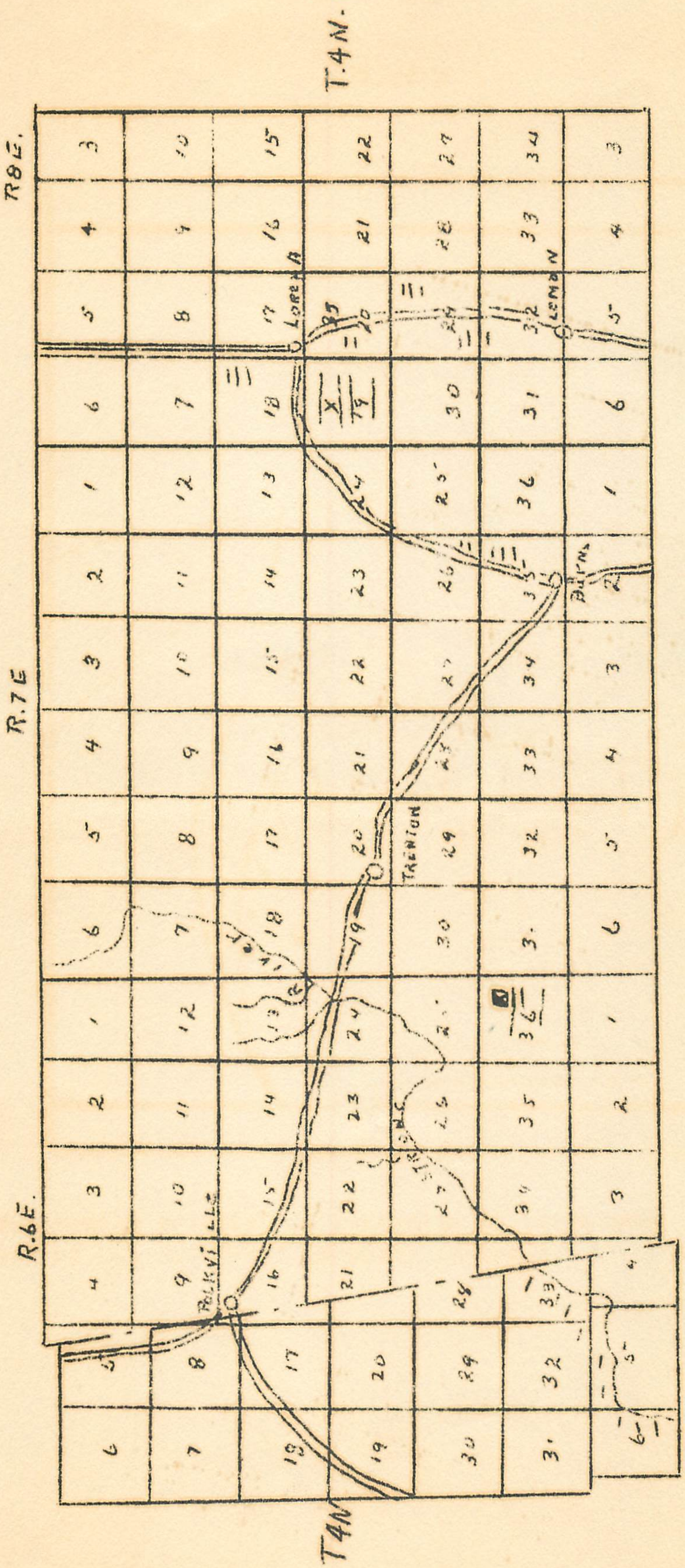
Sketch showing bentonite deposit in gully beside road in Sec.36, T4N, R6E, on property of Mr. James, in Smith County, Miss.

PLATE X



Sketch showing relation of bentonite to overburden in gully 200 yds. west of Mr. Husbands' property in Sec.19, T4N, R8E.

PLATE VIII



Map showing bentonite deposit in Northern part of Smith Co., Miss.
(See plates IX and X)