OTTAWA August 17, 1945.

REPORT

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1917.

Laboratory Separation of Alberta Bituminous Sands, Using Cold Water Medium.

Note:
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Bureau of Mines
Division of Metallic
Minerals

Physical Metallurgy
Research Laboratories

CANADA
DEPARTMENT
OF
MINES AND RESOURCES

Mines and Geology Branch

OTTAWA August 17, 1945.

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Investigation No. 1917.

Laboratory Separation of Alberta Bituminous Sands, Using Cold Water Medium.

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Shipments:

On March 29, 1945, and succeeding dates, a number of samples, 3 to 4 pounds each, of Northern Alberta bituminous sands, and also samples of the barren clay, were received from the Fuels Research Laboratories of this Department. These samples were sections of drill cores received from the Abasand Field in 1944 and 1945.

Location of the Properties:

The bituminous sand deposits are situated within 40 miles of the Northern Alberta railway terminus at Waterways (Fort McMurray), 300 miles north of Edmonton. They are mostly in areas along the Athabaska river and its tributaries. The samples chosen for the present test work were from the Steepbank area.

Characteristics of the Samples:

The bituminous sand samples used in this investigation assayed from 12 to 18 per cent bitumen and consisted entirely of the bituminous sand without any appreciable amount of clay content. The clay samples were selected from the core boxes and were barren of bitumen.

Purpose of the Investigation:

Recent progress reports from Abasand Oils Limited have outlined briefly a separation method according to which the diluent oil is added before the primary separation. It is then possible to carry out the separation with water at a temperature of about 25° C. The purpose of the present work was to investigate the method in so far as is possible with simple laboratory equipment and, especially, to determine the recovery of bitumen and loss of diluent. In addition, a number of tests were made in which 10, 20, and 30 per cent of the weight of the bituminous sands was added to the charge in the form of barren clay, the purpose of such tests being to determine whether the addition of the clay would permit a separation that would give results comparable with those obtained from the bituminous sand alone.

Investigative Work:

Development of a quantitative test procedure presented numerous difficulties, chief of which was the adherence

(Investigative Work, cont'd) -

of bitumen to the laboratory apparatus.

In the <u>grinding</u> it was found that flint pebbles gave the best results. <u>Flotation</u>, as conducted in the Denver Sub-A and Fagergren machines, was not successful. <u>Agitation</u> of the ground pulp in a Wallace agitator, followed by settling and decantation, did not give a method for ascertaining the amount of the diluent losses and the recovery of bitumen.

In addition to the above, a number of small-scale tests were made on the sand in which grinding in a mortar, agitation, and settling in graduated glass cylinders were tried. These tests were followed by larger-scale tests on 500-gram samples, giving a laboratory method which consisted of grinding the sand together with water, coal oil and reagent, transferring the pulp to a large graduated glass cylinder, agitating in a Wallace agitator, settling, and reading the amount of buoyant froth rising to the surface. The froth was analysed. This method was adopted as standard for the ensuing test work. All tests were made at a temperature of about 25° C. By this method, results were obtained on the bituminous sand in which the recovery of the diluent and bitumen averaged 94.9 per cent. In the later tests, in which from 10 to 30 per cent of the weight of the bituminous sand was added to the charge in the form of clay, recoveries in the neighbourhood of 90 per cent were obtained.

<u>DETAILS OF THE TEST WORK:</u>

<u>Grinding</u> -

The sand was first ground, with the requisite amount of diluent, water, clay and reagent, in a jar mill, using iron balls. This method was not successful owing to the bitumen's persistent adhesion to the balls and the consequent difficulty in transferring the pulp. Flint pebbles were then substituted

(Grinding, cont'd) -

for the iron balls and it was found that the bitumen could be readily washed out and no trouble was had in transferring the ground pulp.

Screen tests on the different grinds were as follows:

Mesh	BITUMINOUS SAND	CLAY	BITUMINOUS SAND AND CLAY 10 per cent clay	20 per cent clay	30 per cent clay
	- Weight, Per Cent -				
+65	17.4	10.2	2.3	3.1	6.2
-65 +100	46.8	5.1	14.3	21.6	25.2
-100 +150	32.9	3.2	44.9	41.9	37.8
-150 +200	2.7	2.3	17.2	15.0	14.0
-200	0.3	79.4	20.7	17.1	16.2

Flotation -

Flotation procedures were then attempted, using Denver Sub-A and Fagergren machines. These operations were not successful owing to the comparatively large amount of silica reporting in the bitumen concentrate even after repeated cleanings.

Desliming -

A desliming operation was then made on the pulp from the pebble mill grind, using a laboratory desliming cone. This test was fairly successful, the sand remaining after the departure of the bitumen being quite free from occluded bitumen and the bitumen overflow showing few quartz particles under the microscope. Unfortunately, a large amount of water overflowed with the oil. In a subsequent separation of this bitumen and water by means of a separatory funnel, it was not found possible to obtain a full recovery of the bitumen, owing to its adherence to the glass container.

Agitation -

Agitation of the pulp in a Wallace agitator for 15 minutes was followed by settling for one hour. The major

(Agitation, cont'd) -

portion of the froth rose to the surface and was drawn off by suction. The same difficulty arose as in the previous test in the final separation of the accompanying water and bitumen.

SMALL-SCALE TESTS.

In the small-scale tests a centrifuge apparatus was used as follows: Five grams of the bituminous sand was ground in an agate mortar, together with requisite amounts of coal oil, water and alkaline reagent. The pulp was then transferred to a centrifuge container and rotated rapidly for 10 minutes. Approximately 25 per cent of the bitumen remained in the sand at the bottom of the container.

Small-Scale Tests Nos. 1 to 7.

Small-Scale Tests Nos. 1 to 7 were made as follows: Ten grams of the bituminous sand was ground in a porcelain mortar together with the proper amounts of water, coal oil and alkaline reagent. The pulp was then transferred to a stoppered, graduated 100 c.c. glass cylinder, shaken strongly for 10 minutes, and allowed to settle for 30 minutes. The amount of buoyant froth or bitumen rising to the top of the cylinder and the amount of settled sand at the bottom were then read in centimetres. In all these tests 10 grams of tar sand, 2 c.c. of water, 1.5 c.c. of coal oil, and the amount of reagent as noted, were used in the grind. The pulp was then transferred to the graduated cylinder by using distilled water. Some results of these tests are shown in Table I below:

(Continued on next page)

(Small-Scale Tests, cont'd) -

TABLE I.

Test No.	Reagent added, lb./ton	Readings, in cu. centimetres Froth	Water	Sand	Remarks
1	1 lb. soda ash	7.0	76.0	7.0	Fairly clean sand.
2	1 " lime	5.0	75.0	10.0	Bitumen in sand.
3	1 " caustic starch	6.5	75.5	8.0	Fairly clean sand.
4	1 " NaoH	6.5	76.0	7.5	Clean sand.
5	1 " Na_2SiO_3	5.0	76.5	8.5	Clean sand.
6	1 " lime 1 " soda ash	6.5	75.0	8.5	Bitumen in sand.
7	1 " alum	3.0	75.0	10.0	Dirty sand.

Small-Scale Tests Nos. 8, 9 and 10.

Fifty grams of the tar sand was ground in a mortar with 11 c.c. of water, 8 c.c. of coal oil, and the amount of alkaline reagent as noted. The pulp was then transferred by distilled water to a 500 c.c. stoppered, graduated glass cylinder, shaken for 10 minutes, and allowed to settle for 30 minutes. Table II shows the results.

TABLE II.

Test No.	Reagent added, lb./ton	Readings, in cu. centimetres, Froth	Water	Sand	Remarks
8	1 lb. Na_2SiO_3	23.0	352.0	35.0	Fairly clean sand.
9	1 " $NaCO_3$	20.0	345.0	35.0	" " "
10	1 " alum	7.0	347.0	40.0	Little oil floats.

LABORATORY TEST METHOD.

Finally, after a perusal of the results obtained from the test work up to that point, the laboratory method given below was adopted. This operation should give the amount of bitumen, diluent, water and sand reporting to the surface as froth, the amount of bitumen in the intermediate water, and the amount of bitumen remaining in the settled sand.

500 grams of bituminous sand is weighed and transferred to a jar mill containing 3,200 grams of flint pebbles. A volume of kerosene equal to the volume of bitumen in the

(Laboratory Test Method, cont'd) -

sand is added. The weight of bitumen in the sand was determined by a previous assay and the volume was calculated, assuming pure bitumen to have a specific gravity of 1.0. A volume of distilled water twice as great as the volume of bitumen in the sand is then added to the mill together with a small amount, equivalent to one or two pounds per ton, of an alkaline reagent such as sodium silicate, soda ash or caustic soda. This charge is ground for twenty minutes and then transferred, by rinsing with distilled water, to a graduated glass cylinder 19 c.m. high by 12 c.m. in diameter. In order to prevent the adherence of the bitumen, the cylinder had previously been wiped with a 1 per cent solution of sodium silicate. The pulp is stirred in the cylinder, by means of a Wallace agitator, for 15 minutes. After settling for one hour, the depth of the layer of bitumen that has risen to the top of the cylinder is read, in centimetres. This bitumen layer is then removed by suction, directly into a sample bottle. Stirring and settling are repeated for a second and a third operation and the buoyant bitumen is measured on each occasion. The intermediate water is removed by suction, leaving the settled sand to be removed and sampled. The buoyant bitumen or froth is analysed for water and ash. The intermediate water is analysed for solids and hydrogen ion concentration (pH). The sand tailing is analysed for bitumen after evaporation of the occluded water.

The results of nine tests, using this procedure, on samples containing about 16 per cent bitumen are given below. Following these will be the results of 27 tests in which various amounts of clay were included in the grinding charge. The bituminous sand and clay used for these tests were selected from the unused portions of drill core samples from the Steepbank area that had already been assayed.

(Continued on next page)

(Laboratory Test Method, cont'd) -

Tests Nos. 11 to 46, Laboratory Method.

Tests Nos. 11 to 19 follow the standard procedure as given above.

All tests were conducted at a temperature of 25° C. 500 grams of the bituminous sand was ground in a pebble mill for 20 minutes, together with coal oil in an amount equal to the bitumen in the sample, distilled water in an amount equal to double the amount of bitumen in the sample, and reagents in the amounts as noted. Three agitations in the Wallace agitator were given in each test.

In Tests Nos. 20 to 46, varying amounts of clay were added to the charge to the pebble mill.

(Tables III to VI)
(follow, on Pages)
(9 to 12. Text)
(resumes on Page 13.)

TABLE III. - Results of Tests Nos. 11 to 19.

Test No.	Bitumen content, per cent	Reagent added, lb/ton feed	Buoyant bitumen, cm.	Volume buoyant bitumen, c.c.	Analyses, per cent: BUOYANT BITUMEN: Ash	Analyses, per cent: BUOYANT BITUMEN: Water	Analyses, per cent: INTERMEDIATE WATER: Solids	Analyses, per cent: INTERMEDIATE WATER: (pH)	Analyses, per cent: SAND: Bitumen	Bitumen losses, per cent: Int. H_2O	Bitumen losses, per cent: Sand	Bitumen losses, per cent: Handling	Bitumen recovery, per cent	Diluent loss, per cent
11	17.1	1.0 $NaSiO_3$	2.30	264.5	2.8	38.8	1.20	9.0	0.20	0.6	1.2	2.9	95.3	3.2
12*	17.1	1.0 $NaSiO_3$	2.25	258.7	5.6	42.0	1.10	9.3	1.00	0.6	5.8	2.9	90.7	11.8
13	16.9	1.5 $NaSiO_3$	2.00	230.0	4.2	22.8	0.92	9.5	0.30	0.5	1.8	3.0	94.7	-- **
14	16.9	1.0 $NaCO_3$	2.25	258.7	2.7	38.8	1.50	9.4	0.20	0.8	1.2	3.0	95.0	4.7
15*	16.9	1.0 $NaCO_3$	2.20	253.0	2.1	40.0	1.27	9.7	0.40	0.7	2.4	3.0	93.9	5.6
16	15.9	1.5 $NaCO_3$	2.05	235.7	2.5	34.4	1.00	10.4	0.10	0.6	0.6	3.1	95.7	0.7
17	15.6	1.0 NaOH	1.70	195.5	2.0	21.6	1.12	10.5	0.10	0.6	0.6	3.2	95.6	0.5
18*	15.6	1.0 NaOH	1.65	189.7	2.1	24.0	1.00	11.0	0.60	0.6	3.8	3.2	92.6	6.3
19	15.9	1.5 NaOH	1.60	184.0	1.7	21.6	0.90	11.5	0.50	0.5	3.2	3.1	93.2	8.1

* 15-minute grind. ** Error in sampling or analysis indicated.

Note: A composite sample of the solids contained in the intermediate waters assayed 3.05 per cent bitumen.

TABLE IV. - Results of Tests Nos. 20 to 28.

Charge to Pebble Mill: 500 grams bituminous sand; 50 grams clay; coal oil, water and reagents as in Tests Nos. 11 to 19.

Test No.	Bitumen content, per cent	Reagent added, lb./ton feed	Buoyant bitumen, cm.	Volume buoyant bitumen, c.c.	Analyses, per cent: BUOYANT BITUMEN: Ash	Water	INTERMEDIATE WATER: Solids	(pH)	SAND: Bitumen	Bitumen losses, per cent: Int. H_2O	Sand	Handling	Bitumen recovery, per cent	Diluent loss, per cent
20	15.0	1.0 $NaSiO_3$	2.28	262.2	5.60	62.0	2.45	8.9	3.20	1.7	10.4	3.3	84.6	35.2+
21	14.6	1.0 $NaCO_3$	2.25	258.7	2.56	50.0	2.45	9.3	0.20	1.8	1.4	3.4	93.4	8.4
22	14.6	1.0 NaOH	2.15	247.2	2.56	45.0	2.60	10.7	0.10	2.0	0.4	3.4	94.2	4.1
23	15.6	1.5 $NaSiO_3$	2.05	235.7	2.90	42.0	2.10	9.2	0.90	1.5	5.7	3.2	89.6	10.8
24	15.7	1.5 $NaCO_3$	2.35	270.2	1.37	51.3	1.80	10.2	0.50	1.3	3.1	3.2	92.4	12.5
25	15.7	1.5 NaOH	1.85	212.7	2.69	32.7	2.10	11.6	0.60	1.5	3.8	3.2	91.5	7.2
26	15.1	2.0 $NaSiO_3$	1.65	189.7	4.75	34.0	2.10	10.4	3.7	1.5	24.5	3.3	70.7	16.4
27	15.1	2.0 $NaCO_3$	1.80	207.0	1.11	30.6	1.80	10.8	0.8	1.3	5.3	3.3	90.1	2.5
28	15.1	2.0 NaOH	1.95	224.2	0.80	36.8	2.10	11.5	0.2	1.5	1.3	3.3	93.9	2.5

+ Checked.

Note: A composite sample of the solids contained in the intermediate water assayed 3.70 per cent bitumen.

TABLE V. - Results of Tests Nos. 29 to 37.

Charge to Pebble Mill: 500 grams bituminous sand; 100 grams clay; coal oil. water and reagents as in previous tests.

Test No.	Bitumen content, per cent	Reagent added, lb/ton feed	Buoyant bitumen, cm.	Volume buoyant bitumen, c.c.	Analyses, per cent: BUOYNNT BITUMEN: Ash	Water	INTERMEDIATE WATER: Solids	(pH)	SAND: Bitumen	Bitumen losses, per cent: Int. H_2O	Sand	Handling	Bitumen Recovery, per cent	Diluent loss, per cent
29	15.3	1.0 $NaSiO_3$	2.00	229.9	4.32	46.0	3.70	9.6	1.6	1.9	10.4	3.2	84.5	17.9
30	15.3	1.0 $NaCO_3$	1.95	224.2	4.35	34.8	4.50	9.9	1.0	2.3	6.5	3.2	88.0	3.3
31	15.3	1.0 NaOH	2.35	270.2	1.68	47.5	4.70	10.7	0.6	2.3	3.9	3.2	90.6	3.7
32	15.3	1.5 $NaSiO_3$	1.80	207.0	2.73	39.0	4.80	9.9	1.4	2.5	9.2	3.2	85.1	13.3
33	15.3	1.5 $NaCO_3$	1.95	224.2	2.16	26.7	5.20	10.9	1.0	2.7	6.5	3.2	87.6	5.1
34	15.8	1.5 NaOH	2.10	241.5	1.25	43.0	4.30	11.1	0.5	2.2	3.2	3.1	91.5	9.8
35	15.3	2.0 $NaSiO_3$	2.25	258.7	4.70	53.1	4.00	9.9	1.6	2.1	10.4	3.2	84.3	18.9
36	16.3	2.0 $NaCO_3$	2.10	241.5	4.13	42.2	4.00	10.4	0.7	1.9	4.3	3.0	90.8	12.7
37	16.3	2.0 NaOH	2.00	230.0	1.75	38.9	4.20	11.3	0.3	2.0	1.9	3.0	93.1	11.2

A composite sample of the solids contained in the intermediate water assayed 2.65 per cent bitumen.

TABLE VI. - Results of Tests Nos. 38 to 46.

Charge to Pebble Mill: 500 grams bituminous sand; 150 grams clay; coal oil, water and reagents as in previous tests.

Test No.	Bitumen Content, per cent	Reagent added lb/ton feed	Buoyant bitumen, cm.	Volume buoyant bitumen, c.c.	Analyses, per cent: BUOYANT BITUMEN Ash	BUOYANT BITUMEN Water	INTERMEDIATE WATER Solids	INTERMEDIATE WATER (pH)	SAND Bitumen	Bitumen losses, per cent: Int. H_2O	Sand	Handling	Bitumen Recovery, per cent	Diluent loss, per cent
38	16.3	1.0 $NaSiO_3$	1.90	218.5	2.35	31.9	5.65	10.0	0.20	2.9	1.2	3.1	92.8	6.9
39	16.3	1.0 $NaCO_3$	2.00	230.0	3.40	31.9	5.80	10.3	0.30	3.0	1.8	3.1	92.4	2.5
40	16.3	1.0 MaOH	2.05	235.7	2.20	36.0	5.10	11.0	0.90	2.7	5.5	3.1	88.7	5.1
41	16.3	1.5 $NaSiO_3$	1.95	224.2	4.05	36.5	5.20	10.2	0.70	2.7	4.3	3.1	89.9	11.4
42	16.3	1.5 $NaCO_3$	2.05	235.7	2.20	33.3	6.20	10.3	0.30	3.2	1.8	3.1	91.9	1.4
43	16.3	1.5 NaOH	2.00	230.0	1.80	32.7	6.80	11.5	0.30	3.5	1.8	3.1	91.6	2.7
44	16.3	2.0 $NaSiO_3$	1.80	207.0	3.60	27.1	6.50	9.9	0.90	3.4	5.5	3.1	88.0	6.6
45	16.4	2.0 $NaCO_3$	2.00	230.0	2.23	31.2	5.90	10.3	0.40	3.1	2.4	3.1	91.4	1.6
46	15.3	2.0 NaOH	2.30	264.4	1.30	46.7	5.50	11.4	0.30	2.9	1.9	3.3	91.9	4.3

A composite sample of the solids contained in the intermediate water assayed 2.80 per cent bitumen.

Classifications and Calculations Used in Tests Nos. 11 to 46.

The initial bitumen content of the sample used was supplied by the Fuels Research Laboratories when the sample was submitted. The alkaline reagent added to the grind was in the form of a 1 per cent solution.

The buoyant bitumen is measured in centimetres after each stirring of the pulp in the Wallace agitator and subsequent settling. The resultant volume is obtained by multiplying this result by Πr^2. The chemical analysis followed standard procedure.

In the bitumen losses the amount of loss in the sand or tailing is from the chemical analysis; the loss in the intermediate water was figured from a composite sample of the solids; the handling loss is necessarily approximate and was the average of several trial runs. It was taken as 0.50 per cent of the initial bitumen content of the sample.

The diluent loss is calculated as follows, taking Test No. 12 as an example. The following assumptions were made: Specific gravity of pure bitumen, 1.0; specific gravity of diluent (coal oil), 0.8; specific gravity of sand, 2.8.

Test No. 12:

Analysis: Bitumen content of feed, 17.1 per cent bitumen; the buoyant bitumen or froth assayed 5.6 per cent ash and 42.0 per cent water.

Basis: 100 grams of buoyant bitumen in crude state.

	C.c.	Grams
Sample		100.0
Water	42.0	42.0
Total oil and sand		58.0
Sand	1.2	3.3
Total oil	60.7	54.7
	103.9	100.0

(Continued on next page)

(Classifications and Calculations Used
in Tests Nos. 11 to 46, cont'd) -

103.9 c.c. yields 54.7 grams total oil

258.7 c.c. yields $\frac{258.7}{103.9} \times 54.7 = 136$ grams.

(where 258.7 is the volume of buoyant bitumen)

Recovery $= \frac{136}{154} = 88.2$ grams

(where 154 is the combined amount of bitumen and coal oil in the feed).

Therefore, diluent loss = 11.8 per cent

The bitumen recovery in Test No. 12 is figured as follows:

		Bitumen, per cent
Bitumen content of the bituminous sand,		17.1
Analysis		
(1) Sand (tailing)	-	0.20
(2) Intermediate water (composite sample)		3.05
(3) Handling loss	-	0.50

(1) $\frac{0.20}{17.1} = 1.2$ per cent

(2) $\frac{0.50}{17.1} = 2.9$ per cent

(3) 1500 c.c. of intermediate water assaying 1.1 per cent solids and 3.05 per cent bitumen.

$\frac{(1500 \times 1.1) \times 3.05}{(17.1 \times 5)} = 0.6$ per cent.

$1.2 + 2.9 + 0.6 = 4.7$ per cent.

$100 - 4.7 = 95.3$ per cent, bitumen recovery.

The distinctive results obtained from the use of the three reagents, sodium silicate, soda ash and caustic soda, are interesting. These results, when broken down, give the following figures:

(Continued on next page)

(Classifications and Calculations Used in Tests Nos. 11 to 46, cont'd) -

On the Clean Bituminous Sand (Tests Nos. 11 to 19).

Reagent	Bitumen Recovery, per cent	Diluent Loss, per cent
Sodium silicate:	93.1	5.0
Soda ash	94.9	3.7
Caustic soda	93.8	4.9

Bituminous Sand plus 10 Per Cent Clay (Tests Nos. 20 to 28).

Reagent	Bitumen Recovery, per cent	Diluent Loss, per cent
Sodium silicate	81.6	20.8
Soda ash	91.0	7.8
Caustic soda	93.2	4.6

Bituminous Sand plus 20 Per Cent Clay (Tests Nos. 29 to 37).

Reagent	Bitumen Recovery, per cent	Diluent Loss, per cent
Sodium silicate	84.6	16.7
Soda ash	88.8	7.0
Caustic soda	91.7	8.2

Bituminous Sand plus 30 Per Cent Clay (Tests Nos. 38 to 46).

Reagent	Bitumen Recovery, per cent	Diluent Loss, per cent
Sodium silicate	90.2	8.3
Soda ash	91.9	1.8
Caustic soda	90.7	4.0

From the foregoing results it is apparent that while the use of sodium silicate is effective on the clean bituminous sand, either soda ash or caustic soda is preferable when clay is added to the charge.

An averaging of the results obtained on Tests Nos. 20 to 46, where clay is added to the charge, shows:

(Continued on next page)

(Classifications and Calculations Used in Tests Nos. 11 to 46, cont'd) -

Reagent	Bitumen Recovery, per cent	Diluent Loss, per cent
Sodium silicate	85.5	15.3
Soda ash	90.6	5.5
Caustic soda	91.8	5.6

A résumé of the amounts of ash and water contained in the recovered bitumen and the bitumen losses in the tailings is as follows:

On the Clean Bituminous Sand (Tests Nos. 11 to 19).

Reagent	Ash, per cent	Water, per cent	Bitumen Losses, per cent
Sodium silicate	4.2	34.5	2.9
Soda ash	2.4	37.7	1.4
Caustic soda	1.9	22.4	2.5

On the Bituminous Sand plus Clay (Tests Nos. 20 to 46).

Reagent	Ash, per cent	Water, per cent	Bitumen Losses, per cent
Sodium silicate	3.9	41.3	9.1
Soda ash	2.6	36.9	3.7
Caustic soda	1.8	39.9	2.6

From the above figures it is apparent that when the feed contains appreciable amounts of clay, either soda ash or caustic soda should be used as the reagent, in preference to sodium silicate. The cleanest-cut separation was obtained by the use of caustic soda.

The alkalinity of the solution is important, and it appears, from the results obtained, that a pH of 10.0 will give the best results. A sample of the clay was taken and ground in distilled water and the resulting solution gave a pH of 8.0. Also, a test was run on the bituminous sand in which no alkaline reagent was added to the grind. A very imperfect separation of the bitumen resulted, about 25 per cent remaining in the tailing.

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SUMMARY AND CONCLUSIONS:

In the preliminary work on these bituminous sands, numerous methods of treating the sand on a laboratory scale were attempted. These procedures involved grinding, flotation, desliming, agitation, centrifuging and settling, and are given in some detail in the body of this report. The method finally adopted after these preliminary investigations is given on Pages 6 to 8. By this procedure the recovery of the bitumen can be calculated and also the loss of diluent entailed in the operation. The aim of this laboratory method is to give results comparable with those obtained at the pilot-mill operations presently in vogue at Abasand. All the separations were made at temperatures of approximately 25° C.

Four series of tests were made: In Tests Nos. 11 to 19, clean bituminous sand was used; in Tests Nos. 20 to 28, 10 per cent of the weight of the bituminous sand was added as clay; in Tests Nos. 29 to 37, 20 per cent of the weight; and in Tests Nos. 38 to 46, 30 per cent of the weight. Sodium silicate, soda ash and caustic soda were used as reagents in these tests.

The average results obtained were as follows:

In the Clean Bituminous Sand -

Reagent	Bitumen Recovery, per cent	Diluent Loss, per cent
Sodium silicate	93.1	5.0
Soda ash	94.8	3.7
Caustic soda	93.8	4.9

In the Bituminous Sand Plus 10 to 30 Per Cent Clay -

Reagent	Bitumen Recovery, per cent	Diluent Loss, per cent
Sodium silicate	85.5	15.3
Soda ash	90.6	5.5
Caustic soda	91.8	5.6

(Continued on next page)

(Summary and Conclusions, cont'd) -

Lower ash and water contents of the recovered bitumen were also obtained in nearly all cases where caustic soda or soda ash were used in place of sodium silicate.

In the clean bituminous sand, without any clay in the feed, the bitumen recovery was 93 per cent and the diluent loss 6 per cent. In these tests there appeared to be little difference in the results obtained from the use of the three reagents.

These laboratory tests show that up to 30 per cent of the bituminous sand content can be added to the feed as clay, with bitumen recovery of about 90 per cent and diluent loss of 6 per cent. The tests also show that the use of either caustic soda or soda ash is preferable to sodium silicate in order to ensure these results. Generally speaking, the use of caustic soda is preferable because of the higher alkalinity obtained upon the addition of smaller quantities of the reagent.

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