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SML 384

MOUNT CRAWFORD

PROGRESS REPORTS TO LICENCE EXPIRY/SURRENDER FOR THE PERIOD 1/3/1970 TO 31/8/1970

Submitted by
Springton Clays Pty Ltd
1970

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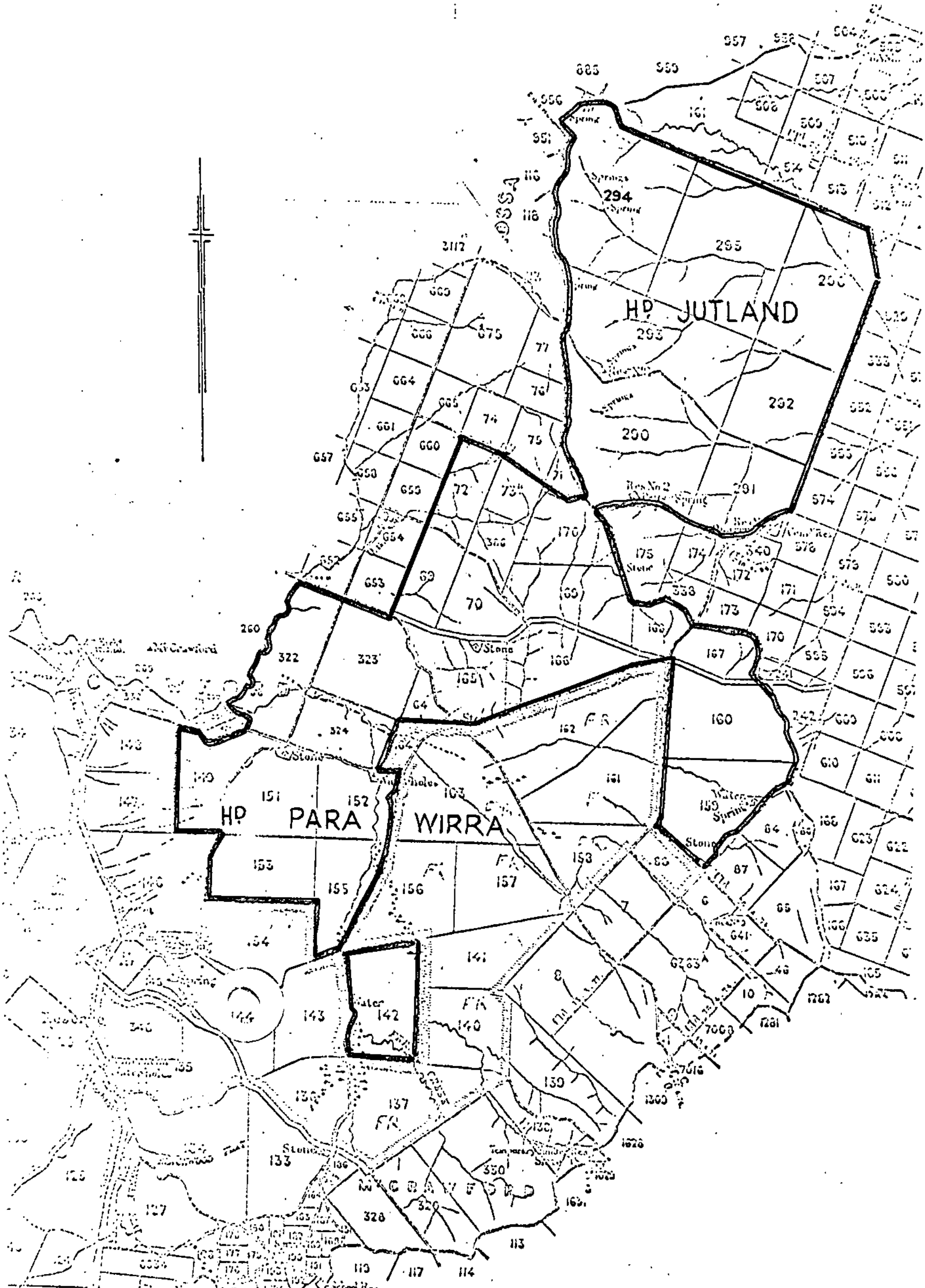
Government of South Australia
Primary Industries and Resources SA



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CONTENTS ENVELOPE 1320

TENEMENT: S.M.L. 384.

TENEMENT HOLDER: Springton Clays Pty. Ltd.

PLANS: Nil.

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SPRINGTON CLAYS PTY. LTD.

SPECIAL MINING LEASE 384

MOUNT CRAWFORD AREA

Period 1st March - 1st June 1970

Report by:

I. H. Haddow, B.E.

Introduction

Special Mining Lease 384 covering areas at Mount Crawford was granted to this Company from the 1/3/70 for a period of 6 months in a Mines Department letter dated 3/3/70 DM 236/70. This Company was to proceed with marketing and development investigation in respect of a white clay deposit and report progress 3 momthly. This report details work completed in the first 3 monthly period.

Summary

Marketing and developmental investigation are being conducted by this Company with the following parties -

Nissho-Iwai (Australia) pty. Ltd.

Kanematsu-Gosshu (Australia) Pty. Ltd.

Ocean Resources Incorporated U.S.A.

Work has been concentrated with a view to determine technical feasibility of marketing the materials from the Mount Crawford Clay Deposit as the area has already been investigated and around 12 million tons of Quartz-Kaolin material indicated as reserve.

Marketing and Development of the Deposit

An outline of the work conducted with the various potential customers of Kaolin is as follows -

1. Nissho-Iwai Co. (Australia) Pty. Limited,
   84 St. George's Terrace, Perth. W.A.

In December, 1968 after extensive hand sampling and a geological inspection by this Company a parcel of 5 tons of material was taken to Japan for evaluation by The Kyoristsu Yogyo Genryo Kaisha Ltd.

........2/

At that stage marketing and technical and feasibility of the material was being conducted by Kaiser Co., U.S.A. Kaiser now having indicated the deposit was too small for their use enabled us to recommence marketing negotiations with Nissho. We are currently awaiting reply from Japan re the potential value of the material and on receipt of a reply further negotiations will be conducted.

2. Kanematsu-Gosho (Australia) Pty. Ltd.
34 Pirie Street, Adelaide. S.A.

A Geologist from Chuo-Kaolin Co. Ltd. Tokyo, Japan visited Mount Crawford site in mid April.
Extensive hand samples were taken from costeens in the area. Technical information regarding reserves and information on product evaluation already in hand was handed to the Japanese representative. The samples were air freighted to Japan for evaluation and the results cabled back to Australia. As these were encouraging some 14 tons of samples were taken from the deposit and shipped to Japan for large scale economical feasibility testing. These samples are currently in transit and results of same should be known in August, 1970.

3. Ocean Resources Incorporated,
3344 Industrial Court, San Diego. U.S.A.

An American Geologist passing through Melbourne phoned this Company regarding the potential marketing of material from the deposit, as he had been asked to enquire of same by his principals in the U.S.A.

We informed him of the Japanese interests in this deposit and he indicated that they would be in contact with us direct.

Conclusions

We are proceeding diligently with investigation of Marketing, and Developmental work of the material from the Mount Crawford site.

At this stage prospects of a firm market for the material appear encouraging, and we are awaiting results of large scale feasibility studies.

THE MT. CRAWFORD CLAY DEPOSIT

1. INTRODUCTION

The Mt. Crawford clay deposit is included in Special Mineral Lease No. 174, which occupies approximately 22 square miles and is held by Australian Blue Metals Ltd., an associate of the Readymix Group. Several samples from this deposit were submitted to Amdel for limited testing between February and May, 1968. Samples were also sent to Kaiser Refractories for assessment in the USA, and they issued a series of reports between May 1968 and November 1969. Mr. Gerke, a director of Mineral Equipment P/L, examined the deposit in May 1968, and made a report to the associated company, Western Titanium N/L. Finally, Dr. P.C. Wright of English Clays Lovering Pochin and Co. Ltd. made a geological and clay evaluation study of the deposit during the period September to November, 1968. It is the object of this paper to attempt an evaluation of the deposit in the light of these reports.

2. GEOLOGY

An original sedimentary series of probable Cambrian age has been metamorphosed to quartzites, schists and gneisses. The quartzites vary from pure to arkosic and micaceons, the felspar being albite and the mica biotite. Talcosic schists also occur. These rocks dip steeply (60 - 70°) to the east, with the result that the deposit is very variable, both horizontally and vertically. Igneous activity is mainly confined to some quartz-felspar-mica pegmatites, intruding a series of mica quartzites and schists, in the south western area of the lease, but felspathic and siliceous veining is sporadically present throughout the area.

The clay deposits are the result of prolonged and intense surface weathering, extending from Tertiary times to the present. The mica quartzites and schists are deeply weathered to 70 feet. The black mica (biotite) is weathered to a colourless variety (hydromica or illite) with release of iron oxides, causing extensive but variable and irregular iron-staining. The presence of talc in the parent rocks has resulted in the formation of montmorillonite, which itself has weathered to kaolinite at the surface. Thus with increasing depth the montmorillonite content increases. Brown, buff, cream and white residual clay deposits cover most of the higher surfaces, and rock outcrops are relatively few. Erosion of these weathered products and deposition in the adjacent valleys has formed extensive deposits of light to dark grey sedimentary clays, of no immediate interest. The potentially valuable clays consist of those portions of the residual clays which are white, and the best kaolin is found in the kaolinised sandstones formed by deep surface weathering of arkosic quartzites. Wright found no evidence of hydrothermal activity.

3. WORK DONE AT AMDEL

About 25 samples were submitted for testing, in most cases merely for a refractoriness test against Orton Cone 31 (1683°C). Of these samples, 19 were selected from two drill holes, of which only two were less refractory than Cone 31.

Several samples were submitted for wet splitting at 76 microns into clay and sand fractions. The clay fractions were filterpressed and dried. One of the dry fractions had a reflectance of 86.0%, compared with magnesium carbonate of nominal reflectance 98%. A chemical analysis was made of this sample, and of the original material, with results as follows, on a dry basis.

	Original Material	Washed Sample
SiO_2	75.8%	47.8%
Al_2O_3	14.7	37.0
Fe_2O_3	0.09	0.22
FeO	0.22	0.18
MgO	0.80	0.74
CaO	0.01	0.02
MnO	$<$ 0.01	$<$0.01
Na_2O	0.62	0.21
K_2O	0.01	0.01
TiO_2	0.32	0.08
SO_3	$<$0.01	$<$0.01
Cl	0.95	0.31
CO_2	0.02	0.01
H_2O^+	6.55	13.5

This sample was afterwards sent to Kaiser Refractories, as is revealed by the above analysis of the washed sample, quoted by them.

Another washed sample had a refractoriness of Orton Cone 34 (1763°C). This was the only sample of which Amdel was asked to determine the actual pyrometric cone equivalent (PCE) and the value approaches the limit for pure kaolin.

The work done at Amdel demonstrated the existence in the area of kaolinised sandstone from which a highly refractory white clay could be extracted by washing.

4. WORK DONE BY KAISER REFRACTORIES

4.1 Assessment of Samples

All samples examined were supplied by the Readymix Group. The first, submitted by Mr. H.G. Fleshman and reported on 8th May, 1968, was the same material as that examined at Amdel, the analysis of which is given above. A wet split was made at 43 microns. The oversize amounted to 52% and was mainly quartz. It had the following analysis, and should make a good glass sand if the kaolin could be efficiently removed:

	%
SiO_2	96.2
Al_2O_3	1.55
Fe_2O_3	0.09
MgO	0.43
CaO	0.10
Na_2O	0.04
K_2O	0.02
TiO_2	0.57
LOI	0.83

The minus 43 micron fraction contained 96% of less than 20 microns and 50% less than 3 microns. Mineralogical analysis of both fractions showed:

	+ 43µ (quartz)	- 43 µ (kaolin)
Kaolinite	4	94
Quartz	94	5
Talc	2	1
Rutile	0.5	trace

Comparison of the analyses given in Section 3 shows that iron and magnesium tend to follow the clay, and titanium the sand. The titanium is evidently mainly present as relatively coarse rutile, and presumably could be recovered separately. The magnesium appears to be present mainly as talc, of comparable particle size to the kaolinite, and hence not separable from it. The magnesium content of the clay fraction (0.74% MgO) is equivalent to 2.3% of talc.

The next sample examined was tested for its refractory properties, and reported on 20th May, 1968. The PCE was Cone 33 (1743°C) and the maximum linear shrinkage 22.4%. The clay did not become volume stable until about 1650°C, when the porosity was 2.5%. Because of the high calcination temperature required to obtain volume stability, it was concluded that the clay would not be satisfactory for the manufacture of refractory aggregate. The high linear shrinkage would also preclude its use as a refractory bond clay. After this, Kaiser appear to have lost interest in the use of Mt. Crawford clay in refractories, since no further reference to this is found in subsequent reports. Instead, they turned attention to its use as a paper clay.

The next report, dated 14th November, 1968, deals with a suite of auger-drilled samples taken from an area of about one square mile around the initial open-cut area from which the first sample submitted by Fleshman had been obtained. 106 samples from 19 holes were examined, but since the samples had no elevation designations, and were not coordinated with any orderly geographical sampling pattern, no estimate of the shape or volume of the deposit was possible.

The samples were split at 43 microns into sand and clay fractions, the mineralogical composition of both of which was extremely varied, both among and within holes. The clay fraction, the yield of which varied from 11 to 86%, was primarily kaolinite, with pyrophyllite as the major impurity, and quartz, plagioclase felspars and muscovite as the minor impurities, as follows:

Kaolinite	60 - 100%
Pyrophyllite	up to 30%
Plagioclase	up to 30%
Quartz	up to 11%
Muscovite	up to 9% (absent from most samples).

Chemical analysis of selected samples (i.e. of the clay fraction) showed large variations in Al_2O_3 - SiO_2 ratios, and Al_2O_3 contents varying from 22.4 to 32.9%. Particle size determinations on selected samples indicated that they were essentially finer than 20 microns, and in general slightly coarser than a standard kaolin (the -2 micron portion of the -43 micron fraction varied from 19 to 76%).

Seventeen samples of the coarse fraction (+43 microns) from 4 holes were examined. The most abundant mineral varied, being either kaolinite, quartz, pyrophyllite or plagioclase, depending on location of hole or depth. Correspondence from the Readymix Group suggested that the samples could have been contaminated due to the drilling method and to wash down from excessive rain during sampling. But contamination could not produce a diversity not originally present.

Two trench samples were also investigated. These were screened at 100 mesh, and treatment of the undersize in a hydrocyclone gave an overflow product amounting to one quarter of the total sample, and containing 90 - 92% of kaolin. The underflow contained 80 - 86% kaolin, so that the separation was not a success. It was concluded that removal of the residual non-kaolin phases may be impossible owing to their small size.

A report dated 15th January, 1969, discusses a sample from Mt. Crawford described as bentonite. This was found to be poorly crystallised kaolinite, with 5 - 10% of plagioclase and traces of rutile and pyrophyllite. It was clearly clay of the same type as that previously examined from the auger samples, and not bentonite.

The results of beneficiation of two samples of sandy kaolin from Pits 3 and 4 are given in a report dated 31st March, 1969. The sample from Pit 3 was said to be similar to the original open cut sample submitted by Fleshman. The samples had already been beneficiated (presumably at Amdel) by wet screening at 200 mesh and filtering and drying the undersize. The samples were treated in a hydrocyclone, which produced a quartz separation at approximately 50 microns. The major impurity (5 - 15%) in the overflow products was reported as pyrophyllite, which was thought to be interlayered with the kaolinite. No talc was found, and residual quartz and plagioclase were each of the order of 1%. The brightness of the beneficiated kaolin was comparable to that of paper grade kaolins.

4.2 Estimates

In a feasibility study by H.G. Fleshman, dated 4th October, 1968, estimates are given for a kaolin production of 55,000 tons and a sand production of 71,000 tons in the first year, rising to 220,000 tons of kaolin and 284,000 tons of sand in the fifth year of operation. The estimates are based on the following assumptions:

Run of mine ore:	55% sand, 45% kaolin.
Sand recovery	95%
Kaolin recovery	90%.

70% of the kaolin product to be sold as raw, water-washed material (dry, spray-dried, or slurry) and 30% as calcined product (refractory aggregate).

Initial cost of plant to produce:

		$US
1.	Water-washed kaolin	2.75 million
2.	Water-washed and calcined kaolin	4.45 "
3.	Water-washed kaolin and silica sand	3.57 "
4.	Water-washed and calcined kaolin and silica sand	5.27 "

To expand the plant to its final capacity 0.24 million should be added to 1 and 2 and 0.33 million to 3 and 4.

The operating costs, excluding depreciation, property taxes, insurance and expense of financing, were estimated as:

Production, tons		Product	$A per ton	
1st year	5th year		1st year	5th year
17,500	70,000	Spray dried kaolin, bulk	6.51	3.24
"	"	" " " bagged	8.01	4.74
7,500	30,000	Calcined kaolin, bulk	14.20	7.10
"	"	" " bagged	15.70	8.60
35,500	142,000	Silica sand, bulk	0.88	0.72
"	"	" " bagged	2.38	2.22

The estimated water consumption was, for water-washed kaolin, 2 tons of water per ton of kaolin, for calcining, 1.2 tons of cooling water per ton of calcine, and for the silica section, 1 ton of water per ton of sand.

A second feasibility study, dated April 1969, is confined to water-washed kaolin. US prices are given as follows:

Price of Paper Grades of Water-Washed Kaolin

	Brightness %	Particle Size % - 2μ	Price, $US per ton* Cartload, Bulk
Coating Grades			
Premium	88 - 92	94 - 97	47.00
No. 1	87	90 - 94	38.60
No. 2	86	80 - 83	29.70
No. 3	85	70 - 73	28.60
Filling Grades	80 - 84	30 - 65	16.20

* Note: long tons, as throughout this paper.

The total potential market (Western US and Pacific countries) available to Mt. Crawford in 1972 was estimated as 349,000 tons per year. To achieve one third of this would require all four coating grades. A substantial price advantage would also have to be offered to customers to induce them to change to a new source of kaolin.

Estimates for production of water-washed kaolin only, rising from 31,500 tons in the first year to 118,000 tons in the sixth, are given for 3 price levels, as follows:

Product sells for $US/ton	Payout years	Return on Investment %
29.70	6.84	10
38.60	4.90	25
47.00	4.02	32

4.3 Reserves

The last report from Kaiser, dated 17th November, 1969 was made by Mr. T.F. O'Neill after he had visited the deposit. He points out that the auger samples were taken from holes located in the best-known clay, and probably represent slightly better than average grade material (the average percentage by weight of the -43 micron fractions for all samples was 39, while 3 of the holes ranged from 17 - 23% and averaged 19%). Microscopic examination of numerous field samples showed that the kaolinite was unusually coarse, silky and lustrous, resembling talc or sericite much more than normal kaolinite. It is presumably present in the form of "stacks".

The -43 micron material was not examined to determine which quality of paper coating clay, if any, could be made from it, though the Refractories research personnel thought that most of the samples submitted to them would produce an acceptable coating clay. This opinion was based on the observation that the brightness of selected samples and the grain size distribution closely resembled those of raw Georgia kaolins from which coating clays are made. No viscosity tests were made.

From his own geological examination of the area and the results available to him, O'Neill estimated the total reserves of white clayey sand that one could reasonably hope to find on the property, and which would be at least 5 ft. thick and have a stripping ratio not exceeding 2:1, as follows:

Area	Dry Tons
Measured Category	1.33 million
Indicated "	4.06 "
Inferred "	5.80 "
TOTAL	11.19 million

These figures he regards as almost certainly including material which has too high a felspar/quartz content in the fine size ranges.

He concludes that the deposit could contain 3.5 - 4 million tons of -43 micron kaolinite-quartz-pyrophyllite-felspar mixture, from at least the better part of which the Refractories research personnel believe that a coating-grade clay could be prepared. Very selective mining, because of the erratic and wide-spread iron staining, would be both necessary and possible. Mining costs should approximate $US 0.57 per ton of raw ore delivered to the plant, including clearing and stripping. Total reserves could be adequate to support the operation envisaged in the second feasibility study (see above) for 10 or perhaps 12 years.

O'Neill recommended a two-stage investigation:

(1) A detailed laboratory examination of the white clay intersections in 10 existing drill cores to establish the quality of the products that could be obtained.

(2) If the results of (1) are encouraging, to begin a systematic exploration and testing programme to establish the reserves of the specific raw material required to produce the desired products.

This investigation has in fact been carried out by Dr. Wright, and the results will be given in the next Section.

5. WORK DONE BY ENGLISH CLAYS LOVERING POCHIN

Dr. Wright laid out a 250 metre grid for a continuous core drilling programme over approximately 1 square mile of ground containing the known clay occurrences, and 42 holes were drilled. White clay considered worth testing was found in 8 of these holes. Trenches were bulldozed in Sections 166 and 169, Hundred of Parra Wirra, to obtain a visual indication of variability of the clay-bearing material. Drill cores and trench samples, together with auger samples obtained by Readymix Concrete Ltd. were sent to St. Austell, UK, for evaluation as paper clays. The Readymix auger samples were mainly taken from the immediate area around the original pit adjoining Section 169, Hd. Parra Wirra, but precise locations were not known. The number of samples tested, with yield and brightness results, are shown below.

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	Samples from		
	Auger	Trench	Drill Core
1. Total number of samples tested	12	8	20
2. No. of samples of acceptable natural brightness	4	1	1
3. No. of samples of acceptable bleached brightness	7	1	2
4. Clay yield of samples in (3), %	10.8-25.6	12.6	13.3-16.3
5. -2 micron fraction of samples in (4), %	65-88	59	77-78

For paper coating clays, the minimum acceptable flowability (expressed as % solids for a viscosity of 5 poise) is 67.0. Not one of the samples tested reached this level, the highest value recorded being 66.7, and the highest for a clay of acceptable brightness (after bleaching) 64.1. This sample, the only one with commercial possibilities, came from the depth zone of 8 ft. 6 in. to 22 ft. and had the following characteristics:

Clay yield	16.3%
-2 micron content of clay yield	77%
Flowability	64.1
Natural brightness	90.5/2.5
Bleach brightness	91.2/1.6

Wright classified the kaolin-bearing formations from which the samples were taken into 5 types:

(1) Mica quartzites and schists. Deeply weathered to depths of up to 70 ft. Clays from this rock group showed heavy iron-staining, derived from weathering of biotite.

(2) Massive quartzites with small amounts of mica. These rocks are resistant to weathering because of their high quartz content, and form most of the high ground in the lease area. Only one sample worth testing was obtained, the clay occurring in veins derived from alteration of felspar. This sample could not be deflocculated, and the brightness was very poor.

(3) Pure quartzites, arkose in part. The most favourable parent body for the formation of kaolinic sandstone by deep surface weathering. The clay is very variable in both yield and quality. Most of the original auger samples came from this rock group. Natural brightness of these samples was generally good, though erratic, but brightness and flowability both declined rapidly at depths greater than 20 ft. The one sample with commercial possibilities, described above, came from

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this group, but in view of the extreme lateral and vertical variation in clay quality, it was considered that this kaolin occurred in an isolated pocket (reserve of raw matrix estimated at 186,000 tons, which, if it could be selectively worked and processed, would probably yield 30,000 tons of paper-grade coating clay).

(4) Sandy quartzites. Generally fairly friable. Clay derived from weathering of this material usually forms a thin capping and is generally iron-stained. It did not meet the specifications required for paper clay. Flowability was bad near the surface, but improved with depth, while the reverse was true of brightness.

(5) Kaolinitic and Talcose Schists. These rocks are very variable. They are fairly susceptible to weathering, although the clay produced is of mixed type, kaolinite predominating at the high levels, with poor flowabilities but reasonable brightness. Clays of this nature were considered unsuitable for any paper industry.

Mineralogy. The processed clay fractions were examined by X-ray diffraction. Kaolinite was the dominant mineral. Montmorillonite was found, in quantities varying from a trace up to 23%, in all samples in which it was sought, except one, the best sample mentioned above, which however contained 3% of talc (and 96% of kaolinite). The montmorillonite of course accounts for the poor flowabilities. Talc, up to 29%, was also a common associate of montmorillonite in these samples. Talc is supposed to have resulted from metamorphism of the original sediments, which probably contained dolomitic and arkosic components. The presence of talc, a mineral rich in magnesium, is also believed to have controlled and favoured the formation of montmorillonite from albitic felspar, in preference to kaolinite, during weathering. At the surface, where weathering conditions are more intense, the montmorillonite itself has been converted to kaolinite.

Reserves.

1. Sec. 166, Hd. Parra Wirra. Probable tonnage of white kaolinite and talcose matrix, unsuitable for paper production, 1.03 million tons, overburden 0.5 million tons. Average clay yield assumed to be 32%, giving a reserve of 0.33 million tons of clay.
2. Sec. 168-170, 175, Hd. Parra Wirra. Probable tonnage of white raw clay matrix 5.59 million tons. Assuming an average clay yield of 23% gives a reserve of 1.29 million tons of white clay, not of paper grade.
3. Sec. 169, 175 Hd. Parra Wirra. Probable tonnage of raw clay matrix with paper grade possibilities, 186,000 tons. Overburden 99,000 tons. Assuming an average yield of 16% gives a reserve of paper grade clay of 30,000 tons.

To sum up, geological mapping failed to reveal the presence of other kaolin-bearing formations within the lease area, apart from those in the Sections listed above. The total reserves of raw white clay matrix were estimated at 6.81 million tons, estimated to yield 1.65 million tons of washed clay, of which

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30,000 tons are of possible paper grade. White kaolinitic material without bad staining is virtually restricted to the depth zone 6 - 25 ft. Dr. Wright concluded both from the geological and clay evaluation results that the lease does not contain appreciable deposits of clay suitable for use in paper production.

6. WORK DONE BY MINERAL EQUIPMENT FOR WESTERN TITANIUM

Mr. Gerke made a feasibility study based on the assumptions that the raw material as mined will contain 50% clay fraction, and that the beneficiated kaolin will contain at least 35% sizing suitable for use as a paper filler clay, and can be finished to a filler clay specification. He estimated the mining cost at $4 per ton of raw material, delivered to the plant stockpile. The capital cost of plant to produce a minimum of 20,000 tons of paper filler clay per year was estimated at $450,000. The cost of production of paper filler kaolin from the established stockpile adjacent to the plant was estimated at $20 per ton bagged, excluding cost of servicing the capital investment.

The proposed plant made provision for bleaching with chlorine gas.

In assessing the feasibility of the project, an average value of the product of $40 per ton was assumed.

Mr. Gerke recommended laboratory work to assess the clay, and production at Amdel of a 5 ton lot of beneficiated kaolin, to provide samples for potential markets.

7. CONCLUSIONS

7.1 Clay Reserves

Two estimates of clay reserves have been made. O'Neill estimated the total reserves of raw white-clay matrix (clayey sand) on the lease at 11.19 million tons, of which slightly more than half (5.8 million tons) was inferred. Wright estimated a total of 6.81 million tons. Wright's estimate is based on a systematic drilling programme which he directed himself, whereas no accurate drilling data were available to O'Neill, so that Wright's estimate is to be preferred.

Wright, taking an overall average clay yield from the matrix of 24%, gets a reserve of washed clay of 1.6 million tons, with 30,000 tons of possible paper-coating grade. Applying the same yield to O'Neill's estimate gives an inferred reserve of washed clay of 2.7 million tons. His own yield of 30 - 35% is based on auger samples which he suspected of representing better than average grade material, a suspicion confirmed by Wright's results.

We may reasonably conclude that the total quantity of white clay that could be obtained from the property by selective mining and washing does not exceed 2 million tons.

7.2 Clay Quality

There are two very marked discrepancies between the mineralogical results reported by Kaiser and English Clays. Kaiser found a small amount of talc in the first sample, but thereafter found pyrophyllite up to 30% regularly present, and they reported no montmorillonite. English Clays found montmorillonite up to 23% regularly present, and talc commonly present up to 29%. They reported no pyrophyllite.

The rocks in the region are well known to contain talc, but pyrophyllite has not, as far as I know, been reported. Talc and pyrophyllite in the pure state are easily distinguished by X-ray diffraction, though they have a peak in common. But the difference may be masked in the presence of kaolinite, and a mineralogist may identify the mineral he expects to find, which in the US could more commonly be pyrophyllite than talc. Accordingly, English Clays are more likely to be right, and Kaiser may be presumed to have identified talc as pyrophyllite, though this is not to deny the possibility that pyrophyllite may also be found in these rocks. The practical difference is not great, since both minerals are equally fine grained, and hence not separable from kaolin, and have similar ceramic properties. Talc is a hydrated silicate of magnesium, and pyrophyllite of aluminium, so that a chemical analysis immediately shows the difference.

Montmorillonite has been reported before in clays from this region, and the finding of English Clays on this point also should be accepted. English Clays would be particularly concerned with montmorillonite since the presence of only small quantities greatly increases the viscosity of clay suspensions, and vitiates them for paper use. Kaiser may not have looked for montmorillonite, small quantities of which would not be of great significance from the point of view of refractories, though refractoriness declines with increasing quantities. Moreover, they made no viscosity tests, which might have led them to suspect the presence of montmorillonite.

The clays were first tested for refractoriness (at Amdel), and it is certain that highly refractory clay (PCE up to Cone 34) occurs in the area. Only one sample was evaluated by Kaiser, and found to be unsatisfactory because of high firing shrinkage, and the high calcination temperature (1650°C) required to obtain volume stability. One sample of uncertain provenance is inadequate, and further testing would be necessary before it could be concluded that clay from the lease is unsuitable for use in refractories, particularly as clay samples from the same region, though not from the area of the lease, have been found which stabilise at about 1300°C.

Kaiser believed, on the basis of brightness and particle size distribution of selected samples, that a coating-grade clay could be produced, but they did not submit samples for evaluation. English Clays, who evaluated the samples only from the point of view of paper-coating clays, showed that they were unsuitable for this purpose (except for the doubtful exception of a small pocket), largely on account of the montmorillonite content, which cannot be removed. Mineral Equipment seem to have reached the same conclusion, though the matter is not discussed, since they contemplate the use of the clay only for paper filling.

To sum up, the washed clay is basically a poorly crystallised but coarse-grained kaolinite, normally contaminated with montmorillonite, and often with talc and fine quartz. It is generally refractory, but its suitability for refractory products needs further investigation. It is not suitable for paper coating. It might find a use as a filler for paper, rubber, plastics, paints etc. and in the manufacture of ceramic whiteware, but its suitability for these purposes has not been investigated.

7.3 Economics of Clay Production

Kaiser's estimates for the production of water-washed kaolin are based on the assumption that paper-coating grades will be produced, and are therefore not applicable. Mineral Equipment give estimates for filling clay at a production rate (minimum) of 20,000 tons per year. This quantity appears too large for local consumption, and too small for an export industry. Mining and production costs, amounting to $24 per ton , are very much larger than Kaiser's estimate, probably because of the very much smaller scale of operations envisaged. The assumed selling price of $40 per ton seems much too optimistic for filling clay, and a price nearer half this value would be more realistic.

Mineral Equipment include bleaching with chlorine in their process. The chief colouring agent is iron, which cannot be bleached by chlorine. In fact, chlorine forms intensely coloured yellow complexes with iron, so that treatment with chlorine could enhance the discolouration. Reducing agents, such as zinc dithionite, are required to bleach clay. These reduce ferric to the almost colourless ferrous iron, which is also brought into solution, and so partially removed in filtration.

The conclusion to be drawn from the available evidence is that the deposit will not support a clay-producing industry, because of the small reserves of clay, the very selective mining required, the high production costs, and the relatively poor quality of the finished clay, which confines it to low-priced grades. The clay, however, could be a useful by-product if the lease were worked for sand production.

0020

7.4 Sand Production

The lease has been explored and sampled with clay production in mind, though the possibility of obtaining sand as a by-product was not overlooked. Kaiser examined the sand from the first sample submitted, and found it suitable for glass-making, if the clay could be efficiently removed. It may now be worth following this up, and re-examining the lease from the point of view of sand production. This may involve drilling somewhat different formations, with particular attention to the sandy quartzites. Washing will be necessary, and this may yield a saleable clay product. A further advantage may be derived from the separation of heavy minerals, particularly rutile.

8. RECOMMENDATIONS

1. The lease should be examined as a sand prospect, and drill samples taken under the direction of a geologist. It is essential that all sampling should be adequately supervised, and related to the geology of the area. Properly selected or bulked samples should be sent to Amdel for sand-clay separation, and the sand fraction should be analysed chemically and mineralogically. Heavy minerals, if present in sufficient quantity, should be separated from the sand fraction and assessed. The clay fractions should be retained.

2. If evaluation of the results of (1) shows adequate reserves of sand of suitable quality, markets for which can be negotiated, the clay fractions reserved should be assessed as filler, refractory and pottery clays, and processing costs estimated.

An Interim Report on Tests Made on Mt. Crawford Kaolin

1. Sample received by s/s "Australia Maru"

Pit No. 1 --	150 bags (Bag No. 151 to 300)	about 3,750 kgs
Pit No. 2 --	50 bags (Bag No. 351 to 400)	about 1,250 kgs
Pit No. 3 --	200 bags (Bag No. 1 to 150 and No. 301 to 350)	about 5,000 kgs
Pit No. 4 --	50 bags (Bag No. 401 to 450)	about 1,250 kgs
Total	450 bags	about 11,250 kgs

2. Test in the Laboratory

   Before conducting tests in their factory, a preliminary test was made in the laboratory of Chuo Kaolin in order to determine the test method. For this preliminary test, 2 kgs each of average samples from every pit were picked out, one kilogram of which was used for tests and the rest retained for future reference. The test results are given in the attached paper.

3. According to the test result obtained in the laboratory, following instructions were issued to the factory.

   a) Decision on Quality

   The entire 200 bags of Pit No. 3 were labelled Lot No. 1.
   Then another lot was made by blending 150 bags of Pit No. 1 with 50 bags of Pit No. 4, which was labelled Lot No. 2.
   50 bags under Pit No. 2 could not be used, because of theirr poor whiteness and coarse particle sizes.

   b) Classification

   To classify each lot to be passed as 325 mesh. Mesh size was determined as -325 mesh under the Wet Method, with less than ½% of +325 Mesh included.

c) Bleaching

Each lot to be bleached to have a whiteness between 80 to 82%.

d) To reject all particles in Lot No. 2 smaller than 3 microns in particle size. Wet separating method to be used.

4. Product obtained

Under production method specified above, our product obtained was as follows:

a) The quantity of refined product obtained from Lot No. 1 was 1,000 kgs.(This yield is about 20%.)

b) The quantity of refined product obtained from Lot No.2 was 2,025 kgs.(This yield is about 40%.)

5. Comments

25 kgs each of refined samples from each lot were sent to paper manufacturers to determine their qualities as paper filler.

6. Prospects of Mt. Crawford kaolin in Japan as paper filler.

Through the above-mentioned tests in the factory, we found this kaolin has the following demerits for economically importing it into Japan.

a) This kaolin has poor whiteness, less than 80%, so that it needs to go through bleaching process for obtaining refined products suitable as paper filler. But it will be too expensive to apply bleaching process to it here.

b) When we import this kaolin, such low yields of refined products as shown under 4. above, present us an economical serious problem. We must have the kaolin refined at the mine in order to make our adoption of it economically feasible.

c) Since ranges of particle sizes of this kaolin are not the same with every pit, attention needs to be paid whether the kaolin selected is of a suitable particle size or not.

While our tests are as yet incomplete, judging from the above demerits, we consider it is unfeasible for us to use this kaolin.

Test result in the laboratory -(1)

粘土鉱物試験報告書

0023

昭和 45 年 9 月 30 日 (30th Sept. 1970)

産地 Location	Mt. Crawford		
鉱種 Kinds of Mine	Kaolin P.T. No.1 (No. 151 ~ 300)		
入荷月日 Date sample obtained	45. 8. 3.	試験月日	45. 8

試験結果 (Test result)

水分 % Moisture	~~8.6~~ 21.0	Limit of particle size	
歩留 % Yield rate	~~22.2~~ 51.4	分級粒度	-325 mesh
白色度 Whiteness	74.9		- 44 μm.
漂白白色度		薬品使用量% Chemical	
pH	6.0	濃度 % Concentration	10
粘度 cps		濃度 %	
表面光沢			
摩耗度 mg			

粒度分布

粒子径 particle size	%	cum. %
+25 μ	9.00	
25 ~ 10 μ	8.30	
10 ~ 5	8.30	
5 ~ 4	3.15	
4 ~ 3	3.25	
-3	68.00	

化学分析

	%
Ig. loss	
SiO_2	
Al_2O_3	
Fe_2O_3	
CaO	
MgO	
K_2O	
Na_2O	
TiO_2	
Total	

摘要	

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Test Result in the laboratory -(2)

粘土鉱物試験報告書

0024

昭和 45 年 9 月 30 日

産地 Location	Mt. Crawford		
鉱種 Kinds of Mine	Kaolin Pit No.2 (試No 251～400)		
入荷月日 Date sample obtained	45. 8. 3	試験月日 Test date	45. 8

試験結果 (Test result)

水分 % Moisture	19.0	Limit of Particle Size	
歩留 % yield rate	49.4	分級粒度	-325 mesh
白色度 whiteness	59.8		
漂白白色度		薬品使用量% Chemicals	
pH	5.5	濃度 % Concentration	10
粘度 cps		濃度 %	
表面光沢			
摩耗度 mg			

粒度分布

粒子径 Particle size	%	cum. %
+25μ	0.70	
25～10μ	6.30	
10～5	11.20	
5～4	4.90	
4～3	4.90	
-3	72.00	

化学分析

	%
Ig. loss	
SiO_2	
Al_2O_3	
Fe_2O_3	
CaO	
MgO	
K_2O	
Na_2O	
TiO_2	
Total	

摘要	

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Test result in the laboratory —(3)

粘土鉱物試験報告書

0025

昭和 45 年 9 月 30 日

産地 Location	Mt. Crowford		
鉱腫 Kind of pit	Kaolin Pit No. 3 (試No. 1~114)		
入荷月日	45. 8. 3	試験月日	45. 8

試験結果 (Test result)

水分 % Moisture	8.6	Limit of particle size	
歩留 % yield rate	22.2	分級粒度	−325 mesh
白色度 Whiteness	77.0		
漂白白色度		薬品使用量%	
pH	6.50	濃度 % Concentration	10
粘度 cps		濃度 %	
表面光沢			
摩耗度 mg			

粒度分布 particle size

粒子径	%	cum. %
+25μ	14.45	
25~10μ	12.92	
10~5	19.63	
5~4	3.80	
4~3	3.20	
−3	46.00	

化学分析

	%
Ig. loss	
SiO_2	
Al_2O_3	
Fe_2O_3	
CaO	
MgO	
K_2O	
Na_2O	
TiO_2	
Total	

摘要	

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Test [result] in the laboratory —(4)

粘土鉱物試験報告書

0026

昭和 45 年 9 月 30 日

産地 (location)	Mt Crawford		
鉱脈 (kind of clay)	Kaolin Pit No.3 (深さ 114 ~ 144)		
入荷月日	45. 8. 3	試験月日	45. 9

試験結果 (Test result)

水分 % (moisture)	11.8	limit of particle size	
歩留 % (yield %)	26.8	分級粒度	−325 mesh
白色度 (whiteness)	78.4		
漂白白色度		薬品使用量%	
pH	6.0	濃度 % (Concentration)	10
粘度 cps		濃度 %	
表面光沢			
摩耗度 mg			

粒度分布 (particle size)

粒子径	%	cum. %
+25 μ	20.83	
25 ~ 10 μ	13.26	
10 ~ 5	17.35	
5 ~ 4	4.17	
4 ~ 3	1.39	
−3	43.00	

化学分析

	%
Ig. loss	
SiO_2	
Al_2O_3	
Fe_2O_3	
CaO	
MgO	
K_2O	
Na_2O	
TiO_2	
Total	

摘要

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Test result in the laboratory -(5)

粘土鉱物試験報告書

0027

昭和 45 年 9 月 30 日

産地 Location	Mt Crowford		
鉱種 Kind of Mine	Kaolin Pit No. 3 (製 No 145~150)		
入荷月日		試験月日	

試験結果 (Test result)

水分 %	6.6		
歩留 %	18.5	分級粒度	-325 mesh
白色度	77.8		
漂白白色度		薬品使用量%	
pH	6.0	濃度 %	10
粘度 cps		濃度 %	
表面光沢			
摩耗度 mg			

粒度分布

粒子径	%	cum. %
+25 μ	10.50	
25~10 μ	9.10	
10~5	19.00	
5~4	5.10	
4~3	3.30	
-3	53.00	

化学分析

	%
Ig. loss	
SiO_2	
Al_2O_3	
Fe_2O_3	
CaO	
MgO	
K_2O	
Na_2O	
TiO_2	
Total	

摘要	

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Test result in the laboratory -(6)

粘土鉱物試験報告書

0028

昭和 45 年 9 月 30 日

産地	Mt. Crawford		
鉱種	Kaolin Pit No 3 (製 No 301~350)		
入荷月日	45. 8. 3	試験月日	45. 8

試験結果

水分 %	8.6		
歩留 %	23.6	分級粒度	-325 mesh
白色度	78.8		
漂白白色度		薬品使用量%	
pH	5.5	濃度 %	10
粘度 cps		濃度 %	
表面光沢			
摩耗度 mg			

粒度分布

粒子径	%	cum. %
+25μ	12.20	
25~10μ	12.55	
10~5	16.60	
5~4	5.02	
4~3	7.23	
-3	46.00	

化学分析

	%
Ig. loss	
SiO_2	
Al_2O_3	
Fe_2O_3	
CaO	
MgO	
K_2O	
Na_2O	
TiO_2	
Total	

摘要	

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Test result in the laboratory −(7)

0029

粘土鉱物試験報告書

昭和 45 年 9 月 30 日

産地	Mt Crawford		
鉱種	Kaolin Pit No 4 (製 10 441~450)		
入荷月日	45. 8. 3	試験月日	45. 8

試験結果

水分 %	9.4		
歩留 %	24.4	分級粒度	−325 mesh
白色度	91.1		
漂白白色度		薬品使用量%	
pH	5.5	濃度 %	10
粘度 cps		濃度 %	
表面光沢			
摩耗度 mg			

粒度分布

粒子径	%	cum. %
+25 μ	14.10	
25 ~ 10	5.65	
10 ~ 5	11.30	
5 ~ 4	0.70	
4 ~ 3	4.25	
−3	64.00	

化学分析

	%
Ig. loss	
SiO_2	
Al_2O_3	
Fe_2O_3	
CaO	
MgO	
K_2O	
Na_2O	
TiO_2	
Total	

摘要	

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