


6-1-1934

Investigations Concerning Bentonite Deposits Near Ramsay, Montana

Anton A. Anjel

John F. Sullivan

Follow this and additional works at: http://digitalcommons.mtech.edu/bach_theses

 Part of the [Ceramic Materials Commons](#), [Environmental Engineering Commons](#), [Geology Commons](#), [Geophysics and Seismology Commons](#), [Metallurgy Commons](#), [Other Engineering Commons](#), and the [Other Materials Science and Engineering Commons](#)

Recommended Citation

Anjel, Anton A. and Sullivan, John F., "Investigations Concerning Bentonite Deposits Near Ramsay, Montana" (1934). *Bachelors Theses and Reports, 1928 - 1970*. Paper 31.

This Bachelors Thesis is brought to you for free and open access by the Student Scholarship at Digital Commons @ Montana Tech. It has been accepted for inclusion in Bachelors Theses and Reports, 1928 - 1970 by an authorized administrator of Digital Commons @ Montana Tech. For more information, please contact astclair@mtech.edu.

jel and Sullivan

INVESTIGATIONS CONCERNING BENTONITE
DEPOSITS NEAR RAMSAY, MONTANA

By *Joseph*
ANTON A. ANJEL
and
JOHN F. SULLIVAN
Lucis

A Thesis
Submitted to the Department of Geology
in Partial Fulfillment of the
Requirements for the Degree of
Bachelor of Science in Geological Engineering

MONTANA SCHOOL OF MINES LIBRARY.
MONTANA SCHOOL OF MINES
BUTTE, MONTANA

JUNE 1, 1934

ANJEL AND SULLIVAN INVESTIGATIONS CONCERNING BENTONITE DEPOSITS NEAR RAMSAY, MONTANA.

INVESTIGATIONS CONCERNING BENTONITE
DEPOSITS NEAR RAMSAY, MONTANA

By
ANTON A. ANJEL
and
JOHN F. SULLIVAN

A Thesis
Submitted to the Department of Geology
in Partial Fulfillment of the
Requirements for the Degree of
Bachelor of Science in Geological Engineering



10865

MONTANA SCHOOL OF MINES
BUTTE, MONTANA

JUNE 1, 1934

MONTANA SCHOOL OF MINES LIBRARY.

CONTENTS

w/4 96-140128

	Page
Part I Field Relations and Origin by Anton Anjel -----	1
Introduction -----	1
Acknowledgments -----	1
History of Bentonite -----	2
General Occurrence and Origin -----	3
Geography of Bentonite Areas -----	4
Perry Deposit -----	4
Kelly Deposit -----	5
General Geology -----	6
Description of Deposits -----	9
Perry Deposit -----	9
Kelly - Bolton Deposit -----	11
Economic Geology -----	14
Summary and Conclusions -----	15
Bibliography -----	17
 Part II Physical and Chemical Characteristics	
by John F. Sullivan -----	1
Introduction -----	1
Acknowledgments -----	1
Definition -----	2
General Characteristics -----	3
Classification and Identification of Commercial Bentonite	
by High Temporary Osmotic Pressure -----	4

	Page
Clarification of Oils and Fats -----	11
Uses of Bentonite -----	11
Cement and Plasters -----	11
Explosives -----	12
Putty -----	12
Removal of Water from Petroleum -----	12
Bentonite as a Medicant -----	13
As a Cleaner and Polisher -----	13
Conclusion -----	13
Bibliography -----	14

ILLUSTRATIONS

Part I

Plate 1 -----	2
" 2 -----	5
" 3 -----	7
" 4 -----	7
" 5 -----	10
" 6 -----	10
" 7 -----	10
" 8 -----	10
" 9 -----	13
" 10 -----	13

Part II

Figure I -----	9
----------------	---

INVESTIGATIONS CONCERNING BENTONITE
DEPOSITS NEAR RAMSAY, MONTANA

Part I

FIELD RELATIONS AND ORIGIN

By
Anton A. Anjel

INTRODUCTION

The purpose of Part I of this report is to determine the origin of the bentonite deposits which are noted on the index map (Plate I) and also to locate them with reference to section corners in the vicinity and to determine their extent.

This report is written as a thesis in partial fulfillment of the requirements for a degree of Bachelor of Science in Geological Engineering at the Montana School of Mines.

The field work for this report was done in the fall of 1933 and during the spring of 1934. The roads, geologic contacts, and culture in general were mapped with the use of an open sight alidade and plane table. Distances were determined on the roads by the speedometer on the automobile; the detailed survey in the immediate vicinity of the deposits was done with use of the Brunton compass and pacing.

The larger deposit, which is located about 16 miles west of Butte, is owned by the Kelly-Bolton Mining Company

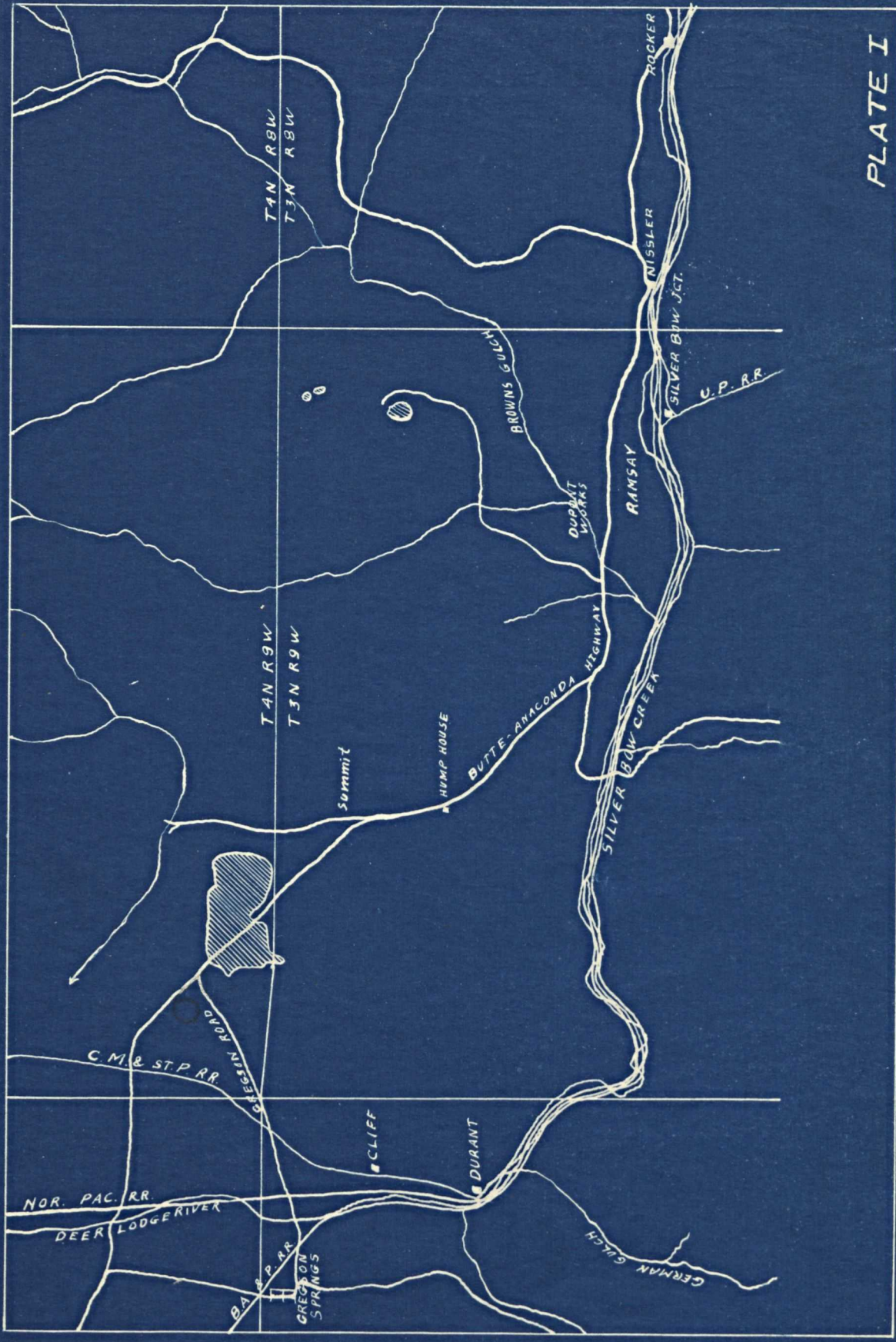


PLATE I

MAP SHOWING LOCATION OF BENTONITE DEPOSITS
 SCALE $\frac{3}{8}$ IN. = 1 MILE
 [Hatched Box] = BENTONITE

of Butte, Montana; the smaller deposit, which is about 10 miles west of Butte, is owned by a Mr. Perry, whose property it adjoins.

It is a pleasure to acknowledge the many courtesies and suggestions given by Dr. E.S. Perry, Mr. John Kelly, Mr. Michael Bolton, and Mr. Perry.

HISTORY OF BENTONITE

Investigators have recognized the occurrence of a peculiar claylike substance which, when wet with water, resembled soft soap and was called "mineral soap" or "soap clay." Early reports show that such material had long ago been used at the Hudson Bay Posts in Canada for washing blankets.²

In 1898 shipments were made from a deposit at Rock Creek, Wyoming. The material was designated "bentonite" from its occurrence in the Fort Benton formation of Colorado (Lower Cretaceous) age.

Considerable interest was shown in bentonite at this time, but it rapidly decreased. Investigations that have developed industrial processes and products in which bentonite has an important part have revived interest in bentonite in the last few years.

Many uses for bentonite have been proposed, but only a few have been tested, and investigators have not worked out the properties of bentonite that determine its particular use, nor have they made the necessary tests to determine what type of material is best suited to the different uses.

GENERAL OCCURRENCE AND ORIGIN

Bentonite usually occurs in beds ranging from a few inches to many feet in thickness. It is sometimes found interstratified with sands, clays, or shales, and in one instance, in Canada, it underlies a lignite bed. Bentonite occurs mainly in Cretaceous sediments, but it also occurs in Paleozoic and Tertiary rocks.

According to Ross², Shannon², and others, most bentonite deposits are the result of devitrification and partial alteration of glassy volcanic ash. The evidence upon which these conclusions are based are the presence, in thin sections of bentonite, of a structure characteristic of volcanic ash, the presence of feldspar, the conspicuous absence of any appreciable quantity of quartz, the chemical composition, field relationships, and the extension of individual beds which are usually of uniform thickness and are spread over large areas.

Although most bentonites are believed to have been formed from volcanic ash, Ross and Shannon² have stated that some deposits have been formed in situ by the devitrification not only of glassy igneous ash or tuff, but occasionally of lava flows and even of hypabyssal intrusives.

The outcrops of bentonite are usually barren of vegetation and show a characteristic weathered surface, with a crinkled, coral-like appearance, caused by alternate swelling and shrinking due to repeated wetting and drying.

For the mineralogical and chemical composition and properties the reader is referred to part 2 of this report.

GEOGRAPHY OF BENTONITE AREAS

The topography of the region in the vicinity of the bentonite deposits is not especially rugged and appears to be in an early mature stage of dissection. Both deposits are found in the same geological formations, namely, the andesitic and rhyolitic flows of Cretaceous and Tertiary age.

Perry Deposit

The Perry deposits are situated in a small lowland that is practically surrounded by andesitic knolls and bluffs, which rise about 500 feet above it, (Plate 2.) This lowland is open to the south in which direction the drainage flows. To the south the bench gives way to a large flat area which is part of the Tertiary lake beds of the region. The bench, which is probably about 50 feet above the level of the lake beds, may have been the former level of erosion of the whole valley to the south, but which, due to slight uplift, has become a remnant.

It is much dissected by gullies which are dry except for a short time in the spring when the heavy rains come. There are two main gulches, one along the east edge of the bench and just beneath the andesite bluffs, and the other traversing the bench from the northwest to the southeast end where it joins the first gulch. The bentonite deposits can be seen in the sides of both gullies.

In the east gulch there is a spring of good water coming out of the andesite at the foot of the bluff. It furnishes



Plate 2

Photograph Showing Topography
at Perry Bentonite Deposit
Looking Northwest

water the year around for the needs of the Perry ranch which occupies the eastern part of the bench.

The vegetation is sparse due to the sterility of the soil which covers the bentonite to a depth of several feet, and which is mainly detritus and wash from the igneous flows. The vegetation consists of juniper trees and sage brush, neither of which require good soil. The lack of rainfall is prohibitive to growth of vegetation, but the soil, where tilled and the boulders removed, can be made to produce potatoes and grain with the aid of irrigation. As can be seen on Plate, there are two small artificial lakes on the property in which water is conserved for this purpose.

The deposit is connected with the Butte-Anaconda highway by a fairly good road, although in wet weather it becomes slippery, due to the clayey material of which the region it traverses is formed.

Kelly Deposit

The Kelly bentonite deposit lies in a basin which is bounded by low hills of andesite and rhyolite on the south and east sides and which opens to wider valleys at lower elevation to the north and west. The surrounding hills are well rounded, having no sharp outlines, and range in height from 300 to 600 feet above the flat. They are all composed of andesite and rhyolite which is weathered and covered with detritus to a depth of several feet along the sides, the solid rock showing only at the tops of the hills. The flat slopes to the northwest in which direction the drainage flows.

Although the basin is for the most part quite smooth, (Plate 3) it is somewhat dissected by small dry washes which come in from the hills to the south and east and converge to the northwest. One main gully traverses the bench from southeast to northwest, and another comes in from the southwest and joins the first wash in about the center of the flat. The streams are dry except for brief periods in the spring or during a heavy rain, and the water table is very low, a well being sunk nearly 100 feet before water was encountered. There is little rainfall in the region, and as the bentonite makes a poor soil, the vegetation is rather sparse, although a little grass furnishes graze for a few cattle.

The Butte-Anaconda highway runs through the center of the deposit in a southeast-northwest direction. There is a small house with outbuildings at the northwest end of the deposit, and an old shaft and a small testing laboratory near the east end.

GENERAL GEOLOGY

The region in the vicinity of the bentonite deposits contains both sediments and igneous rocks. The latter are of three types: andesite, granite, and rhyolite, while the former are lake bed deposits of Tertiary time. Plate 4 shows the distribution of the various rocks, and the following table taken from Billingsley³ gives the sequence of geological events.

1. Middle Cretaceous - Main Rocky Mountain folding, and formation of large earth folds in northwesterly direction.

2. Middle - Upper Cretaceous - Extensive erosion and leveling of folds. Deposition of terrestrial and shore deposits to



Plate 3

Photograph, Looking North, Showing Topography
at Kelly Bentonite Deposit.

The structure to the right is the
loading bin above the shaft, and
the small building to the left
is the testing laboratory.



GEOLOGIC MAP OF THE

Scale $\frac{1}{8}$ " = 1 mile

- Granite
- Alluvium
- Andesite



MAP OF THE AREA
 Scale $\frac{7}{8}$ " = 1 mile
 Legend:
 [Stippled] Andesite [Cross-hatched] Rhyolite [Diagonal lines] Bentonite

east.

3. Upper Cretaceous - Andesite eruption. Deposition of extrusive lavas and breccias upon eroded surface to west, and formation of tuffs and andesitic sediments to east.

4. Upper Cretaceous (?) - Thrust faulting along northwest lines, and local intensification of folding. Andesite sediments are included in this movement.

5. Eocene (?) - Intrusion of Montana granite.

6. Eocene - Extensive erosion. Development of peneplain and well-adjusted river system. Early rhyolite.

7. Oligocene - Normal north-south faulting, and local accumulation of gravels. Erosion of peneplain.

8. Miocene - Further accumulation of river deposits. Later rhyolite and dacite. Same conditions probably extended through the Pliocene period.

The andesite, which covers considerable of the area, is the oldest rock exposed. It is usually reddish, although the color varies slightly in different places, and is composed of a dense and compact ground-mass usually dotted with porphyritic crystals of feldspar, augite, and other minerals. Andesite does not weather smooth like granite and rhyolite, and therefore it stands out as rugged, steep bluffs, with nearly vertical walls. In some places the andesite shows good flow structure, while in other places it is seen as a breccia with darker boulders in a lighter colored and more friable matrix.

The granite, which is not found on the surface in the immediate vicinity of the bentonite deposits, is a part of a

large intrusive igneous body known as the Boulder batholith, having a width of about 18 miles and a length, from north to south, of about 60 miles. It extends from the Highlands, 16 miles south of Butte, to the vicinity of Helena on the north. Granite rocks are believed to underlie the extrusive rocks and sediments over the whole of southwestern Montana. It weathers rather smoothly, the exposed rocks being more or less rounded in shape.

After the granite was intruded, there was considerable erosion, and then the rhyolitic and dacitic lavas were poured out on an uneven and much dissected surface of andesite and granite. They represent the products of the latest period of volcanic activity, which accompanied or followed the disturbance that formed the Miocene lakes.

The rhyolites are the weakest of the rocks, and although they are younger than either the andesite or the granite, they are more eroded and usually form the low places such as valleys and saddles. They are light colored and although fairly fine-grained, are much decomposed and readily break into small fragments.

During Miocene time, at the time of the later rhyolitic eruptions, there occurred a slight tilting of the region, which together with the damming of the water by the lava flows, reversed the drainage of the rivers of southwestern Montana and formed the Tertiary Lakes. The lake beds are formed largely of rhyolitic dust which fell into the waters of the rivers and lakes, and of fine volcanic ash and debris washed down from the

surrounding slopes.

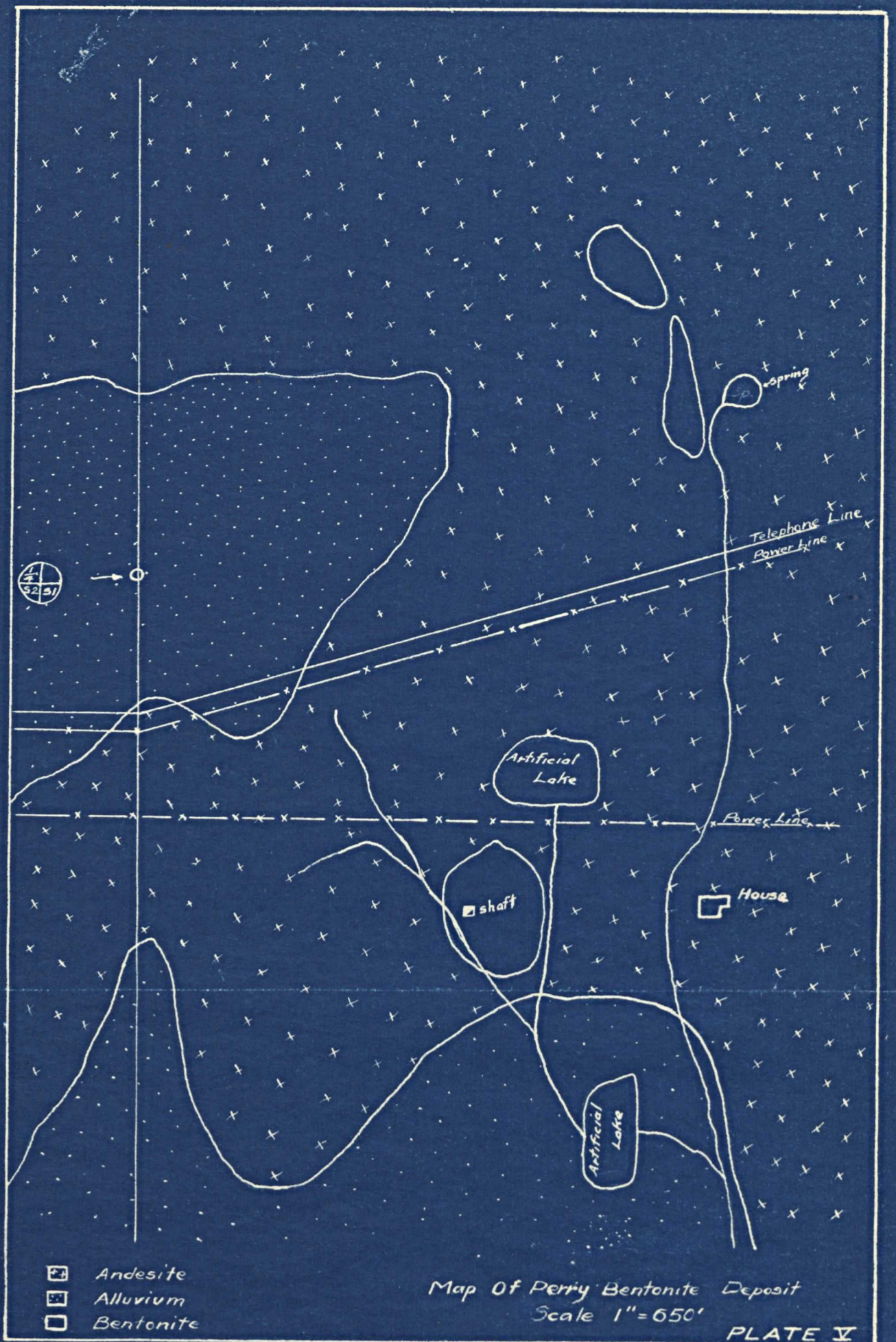
DESCRIPTION OF DEPOSITS

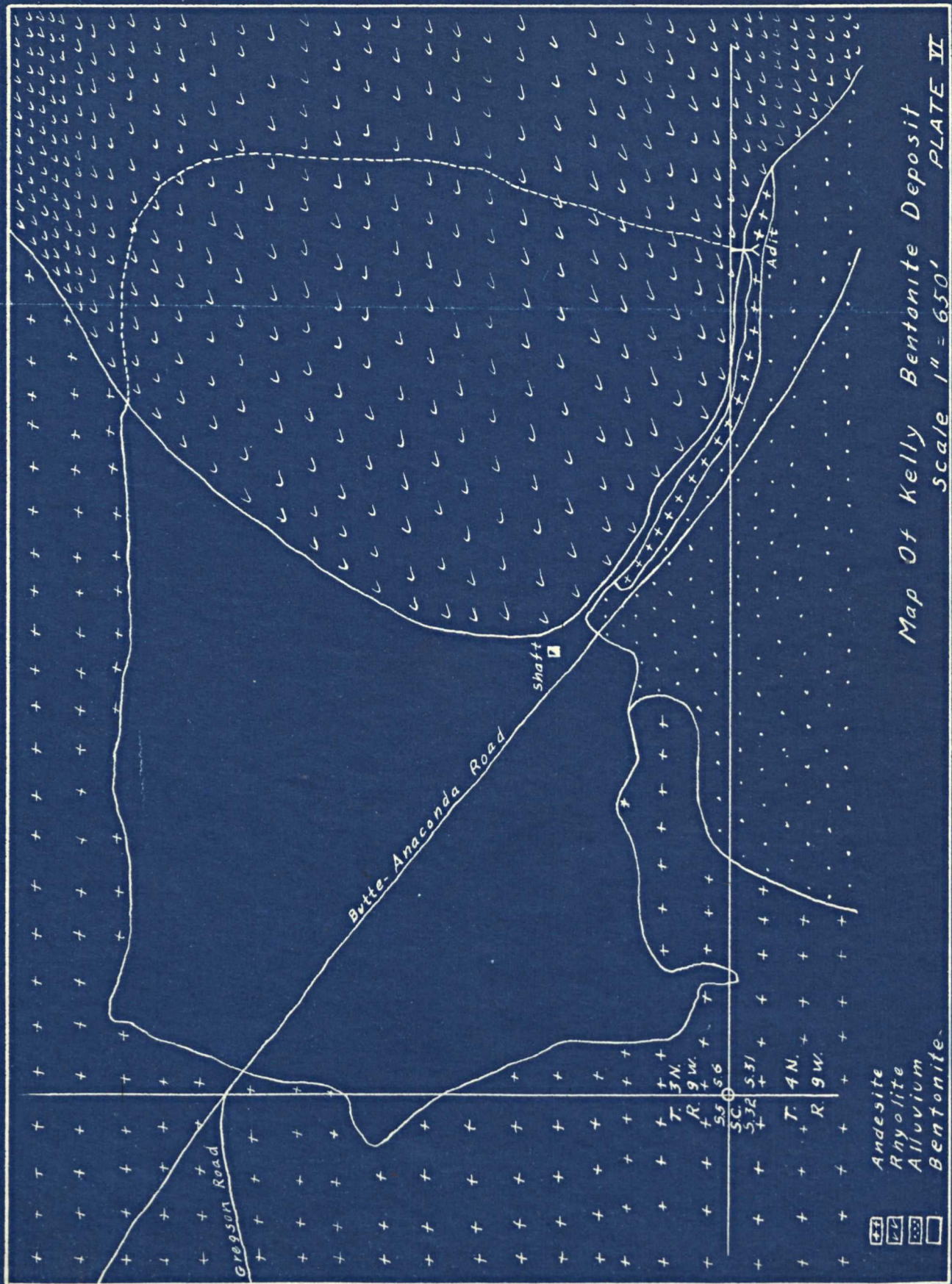
Of the two bentonite deposits, that of the Kelly-Bolton Company is much the larger, although the Perry deposit may be larger than the present development indicates. The extent of the first deposit is shown on Plate 5 while that of the second is shown on Plate 6.

Perry Deposit

This deposit occupies a small upland or bench toward the head of a small valley, and underlies a burden of detrital material averaging several feet in depth. The thickness of the deposit seems to increase toward the lower end of the bench where a development shaft (Plate 7) shows it to be about 40 feet thick. Andesite was encountered at the bottom of the shaft. The bentonite is exposed in the banks of the ravines near the shaft and at the upper end of the deposit, where it can be seen to pinch out.

The deposit shows every indication of having been transported from higher elevations in the valley as it can be seen interstratified with layers of boulders and sand (Plate 8.) The bentonite where exposed in the banks seems to be impure and contains considerable grit in the purest layers. As the shaft was unsafe for descent, the bottom of the deposit could not be examined closely, but as far down as could be seen from the surface the bentonite looked much the same as that near the surface.





Map Of Kelly Bentonite Deposit
Scale 1" = 650'

(+) Andesite
 (v) Rhyolite
 (•) Alluvium
 (L) Bentonite



Plate 7

Photograph Showing Development
Shaft and Exposure of Bentonite
in Ravine, Looking Northeast

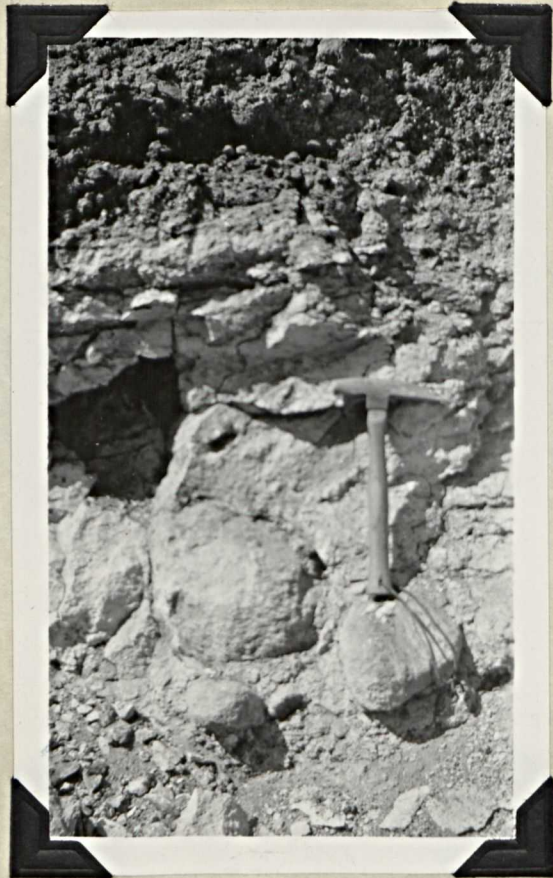


Plate 8

Photograph Showing a Layer of Bentonite
About 2 Feet Thick, Overlain by Dark
Colored Detritus and interstratified
with Large Boulders.

Above the upper end of the deposit the ravine has cut through andesite, and the solid rock can be seen in the walls and bottom, but as one proceeds down the gulch the walls change from solid andesite to loose unconsolidated sediments. The bentonite then appears between two sandy layers, widens out, and then disappears below the level of the creek bed. It seems that the bench was a former level of deposition for the sediments from the upper part of the valley, and that through subsequent slight orogenic movement, became raised and is now being reeroded, exposing the former sediments in the creek banks.

The bentonite is cream in color, and where it is exposed to weathering it becomes cracked, due to alternate swelling and shrinking during wet and dry weather. It looks very much like some of the clay-like deposits of the Tertiary lake beds to the south, and indeed the lake bed material has some of the physical and chemical properties of the bentonite, but to a lesser degree. The climate at the time of deposition must have been similar to that of today, as the bentonite shows by its interstratification with coarse pebbles and sand that it was deposited by floods such as occur in arid or semi-arid regions rather than in humid areas.

There are two different theories as to the origin of bentonite in general, either of which could be applied to this particular deposit. The first is that it was formed by the devitrification and partial alteration of glassy volcanic ash, and the second that it was formed by the devitrification and alteration of an igneous flow. The best, and in some

cases the only method of determining the origin, is by making a study of thin sections of the material under the microscope. Unfortunately, the equipment necessary for the making of thin sections of bentonite was not available, so that this important detail had to be dispensed with. Regardless, however, of the mode of origin, this deposit was laid down in its present location by mechanical agencies, mainly water.

The bentonite may have been derived from the volcanic ash which undoubtedly covered the whole region during the rhyolitic eruptions of Tertiary times. In such a case as this the ash would have to have been washed down from the slopes and deposited in its present position before alteration, which does not seem to be the case, as the embedded pebbles and sands as well as the underlying andesite are unaltered.

As indicated on Plate 4, there is a tongue of rhyolite extending down to within a half mile of the bentonite deposit, and it is possible that a part of this flow may in some way have been altered to bentonite and then transported to its present location.

Kelly-Bolton Deposit

This deposit occupies a flat area which appears to be slightly higher than the Deer Lodge Valley to the northwest and the low lying area near Gregson Springs to the west. Over most of the deposit the bentonite is covered by an overburden of several feet of unconsolidated material, but at the upper or eastern end it is covered by about 20 to 30 feet of

rhyolite. In the wall of the shaft (Plate 9) there can be seen about 2 feet of overburden which is detritus from the rhyolitic lava flows, and below that about 3 feet of a white alluvium which may be volcanic ash washed down from the surrounding slopes, while below this material can be seen the bentonite.

The bentonite in this deposit is much different from the Perry material. It is sometimes red and at other times pink, but the most of it is of a bluish color. Where exposed to weathering, it shows the typical polygonal cracks which are the result of drying and shrinking, but if a fresh surface is obtained, the bentonite has a moist slippery feel.

The deposit is well exposed for a distance of nearly half a mile in the north bank of a dry wash running in a northwest direction through the area. At the eastern end, the bentonite, which at this point is about 20 feet thick, seems to end abruptly at a small fault striking N.55°E, in which the west side has dropped about 10 feet. The bentonite is underlain on the west side of the fault by a partly altered and vesicular andesite which is exposed in the creek bottom for a distance of about 1500 feet and can be seen dipping flatly to the southwest. On the east side of the fault there is no bentonite, but the andesite is overlain by an unaltered rhyolitic flow that appears to be later than the fault, and which extends over the bentonite in a westerly direction about 2000 feet beyond the fault. The altered andesite can be seen in the creek bed to the east for about 50 feet, after which it disappears, and the overlying rhyolite, which is somewhat folded, is all that can be seen. An adit (Plate 10) about 20 feet long and striking N5°E, cuts the fault at an acute angle.



Plate 9

Photograph of North Wall of
Shaft Showing the Darker
Detritus at the Top and the
Lighter Volcanic Ash Below It.
The Bentonite Lies Below this Ash.



Plate 10

Photograph Showing Fault with
Bentonite on the West and and -
esite and Rhyolite on the East.

Looking Northeast.

About 50 feet west of the fault the bentonite can be seen, in the north bank of the creek, overlain by about 3 feet of an overburden of pebbles and sand and this in turn overlain by about 20 feet of the unaltered rhyolite mentioned above.

As one proceeds down the creek the bentonite gradually disappears beneath the surface, due to its slight southwest dip. The rhyolite flow becomes thinner to the west and ends before the shaft is reached, the surface of the rest of the deposit being covered by detritus.

There is a possibility that the bentonite was derived from a rhyolitic flow which is intermediate in age between the andesite and the latest rhyolite that caps the bentonite at the fault. Just west of the adit the bentonite can be seen separated from the late rhyolite cover by an erosion surface and underlain by the altered andesite. About 500 feet east of the shaft rhyolite can be seen actually being altered to bentonite, the harder rock being on top and changing to soft soapy material with depth, while in the shaft itself the partly altered rhyolite is enclosed by the bentonite. This would indicate that the early rhyolite flow, which was poured out on an uneven and dissected surface over the whole region, had filled a large basin where the deposit now lies, and became altered from below, probably by hydrothermal waters derived from the granite batholith which presumably underlies the region. As can be seen from the map (Plate 4) the bentonite is almost entirely surrounded by andesite and at least

in the upper or eastern part, is also underlain by it. The bentonite deposit increases in thickness toward the west from about 20 feet at the extreme east to over 100 feet at the western end, a well dug to that depth failing to reach the bottom.

The exposures along the creek and shaft previously mentioned are practically the only places where the bentonite can be studied, as the well is inaccessible and none of the numerous pits found at various places on the deposit has reached deeper than the overburden, so that the opinion above ventured was based on these limited observations.

ECONOMIC GEOLOGY

There has been practically no development work done on the Perry bentonite deposit. A shaft was sunk to a depth of about 40 feet, at which depth andesite was encountered, and no effort has been made to determine either the lateral extent of the deposit, or the thickness at any other place.

The Kelly deposit has been prospected by means of pits in many places, but most of the holes are only a few feet deep and reach only to the top of the bentonite, although they serve to establish fairly accurately the lateral extent of the deposit.

As far as vertical extent is concerned, the well at the western end of the deposit shows it to be over 100 feet thick, while the shaft located near the center of the deposit was sunk to a depth of about 50 feet, all in bentonite.

The shaft was sunk several years ago, and some bentonite was mined and shipped, but production ceased when the deposit became tied up in litigation, and the shaft became filled up by material washed down from the rhyolite slope to the east. Up to the present time no attempt has been made to reopen the shaft nor to recover the bentonite by any other means.

SUMMARY AND CONCLUSIONS

There are two separate deposits which are claimed to be bentonite but for which there is no positive proof. The first occupies a small bench near the head of a valley about 2 miles northeast of Ramsay, Montana, while the second is located on a flat area about 7 miles northwest of Ramsay, on the Butte-Anaconda highway.

The first deposit shows every indication of having been deposited in its present position by former intermittent streams. There are two theories of origin which could be applied to this deposit: first, volcanic ash, which covered the region during the rhyolitic eruptions, was washed down, deposited, and then altered to bentonite; and second, the rhyolite which can be seen about one half mile north of the deposit was altered to bentonite in some undetermined way, the bentonite then being washed down and deposited in its present location. Of the two theories the second seems the more plausible to the writer.

The second deposit, which is overlain by several feet of volcanic ash and detritus except at the eastern end where it is overlain by a rhyolite flow, shows indications of having been altered in situ, as there are no interstratified boulders or

sand in the material, and in some places rhyolite can be seen actually being altered to bentonite. The bentonite layer has a flat southwest dip and varies in thickness from about 20 feet at the eastern end to over 100 feet at the western end. This indicates that an early rhyolite flow coming from an eastern direction, filled a large basin and became altered by hydrothermal waters, which were probably derived from the granite batholith presumably underlying the region.

BIBLIOGRAPHY

1. Vacher, and Davis, "Bentonite, Its Properties, Mining, Preparation, and Utilization." U.S.B.M. Tech. Paper No. 438
2. Ross, C.S., and Shannon, E.V., "The Minerals of Bentonite and Related Clays and their Physical Properties." Jour. Am. Ceram. Soc., Vol. 9, 1926, PP. 77-79.
3. Billingsley, Paul, "The Boulder Batholite of Montana." Trans. A.I.M.E., Vol LI, 1915, P. 31.
4. Ries: "Clays, Occurrence, Properties and Uses," P 457.
5. Larson, E.S., and Wherry, E.T., "Beidellite, a New Mineral Name." Jour. Wash. Acad. Sci., Vol. 15, 1925, P. 465.
6. Spence, H.S., Bentonite: Canada Dept. Mines, Rept. 626, 1924.
7. Alexander, J., "Bentonite": Colloid Symposium Monograph, Vol. 2, 1925 PP. 99-105.
8. Nelson, W.A., "Volcanic Ash bed in the Ordovician of Tennessee": Bull. Geol. Soc. Am., Vol. 33, 1922, P. 605.
9. Schurecht, H.G., and Douba, H.W., The properties of some clay-like minerals of the bentonite: Jour. Amer. Ceram. Soc., Vol. 6, 1923, P. 940.

INVESTIGATIONS CONCERNING BENTONITE
DEPOSITS NEAR RAMSAY, MONTANA

Part II

PHYSICAL AND CHEMICAL CHARACTERISTICS

By
John F. Sullivan

INTRODUCTION

The purpose of Part II in this report is to determine if the bentonite deposits immediately west of Butte, Montana are of commercial importance and also to determine the use to which they are best suited. This was done by comparing the Butte bentonite with commercial bentonites and others which are listed below. If they are of commercial importance the company is also listed.

- (1) "Volclay" - American Colloid Company, Chicago, Ill. -
Mined at Colloid, Wyoming.
- (2) Fullers' Earth - Floridan Company, Warren, Pa. -
Mined at Quincy, Fla.
- (3) Baroid Sales Company, Baroid, California
- (4) Super Filtral Company, Los Angeles, California
- (5) Glasgow, Montana
- (6) Hardin, Montana
- (7) Kelly Deposit (Ramsay, Montana)
- (8) Perry Deposit (Ramsay, Montana)

The work which was done was carried on under the direction of the geology department of the Montana State School of Mines in an attempt to determine the uses to which Montana bentonites are

best suited, especially the Butte deposits.

The writer desires to acknowledge with much appreciation, the direction and assistance given him by Dr. E.S. Perry, Dr. A.E. Koenig, and Mr. A. Keuchler.

DEFINITION

Bentonite is composed of a group of clay-like minerals characterized by the presence of an alkaline oxide, an alkaline earth content of five to ten per cent, small grain size, high absorptive power, and usually very strong colloidal properties.

Ross and Shannon² defined bentonite as all rocks that contain seventy-five per cent or more of the clay-like minerals montmorillonite or beidellite formed by the surface alteration of igneous material. They stated that bentonite is characterized by a texture inherited from volcanic tuff or ash; that the minerals are characterized by their micaceous habit, facile cleavage, and high birefringence; and that the common accessory minerals are feldspar, biotite, quartz, pyroxenes, zircon, and others typical of volcanic rocks. They suggest that if the clay-like material contains between 25 and 75 per cent of sandy impurities, the substance be called an arkosic bentonite, and with less than 25 per cent of bentonite minerals, a bentonite arkose.

Montmorillonite is designated as $(Mg, Ca, Na) O \cdot Al_2O_3 \cdot 5SiO_2 \cdot nH_2O$ with n equal to 8. Larsen and Wherry⁴ used the name beidellite and assigned it the formula $Al_2O_3 \cdot 3SiO_2 \cdot XH_2O$, in which X frequently is equal to 4, and the alumino is replaceable by other oxides.

Although a chemical analysis of a bentonite means but little in regards to its commercial possibilities, analyses were made of several samples taken from the deposits studied. The analyses are given below.

	Kelly-Bolton	Perry
SiO ₂ -----	55.4 %-----	54.6 %
Al ₂ O ₃ -----	20.94 -----	29.64
Fe ₂ O ₃ -----	5.50 -----	1.50
CaO-----	2.80 -----	2.24
MgO-----	1.48 -----	0.81
Moisture-----	4.00 -----	2.65
Comb. Water-----	8.25 -----	7.68
Na ₂ O+K ₂ O-----	1.63 -----	0.88

GENERAL CHARACTERISTICS

Most of the samples of bentonite which have been examined during the tests made contain gritty or sandy inclusions which are considered impurities and must be removed before marketing. Bentonite when pulverized is fine-grained and commonly light-colored. The color ranges from cream to olive green, but it may be pink, red, dark brown, or even black, the color generally becoming dark upon wetting. Some varieties may be cut into thin shavings; such was particularly characteristic of the bentonite from Glasgow, Montana.

Although varying widely in composition, bentonites have many properties in common. Wherry⁴ has attributed the colloidal properties of bentonite to a felted texture and a micaceous

structure, in which the crystals have appreciable size in two dimensions but a thickness of colloidal magnitude and also have the property of splitting up into still thinner plates. The texture supposedly lets water penetrate the mass quickly, wet the surface, and forces its way between the micaceous-like leaves of the crystals.

CLASSIFICATION AND IDENTIFICATION OF COMMERCIAL
BENTONITE BY HIGH TEMPORARY OSMOTIC PRESSURE

Bentonites similar to the Wyoming type material (without salts) can be recognized easily by their marked swelling and dispersion when placed in water, but for other types no simple test is available.

A scheme has been selected and tried out to identify commercial bentonites and to separate them according to their properties into four groups termed "alkali bentonites," "alkali subbentonites," "alkali-earth bentonites," and "alkali-earth subbentonites."

Definition of these groups follows:

Alkali bentonite - A bentonite containing easily replaceable alkali bases and having original properties which are not permanently destroyed by the action of sulphuric acid, as they can be restored by treatment with an alkali salt followed by regulated dialysis. This group includes Wyoming type bentonite and others similar to it.

Alkali subbentonites - A bentonite containing easily replaceable alkali bases, but having original properties destroyed by acid treatment.

Alkali-earth bentonite - A bentonite containing easily replaceable alkali-earth bases, either before or after acid treatment,

capable of being made to assume the properties of an alkali bentonite by treatment with an alkali salt followed by regulated dialysis.

Alkali-earth subbentonite - A bentonite containing easily replaceable alkali-earth bases, but after treatment with an acid not capable of being made to assume the properties of an alkali bentonite. Most oil refining clays are in this class.

A study of the properties of the bentonites named shows that swelling in water, loss of colloidalilty in heating, absorption of dye, and temporary osmotic pressure place bentonites in the same groups. The first of these, although easy to apply, is subject to serious error if soluble salts are present in the samples to be tested; the second and third require careful manipulation and are also affected by impurities; the fourth property can be used to separate bentonites into two groups, alkali bentonites and alkali-earth bentonites, and is readily applicable in the presence of soluble salts.

This classification depends upon the temporary osmotic pressure produced by bentonites having exchangeable alkali bases and upon the absence of temporary osmotic pressure produced by bentonites with alkali-earth bases.

By the use of the following tests, commercial bentonites may be identified and separated into four groups. Figure I explains how such a classification can be made.

The scheme and tests for classifying bentonites into the four previous named groups were perfected by C.W. Davis and H.C. Vacher³, although many modifications in technique were made by the

author.

In the tests made by Vacher and Davis³, a collodion sac is used as a membrane, and dispersion is an important factor in the classification, being an indication of clay if not present.

In the tests made by the author, a membrane of cellophane is used, and dispersion apparently has no significant bearing upon the classification of bentonites. The latter conclusion was drawn because known commercial bentonites did not show any marked dispersion.

The modified tests are as follows:

The equipment used for the work on each sample consists of the following:

1 liter beaker

1 cellophane membrane

1 ringstand and clamps

1 funnel and filter paper

2 thistle tubes, each with an 8-inch tube, one having a 1/8" bore, the other having a bore small enough so that it can be inserted into the former.

Test 1 - One gram of the sample to be tested is introduced into the bulb of the inverted thistle tube which is of 1/8" bore, by pouring the material through the narrow base thistle tube which stands upright, its tube being inserted in the larger. The cellophane membrane is fastened tightly to the mouth of the inverted thistle tube, and the bulb of the latter is filled with distilled water. The thistle tube containing the sample is immersed up to the top of the bulb in a liter of distilled water,

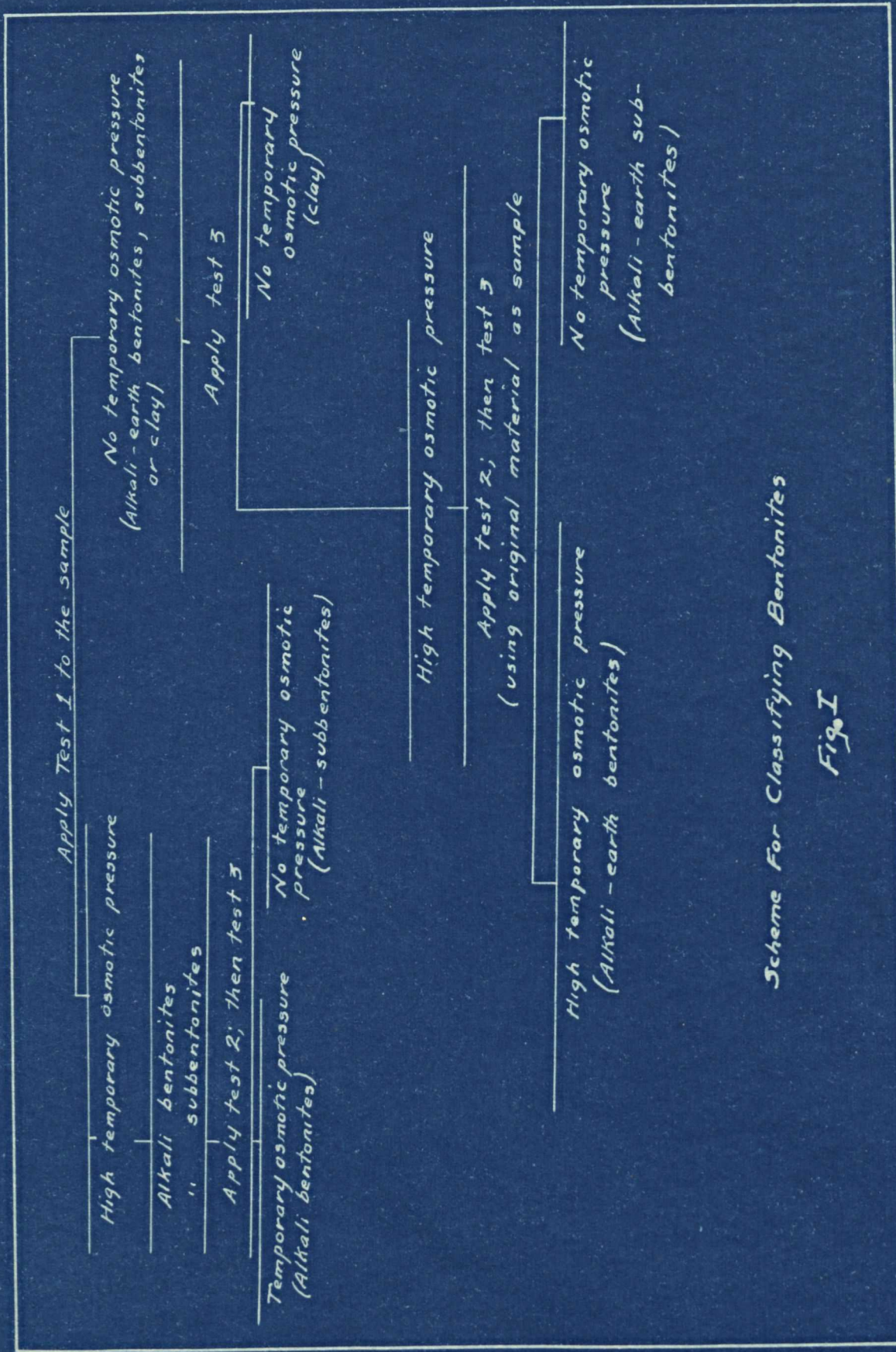
so that the level of water inside and outside the tube is the same. If the sample is free from appreciable quantities of soluble salts, the temporary osmotic pressure will cause the water to rise six inches or more in the tube when the sample is an alkali bentonite such as those of Wyoming or South Dakota, or an alkali subbentonite. If there are soluble salts in the sample, the water in the beaker should be replaced every six hours until the bulk of the salts has been removed, at which time temporary osmotic pressure will be observed with alkali bentonites and alkali subbentonites.

Test 2 - The effect of sulphuric acid on bentonites may be used to differentiate bentonites from subbentonites; the former are but slightly altered, while the latter are so attacked that their original properties cannot be restored. In applying Test 2, a one-gram sample (minus 100-mesh) is boiled with 50 cc. of 25 per cent (by weight) sulphuric acid solution for thirty minutes, then filtered and washed with distilled water until freed from soluble sulphates.

Test 3 - A third test is required to determine the effect of 2 and to differentiate alkali-earth bentonites or alkali-earth subbentonites from other rocks. The material is treated with alkali salts so that temporary osmotic pressure will be given to the alkali-earth bentonites, alkali-earth subbentonites, acid treated alkali bentonites, and acid-treated alkali-earth bentonites, but not to acid-treated alkali-earth subbentonites, acid-treated alkali subbentonites, or rocks other than bentonites. Test 3 is performed as follows:

A one gram sample is pulverized and heated on a water bath with 50 cc. of normal NaCl and 5 cc. of n/10 Na₂CO₃ solutions for two hours, then filtered, and the residue is dried, placed in the bulb having the cellophane membrane and dialyzed in distilled water. High temporary osmotic pressure indicates a bentonite.

The scheme for classifying bentonites is shown in Figure I, on the following page.



Scheme For Classifying Bentonites

Fig. I

Other rocks are not like bentonite, as they may have difficultly replaceable bases or may contain salts with a low degree of hydration.

Many samples of the Kelly and Perry bentonites were identified and separated, each into one of four groups.

<u>Sample</u>	<u>Rise</u>			<u>Classification</u>
	<u>test #1</u>	<u>test #2 & #3</u>	<u>test #3</u>	
	1			
Quincy, Fla. (Fullers' earth)	1 "	3 $\frac{1}{2}$ "	1 $\frac{1}{2}$ "	alkali earth bentonite
Perry's Brown	$\frac{3}{4}$ "	5 $\frac{1}{2}$ "	3 "	" "
Dark Anaconda Highway	1 "	1 $\frac{3}{4}$ "	4 $\frac{1}{2}$ "	" "
Light Anaconda Highway	0 "	1 $\frac{3}{4}$ "	3 $\frac{3}{4}$ "	" "
Glasgow	3 $\frac{1}{2}$ "	6 "	4 "	" "
Baroid, Calif.	6 "	$\frac{1}{2}$ "		alkali sub- bentonite
American Colloid	6 "	4 "		alkali bentonite
Superfitral	5 "	3 "		alkali bentonite
Montana clay	$\frac{1}{4}$ "		0 "	clay
Kelly's pink	$\frac{1}{4}$ "	5 "	5 $\frac{1}{2}$ "	alkali-earth bentonite
" white	$\frac{1}{2}$ "	4 $\frac{1}{2}$ "	4 $\frac{3}{4}$ "	alkali-earth bentonite
" red	$\frac{1}{3}$ "	5 "	5 $\frac{1}{4}$ "	alkali-earth bentonite
" green	$\frac{1}{3}$ "	4 "	3 $\frac{3}{4}$ "	alkali-earth bentonite
Andesite	$\frac{1}{2}$ "	4 "	4 $\frac{1}{2}$ "	alkali-earth bentonite

Most of the samples, as observed in the data sheet, are classed as alkali-earth bentonites. A sample from the Kelly deposit which had an andesitic structure was also classed as such.

CLARIFICATION OF OILS AND FATS

The author spent several days at the testing laboratory at the Kelly deposit experimenting on the clarification of oils and fats. The method and equipment used were rather crude. Greases, which were obtained from Butte restaurants, were heated and poured through a milk filter which contained the sample to be tested.

The Kelly bentonite clarified the grease as well as the fullers' earth from Quincy, Florida. It was the converse with the Perry bentonite. The packing houses are said to be using considerable bentonite for clarifying and bleaching purposes, and it is interesting that there is no waste product, because they use the oil filled bentonite in producing soap.

Samples of crank case oil were filtered through the Kelly and Wyoming bentonites, and the results were practically the same. The oil was practically clean in both instances.

USES OF BENTONITE

Cement and Plasters

Bentonite has been found to increase the speed of set in commercial plaster of Paris, possibly due to the absorption of contained organic retards. It also has the same effect on Portland cement but cannot be used, especially alkali bentonites because of shrinkage on drying.

Explosives

It has been suggested that bentonite be used as an absorbent of nitro-glycerine in the manufacture of dynamite. This may be possible because bentonite has a much higher absorbent power than the earth generally used.

Putty

All types of bentonite are suitable as putty with appreciably less linseed oil than whiting. The resultant bentonite putty is apparently as good as the other, except that its dark color may make it objectionable for some uses. The effect of weathering will have to be determined before its value for glazing can be known.

Removal of Water from Petroleum

Alkali bentonite because of its strong affinity for water might break up emulsions of oil and water, which are formed in the production and refining of oils. It is known that air dried alkali bentonites will remove water from light petroleum fractions, and also the addition of the correct amount of alkali bentonite should tend to neutralize the effect of the emulsifiers already present in crude oils and thus break up the emulsion. The removal of the colloidal matter of crude oils by treatment with acid-treated bentonites or fullers' earth should also tend toward the same result.

Bentonite as a Medicant

Bentonite moistened with water and glycerin has been used, apparently with some success, for rheumatic and pulmonary affections, eczema, abscesses, and the cleaning and healing of sores and wounds.

As a Cleaner and Polisher

Samples of the Kelly bentonite were used to clean the grease and dirt from various wearing apparel, and the results were quite satisfying. Kitchen utensils were cleaned and polished quite successfully, using the same bentonite moistened with water.

CONCLUSION

A simple method for distinguishing bentonite from other rocks is to place a sample of the fine material in the palm of the hand, moisten with water, and rub to determine whether it contains sandy or gritty material. The latter is not desirable in commercial bentonites, so that they must be quite free from impurities before they can be used.

The classification and identification of commercial bentonites by temporary osmotic pressure is a scheme which is quite long, but it is the best method which has been worked out as yet. When important new uses have been found, perhaps enough research will be done so that a simple test will be discovered to distinguish bentonites in the field, and also a shorter and more accurate scheme for classifying bentonites. Of course, the field is as yet a virgin one.

BIBLIOGRAPHY

1. Ross, C.S., quoted by Spence, H.S. "Bentonite," Canada Department of Mines, Bulletin 626
2. Ross, C.S., and Shannon, E.V., "The minerals of bentonite and related clays and their physical properties." Jour. Am. Ceram. Soc. Vol. 9 - 1926 pp 77-79
3. Davis, C.W., and Vacher, H.C. "Bentonite: Its Properties, Mining, Preparation, and Utilization," U.S. Bureau of Mines Tech. Paper 438.
4. Larsen, E.S., and Wherry, E.T., "Beidellite a new mineral name." Jour. Wash. Acad. Sei. Vol. 15, - 1925 p 465

Additional Material

- Schuresht, H.C., and Douda, H.W.,
The Properties of Some Claylike Minerals of the Bentonite Type," Jour. Am. Ceram. Soc., Vol. 6, 1923, p. 940
- Alexander, J., "Bentonite," Coll. Sym. Mono., Vol. 2-1925
- Ries: Clays: Occurrence, Properties, and Uses, pp. 457 - 458.