CONTENTS ENVELOPE 1600

TENEMENT: Not Related

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PLAN: Table 6 - Specification on Properties of Clays 1600-1

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RESEARCH FOR INDUSTRY

THE AUSTRALIAN MINERAL DEVELOPMENT LABORATORIES

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Please address all Correspondence to the Director.

Our reference: CE 1/1/105

Your reference:

4th December, 1967

The Director,
Department of Mines,
Government Offices,
169, Rundle Street,
ADELAIDE.

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12 DEC 1967
DEPT. OF MINES
ADELAIDE

PORCELAIN INVESTIGATION

PROGRESS REPORT NO. 1

For Period Ending 30th November, 1967

seen by LWP

Investigated by: Ceramics Section

Officer in Charge: D.C. Madigan

DC Madigan
for P.A. Young
Director.

1600

1. INTRODUCTION

The aim of this project is the investigation of the development from South Australian raw materials of porcelain for hotel china and electrical insulators. The work is to include the blending of raw materials selected in liaison with the Mines Department, mainly from clays shown to be suitable as the result of the Evaluation of Clays Project. Specimens will be prepared from the blends and fired for assessment.

2. RAW MATERIALS

The following ideal porcelain body has been taken as a starting point:

	%
Kaolinite	50
Potash felspar (orthoclase)	25
Quartz	25

If the constituents were pure this mixture would have the following composition:

	%
SiO_2	64.45
Al_2O_3	24.33
K_2O	4.22
H_2O	7.00

Since orthoclase contains only 18.3% of Al_2O_3, it is clear that the clay used must contain more than 25% of Al_2O_3. This condition is fulfilled by the following clays from those examined under the Evaluation of Clays Project:

Location	Clay Register No.
Pine Point	365
Salt Creek, near Cowell	179, 91
Sec. 739, Hd. Davenport, near Port Augusta	398
Sec. 12, Hd. Stokes	511
Sec. 60, Hd. Stokes	126
Sec. 90, Hd. Stokes	512
Cromer C	401
Sec. 6397, Hd. Talunga (Birdwood)	399
Sec. 1635, Hd. Talunga (Cromer)	400

Chemical analysis of the washed clays is shown in Table 1. Mineralogical analysis is shown in Table 2, and enables the clays to be classified in two groups. In the first group, or kaolins, kaolinite constitutes more than 90% of the clay minerals; in the second, or kaolin-illite group, illite amounts to more than 10% of the clay minerals, though kaolinite is the predominant mineral.

TABLE 1: CHEMICAL ANALYSIS OF WASHED CLAYS

	Pine Point	Cowell	Port Augusta	Hd. Stokes Sec. 12	Hd. Stokes Sec. 60	Hd. Stokes Sec. 90	Cromer C	Birdwood	Cromer
SiO_2	49.8	45.9	52.8	48.3	54.2	50.2	46.4	51.5	46.4
Al_2O_3	36.1	39.2	33.1	36.0	32.7	34.7	38.5	33.8	38.5
Fe_2O_3	0.34	0.75	0.18	0.80	1.05	0.42	0.26	0.14	0.06
FeO	0.11	0.05	0.14	$<$ 0.01	-	0.01	0.10	0.08	0.15
MgO	0.42	0.03	0.67	0.27	0.15	0.35	0.17	0.16	0.14
CaO	0.26	Nil	0.28	0.28	0.39	0.32	0.17	0.10	0.29
MnO	$<$ 0.01	-	$<$0.01	$<$0.01	-	$<$0.01	$<$0.01	$<$0.01	$<$0.01
Na_2O	0.11	0.16	0.31	0.31	0.03	0.31	0.12	0.07	0.07
K_2O	0.38	0.89	0.16	0.20	0.12	2.50	0.03	0.07	0.14
TiO_2	0.10	0.34	0.29	0.27	1.03	0.45	0.21	1.37	0.03
SO_3	0.03	0.02	0.25	0.16	-	0.13	0.28	0.17	0.34
Cl	0.11	0.56	0.33	0.19	-	0.21	0.13	0.05	0.03
CO_2	0.05	-	0.60	0.01	-	$<$0.01	$<$0.01	0.31	0.05
H_2O^+	12.2	12.7	10.8	13.4	11.1	10.5	13.6	12.4	13.6

TABLE 2: CLASSIFICATION OF CLAYS

	Kaolin-Illite Ratio	Quartz Content		Fired Colour	Plasticity
		Washed	Unwashed		
1. KAOLIN					
Cromer C	No illite	-	2	White	Low
Birdwood	do.	10	40	do.	do.
Cromer	100:1	-	4	"	Non-plastic
Pine Point	10:1	8	30	"	Low
Hd.Stokes,Sec.12	10:1	3	-	Off-white	do.
" " " 60	10:1	6	-	do.	"
2. KAOLIN-ILLITE					
Port Augusta	5:1	15	50	White	Medium
Cowell	2.5:1	4	30	do.	do.
Hd.Stokes,Sec.90	2:1	1	-	"	Low

The felspar used was water-ground felspar from Broken Hill, having the following analysis:

	%
SiO_2	64.6
Al_2O_3	18.5
K_2O	10.9
Na_2O	2.90
CaO	0.18
MgO	0.04
Total Fe as Fe_2O_3	0.13

This is equivalent to $(0.65K_2O;\ 0.26\ Na_2O).Al_2O_3.6\ SiO_2$, close to orthoclase $K_2O.Al_2O_3.6\ SiO_2$, with partial replacement of potassium by sodium. Orthoclase has the composition 64.8% SiO_2, 18.3% Al_2O_3, 16.9% K_2O.

The silica (quartz) used was obtained from Rodda and was marked 200 WQ. It gave the following analysis:

	%
SiO_2	99.7
Al_2O_3	0.12
Total Fe As Fe_2O_3	0.04

3. PORCELAIN BLENDS

The blends were formulated to approximate the composition of the ideal porcelain mentioned in Section 2. In this porcelain, 20% of the Al_2O_3 is derived from kaolin. Hence, if clay is to provide 20% of the Al_2O_3, the proportion of clay in the blend will be given by:

$$\%\ \text{clay in blend} = x = \frac{2000}{\%\ Al_2O_3\ \text{in clay}}$$

The quantity of felspar (assumed orthoclase) that must be added to give a K_2O content of 4.22 is then given by

$$\%\ \text{felspar in blend} = y = 5.92\left(4.22 - \left(\%\ K_2O\ \text{in clay} \times \frac{x}{100}\right)\right)$$

and the proportion of quartz is given by $100 - (x + y)$.

These calculations lead to the blends shown in Table 3, and the composition of the blends is shown in Table 4.

TABLE 3: PORCELAIN BLENDS

Clay	Clay %	Felspar %	Quartz %
Pine Point	55	24	21
Cowell	56	20	24
Port Augusta	60	24	16
Hd. Stokes, Sec. 12	56	24	20
" " " 60	61	25	14
" " " 90	58	16	26
Cromer C	52	25	23
Birdwood	59	25	16
Cromer	52	25	23

TABLE 4: COMPOSITION OF BLENDS, %

Clay	SiO_2	Al_2O_3	K_2O	Na_2O	$K_2O + Na_2O$ as K_2O
Pine Point	63.9	24.3	2.83	0.70	3.89
Cowell	62.6	25.6	2.68	0.58	3.56
Pt Augusta	63.2	24.3	2.72	0.70	3.78
Hd. Stokes, Sec. 12	62.5	24.6	2.72	0.70	3.79
" " " 60	63.3	24.5	2.80	0.73	3.91
" " " 90	65.4	23.1	3.19	0.46	3.89
Cromer C	63.3	24.6	2.75	0.73	3.86
Birdwood	62.6	24.5	2.77	0.73	3.88
Cromer	63.3	24.6	2.80	0.73	3.91

The dry ingredients were weighed out to give a batch of 2 kg, wet-ground in a porcelain ball mill to minus 200 mesh BSS, and filter-pressed at 40-50 psi. The moisture content of the pressed cakes was approximately 28%. The cakes were dried and pulverised.

4. PRESSING AND FIRING TESTS

The prepared powder was moistened, granulated by being passed through a 12 mesh screen, and pressed into 2 x 2 in. tiles of three thicknesses, ½, ¼ and 1/8 in. . Tiles were fired at 1100, 1200 and 1300°C with three hours' soaking.

Pressing. The Cromer C blend was difficult to press, and all the 1/8 in. tiles were badly plucked or laminated. There was slight expansion of the specimen on leaving the die. The Cromer blend was rather difficult to press: ejection was not smooth, and the 1/8 in. tiles were plucked or laminated. All the other blends pressed satisfactorily at the moisture content shown in Table 5.

Drying. Drying cracks appeared in the Cowell, Cromer C, Birdwood and Cromer blends. These may be associated with lamination during pressing. The drying shrinkage was zero for each blend.

Fired Properties. Firing shrinkage and 24-hour cold-water absorption are shown in Table 5. All the 1/8 in. tiles were distorted after firing. The darkest in colour was the Sec. 60 Hd. Stokes blend, which was a light buff at 1200°C. The next darkest was the Birdwood blend. The remaining blends were white or off-white. Specimens are submitted to show the fired colour. The Cowell blend showed a slightly mottled surface at 1200°C. This improved at 1300°C, but the surface still remained slightly irregular. The Sec. 60 Hd. Stokes blend also showed a slight mottle at 1200°C, but the surface was satisfactory at 1300.
The other blends all showed smooth surfaces.

5. DISCUSSION

All of the blends are mature at 1300°C, and all make porcelain that could find application in some type of ware. They may be divided into three categories.

1. Section 60, Hundred of Stokes. This blend matures in the range 1150-1200°C, and the firing range is rather short. The colour is somewhat dark. This blend would not make a high-grade porcelain, but would be suitable for floor tiles. For this purpose it might be improved by substitution of portion of the clay (say 20-25%) by a more plastic clay, such as a clay of the Hesso type. This would improve the workability and lower the maturing temperature.

2. Birdwood, Port Augusta and Pine Point. These blends mature in the range 1200-1250°C, and would be suitable for soft porcelain (hotel china and domestic ware). The ware would be bisque fired at about 1250°C and glost fired at a lower temperature. The Birdwood blend might cause some trouble with drying cracks. The Port Augusta blend is the best of the three, having the best colour and the lowest shrinkage at the higher temperatures. The plasticity of the blends could be improved and the firing temperature somewhat reduced by substitution of part of the clay by a more plastic white-firing clay, or the incorporation of a small quantity of bentonite (say 3-4%). A small addition of whiting might also be useful for lowering the firing temperature or improving the translucency.

3. Sections 12 and 90, Hundred of Stokes, Cromer, Cromer C and Cowell

These blends are nearer to the hard porcelain type, but could be used for dinner ware. The best in colour are Sec. 90, Hd. Stokes, Cromer and Cromer C. The Cromer, Cromer C and Cowell blends might give some difficulty with drying cracks. For high-grade insulators the Cowell and Cromer clays are likely to be the best. Since whiteness and translucency are not important in insulators, the blends could be made more workable by replacing part of the kaolin by more plastic clay (e.g. Crystal Brook, Booleroo, Hesso), and at the same time reducing the felspar and increasing the quartz content in order to maintain the firing temperature, and hence the mullite formation and consequent mechanical strength.

6. WORK IN HAND

Plaster moulds for slip casting are being prepared and specimens of soft porcelain will be cast. Glazing tests are being made on the soft porcelain bodies.

TABLE 5: FIRING TEST

Blend	Pressing Moisture %	Firing Temperature °C	Linear Firing Shrinkage, %	24-hour cold water absorption, %
Pine Point	9.0	1100	4.5	11.1
		1200	11.5	0.8
		1300	12.0	0.0
Cowell	9.5	1100	3.2	13.9
		1200	7.5	5.6
		1300	11.0	0.0
Pt Augusta	9.5	1100	6.2	8.6
		1200	10.0	0.6
		1300	11.0	0.0
Sec. 12, Hd. Stokes	9.0	1100	4.5	15.6
		1200	10.5	3.4
		1300	13.5	0.0
Sec. 60, Hd. Stokes	9.5	1100	8.7	10.4
		1200	13.5	0.0
		1300	13.8	0.0
Sec. 90, Hd. Stokes	9.5	1100	3.7	12.6
		1200	8.5	4.4
		1300	11.2	0.0
Cromer C	4.0	1100	6.2	11.5
		1200	8.0	4.0
		1300	15.0	0.0
Birdwood	8.5	1100	6.2	12.7
		1200	12.0	0.5
		1300	12.0	0.0
Cromer	6.0	1100	5.2	13.5
		1200	8.0	6.7
		1300	12.5	0.0

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CE 1/1/105

27th February, 1968

The Director,
Department of Mines,
Government Offices,
Rundle Street,
ADELAIDE.

REC
29 FEB 19
DEPT. OF MINES
ADELAIDE

PORCELAIN INVESTIGATION

PROGRESS REPORT NO. 2

Period Ending 31st January, 1968

Investigated by: Ceramics Section

Officer in Charge: D.C. Madigan

for P.A. Young
Director.

NOTED
Director of Mines

1600

Amount Authorised: $14,000

Amount Spent to 15/1/68: $5,602

1. REVIEW OF PROGRESS

1.1 Glazing Tests

Tile specimens pressed from the nine porcelain blends described in Progress Report No. 1 were biscuit fired and glost fired to test their suitability for glazing. The results were as follows:

Blend	Colour	Glost Firing Temperature, °C	Remarks
Pine Point	Pale blue	1140	Satisfactory
Cowell	" "	1140	Crazed
"	Black	1000	"
Port Augusta	Pale blue	1140	Satisfactory
Hd. Stokes, Sec.12	Black	1000	Slight crazing
" " " 60	Pale blue	1140	Satisfactory
" " " 90	Yellow	1140	"
Cromer C	"	1140	"
Birdwood	Black	1000	Slight crazing
Cromer	White	1070	Crazed
"	Black	1000	"

There was no peeling or crawling, and the results indicated that all blends could be satisfactorily glazed, though of course adjustment of the glaze to the body would be necessary to prevent crazing. Specimens of glazed tiles are submitted. It should be pointed out that no attempt was made to determine optimum glazing conditions, so that the specimens are a bit rough. They serve, however, to indicate the possibilities.

1.2 Casting

The porcelain blends described in Progress Report No. 1 were not suitable for casting. The slips had poor suspension, and the casts did not separate satisfactorily from the moulds. Another series of blends was therefore made up, designed for dinnerware. Some more plastic clay was incorporated with the object of increasing the shrinkage and hence improving release from the moulds. A small proportion of whiting was added in some blends. This is sometimes of assistance in reducing stickiness, and so also assisting release. The chemical and mineralogical analysis of the additional clays used is given in Table 1. These clays were samples received from the Department of Mines, and are numbers 363b(Hesso), 366a(Booleroo) and 368(Georgetown) in the National Clay Register. The bentonite used was Wyoming bentonite. The composition of the blends is shown in Table 2. The calculated chemical composition of the blends with respect to total silica, alumina and alkalis is shown in Table 3.

TABLE 1: ANALYSIS OF CLAYS

	Hesso	Booleroo	Georgetown
SiO_2	64.1	72.4	67.7
Al_2O_3	22.6	17.9	19.4
Fe_2O_3	0.45	0.51	0.60
FeO	0.15	0.05	0.09
MgO	0.67	0.37	1.91
CaO	0.07	0.09	0.14
MnO	$<$0.01	$<$0.01	$<$0.01
Na_2O	1.13	0.36	0.13
K_2O	1.38	1.00	4.05
TiO_2	0.84	0.68	0.79
SO_3	0.28	0.07	0.01
Cl	1.23	0.33	0.03
CO_2	0.36	0.42	0.22
H_2O^+	7.15	5.95	4.75
Kaolin	56	44	18
Illite	14	18	48
Quartz	30	37	31
Felspar	-	1	3

TABLE 2: COMPOSITION OF BLENDS (%)

	1	2	3	4	5	5a	6	7	8	8a	9
Clay											
Pine Point	48.5	47.1	-	-	-	-	-	-	-	-	-
Cowell	-	-	21.8	-	-	-	-	-	-	-	-
Port Augusta	-	-	-	30.0	-	-	-	-	-	-	-
Hd. Stokes, Sec. 90	-	-	33.7	-	-	-	-	-	-	-	-
Birdwood	-	-	-	29.5	-	-	44.0	17.3	-	-	-
Cromer	-	-	-	-	49.4	41.2	-	19.4	30.0	23.0	25.0
Hesso	5.4	5.2	-	-	4.0	3.3	-	1.6	-	-	-
Booleroo	-	-	-	-	-	16.7	10.0	3.9	20.0	35.0	25.0
Georgetown	-	-	-	-	-	-	-	19.6	-	-	-
Bentonite	-	2.9	2.9	-	1.0	0.8	1.0	0.8	2.0	2.0	-
Felspar	23.5	22.8	17.1	24.5	23.8	19.8	23.2	18.3	23.0	19.0	23.0
Quartz	20.6	20.0	24.5	16.0	21.8	18.2	21.8	17.1	23.0	19.0	22.0
Whiting	2.0	2.0	-	-	-	-	-	2.0	2.0	2.0	5.0

TABLE 3: CHEMICAL COMPOSITION OF BLENDS (%)

	1	2	3	4	5	5a	6	7	8	8a	9
SiO_2	63.5	63.7	63.8	64.5	63.5	64.8	67.5	64.4	67.6	68.6	66.6
Al_2O_3	23.0	23.1	24.6	24.4	24.5	23.5	21.2	21.8	19.8	19.1	18.4
K_2O + Na_2O	4.0	3.9	3.5	4.3	3.8	3.4	4.3	3.9	3.9	3.5	3.9

Comparison of this table with Table 4 in Progress Report No. 1 shows that the silica and alkalis tend to increase and the alumina to decrease with the incorporation of the more plastic clays. No. 9 is rather a stoneware than a porcelain body.

The blends were made into slips by ball-milling with water. The moisture content of the slips was 28%, except No. 6, 27%, and No. 7, 26%. The pint weight varied from 32.5 to 34 oz. The deflocculants used were Calgon, sodium silicate and Dispex, a proprietary deflocculant obtained from J. Beith and Co., 373, Francis Street, Footscray, Victoria. The quantities used, expressed as a percentage by weight of the dry matter in the slip, were:

Nos. 1, 2, 3	0.2 Calgon + 0.2 Dispex
No. 4	0.5 Dispex
Nos. 5, 5a, 6, 7	0.2 Calgon + 0.2 sodium silicate + 0.2 Dispex
Nos. 8, 8a, 9	0.5 Calgon + 0.5 sodium silicate

The casting behaviour of the blends was as follows:

No. 1	The slip had poor suspension, and the casts were very uneven
No. 2	Similar to No. 1, with the addition of bentonite. This improved the slip, but there was slight settling after 4 hours. The casts cracked severely in the mould.
No. 3	The slip was stable and cast well. The cast had high green strength.
No. 4	This was made by mixing equal parts of the Port Augusta and Birdwood blends described in Progress Report No. 1. The slip cast well, but the casts cracked on drying.
No. 5	The cast adhered to the mould and cracked.
No. 5a	Prepared from No. 5 by the addition of Booleroo clay. The slip was matured for 4 days, and remained stable, without settling. Casting was satisfactory, but the cast did not release from the mould.

No. 6 The slip cast well, but the cast adhered to the mould and there was no release after 24 hours.

No. 7 After ageing for 3 days, the slip cast well in 5 minutes, but the cast adhered to the mould. After maturing for a further four days, heavy and light casts were made, with reasonable results. The Georgetown clay appears to have improved the casting properties, and incorporation of this clay might improve the other blends.

No. 8 Slight wreathing occurred on casting. After maturing for 5 days the slip cast well, but adhered to the mould.

No. 8a. This was prepared from No. 8 by increasing the content of Booleroo clay. The slip was reground for 8 hours and aged for 10 days, after which it cast well. The cast had high green strength.

No. 9 After ageing for 10 days the slip cast well. The cast had high green strength.

Blends 3, 7, 8a and 9 were satisfactory for casting. Difficulties were experienced with the other blends, but these might be improved by the addition of a suitable ball clay, or by further work on deflocculation.

Only very small samples of most of the clays were available, so that enough casts could not be made for adequate firing and glazing tests to be made. What remained of the blends after the casting experiments was therefore combined to form a composite slip. This cast satisfactorily, and several shapes were bisque fired at 1240°C, with a 3-hour soak. This is not necessarily the optimum firing temperature, and a somewhat higher temperature might have been better. The shapes are forwarded with this report to indicate the character of this type of soft porcelain.

1.3 Hard Porcelain

The original Cromer blend (see Progress Report No. 1) was too short for turning and had a tendency to crack on drying. It was modified by the addition of the more plastic Booleroo clay as follows:

	%
Cromer clay	40
Booleroo	10
Felspar	23
Quartz	27

A batch of 100 kg of this mixture was milled in a porcelain ball mill for 16 hours, passed through a 200 mesh screen and filter-pressed at 75 psi. The filter cakes were extruded de-aired at 24.5% moisture. The blend extruded satisfactorily to give a smooth semi-plastic column. The extruded material dried well without cracking. The linear drying shrinkage was 5%. Some 1-inch diameter round bars fired at 1240°C are forwarded with this report to show the type of porcelain. The firing shrinkage was 8% (the distortion of these bars was due to handling after extrusion, not to drying or firing).

2. WORK IN HAND

Glazing tests will be made on the composite bisque-fired soft porcelain body. Further firing tests will be made on the hard porcelain body to determine the optimum firing temperature, and the properties of the fired ware will be examined. It is hoped to arrange for insulators to be turned from this body.

Further work on this project will depend on the supply of more clay samples.

CONYNGHAM ST. FREWVILLE SOUTH AUSTRALIA 5063 TELEPHONE 79 1662 TELEGRAMS 'AMDEL' ADELAIDE

1430/67

020

THE AUSTRALIAN MINERAL DEVELOPMENT LABORATORIES

PLEASE ADDRESS ALL CORRESPONDENCE TO THE DIRECTOR.

OUR REFERENCE: CE 1/1/105
YOUR REFERENCE:

7th May, 1968

The Director,
Department of Mines,
Government Offices,
Rundle Street,
ADELAIDE.

REC'D.
-9 MAY 1968
DEPT. OF MINES
ADELAIDE

PORCELAIN INVESTIGATION

PROGRESS REPORT NO. 3

Period Ending 30th April, 1968

Director of [illegible]

Investigated by: D.R. Jones

Officer in Charge, Ceramics Section: D.C. Madigan

P.A. Young
Director.

1600

Amount Authorized	$14,000
Amount Spent to 23/4/68	$8,570

1. REVIEW OF PROGRESS

1.1 Glazing Tests

Glazing tests on the composite bisque-fired soft porcelain body mentioned in Progress Report No. 2 were carried out satisfactorily, but were discontinued because of the inability to duplicate this body.

1.2 Hard Porcelain Blends

It was decided to concentrate for the period of this report on compounding a hard porcelain body suitable for the manufacture of high tension insulators.

From results to date it was decided to use Cromer clay as the basic body for future blends.

Some work has also been done with clay separated from Mt Crawford kaolinised sandstone because of the high quality of this material.

The feldspar used was Rodda's minus 200 mesh potash feldspar, and the ball clays were Booleroo and Woocalla.

It has become quite apparent that future blends must be more plastic and have greater green strength to facilitate turning and threading, as in the manufacture of insulators. To impart these properties the addition of more plastic clays and possibly some bentonite is necessary. The blends made up are shown in Table 1.

TABLE 1: COMPOSITION OF BLENDS (%)

	CE 3408	CE 3410	CE 3411	CE 3414	CE 3409	CE 3421	CE 3412	CE 3413
Clay								
Cromer	46.6	45.8	43.3	42.4				
Mt Crawford					48.2	47.4	44.9	44.1
Booleroo	11.6	11.3			12.0	11.7		
Woocalla			10.8	10.6			11.2	10.9
Bentonite		1.9		1.9		1.9		1.9
Feldspar	23.9	23.4	23.3	22.9	24.2	23.8	23.5	23.1
Quartz	17.9	17.6	22.6	22.2	15.6	15.2	20.4	20.0

The composition of these blends, for all practical purposes, falls within the chemical composition of a postulated ideal porcelain body of the following composition:

SiO_2	62-65%
Al_2O_3	23-25%
K_2O	4.2-4.3%

as shown in Table 2.

TABLE 2: CALCULATED CHEMICAL COMPOSITION OF BLENDS(%)

	CE 3408	CE 3410	CE 3411	CE 3414	CE 3409	CE 3421	CE 3412	CE 3413
SiO_2	63.6	63.3	63.3	63.2	63.9	62.6	63.1	62.1
Al_2O_3	24.4	24.3	24.2	24.1	22.3	25.6	24.2	24.3
$K_2O + Na_2O$	4.2	3.8	3.8	3.7	4.2	3.9	3.7	3.9

All blends were weighed out to make 500 gramme lots and milled in a porcelain ball mill for 16 hours. The slurries were passed through a 200 mesh screen and dried out on plaster slabs, then granulated through a 12 mesh screen in preparation for tile pressing.

Some of the material was formed into rough solid cylindrical shapes for turning tests.

1.3 Turning Tests

An effort was made to turn bodies CE3408 and CE3410 using a standard metal lathe, and although these bodies required a rather high moisture content to compensate for lack of green strength and plasticity, the results were rewarding.

1.4 Conclusions

Future bodies will require even more plastic material to increase the green strength so that moisture content can be lowered. Bodies made to date have all tended to be somewhat thixotropic and too short for turning threads.

2. WORK IN HAND

More blends are being made where the plastic clay content is being increased whilst still retaining the original chemical composition.

Pressing of 2-inch tiles made from the eight blends shown is being carried out, and these will be fired at 1250°C, 1300°C and 1350°C.

Further turning tests of bodies will be carried out to select satisfactory bodies for the manufacture of test insulators.

CONYNGHAM ST. FREWVILLE SOUTH AUSTRALIA 5063 TELEPHONE 79 1662 TELEGRAMS 'AMDEL' ADELAIDE

024

THE AUSTRALIAN MINERAL DEVELOPMENT LABORATORIES

PLEASE ADDRESS ALL CORRESPONDENCE TO THE DIRECTOR.

OUR REFERENCE: CE 1/1/105
YOUR REFERENCE:

18th June, 1968

The Director,
Department of Mines,
Government Offices,
Rundle Street,
ADELAIDE, 5000

REC'D.
20
DEPT. OF MINES
ADELAIDE

PORCELAIN INVESTIGATION

PROGRESS REPORT NO. 4

Period Ending 31st May, 1968

Investigation by: D.R. Jones.

Officer in Charge, Ceramics Section: D.C. Madigan.

DCMadigan
for P.A. Young
Director

16

Amount Authorized	$14,000
Amount Expended to 31st April, 1968	$10,236

1 REVIEW OF PROGRESS

1.1 Firing Test No. 1

Firing tests were carried out on the blends shown in Table 1 of Progress Report No. 3 and on the four blends shown in the Table in this report.

It was originally intended to fire all blends at 1250°C, 1300°C and 1350°C but the results obtained from the 1250°C firing, where the samples were subject to impingement of the kiln flames, were not considered satisfactory as over-vitrification was apparent and some specimens were stuck together.

1.2 Firing Test No. 2

To protect specimens from the direct blast of the flames, a sagger was constructed and the tiles were fired in the sagger to 1250°C.

This firing was more successful, however over-vitrification was again evident. The off-white colour of all specimens was quite acceptable.

It is considered the optimum firing range of all blends is between 1200°C and 1230°C. This is below the normal range for the manufacture of high grade porcelain.

TABLE: COMPOSITION OF BLENDS (%)

	CE 3414	CE 3421	CE 3424	CE 3425
Clay				
Cromer	42.4			
Mt. Crawford		47.2	40.4	35.7
Woocalla	10.6		16.3	22.3
Booleroo		11.8		
Bentonite	1.9	1.9		
Feldspar	23.0	23.9	19.7	20.2
Quartz	22.1	15.2	23.6	21.8

1.3 Workability of Bodies

The addition of larger quantities of clay of ball-clay type had to be approached carefully as these tend to destroy the desired properties of porcelain and turn them more towards high quality stoneware bodies. At the same time the very non-plastic nature of the available Kaolins needed the addition of the more plastic clays to impart some plasticity to the bodies to improve their workability and green strength.

This did not prove very successful, as the limit of addition of the plastic clays was reached without greatly benefitting the properties of the bodies. That is the maturing temperature of the bodies was reduced, though they still remained thixotropic and of low green strength.

1.4 Modulus of Rupture Test

One inch rods of Cromer clay were extruded de-aired and the modulus of rupture of 10 bars at 0% moisture content was ascertained. The average modulus of rupture of these 10 bars was 38 lbs/sq. inch. The ideal figure for a good porcelain Kaolin should be in the vicinity of 350 lbs/sq. inch. It is significant to note that green strength of a clay increases with its plasticity.

2 WORK IN HAND

In the absence of Kaolin type clays with any reasonable degree of plasticity, fractionation of the clay is being carried out. The minus 5 micron fraction will be used in future tests as this should increase the plasticity. For this purpose the first material to be tested will be Cromer Kaolin.

CONYNGHAM ST. FREWVILLE SOUTH AUSTRALIA 5063 TELEPHONE 79 1662 TELEGRAMS 'AMDEL' ADELAIDE

028

THE AUSTRALIAN MINERAL DEVELOPMENT LABORATORIES

PLEASE ADDRESS ALL CORRESPONDENCE TO THE DIRECTOR.

OUR REFERENCE: CE 1/1/105
YOUR REFERENCE:
9th September, 1968

The Director of Mines,
169 Rundle Street,
ADELAIDE. 5000.

REC'D.
16 SEP 1968
DEPT. OF MINES
ADELAIDE

INVESTIGATION OF WHITE CLAYS FOR INDUSTRIAL USES

PROGRESS REPORT NO. 5

For Period Ending 31st August, 1968

seen by CWP

Investigation by: Ceramics Section

Officer in Charge: D.C. Madigan

D.C. Madigan
for P.A. Young
Director.

1600

INVESTIGATION OF WHITE CLAYS FOR INDUSTRIAL USES

1. REVIEW OF PROGRESS

The scope of this project has been widened to include the investigation of white clays for industrial uses generally, as well as for porcelain manufacture, and work has continued with the Cromer kaolin.

As mentioned in Progress Report No. 4, this kaolin is too thixotropic and low in plasticity to make a satisfactory porcelain body. It was decided to fractionate the sample, making a split at 5 microns if possible, to see if a product could be obtained having greater green strength and plasticity. The fractionation was carried out by Mr. L.J. Weir, of the Metallurgy Section, who has supplied the following details.

1.1 Fractionation of Cromer Clay

A sample of the clay, previously screened to remove plus 200 mesh material, was dispersed in water, with the aid of a small dosage of sodium hexametaphosphate, to give a slurry containing approximately 4% solids by weight.

A portion of the material was separated by settling a dispersed sample for a known time, and repeated decantation of the suspended fraction. Results of the test are shown:-

Size Fraction	Weight %
+ 5 microns	29.0
- 5 "	71.0
	100.0

Treatment of the slurry in a 'Dorr-multiclone' hydrocyclone was planned to size classify at 5 microns. The unit contains thirty cyclones, each 10 mm in diameter with 2.5 mm feed inlet, vortex finder and apex diameters, operating in parallel. The capacity of the unit is approximately 10 to 20 gallons of feed slurry per minute. However, operating conditions for a specific separation in this cyclone unit were not known, and preliminary testing was therefore done, using a sample of similar clay material, to investigate the separation obtainable at various conditions.

Products from a number of tests were assessed on the basis of solids content and volume, from which a weight split was calculated, and by fractionating grab samples of each product in a cyclosizer. No overflow products were obtained at suitable weight recovery which did not contain significant quantities of material coarser than 10 microns, using single stage cyclone treatment at a range of feed velocities. In addition, the cyclone underflow products were generally not greatly densified over feed solids content, indicating unsatisfactory cyclone conditions.

It was then decided to treat the material in a single laboratory 10 mm diameter hydrocyclone with 3 mm diameter feed inlet, on which the dimensions of vortex finder and apex can be altered for control of the separation. Preliminary tests indicated the following conditions to be suitable:-

Vortex finder diam.	mm	4
Apex diam.	"	1.3
Feed pressure	psi	approx. 30

Cyclone products from treatment at these conditions were sampled and sized using a Shimadzu sedimentation balance. The overflow product contained some material coarser than 10 microns, and was therefore re-passed through the cyclone at similar conditions.

Weights of products from the two-stage treatment are shown in Table 1 and sizings of products are shown in Table 2. It is clear from Table 2 that repassing the overflow through the cyclone gave no significant improvement.

TABLE 1: RESULTS OF CYCLONE TREATMENT

Product		Weight %
Cyclone underflow	1st pass	18.8
" "	2nd pass	9.0
" overflow	" "	72.2
		100.0

TABLE 2: SIZING OF PRODUCTS (SEDIMENTATION BALANCE)

Size Microns	%(wt.) finer than size shown		
	1st pass underflow	1st pass overflow	2nd pass overflow
3	-	-	48
4	-	55	58
5	18	68	68
6	23	76	76
7	26	80	79
8	30	83	83
10	40	87	88
15	70	94	95
20	75	96	98
25	78	98	100
50	90	99	

The overflow and the combined underflow products were dewatered in a pressure filter and dried at 80°C. The products were analysed for particle size distribution by the EEL photosedimentometer and the results are shown in Table 3. The calculated head value is also shown, and the result for Cromer clay from the Clay Register (No. 401) is added for comparison.

The photosedimentometer results show finer products than the sedimentation balance, and are probably to be preferred, though the absolute accuracy of these methods of particle size analysis has not yet been determined. The agreement of the calculated head with No. 401 is reasonably good.

The cyclone overflow product was mixed with water and extruded de-aired at 33.0% water to form a 1 in. diameter column. The extruded column was smooth and fairly strong, but thixotropic and non-plastic. The column was cut into rods which were dried to zero moisture for determination of modulus of rupture. The drying shrinkage was 5.0% and the modulus of rupture 230 lb. per sq. in.

The original sample had a modulus of rupture of 38 lb. per sq. in., (see Progress Report No. 4). Hence hydrocycloning has produced a considerably improved product, but not yet sufficiently strong or plastic to be suitable as a basis for a porcelain body.

TABLE 3: PARTICLE SIZE ANALYSIS (PHOTOSEDIMENTOMETER)

Size Microns	Underflow	Overflow	Calculated Head	Clay Register No. 401
1	2	3	2	6
2	5	16	13	16
3	13	45	36	39
4	19	68	55	53
5	27	81	66	63
6	35	88	73	68
7	41	94	79	71
8	45	97	82	78
10	50	100	86	84
15	60		89	-
20	68		91	-
25	69		92	88
50	100		100	100

Refractoriness. The degritted material had a pyrometric cone equivalent of 34-35 (1763-1785°C), and would hence be suitable for the manufacture of refractories.

Reflectivity. The cyclone overflow material was pressed into a 2 x 2 in. tile. The reflectivity of this, using a neutral density filter, was 82%, relative to pure magnesium carbonate taken as 100%.

1.2 Conclusions

The white Cromer clay from Sec. 143, Hd. Para Wirra, is not suitable for use as a porcelain clay owing to its thixotropic properties and lack of plasticity. Mixing the clay with quartz and felspar gave a porcelain body having satisfactory fired properties, but lacking workability and green strength. Beneficiation of the clay by treatment in a hydrocyclone did not give a significant improvement.

Fractionation of the degritted clay in a high-speed centrifuge to produce kaolin for the paper industry would give a yield of not more than 25% of the de-gritted material, of which about half would be of coating grade and half of filler grade, provided the brightness could be improved by chemical bleaching. The paper-coating grade would probably also be suitable as a "hard" clay for rubber, and the filler grade as a "soft" clay. Treatment of the deposit for the production of these grades is unlikely to be economic owing to the small yields, and accordingly no further work was done on these aspects.

The clay is too coarse-grained to be suitable for use in insecticides or paints.

The most promising use for this clay is in the refractory industry. A high-grade refractory grog could be made by calcining the degritted clay. This could be accomplished in a rotary kiln, the operating conditions being adjusted to produce a stable product by conversion of the alumina to mullite. Calcining temperature would be of the order of 1200°C. The calcined product could be crushed and screened to produce grades suitable for many purposes, e.g. high-duty fire bricks, refractory castables and mortars, high temperature cements, aggregate for dense refractory concrete, addition to ceramic bodies and glazes to adjust shrinkage or alumina content, supports for electrical heating elements, refractories for the glass industry.

2. WORK IN HAND

Further work on this project awaits provision of samples for examination. The following deposits are suggested for consideration.

1. Clays containing less than 30% Al_2O_3, but of low iron content. Apart from chemical analysis, no information is available concerning these deposits. They contain a large proportion of quartz, and beneficiation would be essential. Only large deposits (say of the order of 5 million tons) could have industrial value.

Clay Register No.	Locality
98	Sec. 216, Hd. Nuriootpa
109	Sec. 124, Hd. Clare
125	Sec. 793-4, Hd. Davenport
132	Hamley Bridge
133	Hd. Appila
135	Sec. 4000, Hd. Onkaparinga
140	Co. Manchester
141	Sec. 22, 23, Hd. Belalie
142	Hog Bay, Hd. Menzies
144	Hd. Kapunda
	Sec. 448, Hd. Belvidere
145	Laura
147	Sec. 190, Hd. Onkaparinga
149	Sec. 2999, Hd. Macclesfield
153	Hd. Muloowurtie
154	Sec. 4, Hd. Myponga
157	Olary
158	Sec. 198, Hd. Coglin
165	Hd. Yackamourundie

2. The following deposits contain a high proportion of kaolin, and are low in iron:

100	Sec. 123, 1635, Hd. Talunga
107	Sec. 6, Hd. Mitchell
110	Coward Cliff
115	Arckaringa Creek
138	Charlotte Waters

further action taken in
DM. 1483/64 Project 1/1/100.

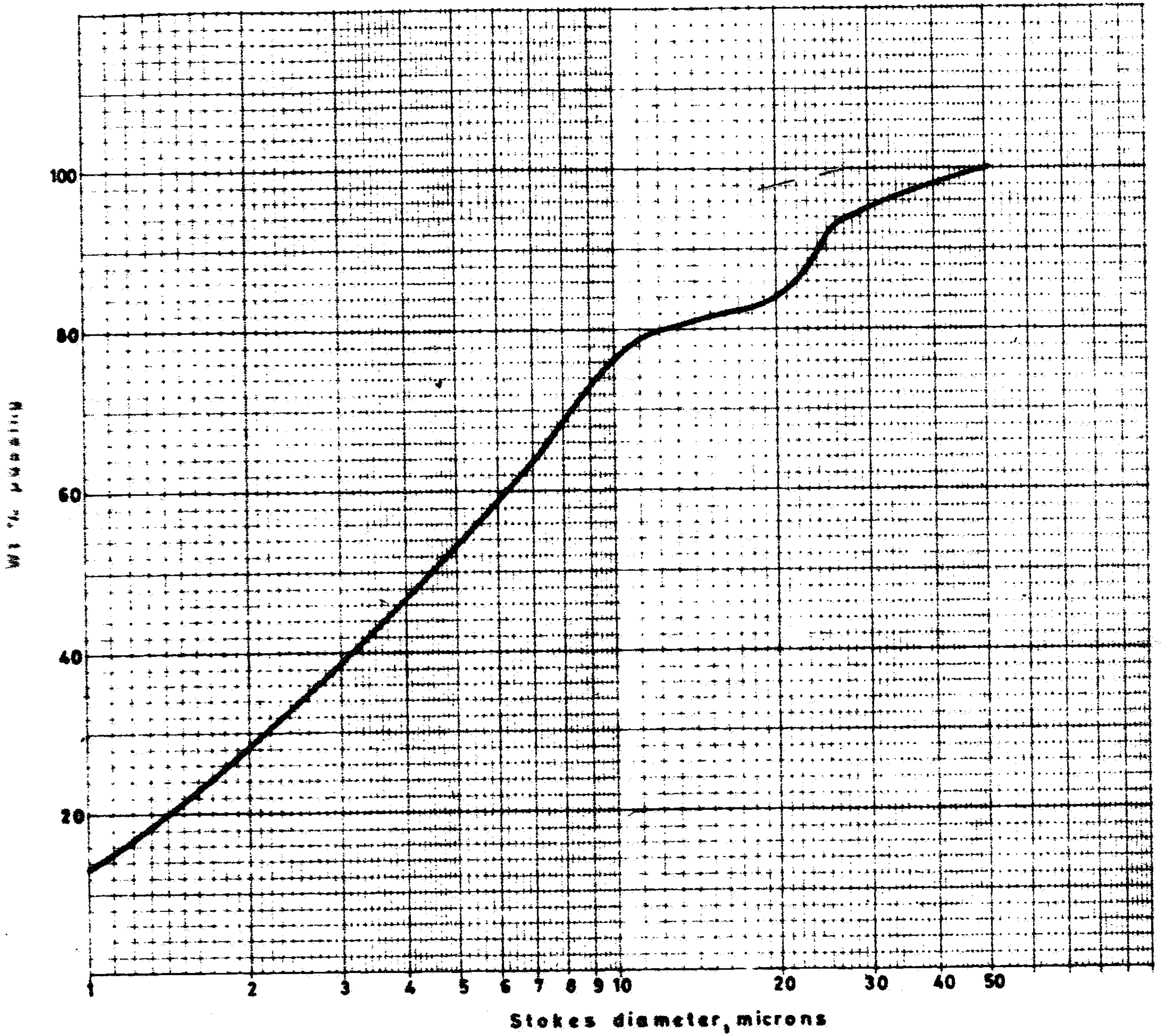

FIGURE 6: PARTICLE SIZE DISTRIBUTION CE 3685

DR11

MT 1/1/103

2nd June, 1969

The Director,
Department of Mines,
Rundle Street,
ADELAIDE.

INVESTIGATION OF WHITE CLAYS FOR INDUSTRIAL USE

PROGRESS REPORT NO. 6

For Period Ending 30th April, 1969

Investigation by: Ceramics Group

Report by: B.J. Baskeyfield

Officer in Charge, Materials Technology: D.R. Ashworth

Ⓐ

for N. Draper
Director.

600

Amount Authorised, 1968/69	$10,000
Amount Spent to 30/4/69	6,105

1. REVIEW OF PROGRESS

Previous work on the properties of Cromer 'C' showed that samples from a particular area, which had been sieved and washed, produce a white burning refractory clay.

It was considered that this material could be processed further to make it suitable for the production of refractory bricks by:

1. Converting the clay to mullite
2. Grading the mullite grog and binding with a plastic refractory clay to produce bricks which, after firing, would possess properties similar to "Molochite".

The material, after screening and washing, was investigated to determine the firing temperature and soak period necessary to obtain optimum mullite conversion. A large batch of treated clay was then crushed, graded and mixed with a refractory bonding clay. Semi-dry pressed bricks were manufactured and fired to 1500°C and soaked for 3 hours, and the resulting product tested for:

1. Refractoriness-under-load
2. Bulk density and water absorption

The results obtained at this stage of the investigation indicate that refractory bricks produced from Cromer C possess good refractory properties, which could be improved by:

1. Reducing the amount of bonding clay
2. Semi-dry pressing of bricks at lower moisture content and higher pressures.

2. WORK IN HAND

A preliminary investigation on the use of Cromer C as an refractory material and its incorporation in a "Molochite" type product has been completed. Further work on this material is now required to improve its refractory properties.

A market survey is also being carried out to obtain information from industrial firms on the consumption, specification and applications of clays for inclusion in paper (coatings and fillers), paints, rubber and plastics. A number of companies have responded to the survey and laboratory work is required to prepare and test a variety of clays for industrial application.

3. MATERIAL EXAMINED

The material used during this part of the project was Cromer C (CB3516), Department of Mines identification A904/68, Hd. Para Wirra, Sec. 154, received 12/12/68.

4. EXPERIMENTAL PROCEDURE AND RESULTS

4.1 Examination of Clay Properties

As a preliminary examination the clay was ground to pass 18 mesh BSS and sufficient water added to obtain a plastic consistency. The material was extruded in a de-airing pug at a moisture content of 35% and formed a smooth, soft, weak and slightly plastic column which distorted on the wire cutting table.

Specimens dried without cracking or distortion in both the moderate(45°C) and severe (105-110°C) drying ovens. The drying shrinkage was determined as 7.1%.

Particle size analysis was evaluated using the EEL photo-sedimentometer and the results are given in Table 1, together with the wet screen analysis. A chemical analysis of this material is given in Table 2.

The samples were then fired over the range 800-1200°C in 50°C steps, with half-hour soak at each temperature. The effect of firing temperature on linear contraction and water absorption is given in Table 3. The PCE of both the material as received and washed and screened (- 300 BSS mesh) was determined in accordance with ASTM C24-56, and the results are shown in Table 4.

TABLE 1: PARTICLE SIZE ANALYSIS

Stokes Diameter Microns	% by Weight finer than Diameter Shown
1	5
2	12
3	20
4	27
5	32
6	39
7	46
8	49
10	54
15	63
20	70
25	80
50	100

Wet Screen Analysis (as received material)

+ 300 mesh BSS	- 300 mesh BSS
16.2%	83.8%

TABLE 2: CHEMICAL ANALYSIS OF RAW MATERIAL

Component	Weight %
SiO_2	46.0
Al_2O_3	39.1
Fe_2O_3	0.56
FeO	0.07
MgO	0.12
CaO	0.05
MnO	$<$ 0.01
Na_2O	0.11
K_2O	0.08
TiO_2	0.27
SO_3	0.01
Cl	0.10
CO_2	0.06
H_2O^+	13.5
H_2O^-	0.95

TABLE 3: LINEAR CONTRACTION AND WATER ABSORPTION

Firing Temperature °C	Linear Contraction %	24-hour Cold Water Absorption %
800	0.6	47.4
850	2.0	46.8
900	2.4	45.8
950	3.8	42.9
1000	4.0	42.2
1050	4.5	41.4
1100	4.6	41.4
1150	7.4	36.7
1200	9.1	30.0

TABLE 4: PYROMETRIC CONE EQUIVALENT

Raw material	Cone down 35 (1785°C)
- 300 BSS and washed	" " 36 (1804°C)

4.2 Conversion of Cromer C to Mullite

The original material was dry screened to pass 18 BSS mesh and then washed to remove soluble impurities. The treated sample was then screened again to pass 300 mesh BSS, all experimental work being carried out on this material.

Samples of approximately 100 grams of fine powder were fired in high alumina crucibles to 1200, 1250, 1300 and 1350°C, and soaked at their respective temperatures for four hours. The fired specimens were then examined for mullite conversion, using an X-ray diffraction technique, and the results are shown in Table 5. Further experiments were carried out to determine the effect of soak time (4, 6 and 8 hour) at a fixed temperature (1250°C), the results being given in Table 6.

TABLE 5: EFFECT OF TEMPERATURE ON MULLITE CONVERSION

Firing Temperature °C	Mullite	Cristobalite	Kaolin
1200	Dominant	Faint trace(5%)	Not detected
1250	Dominant	" "	"
1300	Co-dominant	Co-dominant	"
1350	Sub-dominant	Dominant	"

TABLE 6: EFFECT OF SOAK PERIOD ON MULLITE CONVERSION

Firing Temp. °C	Soak Period hr	Mullite	Low Cristobalite	Kaolin
1250	4	Dominant	Accessory	not detected
1250	6	"	"	"
1250	8	"	"	"

The amount of accessory low cristobalite present in samples soaked for 6 and 8 hours is approximately the same, but greater than that in the sample soaked for four hours.

The sample soaked for four hours at 1200°C was chemically analysed, the results being given in Table 7.

TABLE 7: CHEMICAL ANALYSIS OF SAMPLE SOAKED FOR 4 HOURS AT 1250°C

Component	Weight %
SiO_2	52.8
Al_2O_3	45.2
Fe_2O_3	0.62
FeO	0.11
MgO	0.15
CaO	0.08
MnO	< 0.01
Na_2O	0.14
K_2O	0.32
TiO_2	< 0.01
SO_3	0.12
Cl	0.22
H_2O^+	0.04
H_2O^-	< 0.01

4.3 Production and Properties of "Molochite" Refractory Bricks

Having established optimum firing conditions for the formation of maximum mullite content, extruded briquettes of washed and screened Cromer C were produced. The resulting grog was ground to various sizes before blending with Birdwood clay. Refractory bricks were then semi-dry pressed, at a moisture content of 16%, using the following blend:

20%	Molochite	No. 9
20%	"	No. 10
40%	"	No. 11/40
20%	Birdwood Clay	

The Molochite numbers refer to the grog sizes shown in the Molochite Technical Handbook issued by English China Clay Ltd.

The specimens pressed satisfactorily without plucking or laminating and ejected cleanly from the die. These samples were then fired at 1500°C with a three-hour soak. Specimens for the refractoriness under load test were cut from these samples, and the results are shown below:

TABLE 8: PHYSICAL PROPERTIES OF REFRACTORY BRICKS

Deformation-under-load Test at 1520°C and 25 lbin.^{2} loading

Subsidence	0.9%
Expansion	0.0%
Re Heat Charge (1410°C; 5 hr soak)	0.10%(contraction)
Bulk Density	2.10 gcm^{-3} (132 lb/ft^3)
Water Absorption	6.1%

Sets of specimens are being sent with this report to indicate fired appearance.

5. DISCUSSION

The results obtained at this stage of the investigation indicate that the material is very promising for the purpose of manufacturing a first grade refractory brick. The properties of the fired briquettes compare favourably with British and American standards. The bricks, however, could be improved considerably when produced under industrial conditions, such as by:

1. correct pressing method and higher pressures
2. lower moisture content
3. reduced bonding clay content, to, say, 5%

It is suggested that future work be continued along these lines and that, on completion of the investigation, a large batch of at least a thousand bricks should be produced under industrial conditions and their physical properties evaluated.

1430/67 ×

CONYNGHAM ST. FREWVILLE SOUTH AUSTRALIA 5063 TELEPHONE 79 1662 TELEGRAMS 'AMDEL' ADELAIDE

043

THE AUSTRALIAN MINERAL DEVELOPMENT LABORATORIES

PLEASE ADDRESS ALL CORRESPONDENCE TO THE DIRECTOR.

OUR REFERENCE: MT 1/1/105
YOUR REFERENCE:

21st October, 1969.

The Director,
Department of Mines,
169 Rundle Street,
<u>ADELAIDE</u>, S.A. 5000

CHIEF CLERK
23 OCT 1969
DEPT. OF MINES
ADELAIDE

INVESTIGATION OF WHITE CLAYS FOR INDUSTRIAL USE

PROGRESS REPORT NO. ~~6~~ 7

FOR PERIOD ENDING 30th SEPTEMBER 1969.

NOTE — this report superseded by report dated 8 May 1970.

Investigation and Report by: B.J. Baskeyfield

Officer in Charge,
Materials Technology Section: D.R. Ashworth

DR Ashworth
For N. Draper,
Director.

BJB:sy

1600

FINANCIAL STATEMENT

Amount Authorised 1969/1970	$8,000
Amount Spent to 30th September, 1969	$2,168

INVESTIGATION OF WHITE CLAYS FOR INDUSTRIAL USE

1. REVIEW OF PROGRESS

Preliminary investigations of the two materials A74/69 Hesso clay, Main Pit, Bore 5 and the A75/69 Muloowurtie, Sec 42B cliff face have been completed. Pure Res.

The Hesso material appears to be of a better quality than previous samples received from this locality.

It is considered that with benficiations this material would be suitable for use in pottery and low grade porcelain blends.

The results obtained at this stage of the investigation on the Muloowurtie material indicate that it may be used as a bonding agent in the production of high grade refractories. Providing deposits of this material are large enough it warrants further investigation.

2. WORK IN HAND

A detailed discussion is to be held with the S.A.D.M. to consider which clays are to be investigated further for both ceramic and non-ceramic application.

4. EXPERIMENTAL PROCEDURE AND RESULTS

4.1. Examination of Clay Properties

After drying the materials were ground to pass 18 mesh BSS and mixed with what was estimated to be the optimum water content to give good de-aired extrusion.

Particle size analysis was evaluated using the EEL photo-sedimentometer and the results are given in Table 1. A chemical analysis of the materials is given in Table 2.

Specimens were fired over the range 800-1200°C in 50°C steps and soaked for half an hour at each temperature. The firing, shrinkage and cold water absorption figures are given in Table 3.

The P.C.E. of both the material~~s~~ as received and washed and screened (-300 mesh BSS) was conducted on the Muloowurtie material. This was determined in accordance with ASTM C24-56, and the results are shown in Table 4.

300

?

The preliminary investigation was also conducted on the washed and screened (-330 mesh BSS) materials.

Reflectivity measurements were conducted using the EEL galvanometer and reflectometer MK111 head against a magnesium carbonate block of 98% reflectance with the neutral density filter.

Results - Reflectivity	-300 Mesh BSS
CE 3572 Hesso	68.2%
CE 3574 [illegible]	70.8%

Specimens were tested in duplicate and the average taken.

TABLE 1: PARTICLE SIZE ANALYSIS of -300 mesh material

Stokes Diameter μ ?	% by Weight finer than Diameter Micron shown	
	CE 3572 Hesso	CE 2574 Muloowurtie
1	7	5
2	14	17
3	20	25
4	25	33
5	29	40
6	33	46
7	37	50
8	41	54
10	46	59
15	57	62
20	72	67
25	81	69
50	100	100

WET SCREEN ANALYSIS

CE 3572	+300 mesh BSS 19.2%	-300 mesh BSS 80.8%
CE 3574	+300 mesh BSS 50%	-300 mesh BSS 50%

There figures were queried with Amdel. 31/10/69
On checking found that mistakes had been made in copying
+ the corrected figures applied 3/11/69
JR Adam.

TABLE 2: CHEMICAL ANALYSIS OF RAW MATERIALS

Component	Weight %					
			CE 3572 Hc sso		CE 3574 Mulooworthe	
SiO_2	64.5	54.3	54.3	64.4	64.4	
Al_2O_3	20.5	16.9	16.9	19.6	19.6	
Fe_2O_3	.41	0.35	0.35	0.35	0.35	
FeO	.17	0.14	6.8	0.14	~~0.23~~	0.14
MgO	1.17	0.98	0.98	0.50	0.50	
CaO	.54	6.8	<0.01	0.23	0.01	0.23
MnO	~~0.01~~	<0.01	0.42	<0.01	0.58	<0.01
Na_2O	.25	0.21	0.21	1.25	1.25	
K_2O	.50	0.42	0.81	0.58	~~0.11~~	0.58
TiO_2	.97	0.81	7.85	0.11	0.19	0.11
SO_3	.78	7.85	0.14	0.19	0.14	0.19
Cl		0.01	0.01	1.68	1.68	
CO_2	1.9	1.6	1.6	1.1	1.1	
H_2O+	7.0	6.13	6.13	7.82	7.82	
H_2O-	3.7	3.13	3.13	1.06	1.06	

CaO
MnO
K_2O
TiO_2
SO_3
FeO

Ilmenite content 14.3
+ extra TiO_2 = .35

Analysis of screened material?

about 9% by volume is ilmenite

Gypsum $CaSO_4 + 2H_2O$
$40+32+64+36 = 172$
CaO SO_3 H_2O
32% 46% 21%
$1.8 + 4.8$
$5.4 + 7.8 + 3.6 = 16.8\%$ Gypsum

ilmenite 36.8% Fe
31.6% Ti
31.6% O

TiO_2
56 47.6 FeO 56+32 = 88
48 52.4 TiO_2 48+64 = 112

If remove 90% of Gypsum i.e. reduce out 15 lbs in 100

TABLE 3: FIRING SHRINKAGE -COLD WATER ABSORPTION (24 HOURS)

Firing Temp. °C	Firing Shrinkage CE 3572 Raw Material	Cold Water Absorption (24 Hours) CE 3572 Raw Material	Firing Shrinkage CE 3572 Washed Material	Cold Water Absorption (24 hours) CE 3572 Washed Material
800	0.0	18.5	-1.4	17.7
850	0.0	18.2	-1.3	17.3
900	1.7	17.2	-0.2	16.1
950	4.0	13.9	2.5	14.4
1000	6.0	10.7	4.1	11.7
1050	8.4	6.1	6.5	7.5
1100	9.3	3.9	7.8	4.7
1150	9.9	1.5	8.9	1.7
1200	Bloating	5.6	Bloating	Bloating

Firing Temp. °C	Firing Shrinkage CE 3574 Raw Material	Cold Water Absorption (24 hours) CE 3574 Raw Material	Firing Shrinkage CE 3574 Washed Material	Cold Water Absorption (24 hours) CE 3574 Washed Materia
800	0.2	18.4	0.4	31.0
850	0.2	18.3	0.5	31.0
900	0.2	18.1	0.9	31.0
950	0.2	17.9	1.3	29.7
1000	0.2	17.8	1.3	29.7
1050	0.2	17.7	1.5	28.8
1100	0.2	17.1	2.7	27.9
1150	0.2	16.0	4.7	24.4
1200	0.2	15.3	8.3	19.2

TABLE 4: PYROMETRIC CONE EQUIVALENT CE 3574 MULOOWURTIE

Raw Material	Cone Down 28	1646°C
-300 BSS and Washed	" " 34	1763°C

Not on corrected assays
see page 3

5. DISCUSSION

The results obtained at this stage of the investigation indicate that both the materials are promising.

The Hesso material appears to be of a better quality than any of the previous samples from this locality. Although it is fairly high in iron content, the fired material is lighter in colour than previous samples. It is considered that with benificiation the material is suitable for pottery and low grade porcelain blends. The material is high in ~~titanium Oxide~~ Calcium sulphate and this could possibly be extracted. [illegible] content 14.3%

The Muloowurtie material is very promising as a refractory bonding agent. The benificiated material has a much higher P.C.E. value than the raw material and providing deposits are large enough it warrants further investigations in the refractories field.

It is interesting that this Hesso sample has very low Cl content (0.01) & so low salt. (Na_2O is ·21)

N

NaCl 35 + 23 = 58
60% + 40%

NOTE:

7

Revision of Progress Report first issued 21st October, 1969.

seen by KRM

16

CONYNGHAM ST. FREWVILLE SOUTH AUSTRALIA 5063 TELEPHONE 79 1662 TELEGRAMS 'AMDEL' ADELAIDE

THE AUSTRALIAN MINERAL DEVELOPMENT LABORATORIES

PLEASE ADDRESS ALL CORRESPONDENCE TO THE DIRECTOR.

OUR REFERENCE: MT 1/1/105
YOUR REFERENCE:

8 May 1970

The Director,
S.A. Department of Mines,
Government Offices,
169 Rundle Street,
ADELAIDE, 5000

CHIEF CLERK
12 MAY 1970
DEPT. OF MINES
ADELAIDE

INVESTIGATION OF WHITE CLAYS FOR INDUSTRIAL USE

PROGRESS REPORT NO. 7

for period ended 30th September, 1969

Investigation and Report by: B.J. Baskeyfield

Officer in Charge, Materials Technology Section: D.R. Ashworth

D.R. Ashworth

for N. Draper
Director.

BJB:scy

FINANCIAL STATEMENT

Amount authorised 1969/1970	$8,000
Amount spent to 30th September, 1969	$2,168

INVESTIGATION OF WHITE CLAYS FOR INDUSTRIAL USE

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1. REVIEW OF PROGRESS

Preliminary investigations of the two materials A74/69 Hesso clay, Main Pit, Bore 5 and the A75/69 Muloowurtie, Sec. 42B cliff face have been completed.

The Hesso material appears to be of a better quality than previous samples received from this locality.

It is considered that with beneficiations this material would be suitable for use in pottery and low grade porcelain blends.

The results obtained at this stage of the investigation on the Muloowurtie material indicate that it may be used as a bonding agent in the production of high grade refractories. Providing deposits of this material are large enough, it warrants further investigation.

2. WORK IN HAND

A detailed discussion is to be held with the SADM to consider which clays are to be investigated further for both ceramic and non-ceramic application.

4. EXPERIMENTAL PROCEDURE AND RESULTS

4.1 Examination of Clay Properties

After drying the materials were ground to pass 18 mesh BSS and mixed with what was estimated to be the optimum water content to give good de-aired extrusion.

Particle size analysis was evaluated using the EEL photo-sedimentometer and the results are given in Table 1. A chemical analysis of the materials is given in Table 2.

Specimens were fired over the range 800-1200°C in 50°C steps and soaked for half an hour at each temperature. The firing shrinkage and cold water absorption figures are given in Table 3.

The P.C.E. of both the materials as received washed and screened (-300 mesh BSS) was conducted on the Muloowurtie material. This was determined in accordance with ASTM C24-56, and the results are shown in Table 4.

The preliminary investigation was also conducted on the washed and screened (-300 mesh BSS) materials.

Reflectivity measurements were conducted using the EEl galvanometer and reflectometer MK111 head against a magnesium carbonate block of 98% reflectance with the neutral density filter.

<u>Results - Reflectivity - 300 Mesh BSS</u>

CE 3572 Hesso	68.2%	
CE 3574 Pine Point	70.8%	91%?

Specimens were tested in duplicate and the average taken.

5. DISCUSSION

The results obtained at this stage of the investigation indicate that both the materials are promising.

The Hesso material appears to be of a better quality than any of the previous samples from this locality, in that the fired material is lighter in colour than previous samples. It is considered that with beneficiation the material is suitable for pottery and low grade procelain blends. The material is high in calcium sulphate and this could possibly be extracted.

The Muloowurtie material is very promising as a refractory bonding agent. The beneficiated material has a much higher PCE value than the raw material and providing deposits are large enough it warrants further investigations in the refractories field.

TABLE 1: PARTICLE SIZE ANALYSIS

Stokes Diameter	% By Weight finer than Diameter Micron Shown	
	CE 3572 Hesso	CE 3574 Muloowurtie
1	7	5
2	14	17
3	20	25
4	25	33
5	29	40
6	33	46
7	37	50
8	41	54
10	46	59
15	57	62
20	72	67
25	81	69
50	100	100

WET SCREEN ANALYSIS

CE 3572 +300mesh BSS 19.2% -300 mesh BSS 80.8%
CE 3574 +300mesh BSS 50% -300 mesh BSS 50%

TABLE 2: CHEMICAL ANALYSIS OF RAW MATERIALS

Component		Weight %	
		CE 3572 Heso	CE 3574 Malinwatte
Silica	SiO_2	54.3	64.4
Aluminium oxide	Al_2O_3	16.9	19.6
Ferric oxide	Fe_2O_3	0.35	0.35
Calcium oxide	CaO	6.8	0.23
Magnesium oxide	MgO	0.98	0.50
Manganese oxide	MnO	0.01	0.01
Potassium oxide	K_2O	0.42	0.58
Sodium oxide	Na_2O	0.21	1.25
Titanium oxide	TiO_2	0.81	0.11
Sulphur trioxide	SO_3	7.85	0.19
Ferrous oxide	FeO	0.14	0.14
Chlorine	Cl	0.01	1.68
Moisture	H_2O^-	3.13	1.06
Moisture	H_2O^+	6.13	7.82
Carbon dioxide	CO_2	1.6	1.1

TABLE 3: FIRING SHRINKAGE - COLD WATER ABSORPTION (24 HOURS)

Firing Temp ^0C	Firing Shrinkage CE 3572 Raw Material	Cold Water Absorption (24 hours) CE 3572 Raw Material	Firing Shrinkage CE 3572 Washed Material	Cold water Absorption (24 hours) CE 3572 Washed Material
800	0.0	18.5	-1.4	17.7
850	0.0	18.2	-1.3	17.3
900	1.7	17.2	-0.2	16.1
950	4.0	13.9	2.5	14.4
1000	6.0	10.7	4.1	11.7
1050	8.4	6.1	6.5	7.5
1100	9.3	3.9	7.8	4.7
1150	9.9	1.5	8.9	1.7
1200	Bloating	5.6	Bloating	Bloating

TABLE 3: CONTINUED

Firing Temp °C	Firing Shrinkage CE 3574 Raw Material	Cold Water Absorption (24 hours) CE 3574 Raw Material	Firing Shrinkage CE 3574 Washed Material	Cold Water Absorption (24 hours) CE 3574 Washed Materia
800	0.2	18.4	0.4	31.0
850	0.2	18.3	0.5	31.0
900	0.2	18.1	0.9	31.0
950	0.2	17.9	1.3	29.7
1000	0.2	17.8	1.3	29.7
1050	0.2	17.7	1.5	28.8
1100	0.2	17.1	2.7	27.9
1150	0.2	16.0	4.7	24.4
1200	0.2	15.3	8.3	19.2

TABLE 4: PYROMETRIC CONE EQUIVALENT
CE 3574 MULOOWURTIE

Raw Material	Cone Down 28	1646°C
-300 BSS and Washed	" " 34	1763°C

CONYNGHAM ST. FREWVILLE SOUTH AUSTRALIA 5063 TELEPHONE 79 1662 TELEGRAMS 'AMDEL' ADELAIDE

058

THE AUSTRALIAN MINERAL DEVELOPMENT LABORATORIES

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OUR REFERENCE: MT 1/1/105
YOUR REFERENCE:

CHIEF CLERK
11 MAY 1970
DEPT. OF MINES
ADELAIDE

The Director,
S.A. Department of Mines,
Government Offices,
169 Rundle Street,
ADELAIDE 5000

BENEFICIATION OF S.A. CLAYS FOR PAINT AND PAPER FILLER APPLICATIONS

PROGRESS REPORT NO. 8

for period ending 31st March 1970

Investigation and Report by: T.M. Lennox and D.R. Ashworth

Officer in Charge,
Materials Technology Section: D.R. Ashworth

DR Ashworth.

for N. Draper
Director

scy

Seen by KRM
Director of

1600

FINANCIAL STATEMENT

Amount allocated 1969/1970	$8,000
Amount Spent to 31/3/70	$7,105

BENEFICIATION OF S.A. CLAYS FOR NON-CERAMIC APPLICATIONS

1. REVIEW OF PROGRESS

A total of five clays have been received for investigation under this project.

1. A 643/69 - CE 3672 - Cromer C
2. A 644/69 - CE 3673 - Cromer C
3. A 645/69 - CE 3674 - ABM Pit
4. A 8/70 - CE 3684 - Booleroo
5. A77/70 - - CE 3685 - Hesso

The material from Booleroo (A 8/70) was eliminated from the investigation as an analysis of the -2 micron fraction showed that it contained up to 50% of very fine free quartz and was therefore not likely to be suitable for paint or paper filler applications. All of the other materials received have been beneficiated by blunging with water and screening on a 200 mesh BS sieve.

The percentage oversize and undersize on 200 mesh BSS has been determined in each case and the following tests have been carried out on the oven dried minus 200 mesh BSS materials.

1. Chemical analysis
2. Mineralogy
3. Differential thermal analysis
4. pH (20% aqueous extract)
5. Specific gravity
6. Refractive Index
7. Reflectivity
8. Particle size distribution
9. Water solubles
10. Bulk density (scott volumeter method)
11. Valley abrasion test
12. Feel of slip

Specifications for paint, paper coatings and fillers and clays used in the cosmetic and rubber industry have been obtained from major user companies in Australia and a copy of these specifications have been included in this report.

2. WORK IN HAND

The project will be continued as soon as samples from Mount Crawford, Hundred of Stokes and Hundred of Barossa are available from the S.A. Mines Department.

3. EXPERIMENTAL PROCEDURE AND RESULTS

All of the materials received were oven dried at 105°C. Representative samples were then cut out, blunged with water and screened on a 200 mesh BS sieve. The percentage oversize and undersize material was calculated and is reported in Table 1. All subsequent tests were carried out on the oven dried (105°C) minus 200 mesh BSS materials.

The chemical analysis is shown in Table 2 and the results of the mineralogical examination shown in Table 3. The pH of a 20% aqueous solution, specific gravity, refractive index and reflectivity values are given in Table 4 and particle size distribution in Table 5 and Figures 3, 4, 5 and 6. Bulk density values obtained by the Scott Volumeter technique and water soluble values are shown in Table 6. Additional properties of paper coatings and filler clays, and rubber grade clays are given in Tables 7 and 8.

4. DIFFERENTIAL THERMAL ANALYSIS

Differential thermal analysis was carried out under the following conditions:

1. Sample weight 0.100 g plus 0.200 g diluent.
2. Sample sizing - 200 mesh BSS.
3. Reference sample and diluent material -200 mesh calcined alumina.
4. Heating rate 10°C per minute over the range 50°C to 1200°C.

5. RESULTS

Copies of the traces obtained at 1/3 of the original scale are shown in Figures 1 and 2. The endothermic peaks at approximately 550°C and the exothermic peaks at approximately 1000°C are characteristic of a kaolin mineral and the symmetry of the endothermic peaks suggests that the component is kaolinite. No other components were detected. From the size of the peaks, CE 3672 and CE 3673 appear to be substantially all kaolinite, sample CE 3674 appears to contain about 75% and CE 3685 about 50% kaolinite.

6. DISCUSSION

The specification of clays supplied by users, together with the results obtained in this investigation on South Australian clays is shown in Table 6. Comparing the results given in Table 6, the following observations are made:

6.1 Paint Fillers

In general the two Cromer 'C' clays (CE 3672 and CE 3673) compare favourably with the specification given for the seven grades of Balm Paint clays. The pH values (20% solution) however, is usually higher (7.7 - 8.5) than the Balm Paint clays (5 grades between 4.2 and 5.5, the remainder at 8.0). There is also wide variation in the silica and alumina content, particularly K102 and 169A which would indicate a large percentage of free quartz or other clay-like minerals in these clays.

The particle size distribution of the Cromer 'C' clays show variations between the two samples and with the specification but what effect this would have on the paint properties is not clearly defined.

The Talunga and Hesso clays (CE 3674 and 3685), although containing a high percentage of free quartz and other impurities including CaO, may also be considered suitable for use as a paint filler, probably as a lower grade than Cromer 'C'.

It is recommended that all four clays should be submitted to Balm Paints for evaluation by their laboratories.

6.2 Cosmetics

Apart from pH, the two Cromer 'C' clays appear suitable for use in the cosmetic industry and samples should be submitted to Johnson and Johnson for evaluation.

The Talunga and Hesso clays are slightly gritty and therefore do not match the specification.

6.3 Paper Coatings and Fillers

The Valley abrasion test shows that both Cromer 'C' clays are comparable with the best coating clays used in the U.S.A., typical figures being 13 - 16mg compared with 6 - 10mg for the Cromer clays. The excessive high values for Talunga and Hesso make them unsuitable even as filler clays, the minimum acceptable value in the U.S.A. being given as 25 mg (Talunga 237 mg, Hesso 173 mg). Pine Point – 57mg see PR9.

These values have been obtained on wet sieved clays, the particle size distribution being too coarse for coating or filler clays. From the values given in Table 6 and those quoted from other sources (Table 7) it is possible that if the +10 micron fraction was removed, completely or partially, the Cromer 'C' material would be suitable as a filler but not as a coating clay.

6.4 Rubber Grade Clays

The values given in Table 8 show that Cromer 'C' would not be suitable as a 'hard' or 'soft' rubber filler, because of the low yield of particles below 2 microns.

6.5 Methods of Improving Cromer 'C'

It is possible that a micronising technique could be used to produce Cromer 'C' material with a particle size distribution in the range 50-80% less than 2 microns. If this does not prove successful then a centrifuge technique could be used to separate out the -5 micron and -2 micron fractions.

In both cases about one ton of material would be required to carry out the experiments.

TABLE 1: WET SCREEN ANALYSIS ON 200 MESH BSS

Sample	Oversize +200 Mesh BSS %	Undersize -200 Mesh BSS %
CE 3672 (Cromer C)	13.5	86.5
CE 3673 (Cromer C)	20.4	79.6
CE 3674 (Talunga)	7.4	92.6
CE 3685 (Hesso)	15.5	84.5

Pine Point + 300 mesh 39.8 -300 Mesh 61.2

TABLE 2: CHEMICAL ANALYSIS of - 200 mesh material

	CE3672 Cromer C	CE3673 Cromer C	CE3674 Talunga	CE3685 Hesso
SiO_2	46.6	46.7	57.9	64.7
Al_2O_3	37.2	36.7	27.8	20.6
Fe_2O_3	1.71	1.90	1.80	1.82
FeO	0.10	0.10	0.10	0.40
MgO	0.11	0.15	0.19	0.96
CaO	0.27	0.28	0.46	1.39
MnO	0.04	0.04	0.02	0.02
Na_2O	0.19	0.20	0.11	0.15
K_2O	0.32	0.68	0.50	1.53
TiO_2	0.08	0.14	1.43	0.82
SO_3	0.04	0.10	0.04	0.23
Cl	0.18	0.27	0.08	0.04
CO_2	0.03	0.03	$<$ 0.01	0.49
H_2O^+	13.9	13.6	10.05	7.7
H_2O^-	1.22	0.51	0.85	0.79

TABLE 3: MINERALOGY

Sample	Free Quartz %	Qualitative Analysis
CE 3672	0.1%	Non-clay minerals - Nil Clay mineralogy - well crystallised kaolinite
CE 3673	About 0.1% on limit of detection	Non-clay minerals - trace of quartz Clay mineralogy - well crystallised kaolinite, trace of montmorillonite.
CE 3674	23.0%	Clay mineralogy - dominantly well crystallised kaolinite, slight trace of montmorillonite and a little illite.
CE 3685	38.0%	Clay mineralogy - well crystallised kaolinite, montmorillonite and illite, probably in that order. Also present a slight trace of calcite.

TABLE 4:

Sample	pH (20% aqueous extract)	Specific Gravity	Refractive Index	Reflectivity (against $MgCO_3$ at 98%)
CE 3672	7.70	2.62	1.563	88.0%
CE 3673	7.45	2.65	1.565	92.0%
CE 3674	7.60	2.62	1.565	78.5%
CE 3685	8.45	2.64	1.557	73.5%

TABLE 5: PARTICLE SIZE DISTRIBUTION %
(Photosedimentometer Method)

Stokes Diameter (Microns)	CE 3672	CE 3673	CE 3674	CE 3685
-50	100	100	100	100
+20	13	32	26	8
10 - 20	4	6	22	15
5 - 10	25	15	22	24
2 - 5	37	30	17	25
1 - 2	15	13	6	15
-1	6	4	7	13

TABLE 7: PROPERTIES OF PAPER COATINGS AND FILLERS

	English China Clay			Huber Clays	
	Coating	Filler Grade A	Filler Grade E	Coating	Filler
+10 microns	0.2%	10%	25%	-	-
-5 microns	-	-	-	3-8%	12-35%
-2 microns	80% 1	50%	20%	71-80%	30-68%
Brightness	91%	87%	80%	83-86%	79-84%
pH	5.0	5.0	5.0	4.5-7.0	4.5-7.0

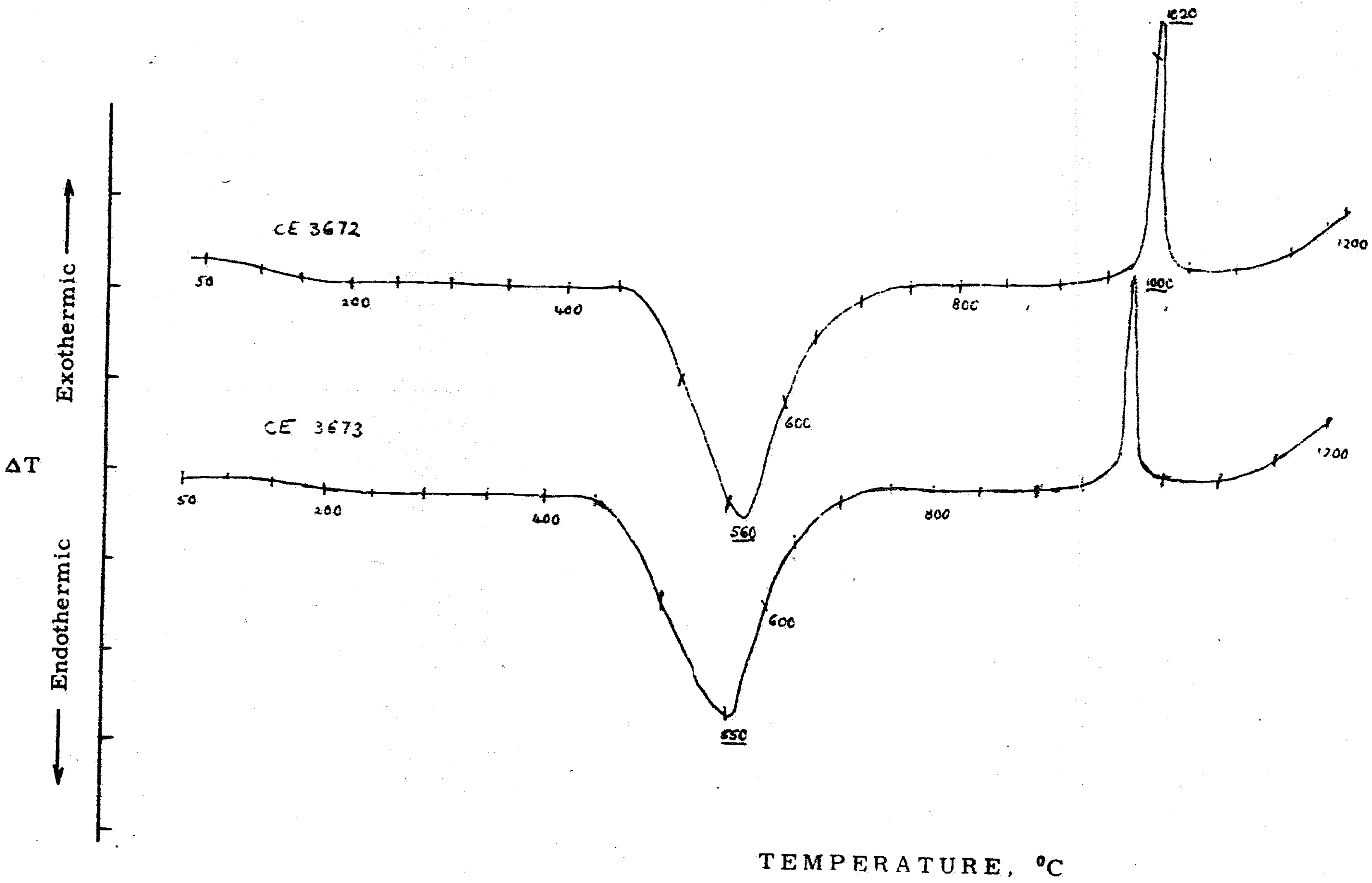
TABLE 8: RUBBER GRADE CLAYS

	Hard (1)	Soft (1)	Soft (2)
S.G.	2.60	2.60	2.60
+325 mesh	0.17%	0.05%	0.3% Max
Colour	76-77%	78-84%	light cream
pH	4.5-5.5	4.5-7.0	4.5-5.5
+5 microns	3-5%	8-25%	20%
-2 microns	87-92%	55-74%	61%

1. Kaolin Clays and Their Industrial Uses.
   1955 J.M. Huber Corporation
   New York, N.Y. U.S.A.

2. Dunlop Company

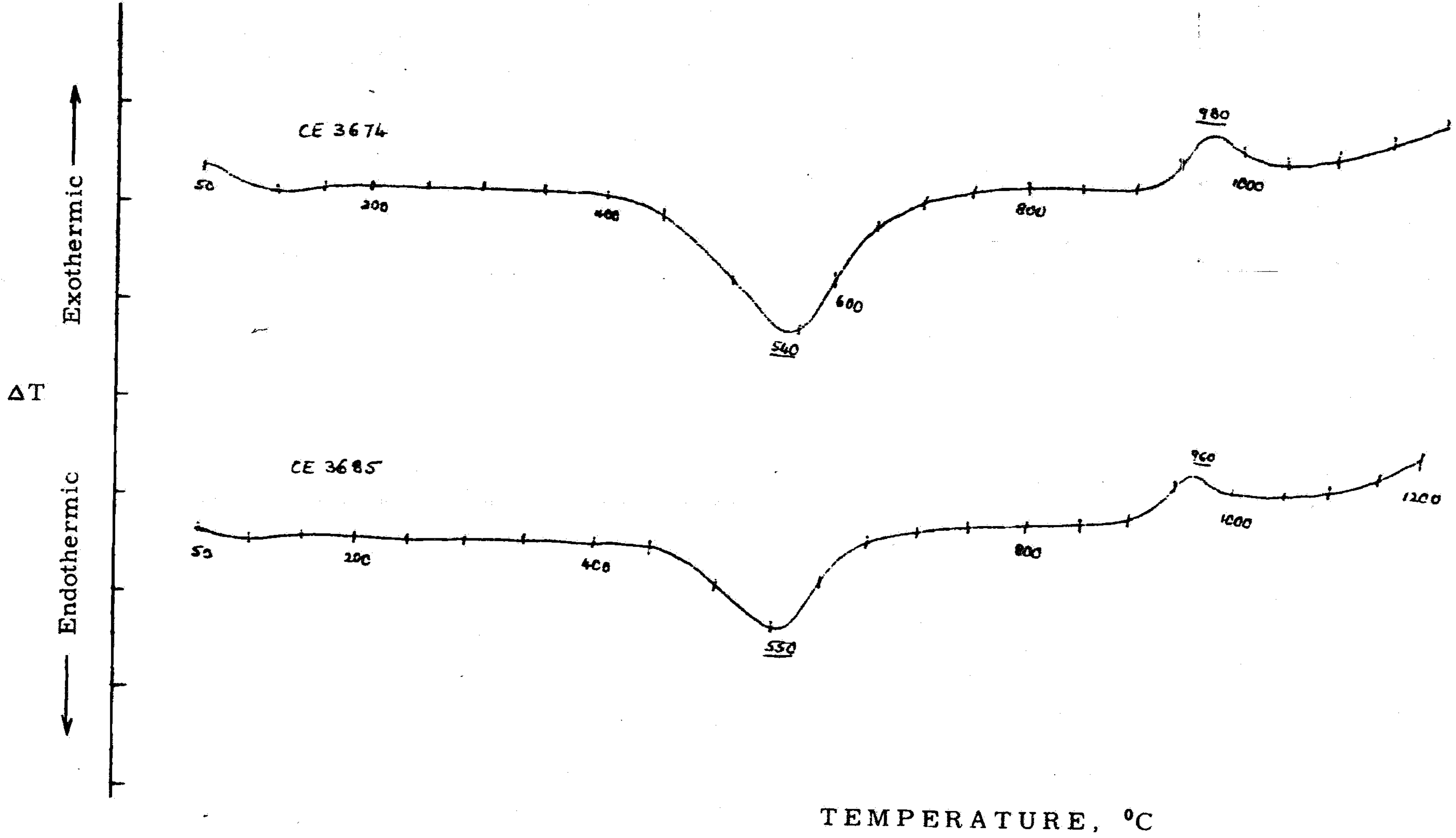
DIFFERENTIAL THERMAL TRACES



Each division on the ΔT axis is approximately equal to 0.01 Mv
i.e. approximately equal to 1.0°C at 500°C

FIGURE 1: Cromer 'C' 2 samples

DIFFERENTIAL THERMAL TRACES



Each division on the ΔT axis is approximately equal to 0.01 Mv
i.e. approximately equal to 1.0°C at 500°C

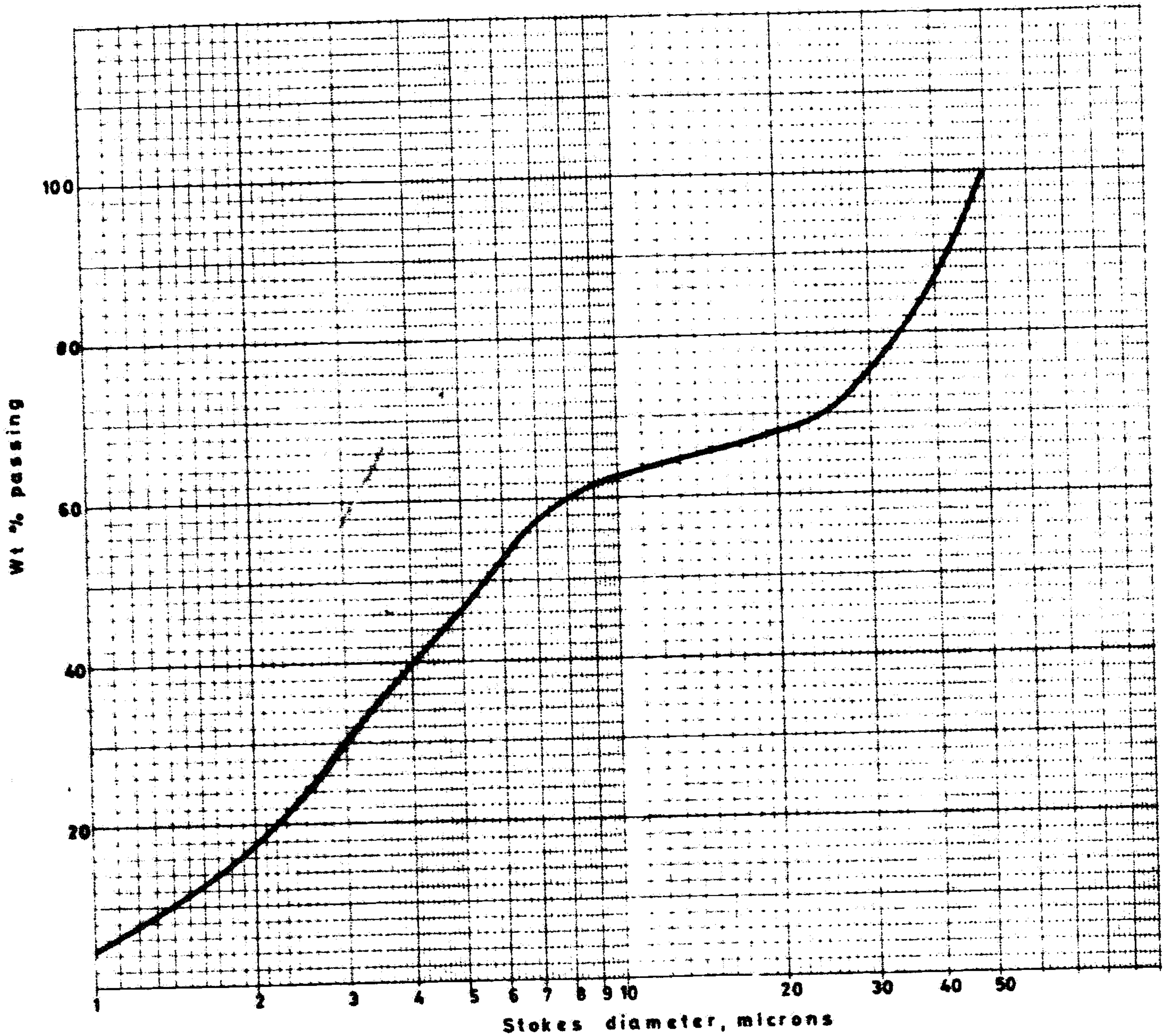


FIGURE 3: PARTICLE SIZE DISTRIBUTION CE 3673

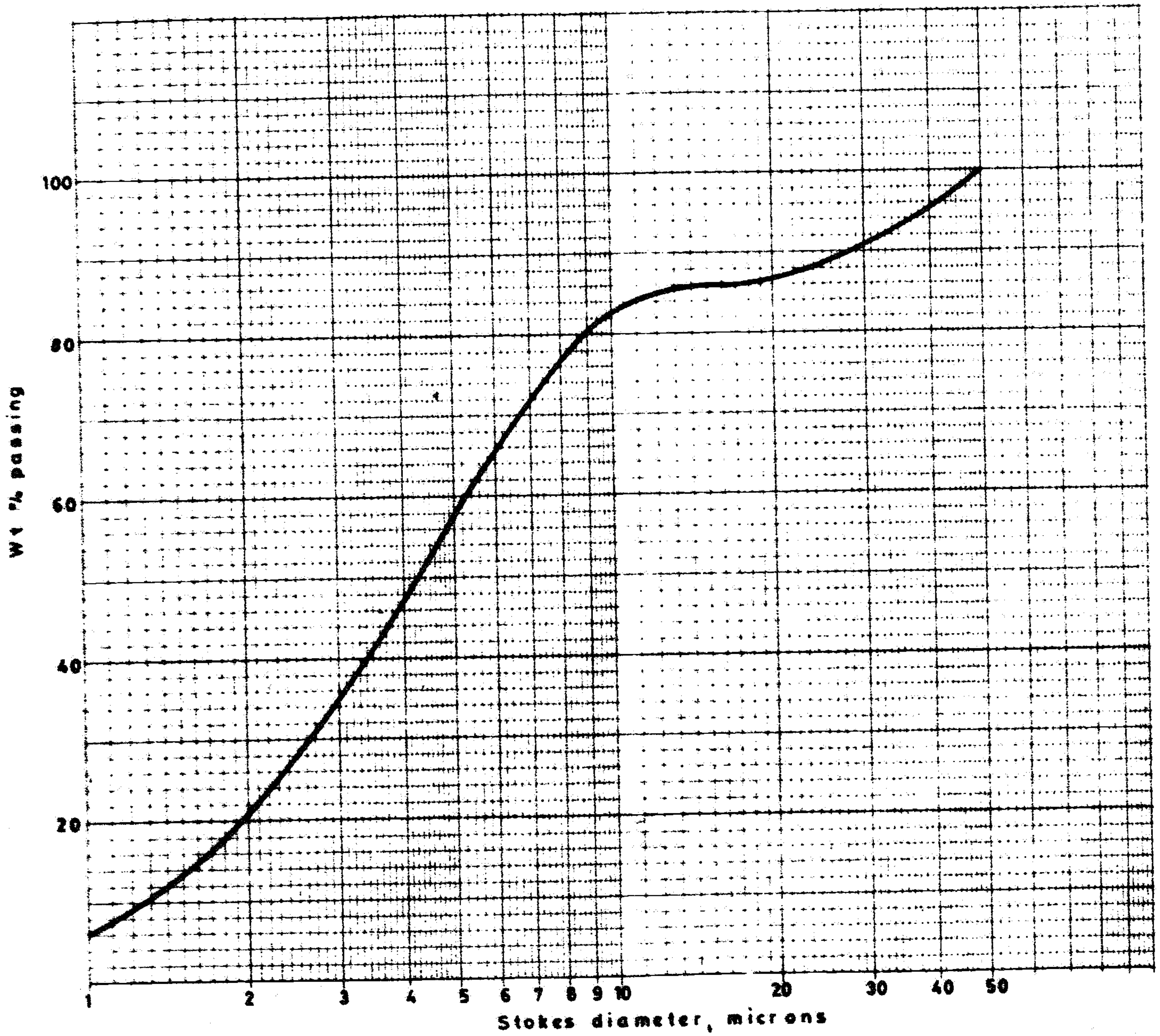


FIGURE 4: PARTICLE SIZE DISTRIBUTION CE 3672

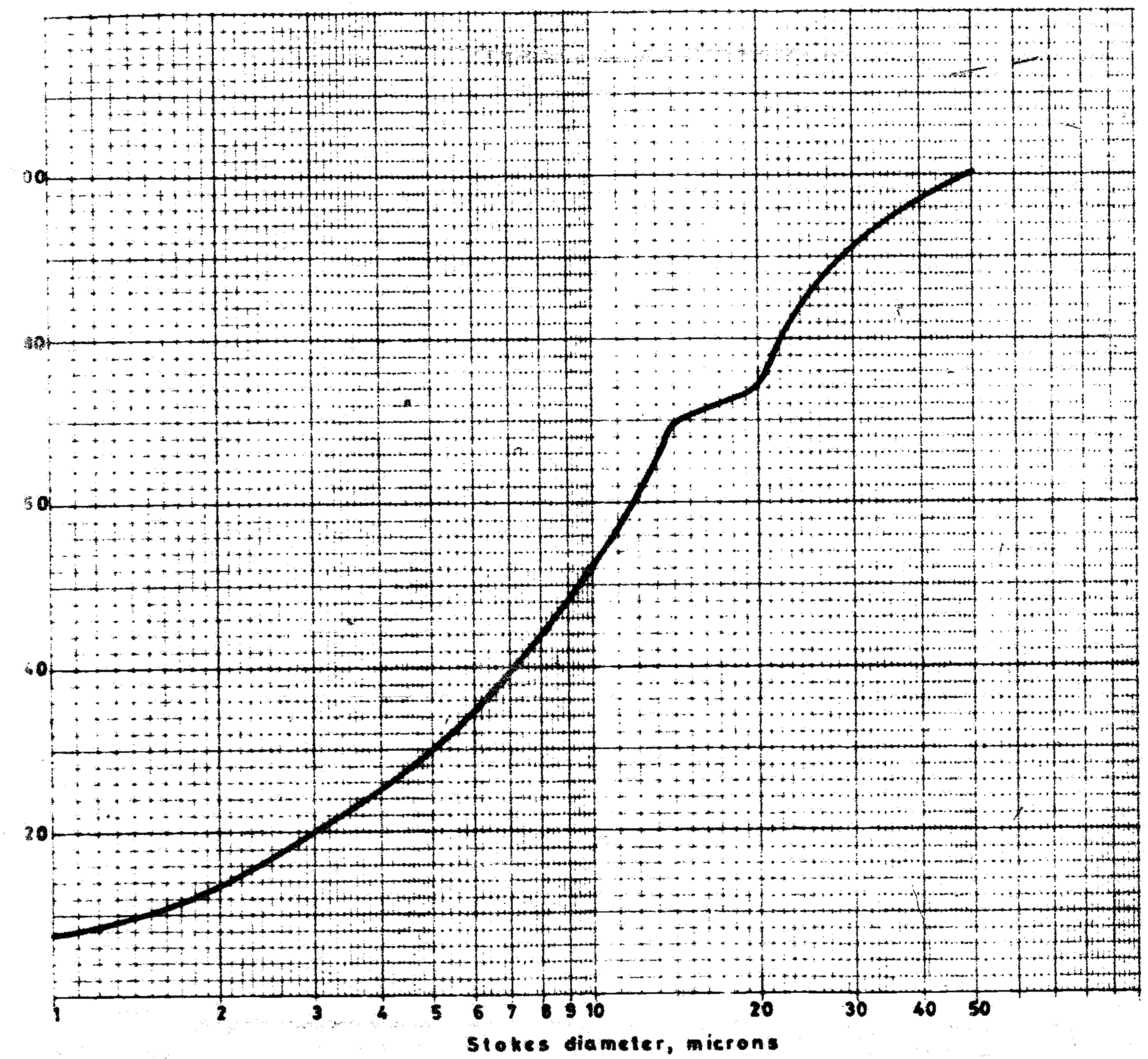


FIGURE 5: PARTICLE SIZE DISTRIBUTION CE 3674

073

amdel
The Australian Mineral Development Laboratories
Flemington Street, Frewville, South Australia 5063
Phone 79 1662, telex AA82520

Please address all correspondence to the Director
In reply quote: MT 1/1/105

31 May 1971

The Director
South Australian Department of Mines
Government Offices
169 Rundle Street
ADELAIDE 5000

INDUSTRIAL APPLICATIONS OF SOUTH AUSTRALIAN CLAYS

PROGRESS REPORT NO. 9

for period ending 31 May 1971

CHIEF CLERK
- 4 JUN 1971
DEPT. OF MINES
ADELAIDE

Investigation and Report by: D.R. Ashworth, D.R. Jones and K.M. Pluck

Officer in Charge, Materials Technology Section: Dr G.L.F. Powell

Powell
for F.R. Hartley
Director

scy

1600

1. REVIEW OF PROGRESS

Due to the lack of samples normally supplied by the Mines Department, only one clay, from the Pine Point area, has been investigated and its properties, particularly as a paper coating clay, determined. This includes separation of the minus 20-micron fraction by hydrocycloning, viscosity, brightness, chemical analysis and mineralogical assessment.

The results show that the minus 20-micron fraction would be suitable, after slight up-grading, as a paper coating clay and further work on the minus 2-micron fraction, obtained by a centrifuge technique is recommended.

2. WORK IN HAND

No further samples are in hand for assessment and it is recommended that the search for new clays should be directed towards white clays, as there is a demand for such clays in the paper coating, paper and paint filler, refractory and wall tile industries.

3. MATERIAL EXAMINED

Pine Point clay - CE 3574.

4. PROCESSING OF CLAY

Approximately 25-lbs of the clay sample, after pulverising to minus 25-mesh, was blunged in water for 24-hours and wet sieved on a 300-mesh (BSS) sieve. The plus 300-mesh material was determined as 39.8%. The residue on 300-mesh was mainly quartz, few clay lumps or other extraneous material were found.

It was observed that the minus 300-mesh material was not fully deflocculated as it settled rapidly. Accordingly sodium-hydroxide was added until optimum dispersion was, visually, attained.

The minus 300-mesh material was then hydrocycloned to obtain separation at 20-micron. The oversize was re-cycled several times to ensure complete separation.

5. EXPERIMENTAL PROCEDURE AND RESULTS

5.1 Minus 300-Mesh Material

5.1.2 Particle Size Distribution

The particle size distribution was measured using an EEL Photosedimentometer and three methods of agitation and dispersion were used, and the results compared as shown in Table 1 and Figure 1. This indicates that agitation by ultrasonics or high speed stirring is most effective in dispersing the slurry.

5.1.2 Mineralogy

The quartz content of the minus 300-mesh material was determined as 7% while in the minus 2-micron fraction, obtained by sedimentation, no non-clay minerals were detected. The sample consisted of kaolin and a trace of mica (ratio of mica to kaolin in the minus 2-micron fraction being approximately 1:30).

5.1.3 Chemical Analysis

The chemical analysis of the minus 300-mesh material is given in Table 2 which shows that the clay has a very low iron content

$(Fe_2O_3 + FeO = 0.52\%)$.

The high K_2O is probably due to the presence of mica. The chemical composition of pure kaolin is also given as a comparison.

The clay is also high in chlorine (salt) and this is probably the cause of the flocculation and the need to add sodium-hydroxide for dispersion.

5.2 Minus 20-Micron Fraction

5.2.1 Particle Size Distribution

The particle size distribution is shown in Table 3 and Figure 2, which indicates that a good split was obtained at the desired micron size.

5.2.2 Brightness

The minus 20-micron fraction was lightly ground to pass a 100-mesh sieve, pressed in a special die to 30 psi, according to TAPPI Standard T646m-54 (Technical Association of the Pulp and Paper Industry) and the reflectivity measured using the EEL Reflectometer. The results, shown in Table 4, indicate that in neutral light the clay has a brightness of 91%, compared with a magnesium-carbonate block and is well within the specification for a paper coating clay (83-85% or better).

In addition a portion of the same clay was sent to the Institute of Paper Chemistry for brightness measurement using a more reliable instrument which complies with The TAPPI Standard. The value obtained, 84.0%, is just within the acceptable limit but could be improved to say 85-86% by bleaching using HCl or zinc dithionate.

5.2.3 Viscosity

Viscosity measurements were carried out using a Brookfield Viscometer type RVT with a number-3 spindle at 10 and 100 rpm as recommended by TAPPI Standard T648sm-54. A high solids content (70%) was initially prepared, but had to be reduced to bring the viscosity within the specified range of 500 cps. The final results were as follows:

10 rpm 500 cps) - at 62% solids
100 rpm 670 cps)

The soldis content is less than the usually acceptable value of 67% or greater. The low value, however, may be due to the particle size as the specified values are for the minus 2-micron fraction. In addition, the minus 20-micron fraction contains a small proportion of the original deflocculant which may either interfere with the additional deflocculant or cause the slurry to be over deflocculated.

5.2.4 Chemical Analysis

The chemical analysis values show that silica has been reduced with no increase in Fe_2O_3 and the values are closely approaching that of pure kaolinite. It is assumed that excess silica is in the form of free quartz and that at the 2-micron level a further improvement would be obtained if the free quartz was removed.

5.2.5 Valley Abrasion Value

A sample of the minus 20 -micron fraction was sent to the Institute of Paper Chemistry in the U.S.A. and a Valley Abrasion test carried out. The value obtained, 57 mg, indicates that the clay is quite abrasive, the range 20-60 mg being questionable in that excessive wear of paper manufacturing equipment could occur.

The abrasive behaviour is probably due to free quartz and it is expected that at the minus 2-micron level the lower free quartz content would produce a lower Valley Abrasion value.

6. DISCUSSION

The sample of Pine Point clay submitted under CE 3574, has been investigated as to its application to paper coatings. After hydrocycloning to obtain the minus 20-micron fraction, a series of tests were carried out to TAPPI Standards, with the following results:

a. colour 84% (G.E. Meter),
b. Valley Abrasion 57 mg and
c. viscosity 62% solids.

The reflectivity is just within the limits of acceptability (83-84%), but the colour could be improved by chemical bleaching with HCl or zinc dithionate. The expected improvement would be about 2 or 3% (i.e. 86-87%).

A Valley Abrasion value 57 mg is probably too high to be readily acceptable by most paper manufacturers, but it is anticipated that at the minus 2-micron level the free quartz level would be less than in the minus 20-micron fraction with consequent reduction of abrasion.

The minimum solids content for an acceptable viscosity figure (500 cps) is generally above 67% solids, the clay under investigation being 62% solids. It is possible that the minus 2-micron fraction may have improved viscous properties as there is no apparent reason why the solids content should be low, as the material is virtually pure kaolinite with a trace of mica, no deleterious materials, such as montmorillonite being present.

In conclusion the Pine Point clay looks promising as a paper coating clay as very little processing would be required to up-grade the minus 20-micron fraction to meet standards set by the paper industry.

The clay would also find a use as a paper, rubber or paint filler and as a refractory clay.

TABLE 1: PARTICLE SIZE DISTRIBUTION (MINUS 53 MICRON)

Particle Size (micron)	Without Ultrasonic Agitation	With Ultrasonic Agitation	High Speed Mixer
50	100	100	100
25	96.7	-	100
20	93.5	-	95.6
15	85.6	90.8	91.4
10	75.9	81.8	84.6
8	69.6	76.0	77.7
7	66.1	72.0	73.3
6	60.1	65.7	67.7
5	49.7	57.3	60.3
4	39.5	47.1	51.6
3	29.1	34.3	40.7
2	16.8	16.9	23.9
1	6.5	7.8	8.7

TABLE 2: CHEMICAL COMPOSITION (WT. %) MINUS 300-MESH FRACTION

Component	CE 3574	Pure Kaolinite	Typical Paper Coating Clay (E.C.C.)
SiO_2	50.5	46.54	46.2
Al_2O_3	35.2	39.50	38.7
Fe_2O_3	0.5	-	0.56
FeO	0.02	-	-
CaO	0.01	-	0.2
MgO	0.58	-	0.2
Na_2O	0.1	-	0.07
K_2O	0.65	-	1.01
MnO	0.01	-	-
P_2O_5	0.01	-	-
TiO_2	0.31	-	0.09
Cr_2O_3	0.1	-	-
V_2O_5	0.01	-	-
SO_3	0.05	-	-
Cl	0.12	-	-
CO_2	0.1	-	-
H_2O^+	12.2	13.96	13.14

TABLE 3: PARTICLE SIZE DISTRIBUTION (MINUS 20 MICRON)

Particle Size (micron)	Weight Percent Passing (%)
50	100
25	100
20	100
15	93.9
10	89.9
8	87.0
7	84.7
6	80.8
5	77.8
4	62.3
3	47.3
2	35.7
1	30.36

TABLE 4: REFLECTIVITY

Filter	Brightness, % Compared With $MgCO_3$ Block	Yellowness Factor, %
White	91	
Neutral	91	2.0
Yellow	91	
Red	91	
Green	89	
Blue	89	

TABLE 5: CHEMICAL ANALYSIS MINUS 20-MICRON FRACTION

Component	Weight, % (-20 micron)	Weight, % (-300 mesh)	Weight, % (pure kaolinite)
Al_2O_3	36.1	35.2	39.50
SiO_2	47.4	50.5	46.54
Fe_2O_3	0.5	0.5	
FeO	0.16	0.02	
P_2O_5	0.56	0.01	
Na_2O	0.1	0.1	
TiO_2	0.07	0.31	
Cl	0.01	0.12	

[illegible]

• without u/s
○ – u/s
× Particle mixer

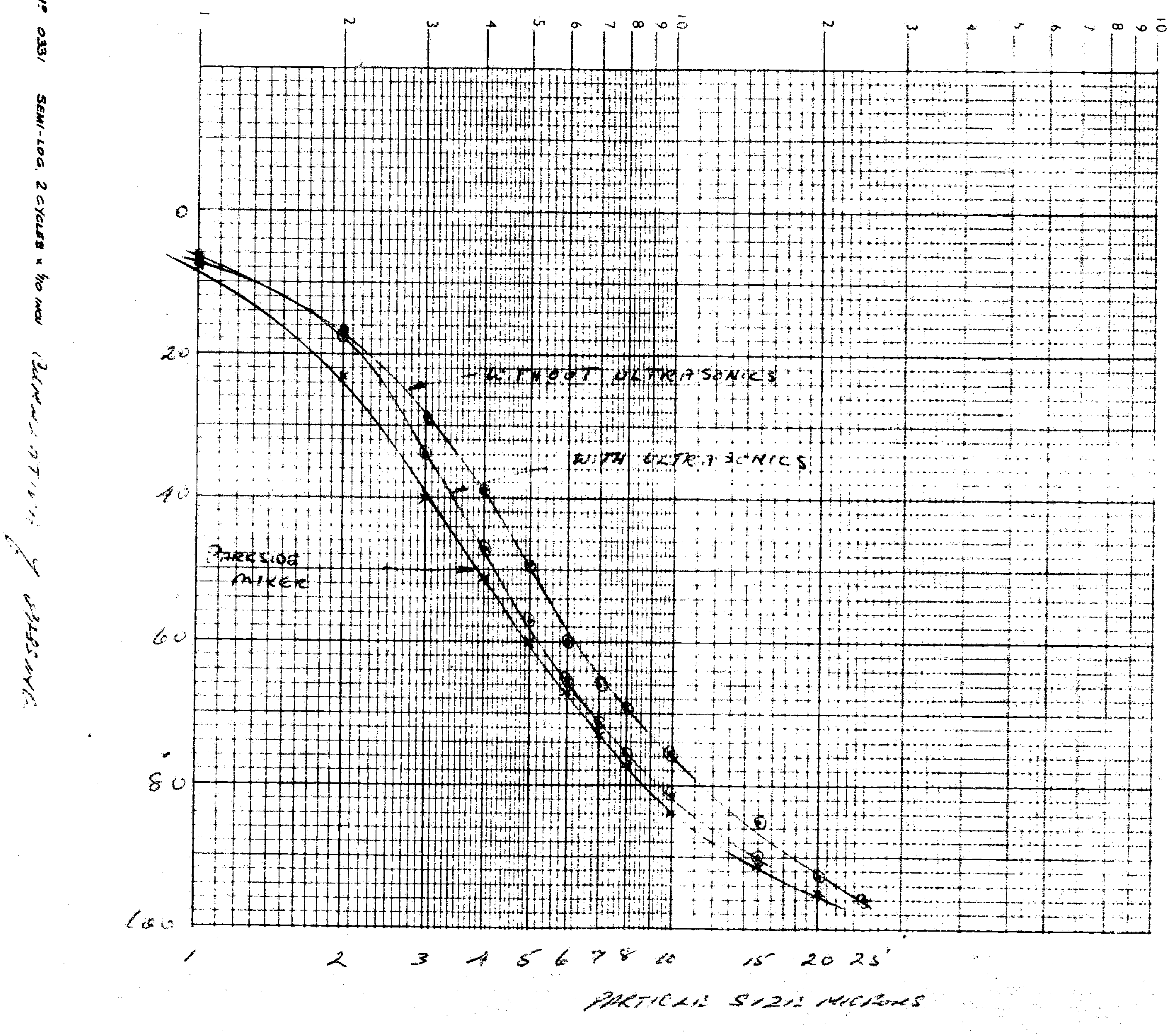
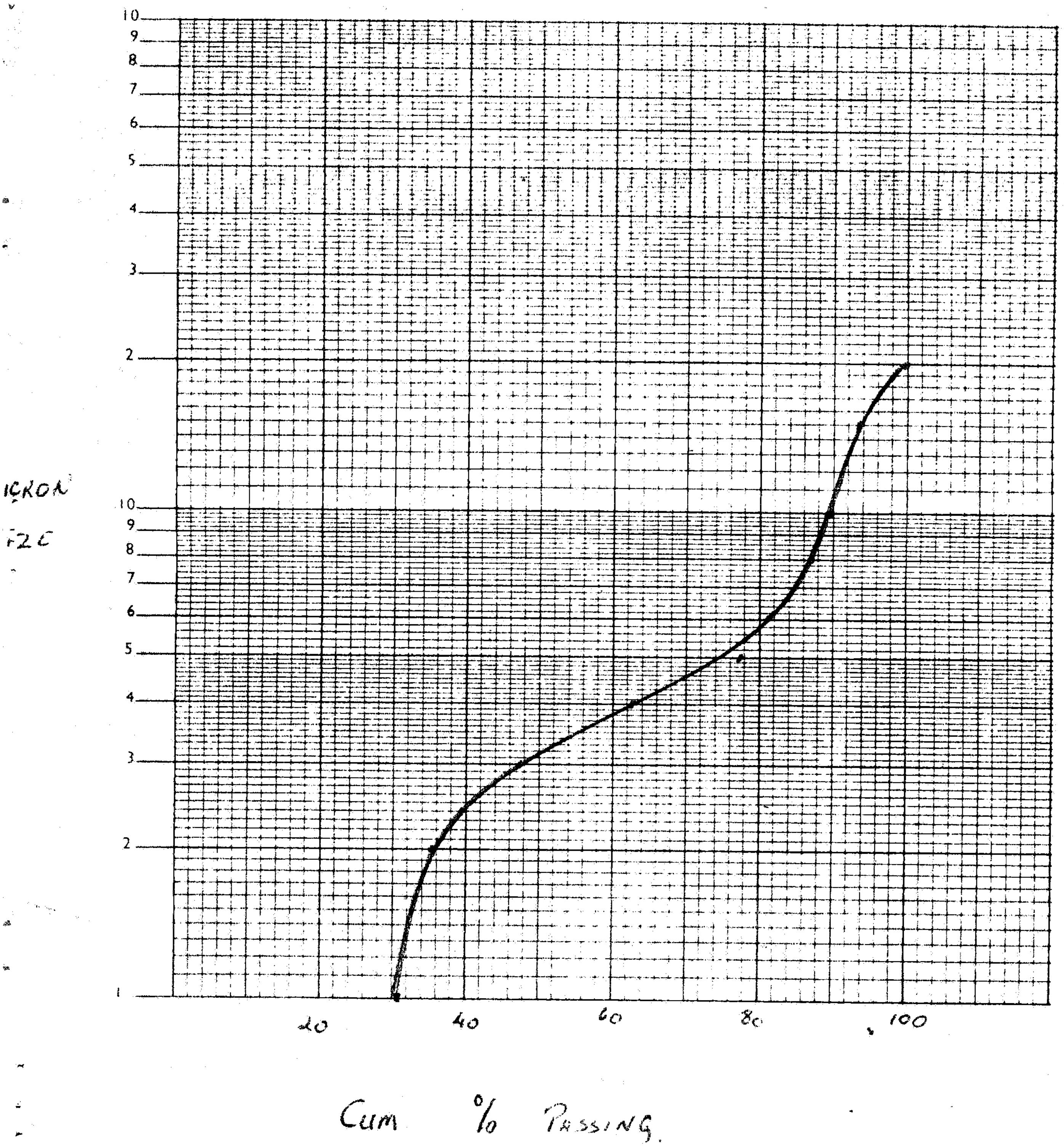


FIG. 1. PARTICLE SIZE DISTRIBUTION.

082

1/1/105 CE 3574



Nº 0331 SEMI-LOG, 2 CYCLES × 1/10 INCH

FIG. 2. Particle Size Distribution
([illegible])

	AUSTRALIAN PAPER MANUFACTURERS	AUSTRALIAN PAPER MANUFACTURERS	JOHNSON & JOHNSON	BALM PAINTS	BALM PAINTS	BALM PAINTS	BALM PAINTS	BALM PAINTS	BALM PAINTS	BALM PAINTS	CE 3672 Cromer C	CE 3673 Cromer C	CE 3674 Hd. Talunga	CE 3685 Hesso
MATERIAL	Clay (filler)	Clay (coating)	Kaolin	China clay K.102	Clay K.117	Clay K.129	Clay K.107 A	Clay 139 A	Clay 162 A	Clay 169 A	Clay	Clay	Clay	Clay
pH		5-5·5	4·2-5·2	5·5 (10 %)	5·1 (5 %)	8·0 (25 %)	8·0 (25 %)	4·2-5·2 (20 %)	5·1	5·5 (10 %)	7·7 (20 %)	7·45 (20 %)	7·60 (20 %)	8·45 (20 %)
S.G.				2·6	2·3-2·9	2·6	2·5-2·7	2·58	2·3-2·9	2·6	2·62	2·65	2·62	2·64
R.I.								1·56	1·56		1·563	1·565	1·565	1·557
MOISTURE VALUE			3·0 % max.	3 % max.	1 % max.	2·0 % max.	1 % max.	1 % max.	1 % max.	3 % max.				
COMBINED WATER					12 5 %			13·97 %	12·15 %		13·9 %	13·6 %	10·05 %	7·7 %
FREEWATER									0·9 %					
WATER SOLUBLES				0·3 % max.	0·2 % max	3·5 % max.	0·3 % max.		0·2 % max.		0·08 %	0·23 %	0·05 %	0·08 %
VISCOSITY		For 25 poise 71												
VALLEY ABRASION TEST											6 mg	10 mg	237 mg	173 mg
BRIGHTNESS	80 % 78 5 % mi	87 % (violet 4 % (yellow)						% Mg 80-84			% Mg $_3$ 88·0	% MgCO_3 92·	% MgCO_3 78 5	% MgCO_3 73·5
OIL ABSORPTION					45-55	35-40	42-48	27						
FEEL OF SLIP			Smooth non gritty must adhere to skin								Smooth non gritty adheres to skin	Smooth non gritty adheres to skin	Smooth slightly gritty adheres to skin	Smooth slightly gritty adheres to skin
BULK DENSITY			11·4-12·2 lb ft^{-3}	40 lb ft^{-3}						40 lb ft^{-3}	10·1 lb ft^{-3}	10·71 lb ft^{-3}	21·4 lb ft^{-3}	25·7 lb ft^{-3}
SiO_2				62·3	48·2	48-56	46·2	45·30	48·2	66·2	46·6	46·7	57·9	64·7
Al_2O_3				24·30	38·4	29-35	40·0	38·38	38·4	20·9	37·2	36·7	27·8	20·6
CaO				0·14			0·3	0·05			0·27	0·28	0·46	1·39
MgO				0·95				0·25		0·8	0·11	0·15	0·19	0·96
TiO_2				1·5			0·4	1·44		1·4	0·08	0·14	1·43	0·82
Fe_2O_3				1·5 max	0·8 % max.	0·5 % max.	0·3 % max.	0·3 % max.		1·5 % max.	1·71 %	1·90	1·80	1·82
Na_2O								0·27		0·2	0·19	0·20	0·11	0·15
CuO										0·2				
MnO										0·004 %	0·04	0·04	0·02	0·02
FINENESS	+200 mesh 0·1 % max.	+300 mesh 0·02 % - 2 µ 75 % +10 µ 0·5 %	100 % trough 200 mesh	99·8 % less than 200 mesh	99·5 % less than 200 mesh	99·7 % less than 200 mesh	98·0 % less than 300 mesh	99·5 % less than 325 mesh	99·5 % less than 325 mesh	99 % less than 300 mesh	100 % less than 200 mesh	100 % less than 200 mesh	100 % less than 200 mesh	100 % less than 200 mesh
PARTICLE SIZE DISTRIBUTION				+ 20 µ 20 % 10-20 µ 10 % 5-10 µ 10 % 1-5 µ 50 % -1 µ 10 %				+ 20 µ 12 % 10-20 µ 22 % 5-10 µ 28 % 2-5 µ 20 % 1-2 µ 6 % -1 µ 12 %	+ 20 µ 12 % 10-20 µ 22 % 5-10 µ 28 % 2-5 µ 20 % 1-2 µ 6 % -1 µ 12 %	+ 20 µ 20 % 10-20 µ 10 % 5-10 µ 10 % 1-5 µ 50 % -1 µ 10 %	+ 20 µ 13 % 10-20 µ 4 % 5-10 µ 25 % 2-5 µ 37 % 1-2 µ 15 % -1 µ 6 %	+ 20 µ 32 % 10-20 µ 6 % 5-10 µ 15 % 2-5 µ 30 % 1-2 µ 13 % -1 µ 4 %	+ 20 µ 26 % 10-20 µ 22 % 5-10 µ 22 % 2-5 µ 17 % 1-2 µ 6 % -1 µ 7 %	+ 20 µ 8 % 5-10 µ 15 % 5-10 µ 24 % 2-5 µ 25 % 1-2 µ 15 % -1 µ 13 %
ANNUAL CONSUMTION	1750 to 2000 tons	2000 tons			87 tons	25 tons	23 tons	440 tons	21 tons	35 tons				

TABLE 6 : SPECIFICATION ON PROPERTIES OF CLAYS

1600-1