B E N T O N I T E

EXPLORATION REPORT W. S. FORD BENTONITE LEASE - PRINCETON AREA, B.C.

INTRODUCTION:

The largest deposits of Bentonite Clay in the Princeton area of British Columbia have been known for many years and were reported on by H. S. Spence of the Canadian Geological Survey in 1924 and subsequent writers to as late as 1951. Up until recent years, however, when new oil field development in Alberta and North Eastern British Columbia created a large demand for drilling mud, the established markets were too distant to permit economic development.

The term Bentonite is not an exact mineralogical name nor is the material of a definite mineralogical composition with definite physical and chemical properties. Originally the term was applied only to a greenish-yellow, exceedingly plastic, claylike material found in parts of Wyoming and South Dakota. An outstanding characteristic of this material was its ability to swell enormously when wetted with water. Later, other claylike materials having some but not all of the characteristics of the Wyoming deposit were also classified as Bentonite although most of them were non-swelling.

So-called Bentonites are now divided into five classes as shown by P. G. Nutting: Absorbent Clays, Their Distribution, Properties, Production and Uses. U.S.Geol.Survey Bull.928-C 1943 pp 127-221, as follows:

(1) Inactive and nearly inactivable Montmorillonite Clay of the Bentonite type (Wyoming and Black Hills). Swell enormously and gel freely in water. Principal uses, drilling muds, for waterproofing earthen dams and reservoirs, as carriers of insecticides and as additions to moulding sands.

(2) Inactive but highly activable clays, chiefly very pure Bentonite (Princeton Deposit). Moderately swelling, gel freely in water. Principal uses same as for No.1 and in addition make highest grade activated clay. May be converted to greater swelling type by saturation with Sodium solution.

(3) Active and highly activable clays, English Fullers Earth.

(4) Active clays little affected by acid treatment, probably an altered and reworked Bentonite mixed with Silt.

(5) Active clays whose activety is lowered by acid leaching, Fullers Earth type from Florida.

The principal difference between the Wyoming and Princeton Clays is the former is a Sodium Clay and the latter Calcium, and while the Wyoming brand has been remarkably successful in oil well drilling the Princeton variety is, in some instances at least, even more desirable owing to the fact that it will form a gel in salt water by a marked cation exchange, whereas the sodium clay will not. It can also be successfully treated to form a gel with oil or gasoline.

Dr. Ernst A. Hauser, professor of Colloidal Chemistry at the Massachusetts Institute of Technology and the Worcester Polytechnic Institute, who made an examination of the area for private interests, stated at a luncheon in the Georgia Hotel in Vancouver in 1951 to a number of science professors and members of the Canadian Institute of Mining and Metallurgy that "You have quite close to Vancouver, not the largest but pretty close to the largest, clay deposit in the world. This is near Princeton, B. C., and on the basis of my own research it is the finest clay deposit I have ever seen." In a later talk at Princeton before the Similkameen Branch of the C.I.M.M., Dr. Hauser enlarged on the importance of the local clay as an oil well drilling mud.

LOCATION OF PROPERTY:

The W. S. Ford lease consists of 41 acres located in the south half of the south half of District Lot 2925-S in the Princeton Assessment District, Similkameen Land District, Division of Yale, B. C. and is for a period of five years commencing September 2nd, 1950. It is renewable for further periods at the discretion of the Minister of Lands.

It is approximately five miles South of the town of Princeton in an air line and may be reached by following the hard surfaced road to Copper Mountain for a distance of 4.1 miles and thence by winding trail for another 4.3 miles. The present road can be shortened by at least one and a half miles by doing a small amount of work on an old logging trail which leads into Allenby and thence by well-graded road to the highway.

The Copper Mountain branch of the C.P.R. bisects the property and a loading spur could be constructed at moderate cost.

Water for industrial use is available from a small lake adjoining the lease but was not tested for human consumption.

Working conditions are ideal and mining could be carried out by the open pit method. There is comparatively little overburden and the dip of the strata conforms very closely with the present surface of the ground.

MINING AND TREATMENT

As this deposit may be described as massive, the most economical mining method would be by power shovel and dump trucks, if sufficient volume can be marketed, otherwise a small inexpensive scraper should be used or more preferably a bulldozer of about D-4 size with wide tracks, dozer blade and bucket.

As mined, Bentonite commonly carries considerable moisture, sometimes even to the extent of being sticky, consequently it is usually necessary to air dry it on the open quarry floor or on drying platforms or mechanical rotary driers to reduce the moisture content to about 7%. It could then be loaded directly into the cars, if bulk shipments for drilling mud are to be made, or pulverized in roller or swing hammer mills if it is to be bagged for shipment. If the clay is to be used for bleaching purposes and must be activated, further treatment is necessary.

USES OF BENTONITE:

Bentonite is one of the most interesting and versatile of minerals and Davis, Vacher and Conley, in Bentonite: Its Properties, Mining, Preparation and Utilization, U.S.Bureau of Mines Technical Paper 609, and Revision Paper 438, devote 25 pages to the uses alone. However, at the present time over 90 percent of the total production is consumed by rotary drilling mud, foundries and steelworks and oil refining. Among the many smaller applications are its use as a filler, binder and plasticizer in paper, paint, rubber, linoleum; etc., as a suspending agent in horticultural sprays and cold water paints; as a colloidal base for pharmaceutical and cosmetic preparations; in water and sewage treatment, for softening hard water, for adsorbing impurities, and assisting in coagulation of bacterial contaminents; in the preparation of a mica substitute known as "Alsifilm"; for waterproofing earth dams and clay cores in dykes.

Bentones, which are chemical derivatives of Bentonite made by reaction with organic ammonium salts, are used extensively in the paint industry.

PRESENT WORK:

As the writer is now associated with Mr. Philip D. Graham in controls of this lease, the present work was confined to a plane table survey of the lower portion and six test holes ranging in depth from 16' to 66' to determine possible minimum tonnage which may be immediately available. The general inclination of the strata for mining purposes and the general extent of the deposit at this point. The map and testhole logs are appended.

TONNAGE:

The deposit at one place is measurable in situ where the railway cut bisects the lease. Here the clay outcrop is 180' wide, 51' deep and dips at an angle of 42 degrees to the South.

No. 1 Testhole, which was drilled back from this face, was carried to a depth of 66' before encountering the underlying sand. Practically all this material can be classified as Bentonite which will be suitable for most purposes including drilling mud. Two seams of very pure Bentonite, one measuring 11' and the other 6', were encountered about half way through and 12' above the base. These seams have resisted ordinary erosion and form the floor of the valley for several hundred feet to the south where the dip has apparently been interrupted by more sharp folding or possible faulting.

No. 2 Testhole, was located 400' S.W. of No. 1, and carried to a depth of 19' and after passing through 14" of carbonaceous Bentonite was in good material to the bottom.

No. 3 Testhole, 300' S. 45 deg.W. from No. 2 became quite sandy at 6'4" and was discontinued.

No. 4 Testhole, 400' N. 40 deg.W. of No. 3, had 3' of surface material followed by Bentonite to 20'.

No. 5 Testhole, 400' N. 45 deg.W. of No. 4, was in Bentonite from 1'9" below the surface to 20'.

No. 6 Testhole was drilled to a depth of 15', 150' due East of No. 1, and had 7' of overburden before the Bentonite was encountered. It was a reconnaisance hole to determine the continuation of the deposit to the Eastward of the outcrop in the railway cut.

The difference in elevation between No. 1 and No. 5 testholes indicated that the deposit forms a saddle which dips to the South and plunges to the West. Outcrops of Bentonite Clay at considerable distances farther up the hillside also indicate that this is the case.

As it is not certain that much of the Bentonite indicated can be marketed in the raw state without removing the unaltered material and other impurities, the probable immediate tonnage is based on the continuity of the two pure seams with an average thickness of 12 feet. This when multiplied by the length of the area tested and the indicated minimum width shows slightly over 400,000 tons of very high grade material which can be made available without treatment, except for drying, in this portion of the area.

The disposal problem for waste material appears quite simple as it is not expected that workable beds will be found North of the outcrop, due to the abrupt termination of sedimentary strata in that direction.

This condition also provides an excellent site for drying floors and storage bins from which the clay could be loaded directly into railway cars.

Much more work will have to be done before a complete evaluation of the probable tonnage on the whole property can be made, but it was felt that for the present requirements further investigation at this time was not necessary.

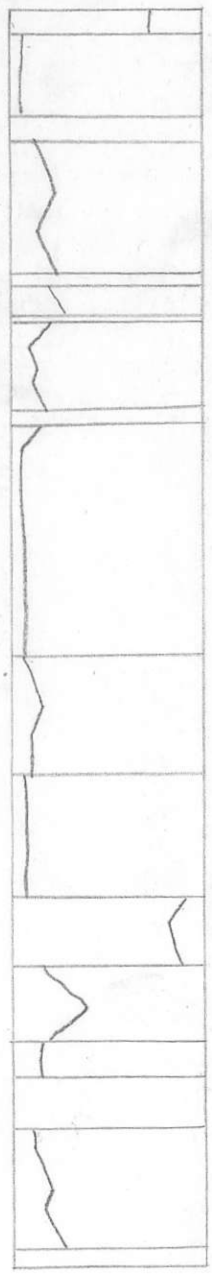
A total of ten days was spent on the present examination.

TESTHOLE NO. 1

BENTONITE PROPERTY. PRINCETON. B.C.

GRAPHIC LOG

SOIL CLASSIFICATION



2725'

Surface Soil. Silty Sand and Clay.

Bentonite with unaltered material

Bentonite

10'

Slightly Sandy Bentonite

Sand

Sandy Bentonite

Sand

20'

Slightly sandy Bentonite

Sand

Bentonite

30'

Slightly Sandy Bentonite

40'

Bentonite

Bentonite Sand

50'

Sandy Bentonite

Carbonaceous Clay & Impure Coal

60'

Sand

Slightly Sandy Bentonite

Sand

70'

TESTHOLE NO. 1

Site: District Lot 2925 S   Elevation: 2725'

Type of Drill: Comb. Earth Auger

Method of drilling and sampling: Rotating

Date Started: Oct., 1953

Hole refilled.

DEPTH	DESCRIPTION	FIELD CLASS.	
0' 0" – 1' 7"	Surface soil. Sandy clay		
1'7"-6'0"	Dark slightly sandy Bentonite. Small % Impurities	7	93
6'0"-7'4"	Light Grey Green Pure Bentonite. Slightly moist		100
7'4"-23'0"	Dark Brown Green slightly sandy Bentonite with occasional sand lenzes	15 90	85 10
23'0"-34'0"	Light cream colored pure Bentonite, occasional unaltered volcanic material	3	97
34'0"-40'2"	Brownish Green partially unaltered volcanic matter in matrix of Bentonite. Small % sand	7 12 5	93 88 95
40'2"-46'6"	Light cream colored pure Bentonite. Minor amounts unaltered volcanic matter.	3	97
46'6"-49'9"	Dark Carbonaceous material, Impure Coal and sandy Bentonite	70 85	30 15
49'9"-65'0"	Brown Green Bentonite with small % unaltered volcanic material and sand lenses	10 95 15	90 5 85
65'0"-66'0"	Brown medium fine grained sand with minor % Bentonite	98	2

TESTHOLE No. 2

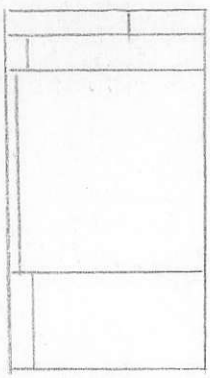
Soil Classification

El.2570

3'2"

14'

19'



Surface Soil. Sandy Clay. Carbonaceous

Slightly sandy Bentonite

Olive Green Bentonite

Brown Green Bentonite, partially unaltered

Type of Drill: Comb. Earth Auger.

Date Started. Oct., 1953

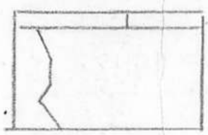
Hole Refilled.

DEBTH	DESCRIPTION
0'0"-1'2"	Black, Carbonaceous Sandy Clay (Bentonitic)
1'2"-3'2"	Dark Brown Green slightly sandy Bentonite
3'2"-13'9"	Light Olive Green Bentonite. Slightly moist. Greasy
13'9"-19'0"	Brown Green partially unaltered Bentonite

TESTHOLE NO. 3

Soil classification

El.2560'



Surface Soil, Carbonaceous Bentonite
Olive Green Sandy Bentonite

6'4"

Type of Drill. Comb. Earth Auger

Date Started: Oct., 1953

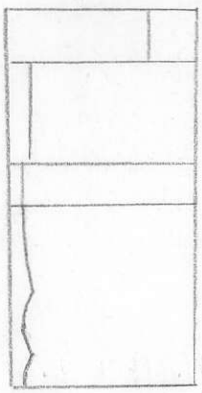
Hole Refilled

DEPTH	DESCRIPTION
0'0"-0'11"	Olive Geeen Bentonite in matrix of Carbonaceous material
0'11"-6'4"	Olive Geeen Bentonite, slightly moist, Sandy in part. May be mostly transported from outcrops to North

TESTHOLE NO. 4

Soil Classification

El. 2600'



	Soil Classification
3'0"	Surface Soil. Carbonaceous Bentonite
	Sandy Bentonite
8'2"	
	Olive Green Bentonite
10'3"	
	Brown Green Bentonite. Slightly sandy in part
20'0"	

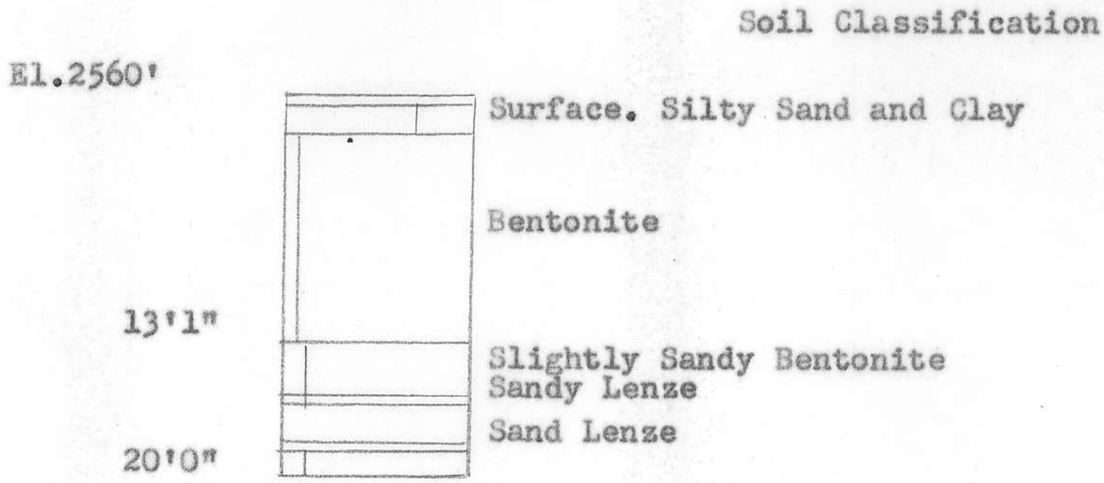
Type of Drill: Comb. Earth Auger.

Date Syarted: Oct., 1953

Hole Refilled

DEPTH	DESCRIPTION
0'0"-3'0"	Black Carbonaceous Sandy Clay and Bentonite
3'0"-8'2"	Dark slightly sandy Bentonite
8'2"-10'3"	Olive Green Bentonite. Greasy. Slightly moist.
10'3"-20'0"	Brown Green Bentonite, slightly sandy in part. Some unaltered material.

TESTHOLE NO. 5



Type of Drill: Comb. Earth Auger

Date Started: Oct., 1953

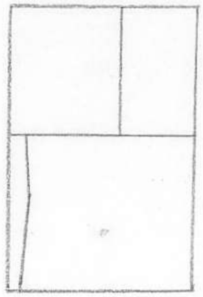
Hole refilled

DEPTH	DESCRIPTION
0'0"-0'7"	Surface soil.
0'7"-1'9"	Brown Sandy Clay, slightly Bentonitic
1'9"-13'1"	Olive Green Bentonite, Slightly unaltered in part. Greasy. Slightly moist
13'1"-20'0"	Brown Green Bentonite with some Sandy Lenze interbanding

TESTHOLE NO. 6

Soil Classification

El.2700'



Surface Soil. Sandy Clay

7'

Slightly Sandy Brown Green Bentonite

15'

Type of Drill: Comb. Earth Auger

Date Started: Oct., 1953

Hole Refilled.

DEPTH	DESCRIPTION
0'0"-7'0"	Brown Sandy Clay
7'0"-15'0"	Brown Green Bentonite, slightly Sandy in part. Greasy. Apparently correlates with upper horizon on West side of cut.

SUMMARY AND CONCLUSION:

Although the present investigation was confined almost entirely to the lower half of the property, it indicated that there should be in excess of four hundred thousand tons of an excellent grade of Bentonite in this portion of the lease.

Mining can be carried out by the open pit method and as the Bentonite has been more resistant to local erosion than the sand or carbonaceous shale, it immediately underlies the present contours of the ground and can be stripped in a North-South direction which will be a great help in providing natural drainage.

The abrupt termination of the deposit at the North end leaves adequate space for disposing of water material and a three or four car loading spur could be constructed in this area at small cost.

The freight rate from Princeton to Calgary on raw clay in minimum car load lots of 40,000 lbs. is $7.00 per ton so this type of material could be landed at the Alberta market for a maximum of $10.00 a ton.

The Wyoming Sodium Bentonite has enjoyed remarkable success in rotary oil well drilling but recent colloidal chemistry experiments have now indicated that high grade Calcium Bentonite should be even more preferable owing to its ability to form a gel in salt water, as this type of water is frequently encountered in deep drilling and is almost invariably an end product of oil production.

The cost of placing the property in production will depend entirely on the initial volume of oil field mud which can be contracted for in the raw state. For limited requirements this could be accomplished by renting a local bulldozer, air drying on the quarry floor and loading by means of a small mechanical scraper; however if the volume justifies the initial expenditure it would appear desirable to purchase a small tractor of about D-4 size equipped with an eight foot blade, power control unit and half yard bucket. Proper drying floors should be installed and a minimum of a one hundred ton loading bin constructed beside the spur. This would require a comparatively small crew to handle all operations.

The grade for the spur could be prepared from waste overburden material and as it is understood the railway bear part of the cost, the spur outlay should not exceed $600.00.

Most of the commercial loaders are now so versatile this type of equipment would be adequate for production up to fifty tons a day and also prove very useful if and when production was stepped up. The capital required for this limited operation would not exceed $10,000.00

For production of raw clay in excess of fifty tons a day, with proper drying and loading facilities, a minimum of $25,000.00 should be available.

RECOMMENDATIONS:

As the writer has had over thirty years experience in all types of oil field and information drilling methods, and has been using this clay whenever the occasion demanded since 1948, I am satisfied that basically it will meet an y oil field drilling mud requirement.

An ever expanding market is being developed for this product in Alberta and British Columbia within a favourable freight rate range of the deposit.

It can be mined cheaply by the open pit method and is situated within the dry belt of the province so it can be air dried and extra tonnage stock-piled during the summer months.

It is of a quality which will probably find additional markets in oil refining, foundries, and other industrial uses including the manufacture of artificial Mica sheets.

I recommend that the possibilities of entering the drilling mud market in Alberta be immediately explored and that suitable equipment be installed to supply reasonably authenticated requirements.

Respectfully submitted,

ROCANEN ENGINEERING COMPANY LTD.

BY: "H. M. B. Inglis" P. ENG.

CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

MINES BRANCH

OTTAWA

Results of drilling mud tests and foundry sand bond tests

on

Bentonite from Princeton, B. C.

Submitted by:

H. M. B. Inglis,

Vancouver, B. C.

by

T. H. Janes,

Industrial Minerals Division

I.M. Report No. 300 December 17th, 1954

RESULTS OF DRILLING MUD TESTS, AND FOUNDRY SAND BOND TESTS

ON BENTONITE FROM PRINCETON, B. C.

Drilling Mud Tests on Bentonite from Princeton, B. C.

Source of Material: A sample of ground bentonite, weighing twenty-five (25) pounds, was submitted by Henry M. B. Inglis, consulting mining engineer of Vancouver, B. C. Mr. Inglis reported the sample was secured from an eight foot bed on the "lower" end of the H. Knighton lease at Princeton, B. C.

Mr. Inglis also reported that the material swells approximately six times its original volume when wetted and that the tests conducted by the B. C. Research Council indicated that with the addition of 5 per cent sodium carbonate by weight its properties are very similar to the commercial American swelling bentonites.

Extent of the Deposit: Mr. Inglis in his letter of October 28th, says: that:-

> "From the visible outcrops in the railway cut and the drilling we have done on the property, over a million tons are indicated on less than one-third of the property, and this is only figuring the two pure seams, one of which is about 5 feet in depth and the other from 8 to 14 feet. In one place where it outcrops, it measures 55 feet in depth but except for the two pure seams, the remainder carries about 10 per cent sand and minute coal veinlets."

Sample Preparation: A small portion of the sample was dried overnight at 105°C. Two samples of 50 grams each were cut from this portion and the sand content (-200 mesh material) was determined.

About half the remainder was ground so that 90 per cent passed through a 200 mesh screen and dried at 105°C. This dried, ground material was kept in airtight sealers for further testing.

The swelling property, sand content, percentage of colloidal material, viscosity of different bentonite concentrations, the immediate and 10 minute gel strengths of different bentonite concentrations, the pH of a 5 per cent suspension, and wall building properties were determined. The yield of 15 centipoise drilling mud per ton of bentonite was calculated. The effect of the addition of 1, 2, 3, and 4 per cent of sodium carbonate (Na_2CO_3) by weight of bentonite to a 7 per cent bentonite suspension was also determined. The results of the laboratory testing is contained in the accompanying table.

Laboratory testing of two swelling bentonites currently being marketed in Western Canada was also conducted and the results are contained in the table for comparison with the bentonite submitted by Mr. Inglis.

Test Procedures

Swelling Property: This test provides a means of gauging the amount of swelling of a bentonite in comparison with good grade swelling bentonites. To 100 c.c. of distilled water at 25°C contained in a standard glass graduate of 100 c.c. capacity was added 2 grams of dried bentonite in small divided portions, allowing each portion to settle before the next was added. One hour after the last portion was added, the apparent volume of the bentonite was noted. For accurate results only a pinch of bentonite at a time (.10 to .15 gram) should be added, possibly from the point of a knife blade, and about 6 minutes should elapse before another portion is added. A moderately swelling bentonite will show 20 c.c. of gel; a good grade will show about 25 c.c.; and a very high swelling bentonite will show more than 30 c.c. of gel.

Sand Content Test: Two portions, 50 grams each, of the original, dried, sample were dispersed in sufficient water (400 - 500 c.c.) to make thin suspensions and these were stirred with a high speed moxer (Waring Blender) for 20 minutes. The suspensions were allowed to stand for 24 hours and again stirred for 20 minutes. The suspensions were then poured, and washed, through a 200 mesh screen and the percentage of retained grit (after drying) was determined for each. The average of the two portions of retained grit expressed as per cent by volume constitutes the sand content in the table.

Colloidally Suspended Material: The standard test procedure for determining the quantity of material remaining in colloidal aqueous suspension for a period of 18 hours was followed for this test. Ten grams of ground, dried bentonite were dispersed in 500 c.c. of distilled water with the high speed mixer for 20 minutes. The mixture was allowed to stand in a 500 c.c. graduate for 18 hours. After 18 hours, the material in suspension was slowly poured off, the sediment remaining in the bottom was dried at 105°C, and the amount of material that had remained in suspension for the 18 hour period was determined by difference.

Capacity Yield Test: For the capacity yield test, several suspensions of the dried, ground bentonite were prepared on a per cent by weight basis of bentonite in distilled water. The suspensions were mixed with the high speed mixer for 20 minutes before the viscosities were measured with the Stormer viscosimeter.

The viscosities of the various suspensions, determined as outlined above, were plotted against the per cent of bentonite in the suspensions and the per cent of bentonite necessary to yield a mud having a viscosity of 15 centipoises was determined from the graph. Knowing the per cent by weight to yield a 15 cp. mud, and using 2.5 as the specific gravity of the bentonite, the yield of 15 centipoises drilling fluid in barrels (42 U.S. gal) per ton of bentonite is determined from the following relationship:

$$Y = 2.3 \text{ plus } \frac{5.72\ (100-C)}{C}$$

Where Y = yield of 15 cp. drilling mud in barrels per ton of bentonite

C = per cent of bentonite by weight that yields a drilling mud having a viscosity of 15 centipoises

Determination of Immediate and 10-minute Gel Strengths: The tests for gel strengths were conducted on the various suspensions after the viscosities had been determined. The initial gel strengths were obtained by noting the driving weight (in grams) necessary to start rotation of the cylinder in the cup of the Stormer Viscosimeter immediately after thorough agitation of the suspension. The weight (in grams) necessary to start rotation of the cylinder in the cup after the suspensions were allowed to stand undisturbed in the cup for 10 minutes constitutes the 10-minute gel strengths of the various suspensions.

pH Determination (hydrogen-ion concentration); Test paper having a sensitivity to permit estimation of the pH of the 5 per cent suspension of bentonite in distilled water was used. By comparing the colour of the test paper with a colour chart, a close approximation of the pH can be made.

Wall Building Properties: The standard A.P.I. 30-minute filtration test was made on the same samples prepared for the capacity yield tests. The cubic centimeters of filtrate and the cake thickness in inches under 100 pounds per square inch pressure were recorded for each suspension of bentonite in distilled water.

Testing Imported Swelling Bentonites: Complete testing in the laboratory of two swelling bentonites that are marketed in Western Canada for use in drilling muds was also conducted for comparison purposes.

All tests were carried out at a temperature kept as close as possible to 25 degrees centigrade. The results obtained in laboratory testing are contained in the accompanying table.

The Effect of Adding Sodium ions to a 7% Mix: To determine the effect of the addition of sodium ions (Na^+) to a moderately swelling bentonite, such as the one submitted, a series of tests were run on seven per cent bentonite suspensions to which were added varying percentages of sodium carbonate. Amounts of soda from 1 to 4 per cent of the bentonite present in the 7 per cent suspension were added and the viscosities, initial and 10-minute gel strengths were determined for each mix. The mixes were allowed to stand for 24, 48, and 72 hour periods, thoroughly stirred with the high speed mixer and checked at each 24 hour period for viscosity. This was done to determine if the original improvement in viscosity and gelling qualities on the addition of soda to the 7 per cent suspension was "permanent" or if the properties deteriorated toward the original determination, which is usual. The results from this series of tests are also included in the table.

Foundry Sand Bond Tests: About 10 pounds of the ground bentonite received from Mr. H. M. B. Inglis was submitted to Mr. A. E. Murton of the Physical Metallurgy Division of the Mines Branch for testing as a bond in foundry sand moulds. His report, P. M. Test Report No. 9970, Re: "Foundry Suitability of a Sample of Bentonite from Vicinity of Princeton, B. C." is attached.

Comments on Results of Tests: The most important test in determining the value of a bentonite to be used in oil well drilling muds is that of the capacity yield - i.e., the number of barrels of 15 centipoise drilling mud that can be obtained from one ton of bentonite. The sample of bentonite submitted from Princeton, B. C. gave a yield, in laboratory testing, of 63.1 barrels per ton. The other two bentonites, imported from the United States, that were tested in conjunction with the sample from Princeton, gave yields of 126.3 and 100.3 barrels per ton. A yield of 100 barrels is considered good and above 90 would provide good drilling muds if other properties are within limits. To make a drilling mud having a yield of 100 barrels of 15 c.p. mud per ton would require about one and a half the amount of Princeton bentonite as would berequired for a like amount of commercial bentonite 2, listed in the table.

In practice the pH of the drilling fluid usually ranges from 8 to 12 (alkaline) when taken on a 5 per cent bentonite suspension. The pH of a mud is often considered to be of minor importance although it is generally believed that corrosion, gelation of colloidal matter, and other factors are affected by the pH of the mud.

The gel strength of a drilling mud represents the ability of a mud to lift rock cuttings out of the hole and to keep cuttings in suspension when the pumps are shut down. The initial gel strengths of the sample submitted, as seen from the table, are below those of commercial bentonites for equal bentonite concentrations. The same holds true for the 10-minute gel strengths. For example, - a 9 per cent suspension of the sample has approximately the same gel strengths as a 3 per cent suspension of commercial bentonite No.1 and 5 per cent suspension of commercial bentonite No.2. However, there is no substitute for on-the-job evaluation of gel properties and much oil well drilling has been done with bentonites having relatively low initial and 10-minute gel strengths.

A comparison of the swelling property, sand content, and colloidally suspended material of the three bentonites listed in the table shows that in these properties the Princeton bentonite sample is inferior to the commercial bentonites tested.

The wall building properties, as listed in the table, indicate that the sample submitted is at least on a par with, or better than, the two imported bentonites used for comparison. The filtration rate, or water loss, is a measure of the amount of water lost to the rock formations. The cake thickness is a measure of the amount of gel deposited on the side of the hole. The lower the filtration rate an the lower is the loss of water to any porous formation and the better is the drilling mud. Also, the thinner the filter cake, the better is the wall building characteristics of the mud. A filter cake can become thick enough to cause a "tight" spot in the hole which might cause the drill stem to stick. In practice, the filtration rate for 15 c.p. mud is usually 15 c.c. or less (standard A.P.I. 30-minute test), and the filter cake about 2/32 of an inch thick.

Comments on Results of Drilling Mud Tests on Princeton Bentonite when Na_2CO_3 is Used as an Additive: If the average viscosities of the 7 per cent bentonite suspensions obtained when 1 - 4 per cent soda is used in the suspensions (see table) are plotted against the percentage of soda used a smooth curve is obtained. From this curve where it crosses the 15 centipoise line and following back to the other ordinate one finds that to obtain a mud having a viscosity of 15 c.p. with a 7 per cent bentonite suspension it would be necessary to add 1 per cent of the weight of the bentonite as soda (Na_2CO_3). Then by using the relationship $Y = \frac{2.3 \text{ plus } 5.72(100-C)}{C}$ one determines that the yield of 15 centipoise mud using 7% bentonite and 1 per cent soda per ton of bentonite would be 78.3 barrels. Similarly if a 6 per cent bentonite suspension had been used there would be a point on the curve where by the addition of a definite percentage of soda (perhaps 2 per cent) a 15 c.p. mud would be obtained. In this instance, the yield would be 83.3 barrels per ton of bentonite. This sort of "progression" couldn't go on indefinitely as it appears from the results obtained (see table/ the gel strengths get way out of hand and a very stiff gel results with no improvenemts, or even worsening, of other properties. I do believe, however, that too stiff a gel would cause difficulties in drilling. In the laboratory when a gel is "too stiff" only the centre core of the gel where the spindle sits in the cup turns with the spindle and the remainder stays in place. Field testing would probably give the best indication at what concentrations the bentonite and soda might be used.

In previous testing of poor of moderately swelling bentonites it was also found that the addition of soda improved the quality of the mud. However, it was found that if the suspensions were left standing then remixed and checked again that the viscosities had become lower and approached the viscosity of the bentonite suspension to which no soda had been added. It was for this reason that a series of tests over a 72 hour period was conducted on the Princeton bentonite. It did not show the usual "reversion" evidenced in other moderately swelling bentonites that have been tested.

<u>6omments on the "Foundry Suitability of a Sample of Bentonite from Vicinity of Princeton, B.C."</u> P.M. Test Report No.9970 on the above subject, a copy of which is attached, prepared by Mr. A. E. Murton of the Physical Metallurgy Division of the Mines Branch concludes that:-

> "The sample of clay from the Princeton district has similar properties as a foundry bonding clay to those of the Wyoming bentonites. The chief difference between these clays is that slightly larger quantity of the Princeton clay would be required to produce similar sand mixtures."

<u>Conclusion</u>: From the results obtained in testing the bentonite sample submitted by H. M. B. Inglis from near Princeton, B. C., it appears the material could be used for those purposes to which a swelling bentonite is put. These include oil well drilling muds, foundry sand bond, pelletizing taconite concentrates, sealing irrigation ditches, diamond drilling and other minor uses. However, larger quantities of it would be necessary to achieve the same results as are achieved by bentonites from Wyoming and South Dakota that are presently on the market.

The addition of sodium carbonate in small amounts to the dried ground bentonite produces a material the properties of which show a considerable improvement. Intimate mixing and close control of the sodium carbonate would be necessary. Field testing of such a mixture is the only practicable method of evaluating its merits.

"T. H. Janes"

Engineer

Drilling Mud Test Results on Bentonite from Princeton, B. C., submitted by Mr. H. M. B. Inglis, Vancouver, and on Two Commercial Bentonites

Source of Sample	Swelling Property (in c.c. of gel)	Sand Content (% by vol)	Colloidally Suspended Material (% by wt)	% by wt of Bentonite in Suspension	pH of 5% Suspension	Viscosity in Centipoises	Gel Strength (in grams) Initial	Gel Strength (in grams) 10-Minute	Wall Building Properties (Standard A.P.I. 30-minute tests) Filtrate (in c.c.)	Wall Building Properties Cake Thickness (in ins.)	Yield (in bbl. of 15 c.p. drilling mud per ton of Bentonite)	Remarks
A. Knighton lease Princeton B.C.	15	0.90	69.2	5	8.5	3.2	3.0	5.0	16.0	2/64	63.1	Only a moderately swelling bentonite but is the best yet received from the Princeton area
				6		5.0	3.0	5.5	13.5	2/64		
				7		7.0	3.0	7.0	12.5	3/64		
				8		14.5	3.0	9.0	11.0	3/64		
				9		21.8	3.0	15.0	10.5	3/64		
				10		53.0+	8.0	28.0	-	-		
Commercial Bentonite No.1	40	0.5	94.5	2	9.0	under 1	3.0	4.0	32	3/64	126.5	A very high swelling bentonite - the highest yet checked in the laboratory by the writer
				3		4.2	4.0	12.0	29	3/64		
				4		11.3	13.0	23.0	21	3/64		
				5		23.8	40.0	45.0	16	4/64		
				6		37.5	62.0	80.0	16	5/64		
Commercial Bentonite No.2	34	0.6	97.7	3	8.0	4.2	2	3	28	2/64	100.3	This represents a good swelling bentonite with properties and yield satisfactory
				4		7.0	2	6	22	3/64		
				5		9.7	8	14	20	3/64		
				6		21.5	16	33	18	5/64		
				7		37.0	42	66	16	7/64		

Drilling Mud Test Results on Bentonite from Princeton, B. C., in a 7% suspension on Using Soda as an Additive to Improve the Quality

% by wt. of Bentonite in Suspension	Amount of Na_2CO_3 added (0.5% of Bent.)	pH	Viscosities in Centipoises Initial	After 24 hr	After 48 hr	After 72 hr	Gel Strength after Initial Viscosities Initial Gel	10-minute Gel	Wall Building Properties after Initial Vis. Filtrate	Wall Thickness	Average of Viscosities	Remarks
& 7	0	10	7.0	-	-	-	3.0 gm	7.0 gm	12.5 cc	3/64 in.	7.0 cp	See text of report
7	1		15.6	17.2	16.4	17.2	12.0 gm	35.0 gm	13.0 cc	3/64 in.	16.6 cp	
7	2		19.5	18.2	17.8	19.5	23.0 gm	36.0 gm	13.5 cc	4/64 in.	18.7 cp	
7	3		27.0	22.6	22.8	27.2	33.0 gm	55.0 gm	11.0 cc	5/64 in.	24.9 cp	
7	4		27.2	30.5	24.5	28.0	55.0 gm	75.0 gm	11.0 cc	5/64 in.	27.5 cp	

"T. H. Janes"

COPY

Physical Metallurgy Division

568 Booth Street,
Ottawa, Ontario
December 10, 1954

P. M. Test Report No. 9970

Re: Foundry Suitability of a Sample of Bentonite from Vicinity of Princeton, B. C.

To: Industrial Minerals Division, 40 Lydia Street, Ottawa, Ontario
Attn: Mr. T. H. Janes, Engineer

- -

Introduction:

On December 1, 1954, a sample of bentonite was received from Industrial Minerals Division of the Mines Branch, Department of Mines and Technical Surveys, for test to determine if it was suitable for use on a foundry bonding clay.

Method of Testing:

Equipment and procedures recommended by the American Foundrymen's Society (Foundry Sand Testing Handbook, 1952 edition, AFS) were used in testing the clay. The clay was tested by using it to bond a New Jersey silicon sand of the following screen distribution:

U.S. Screen No.	Per Cent Reatined
30	0.2
40	3.3
50	14.6
70	37.8
100	38.2
140	5.5
200	0.3
270	trace
pan	trace
AFS Clay	0.0
AFS Fineness No.	58

Mixture Used:

3000 gm New Jersey silica sand
195 gm bentonite (sand: clay ratio 100:6.5)

moisture to give 3.5 percent

mulled 1 minute dry, 5 minutes wet in a laboratory sand muller

Test Results:

(Results of tests on a Wyoming bentonite are included for comparison)

	Princeton Bentonite	Wyoming Bentonite
Green compressive strength, psi	6.4	7.0
Green deformation in./in.	0.021	0.022
Green tensile strehgth, oz./in.^{2}	13.1	24.8
Dry compressive strength, psi	7.4	82

Properties after heating the mixture to 900°F in a furnace at 1100°F, and remulling the sand:

	Princeton Bentonite	Wyoming Bentonite
Green compressive strength, psi	6.5	6.6
Green deformation, in./in.	0.020	0.021
Green tensile strength, oz./in^2	11.7	20.0
Dry compressive strength, psi	38	52

Conclusion:

The sample of clay from the Princeton district has similar properties as a foundry bonding clay to those of the Wyoming bentonites. The chief difference between these clays is that slightly larger quantity of the Princeton clay would be required to produce similar sand mixtures.

(signed) "A. E. Murton"