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DEPARTMENT OF SUPPLY AND DEVELOPMENT

COMMONWEALTH COPPER AND BAUXITE COMMITTEE.

SEVENTH REPORT.

LAKE CAMPION ALUNITES.

(Prepared by Mr. M. J. Martin,
a Member of the Committee).

DEPARTMENT OF SUPPLY AND DEVELOPMENT.

COMMONWEALTH COPPER AND BAUXITE COMMITTEE.

Personnel of Committee.

Sir Colin Fraser	... Chairman
Dr. H.G. Raggatt	... Deputy Chairman.
Mr. J.M. Newman	... Members
Mr. A.J. Keast, General Superintendent, The Zinc Corporation Ltd.	
Mr. M.J. Martin, Managing Director, Sulphates Pty. Ltd.	
Mr. J. Horsburgh, Mount Morgan Limited.	
Mr. M.A. Mawby, Mill Superintendent, The Zinc Corporation Ltd., Broken Hill.	

LAKE CAMPION ALUNITE.

WESTERN AUSTRALIA.

During the visit of the Copper and Bauxite Committee to West Australia, the Lake Campion Alunite deposits, as a source of Alumina, were investigated.

On the morning of Saturday, 20th September, 1941, a visit was made to the Perth University. At the Engineering School an experimental rotary kiln on which calcination experiments had been carried out was inspected. The kiln was not in operation, but the method of calcination was explained to the Committee by Professor Bayliss, and the chemical results were discussed with Professor Bayliss and Mr. H. Bowley, the Government Mineralogist and Assayer. After inspecting the kiln, the party proceeded to the Chemistry School where investigational work on the calcined alunite was being carried out, and small scale leaching experiments on the alunite, together with some of the products obtained therefrom, were shown to the Committee.

On Monday afternoon, 22nd September, the Committee met the Alunite Panel under the Chairmanship of Mr. Fernie. Professor Bayliss and Mr. Bowley were present at this meeting, as well as representatives of the Potash Alumina Development Syndicate and their Consulting Engineer, Mr. A. F. B. Norwood. The following Reports (copies of which are appended) were placed before the Committee for their information:

(A) Dodd's Report - This covered the boring and sampling of Lake Campion Alunite. The report was unsigned and undated and appeared to be an extract from a larger report. This report postulates the existence at Lake Campion of 10 million cubic yards of aluniti̇c clay containing 60% of "Alunite".

(B) C.S. & I.R. Report No. 207 on Alunite from Lake Campion. This report covered Mineragraphic Investigations carried out by Mr. Frank L. Stillwell, and was dated 6th March, 1941. It deals with the physical composition of the Lake Campion alunitic mud.

(C) A Report on the Lake Campion Residues after leaching to extract Potash and other soluble salts. It was dated 22nd September, 1941, and signed by Professor N. S. Bayliss.

(D) Estimates of Plant and Cost of Production of Potash (Sulphate of Potash) prepared by Mr. A. F. B. Norwood dated 19th August, 1941.

Note:

(E) These Estimates (D) were subsequently amended and the "Revised Estimates" (copy attached) "E" were handed by Mr. A. F. B. Norwood to Mr. M. J. Martin in Melbourne on 5th January, 1942.

Further data was supplied by Professor Bayliss and Mr. Bowley on both the chemical composition of the alunite and various products. Mr. Bowley exhibited a boring diagram of the Lake Campion which, in part, supported the Dodd's Report (A) as to quantity of material available. Mr. Bowley had restricted his boring programme to 3 ft. depth, and on the evidence in his possession, was only prepared to assess the alunitic mud available as two million tons. He made it clear, however, that this did not mean that a much larger tonnage was not available.

On Tuesday afternoon, 23rd September, further discussions took place with Professor Bayliss at the Chemistry School, particularly on the type of alumina extracted from the residues. Unfortunately, no samples of this alumina were available for inspection, it being pointed out by Professor Bayliss that the work had so far been concentrated on the Potash Salts.

The position with regard to the Lake Campion Alunite Deposits may be set out as follows:-

1. Quantity: On the evidence submitted it is apparent that the Alunitic Mud available in Lake Campion is not less than 2 million tons and probably exceeds 10 million tons.

2. Physical Nature: An examination of the mud suggests that it is in a very finely divided condition and this is proved by the Report (B), C. S. & I. R. No. 207. The actual particles of alunite are somewhat smaller than the silica (quartz) with which it is mixed. The Lake mud would at first sight appear to present treatment difficulties because of the fine state of division of the particles, but the calcination tests have shown that if, after air drying and suitable disintegration, the granulated particles are passed through kiln then these particles retain their form during the subsequent leaching operations for the removal of the soluble salts, and therefore no slime problems are met with.

Furthermore, on the investigations made by Professor Bayliss the alumina in the residue appears to be readily soluble in weak sulphuric or hydrochloric acid (Report "C" - Table II). Slime trouble may be encountered if a high percentage of the alumina is extracted from the residue by acid treatment.

Another fact which has been determined in the calcination tests and which may be attributed to the particular physical character of this alunitic mud is that the gases issuing from the kiln have been found to consist of SO_3, together with HCl (hydrochloric acid) and the other products of combustion. The whole of the SO_2 (sulphur dioxide) evolved apparently is oxidised to SO_3 (sulphuric anhydride) on passing through the semi-calcined alunite which has therefore acted as a "contact mass". Professor Bayliss, in Report "C", suggests that the hydro-chloric acid can be separated from the SO_3 by selective absorption in water and sulphuric acid.

3. Chemical Nature: In all of the reports submitted on the Lake Campion Alunites, the alunitic mud has been reported as containing "X%" (average 60%) Alunite. Only one complete analysis of the Lake Campion alunitic mud is apparently available, and that was supplied by Mr. Bowley with the comment -

> "represents the average of the top three feet of the higher grade Alunite".

The analysis is as follows:-

Al_2O_3	25.42
Fe_2O_3	2.30
K_2O	6.82
Na_2O	.34
SO_3	24.78
H_2O	11.19
H_2O	2.34
P_2O_5	.15
TiO_2	.17
SiO_2	19.40
C	.81
CaO	.18
MgO	.65
NaCl	5.36
	99.97

Mineral Composition	
Alunite	64.2
Jarosite	?
Quartz	18

If the alunite was Potash Alunite, and the residual impurities were only Silica and Iron Oxide, then there would be no apparent difficulty in producing a relatively high grade Sulphate of Potash from the alunite. The soluble salts, however, obtained on leaching the calcines from the Lake Campion alunite, produce a salt of approximately the following composition:

(a)	Potassium Sulphate	54.7%	= (29.5% K_2O)
(b)	Sodium Sulphate	27.65%	
(c)	Magnesium Sulphate	10.48%	
(d)	Aluminium Sulphate	4.48%	
(e)	Calcium Sulphate	1.46%	
(f)	Ferric Sulphate	0.15%	
(g)	Chlorine (as chloride)	0.66%	

Professor Bayliss.

This complex mixed salt is produced because the Lake mud is saturated, more or less, with a brine containing a large percentage of magnesium and sodium chlorides. When the unwashed but dried alunitic mud is passed through the calcining kiln the salts from the brine react with the SO_3 evolved during the calcining process with the result that magnesium and sodium sulphates are formed and leach out from the kiln product.

It was stated to the Committee that this mixed salt could be used for fertiliser purposes, but as shown in the Table, this product would contain only 29.5% K_2O, which is the basis used for evaluating potash fertiliser. For purposes of comparison, it may be stated that imported potash fertilisers sell on the following basis:-

(1) Fertiliser Grade Sulphate of Potash (K_2SO_4) = 48.5% K_2O

(2) " " Muriated Potash (KCl) = 50% K_2O

The selling price of Fertiliser Grade Potassium Sulphate prior to the war is set out hereunder.

	Cost C.I.F.& E.	Selling Price to Consumer
Fertiliser Grade Potassium Sulphate (48.5% K_2O)	£12/8/- per ton	£15/2/6 per ton
Present Fixed Price	?	£21/10/- per ton

The Committee was informed that from the mixed salts a double Sulphate of Potash and Soda could be crystallised out, and this salt would contain 78% K_2SO_4 = 42.5% K_2O. It was also stated that this double salt corresponded to the double sulphate termed "Glaserite". It was further stated that this double sulphate was acceptable for the Agricultural Authorities as a fertiliser material.

It was proposed to separate the Glaserite from the mixed salts either by fractional crystallisation or by means of flotation. If this latter process could be successfully applied, it would cheapen the cost of both plant and production. The mixed salts remaining after the separation of the Glaserite have such a composition that it may be difficult to separate sodium sulphate from them, as the sodium sulphate remaining would most likely combine with the magnesium sulphate to form the double sodium magnesium sulphate $Na_2SO_4.MgSO_44H_2O$ (Astrakanite). As there is a market in the eastern States for sodium sulphate in the form of Salt Cake for both the Glass Industry and the Paper Pulp Industry (Kraft Pulp), a market could be possibly found for a large tonnage of this chemical, particularly under post-War conditions. The salt cake required for the Paper Pulping Industry must, however, meet the following specification.

SALT CAKE.

Sodium Sulphate Na_2SO_4	96% min.
Sodium Chloride NaCl	1.5% max.
Oxides of Iron & Aluminium	0.5% "

Magnesium Sulphate is not usually found in commercial Salt Cake, and it is probable that this would not be allowed to exceed 1% maximum for either of the two industries above mentioned.

The price of Salt Cake is as follows:-

Pre-War	£6/-/-	per ton max.
Present Price	£7/-/-	" " "

As the calcination of the Alunite releases a large amount of SO_3, it may be possible to add Sodium Chloride (Salt) to the furnace charge in sufficient quantity to fix the SO_3 evolved as Sodium Sulphate. By this means additional Sodium Sulphate could be able to be obtained from the process.

The residues after leaching have the following approximate composition:

	SAMPLE "A" (Calcination at 800° C.)	SAMPLE "B" (Calcination at 750° C).
Al_2O_3	46.03%	47.75%
SiO_2	37.18	37.44
Fe_2O_3	3.49	3.59
K_2O	3.94	3.18
Na_2O	1.04	0.76
MgO	0.28	0.29
TiO_2	0.28	0.11
SO_3	4.78	3.99
P_2O_5	0.13	0.10
Cl		0.04

(Sgd.) Professor Bayliss.

From the analysis, it is obvious that the residue is very similar in composition, in so far as the alumina and silica are concerned, to a calcined aluminous clay. The alumina content, however, is much lower and the silica content much higher than is found in the siliceous Australian Bauxites. An analysis of Victorian siliceous bauxite is as follows:-

	Run of Mine Ore	Calcined
Alumina Al_2O_3	52%	70%
Iron Oxide Fe_2O_3	3.5%	4.7%
Titanium Oxide TiO_2	4%	5.5%
Silica SiO_2	15%	20%
Water H_2O	26%	

An advantage of the calcined residue from the alunite, according to Professor Bayliss, is the ease with which the alumina is soluble in acid. This would give it, from a process point of view, a definite advantage over the aluminous clay, and possibly some slight advantage over a siliceous bauxite. It is agreed that this residue cannot be used for the production of alumina by an alkaline process such as the "Bayer" unless some mechanical process, such as selective flotation, could be employed to produce a high alumina-low silica concentrate. Therefore any processes for the extraction of alumina from this residue must be Acid Processes.

Acids which have been employed are Sulphuric, Hydro-chloric Nitric and Sulphrous Acid (SO_2), and also the acid bi-sulphates such as Ammonium Bi-Sulphate. As a considerable amount of investigational work has already been done on the acid process of extraction of the alumina from siliceous aluminous minerals abroad, it is as well to carry out tests on this residue with those processes which appear to have been used for the production of alumina with some measure of technical success. The acid processes for the extraction of alumina were investigated and reviewed in the U.S. Bureau of Mines Bulletin No. 267 published in 1927, which publication is well known to both Professor Bayliss and Mr. Bowley. It does not appear, however, that any of these processes have been put into operation on a technical and commercial scale for the production of alumina suitable for use in the aluminium reduction furnace. The physical condition of the alumina is of as much importance as its chemical composition for this purpose, and a study of the literature and patent specifications indicates that it is most difficult to prepare a suitable alumina, particularly from Sulphate of Alumina. The following processes are suggested as ones being worthy of investigation for the treatment of the residue:

(1) Ammonium Sulphate Process: A process termed the Aloton Process evolved by Buchner in Germany is described briefly in the Mining Magazine of May, 1940. The comment made on this process is as follows:

> "The high cost of operation is due mostly to losses of ammonia and large consumption of fuel for heating and evaporation."

A process termed the White Metals (Australia) Pty. Ltd. Process using Ammonium Sulphate has been investigated up to the pilot plant stage. This process was similar in some respect to the Aloton and claims to have overcome certain of the inefficiency in the former process which led to the loss of ammonia through decomposition.

(2) Sulphurous Acid Processes: A process using SO_2 evolved by Goldsmith in Germany is also described in the May 1940 Mining Magazine. This, as far as is known, is the only process producing Alumina on a large scale from clay. The comment made on it is as follows:

> "The principal advantage of the S.T. process lies in the use of cheap sulphurous acid. One disadvantage is the necessity for the repeated treatment in order to obtain sufficiently pure alumina. The double precipitation influences the ultimate recovery which may be appreciably less than 80%."

This appears to be the only Sulphurous Acid Process evolved up to the present time which has any possibilities of technical and commercial success.

(3) Hydrochloric and Nitric Acid Processes: In both Italy and Japan a considerable amount of investigational work has been done to extract alumina from leucite, alunites and aluminous clays. A summary of some of the Japanese processes will be found in the Mining Magazine for August, 1938, and in the case of Italy in the Mining Magazine for July, 1939.

From later information available, it would appear that no large scale technical or commercial production of alumina for aluminium by these processes is being carried out in either country, as the Aluminium Industry in each appears to have reverted to the use of Bauxite.

(4) Kalunite Process: This is a process which has been developed by the Kalunite Corporation of America. This Corporation is owned by the Western Cartridge Co., and investigations on the processes for treating Marysvale, Utah, Alunite have been carried on for a long period. The process entails calcination of the Alunite at about 500° C., separation of the Alumina and Potash as Potash Alum, autoclaving of the Alum so formed with the reformation of synthetic Alunite (?), which is then recalcined at a temperature of 700 to 800° C., and the soluble Potassium Salts are removed from the insoluble Alumina Residue. The alumina is claimed to be suitable for the production of Aluminium in the electric furnace. This claim has been questioned because it is reputed to be impossible to remove all of the K_2O from the aluminium oxide, and for aluminium production the K_2O content of the alumina must not exceed 0.01%. It would therefore appear that the alumina would have to be redissolved as Sodium Aluminate and reprecipitated as in the "Bayer" method.

Reports from America claim that a large plant was to be erected to process Marysvale alunite by this process, the capacity was to be 12,000 tons of alumina per annum, but up to 30th September, 1941, the contract for the construction of the plant had not been authorised. From private information to hand from America, it is stated that not more than 50 tons of alumina have been produced by the Kalunite Process up to the present time.

(5) Miscellaneous Processes: A search of the technical literature and the Chemical Abstracts reveals that a multitude of processes have been proposed for treating Alunite for the recovery of Potash and Alumina, but there is no technical information showing that any such processes have been proved to be commercially feasible for the production of Alumina as compared with the extraction from Bauxite.

NOTE: Abstracts of these various Processes are available for the information of the Committee, and also flow sheets of the Kalunite and Ammonium Sulphate Processes, as applied to Lake Campion alunite.

On the data at present available for the guidance of the Committee it would not appear that any definite recommendation as to the value of the Residue from Lake Campion alunite as a source of alumina for Aluminium manufacture can be made.

It does appear, however, on the data and estimates available that the project could proceed on the basis of producing Potash for fertiliser purposes in Australia. For the information of the Committee, Australia's imports of Potassium Salts for the two years prior to the War are shown hereunder:

POTASH SALTS IMPORTED INTO AUSTRALIA

	1937-38		1938-39	
	Sulphate of Potash	Muriate of Potash	Sulphate of Potash	Muriate of Potash
New South Wales	307 tons	1793 tons	280 tons	1625 tons
Victoria	811 "	330 "	530 "	465 "
Queensland	700 "	4361 "	932 "	4827 "
South Australia	421 "	80 "	270 "	110 "
West Australia	1196 "	306 "	1024 "	490 "
Tasmania	33 "	277 "	96 "	502 "
TOTALS	3468 tons	7147 tons	3132 tons	8019 tons

SUMMARY OF INVESTIGATIONS.

Recent investigations resulting in the formulation of a proposal to erect plant to produce Fertiliser Grade Potash from these Alunite deposits have been sponsored by the Potash Alumina Development Syndicate of Perth, W.A. The Syndicate have provided finance to investigate treatment processes, and in this project have received financial and other assistance from the West Australian Government and technical assistance from the Commonwealth Government through the C.S. & I.R. The investigational work has been under the direction of Professor Bayliss of the West Australian University, and Dr. Wark and other Technical Officers of the C.S. & I.R. have co-operated in the matter, and their Reports are available for the information of the Commonwealth Government.

When the Copper & Bauxite Committee visited Western Australia on 20th September, 1941, an inspection was made of the pilot plant, and data which was then available was placed before the Committee. At this stage the main factor which had been determined was the optimum conditions for calcination and the leaching experiments on the residue, and the method for recovering the potash product was only being worked out. The estimates placed before the Committee, which were made on behalf of the Potash Alumina Development Syndicate, and also the production costs were therefore at this stage based on calculations made by the Consultant to the Syndicate, Mr. A. F. B. Norwood.

The crude salt produced on leaching the calcines would give a product containing not more than 54.7% of Potassium Sulphate (K_2O equivalent equals 29.5%). Note: All Potash Fertilisers are evaluated on their K_2O percentage. This crude salt, however, would contain 27.6% of Sodium Sulphate, and 10.5% of Magnesium Sulphate, and 4.5% of Aluminium Sulphate - all of which would be regarded as deleterious salts in certain classes of soil if the crude salt were employed as a fertiliser. It was demonstrated at this time that a more concentrated salt containing up to 78% Potassium Sulphate (42.5% K_2O) could be crystallised out from the other impurities, but the technical methods of so doing included evaporation and crystallisation, and even flotation, at this stage, was being considered as a method of separation.

It is gratifying to learn that, in the last few months, the continued investigations carried out on behalf of the Potash Syndicate under the direction of Professor Bayliss and in co-operation with the C.S. & I.R. and Officers of the West Australian Government, have shown that, by a method of cyclical leaching, a Potassium Sulphate containing 75% (equivalent to 40.5% K_2O) can be produced without any evaporation and with the resultant considerable reduction in plant and equipment required in the project.

The project now under consideration entails the erection of plant and equipment to treat

130 tons of raw Alunite per 24 hours

and this is calculated to yield an extraction of

13 tons Potassium Sulphate per day (24 hours)

in the form of a mixed salt containing 75% Potassium Sulphate, the remainder being mostly Sodium Sulphate. The tonnage of this mixed Salt will therefore amount to

17-1/3rd tons 75% Potassium Sulphate per day (24 hours)
(equivalent 40.5% K_2O)

According to the amended estimates now prepared by Mr. A. F. B. Norwood, the cost of production will be reduced from £17/7/6 per ton to £15/6/8 per ton calculated on a basis of 100% Potassium Sulphate, but as the product contains only 75% Potassium Sulphate, the cost per ton of this product will be now

£12/5/- per ton F.O.R. Fremantle,

for a product containing 40% K_2O.

The selling price of Fertiliser Grade Potassium Sulphate prior to the War is set out hereunder.

	Cost C.I.F.& E.	Selling price to Consumer.
Fertiliser Grade Potassium Sulphate (48.5% K_2O)	£12/8/- per ton	£15/2/6 per ton
Present Fixed Price	?	£21/10/- per ton

As it takes approximately 1.2 tons of the proposed 75% product to equal 1 ton of Fertiliser Grade Imported Potash, the equivalent price F.O.R. Fremantle of this Australian produced Potash would be

£12/5/- x 1.2 = £14/14/- per ton.

Therefore, it is evident that whilst the cost of production F.O.R. Fremantle would be more than the C.I.F. & E. price pre-war at Australian ports, this cost is well below the pre-War selling price and considerably below the present fixed price of Fertiliser Grade Sulphate of Potash.

The production rate in the plant now proposed in the first unit will give approximately

5,000 tons 75% Sulphate of Potash per annum.

Imports into the various States for the last two pre-War years show that West Australia used approximately 1,000 tons Potash Sulphate; Queensland 900 tons, and Victoria about 500 tons, and the total imports of Potash Sulphate was slightly in excess of 3,000 tons per annum. However, in addition to this, from 7,000 to 8,000 tons of Muriate of Potash (Potassium Chloride) were also imported - the largest user being Queensland with from 4,000 to 5,000 tons per annum; the next largest user being New South Wales with over 1,500 tons per annum. It is interesting to note that, though Muriate of Potash contains 50% of K_2O, it generally sells for some 10% less per ton than Sulphate of Potash, as in most cases agriculturists consider the Sulphate to be a more satisfactory fertiliser.

Whether the 75% Australian Potash containing Sodium Sulphate as an impurity will be regarded with favour by Australian agriculturists is a matter which must be considered. This matter has been referred to certain Australian authorities, such as Professor Richardson, whom, it is understood, has stated that the Sodium Sulphate would not be a deleterious impurity for most agricultural purposes.

The cost of establishing the industry on the basis of treating 130 tons of Alunite per day was originally estimated by Mr. A. F. B. Norwood to require £148,410.

This has now been reduced because of the simplification of the process and by eliminating the purchase of certain tractors and excavators for winning the Alunite to a total of

£110,000. 0. 0

It is now proposed to have the Alunite mined by contract, and the value of the plant so saved is approximately £9,000, so that the capital cost saving as a result of the adoption of the cyclical leaching process, already referred to, has saved approximately £30,000 of capital outlay.

Economics of Proposal:

On the first stage of production now proposed, that is, treating 130 tons of Alunite per day, though the estimates for plant and the estimated costs of processing and production at the Works appear to be quite sound, consideration must be given to the economics of the Industry in regard to the pre-War selling price of Potash Sulphate and the present selling price.

The pre-War selling price to consumers was £15/2/6 per ton ex Store for Sulphate of Potash (48% K_2O). As the product from Alunite will only contain 40% K_2O it cannot command a price more than

$$\frac{40}{48} \text{ or } \frac{5}{6} \text{ of the selling price of Imported Potash.}$$

So that on the pre-War selling price, the local product could not sold for more than

$$\frac{5}{6} \text{ of £15/2/6} = \text{£12/12/- approximately.}$$

As the bare cost price F.O.R. of the Australian product is £12/5/- per ton F.O.R. Fremantle, this only shows a 7/- gross margin below the pre-War price of Potash.

Taking the present fixed price of £21/10/- per ton the comparison is as follows:

$$\frac{5}{6} \text{ of £21/10/-} = \text{£17/18/4}$$

The margin between bare production costs of the Australian product and the present fixed price would therefore show a gross profit margin of:

£17/18/4 less £12/5/- = £5/13/4 per ton

which, on an output of 5,000 tons per annum, amounts to

£28,333. 0. 0

In Mr. Norwood's costs certain overhead charges and depreciation have been allowed for, but no charge has been made in the costs for amortisation, taxation, etc. Furthermore, marketing and selling costs must be paid, and these will further reduce the nett profit margin.

4,000 tons of the 5,000 tons output must be sold in the Eastern States, and the freight charges alone at present ruling rates would amount to not less than £2/10/- per gon, equals

£10,000 per annum

It would therefore appear that it may be necessary to subsidise the industry even under present conditions by either paying a bounty on product sold in the eastern States or subsidising the freight to the eastern States. Alternatively, the selling price of Potash could be raised to the consumer, and it must be borne in mind that even under pre-War conditions, Sulphate of Potash has sold in Australia for as high as £35/-/- per ton. Consideration must be given, however, to the effect that any rise in price will have on the quantity of Potash Fertiliser consumed in Australia.

In order to meet the full Australian requirements the plant now proposed would have to be doubled in capacity, and whilst this would not mean doubling the capital costs, a certain saving in production costs should be attained.

Under post-War conditions it would appear that the Industry would require assistance by either bounty or duty to compete with imported potash.

The Alunite available in Lake Campion and the adjacent areas on the evidence available shows that some millions of tons of raw material can be readily obtained, and from this it would appear that Australia's requirements of Potassium Sulphate could be supplied on an ever-increasing scale over many years.

The position may be summarised as follows:

(1) Ample supplies of the raw material - Alunite - are available at Lake Campion.

(2) Technical problems on the calcination of this raw material have been thoroughly investigated in the pilot plant at the West Australian University, under competent Authorities.

(3) Methods of leaching the calcined material have been worked out but these have not been carried through the pilot plant stage because of time required. Large scale laboratory tests have been carried out and on a process such as leaching these can be regarded as satisfactory and adequate investigations.

(4) Estimates of plant and the equipment required appear to have been carefully calculated. So also are the estimates of production costs at Works. The economics of the industry, however, require close consideration as it may be necessary to subsidise the Industry even under present conditions with high prices for imported Potash. Under post-War conditions it would appear that the Industry must be assisted by bounty or by duty.

(5) A Sulphate of Potash product containing 75% Potassium Sulphate (40% K_2O) can be produced in quantity from the alunite as a basic raw material.

(6) The question whether this 75% Sulphate of Potash product containing up to 25% Sulphate of Soda is a suitable general fertiliser has been raised. Certain authorities have stated that the product is satisfactory. This would appear to be the only doubtful point in the whole project at this stage, and possibly the advice of agricultural experts in the principal consuming States, namely Queensland and New South Wales, should be obtained on this matter as a further precautionary measure.

The possibility of carrying out some trial runs with Campion Alunite through a large furnace such as would be available at a Cement Works and producing Potash Salts which could be tested out on a large scale prior to the erection of the proposed treatment plant is worthy of consideration.

(7) Owing to the importance of Potash economically and industrially to Australia, the support necessary for the establishment of this industry by the Commonwealth Government appears warranted and justifiable.

(Sgd.) M. J. MARTIN.

Member of the Copper and
Bauxite Committee.

15th January, 1942.

(COPY)

"A"

DODD'S REPORT

BORING AND SAMPLING THE LAKE CAMPION ALUNITE DEPOSIT

BORES PUT DOWN AT LAKE CAMPION.

Total number of bores 44. Total footage 622.6

Two men were employed, using a 4" posthole augur attached to ½" piping. In several cases, where hard bands were encountered a chopping bit was run on rods and then an ordinary sand pump was used to collect the samples. Boring was fairly easy and recovery of core good, although in deep holes any sandy core tended to be washed during the withdrawal of the ore. The alunitic clay is very tough in many places but when sand content increases the mass becomes more friable. The lakes were under water when the sampling was done but the depth was not over 5" in any place. Owing to the flat surface of the lake the water was moved from side to side by the prevailing winds. The surface of the lake in each case, was, therefore, assumed as being level and the elevation of all bores was caled zero. When partly dry, the material is very tough and work with pick and shovel is very slow. When wet, such work is even more difficult. The cores dried rapidly when exposed to the sun, although the heat thereof (in August) was not very great. This work continued for two months when sampling was completed.

Locating Bores;

In each case a base line was measured, using a mineral lease corner peg as datum point. A network of sites was then marked out.

Notes on Boring and Strata Encountered

All the holes were cored to bedrock, save three; the deep ones. In these it was found that boring was too slow and rod breakages delayed work, so 33 ft. was the deepest drilled. The bottom should be granite since this rock outcrops at the north end of Lake Campion. In practically every case a layer of hard red gravel over-laid the bedrock. With the aid of heavy rods and a chopping bit some samples of the rock were obtained, showing that it consists of a coarse sand cemented with material which is probably silica. Similar conglomerate was observed covering the outcrops.

In almost every case a tough bluish-grey alunitic clay, fairly rich was the cover. Near the shores there was a thin cover of gypsum of which the banks are composed. Many colours were noted in the clays, owing to the proportion of iron oxide present. Such oxide might be a by-product of value, if isolation is effected during concentration operations. These colours vary from pale pink through maroon to deep red. The colour of the material was a fair guide to its richness. The lighter samples were richer. Values decreased, as a rule with depth but exceptions showed up at the deepest holes. For the first 5 to 10 feet the percentage of alunite was high. Sandy or gravelly strata invariably were low in alunite. In winning operations there would be work for a long time merely stripping the upper 10 feet of material, which would, most probably run over 70% alunite.

Water.

During operations the lake was covered with water, the work being carried on during July and August. This water was rain water. In the summer it is dry, but water, permanent, occurs a few feet below the surface. It is almost artesian, since it rises nearly to the surface; is very brackish, and shows a small percentage of free sulphuric acid. The action of this water on the skin is painful, and is rapid in its corroding power upon metallic objects. This fact is of importance when considering methods of winning the material. The lake may have a slight slope (surface considered only) to the south-west but it is too small to be of much account, so the levels of bore-hole collars were considered as zero. In this "Lake Country" there is in winter, a good supply of brackish water which could be impounded for use. In addition the nearest terminus of a branch from the Kalgoorlie Pipe Line is about 3 miles. Water could be laid on to the works.

Chemistry. Analysis of samples.

Samples were, for the first few holes, cut from each foot of core, or from each formation. Later the cores were samples when removed from augur, being finally mixed and quartered down to a reasonable size. Samples were air-dried upon receipt at the laboratory for two days; crushed and quartered. Moisture was then determined. Soluble salts were got by digesting 0.5 gm. in 200 c.c. of water for several hours (the SO_3) radical being precipitated as $BaSO_4$ in the usual manner. For alunite 0.5 gm. of sample was warmed in weak NaOH solution until all soluble matter went into solution. Total sulphates were then determined in the usual way, and soluble sulphates subtracted, leaving a figure which was converted to be shown as alunite, using a factor (SO_3) to alunite of 2.60, this having been shown to be correct.

Moisture:

Air-dried samples showed varying percentages of water, the general average being 6%. A core sample, extracted from a wet hole dried for 15 minutes in the air, bottled, showed 16.8% of water. Seeing that many of the stratas are dry and tough the average percentage of moisture in the lake bed as it lies should be nearer 10%. The main point about the Campion alunite is that it is insoluble in water but soluble in the weakest of alkalies and mineral acids. Even $CaCO_3$ in solution will attack it. Above 300°C. at which temperature alunite is unaffected, decomposition begins. The main impurity is sand. Some clay and gypsum also occur in varying proportions. Since alunite and quartz have about the same specific gravity, the removal of the sand might be difficult, but the alunite is floury and the sand gritty, so classification in water should suffice.

With regard to concentration it may be said that a careful analysis of costs would be necessary in order to establish whether to concentrate at the deposit or rail the bulk to Perth. A railway runs only 7 miles away and no difficulty should exist in putting in a spur line to the deposit. The distance from the lakes to Perth by rail would be close on 250 miles.

Pure alunite contains approximately 36% of alumina and approximately 11.4% of potash.

Estimate of quantity:

An estimate of the average values of the cores was made by multiplying % alunite by feet sample, then dividing the product by the depth.

Sum of Products - % feet.

$\frac{D.\ v}{d}$ = Average of Feet depth = average % alunite.
This was repeated to gain the general average, thus:-

$\frac{d\ .\ v}{d}$ = General average.

For Lake Campion this came to:

$\frac{37.339}{622.5}$ = 59.9 or 60% alunite general average.

This figure is based on air-dried samples containing an average water content of 6%.

$$\frac{\text{Moisture \%}}{\text{Number of samples}} = \frac{926}{154} = 6\%.$$

Calculation of cubical content.

Profiles were drawn, one for each line of bores and the area obtained by a planimeter. Results were multiplied by half the distance on each side between the lines. This is sufficiently close since the deposit manifestly extends some distance under the present banks.

Weight of material. A kerosene tin full of air-dried core samples was weighed and found to contain 85 lbs. net. This is equal to 3,950 to the cubic yard. Now 1 cubic yard of water weighs 1687 lbs. and the specific gravity of alunite is 2.65. Taking 60% alunite as general average we get for comparison:-

$$\frac{1{,}687 \times 2.65 \times 60}{100} = 2{,}690 \text{ lbs.}$$

and

$$\frac{3{,}950 \times 60}{100} = 2{,}370 \text{ lbs.}$$

These figures are close enough considering the variable moisture content of the samples to show that the weight per yard and the general values are not far from correct.

Proceeding thus we find:-

LAKE CAMPION. contains 10,000,000 cubic yards of alunitic clay of an average of 60% alunite and, an average water content of 6% (from air-dried samples) or 10% as a fair estimate as the bed lies.

Note:- The yardage estimate is low, since, for Lake Campion, with an area of 426 acres, and assuming 400 acres of an average depth of 14 feet we would have 9,034,480 cubic yards.

Summary. There is an enormous quantity of rich alunitic material lying within easy distance of a railway. The climate corresponds with that of the Goldfields area, although hot in summer it is dry and quite healthy. The winters are very pleasant. Cheap electric power could be obtained at Hobart, Tasmania, for the production of metallic aluminium.

(COPY)

"B"

MINERAGRAPHIC INVESTIGATIONS
OF THE COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH

Report No. 207. UNIVERSITY OF MELBOURNE.

6th March, 1941.

ALUNITE FROM LAKE CAMPION, W.A.

Twenty-four bore-core samples of alunite ore from Lake Campion and one sample from Red Lake, W.A., have been submitted for microscopic examination by Professor Bayliss, University of Western Australia.

The samples were treated by puddling in water and decanting off the easily suspended clay matter. The decantation products and the residues left after decantation were then examined under a petrological microscope. This implies that crushing is not necessary to liberate the alunite.

Decantation Products: The solid particles in the decantation produces consist mostly of minute plates or grains about 0.002 to 0.005 mm. diameter, which are regarded as alunite. Alunite cannot be satisfactorily identified in this form by microscopic methods, neither can the absence of kaolin be determined. In addition to the alunite, grains of quartz ranging in size from 0.014 to 0.020 mm. diameter were always present, though in varying amount. Occasional grains of bleached biotite and of limonite were present, and in several specimens, notably the lower samples of Bore C. which were red-coloured, abundant granules of limonite accompanied the quartz. Skeletons of diatoms were present occasionally in the samples from nearest the surface, but were only present in any number in the single sample from Red Lake.

Residues: The residues varied considerably in amount and grain size, from sample to sample, and level to level in the bores, though there was a general tendency towards increase in quantity with depth. The chief mineral present is quartz in grains ranging from 3.0 mm. diameter to 0.05 mm. Very occasional crystals of pyroxene were detected in one or two samples, togeth r with flakes of bleached biotite and grains of limonite. Very occasionally needles of gypsum were observed. The Red Lake Sample was distinct in this respect, that gypsum crystals up to 1 mm. long were abundant as quartz. In the reddish-coloured samples from Bore C. limonite was abundant, occurring as lumps up to 10.0 x 3.0 mm. Such lumps when crushed were found to consist of abundant limonite, cementing fine grains of quartz. Some appeared to consist wholly of limonite. The details for the several specimens are set out in the tables below.

BORE A.

Sample	Decantation	Residue
2½ ft.	dark grey, consisting of minute granules of alunite .002 - .005 mm. diameter with a little quartz .0135 mm. diameter and smaller	none (tr)
4 ft.	do, only whiter	Very small residue of quartz o.050 - 0.05 mm. One grain pyroxene one altered biotite.
6 ft.	do.	Slightly larger residue. Quartz 0.5/0.05 mm. A little limonite bleached biotite gypsum.
8 ft.	do.	Larger and coarser residue 2 mm. mostly 1 m.-0.05 Rare pyroxene, a little limonite
10½ ft.	do.	About same residue as in 8. Trace of limonite, one large crystal of gypsum.

BORE B.

1 ft.	Alunite .002 - .005 mm. grains, quartz .014 - .020 mm. occasional diatom skeleton.	None
2 ft.	do.	Mere trace; quartz 0.50 - 0.05 mm.
3 ft.	do. no diatoms	Present, but very small amount
4 ft.	do.	Small quartz up to 1 mm. diameter, occasional limonite grain.
4½ ft.	do.	do.

BORE C.

Sample	Decantation	Residue
Grey White 2 ft.	White consisting chiefly of particles of alunite about 0.002 - 0.005 mm. A little quartz 0.015 - 0.020 mm. Similar to A.	Merest trace; 0.5 - 0.05
4 ft.	do.	do.
7 ft.	Creamy pink. Distinctly more quartz, 0.015 - 0.020, than above	Residue 1/3-½ total sample. Coarse quartz up to 3 mm. Partly coated with iron oxide.
9.ft.	Pinkish, red tinge in aggregates. Number of quartz particles stained with iron oxide. Some red limonite particles 0.01 - 0.02	Residue 1/3-½ total. Consists of quartz and limonite. Limonite particles up to 1 cm. x 0.3 mm. Consists of abundant limonite cementing fine quartz grains. Some grains appear solely limonite.
11 ft.	Dark red. Increased content of quartz, stained with iron oxide. Abundance of limonite granules 0.010 diam.	Residue ½ sample or more. Chiefly quartz up to 2 mm. - A few grains of limonite; mostly coating quartz. not as coarse-grained as C.9

BORE D.

The samples were puddled with water, and the fine-grained material decanted off.

2 ft.	White product consisting essentially of alunite, with minor amounts of quartz, very occasional diatom skeleton, and a rare prism of an unidentified silicate-alunite .005 x .005, quartz .014 - .020.	Moderate residue of quartz, ranging in size from 0.05 to 2.0 and 3.0. Angular but waterworn.
4 ft.	do.	Only a trace of residue Quartz 0.140 x 0.080 largest grain. 1 grain of tourmaline.
6 ft.	do.	Increase in residue. Less than in 2. greatly exceeds 4. Grains from 1.0 mm. down
8 ft.	do.	Less than in 6. Quartz 1.0 mm. and less
10 ft.	Reddish brown, but otherwise (pinkish) similar.	More than in 8, not as much as in 2. Some grains ironstained, 1.0 mm. and less.
12. ft.	White otherwise similar	Large gritty residue, larger than 2. Grains quartz, 2-3 mm. down to 0.05 mm. Occasionally iron stained.
14 ft.	Pinkish do.	Still larger and equally coarse residue of quartz A number of grains ironstained.

(Signed) Frank L. Stillwell.

(COPY) "C"

LAKE CAMPION ALUNITE DEPOSIT

COMPOSITION OF THE RESIDUES FROM THE PRODUCTION OF POTASH

The following are analyses of typical residues after alunite from the upper 3 ft. of the deposit had been calcined and leached with water to extract water soluble salts. The analyses were carried out by the Government Chemical Laboratory for the constituents mentioned, and are re-calculated to a moisture-free basis at 100°C. The determination of SiO_2 was not requested in the case of Sample B; but it would be similar to A.

TABLE I

	SAMPLE A. (Calcination at 800°C.)	LEACHED RESIDUES SAMPLE B. (Calcination at 750°C.)
Al_2O_3	46.03%	47.75%
SiO_2	37.18	37.44
Fe_2O_3	3.49	3.59
K_2O	3.94	3.18
Na_2O	1.04	0.76
MgO	0.28	0.29
TiO_2	0.28	0.11
SO_3	4.78	3.99
P_2O_5	0.13	0.10
Cl		0.04

SUGGESTED PROCESSES FOR PREPARATION OF ALUMINA:

Owing to the high silica content of the above residues as shown in Table I, it was considered that the material would not be amenable to treatment by the Bayer process using caustic soda. The investigations were therefore directed to acid extraction processes (using either sulphuric or hydrochloric acid) with the object of preparing pure aluminium sulphate or aluminium chloride from which alumina could be prepared by calcination.

The acid processes offered attractive economic possibilities, particularly if the alumina were to be produced at Lake Campion. The flue gases from the original calcination of alunite contain both SO_3 and HCl. Experimental work has shown that the HCl can be practically completely absorbed in water. (Practically no SO_3 being absorbed at this stage) and that the SO_3 can subsequently be largely absorbed (over 50%) in 5% H_2SO_4. (The use of 98% H_2SO_4 would be impractical owing to the moisture content of the flue gases.) Together with the SO_3 or HCl arising from the calcination of the aluminium sulphate or aluminium chloride, ample supplies of the necessary acid could be made as by-products.

THE EXTRACTION OF THE RESIDUES WITH ACID:

It was found that the alumina content of the above residues (Table I) was readily extracted by either dilute sulphuric or dilute hydrochloric acid.

TABLE 11.

(a) Using 6 N (25%) sulphuric acid in an amount 25% in excess of that required theoretically to dissolve the Al_2O_3, the following percentages of the Al_2O_3 content were extracted at 90°C :-

1 hr.	2 hrs.	3 hrs.	4 hrs.	5 hrs.
33%	60%	77%	87%	88%

(b) Using 100% excess of 6 N sulphuric acid at 90°C, 94% of the Al_2O_3 content of the residues was extracted in 3 hrs., and 99% in 5 hrs.

(c) Using 6 N (contant boiling) hydrochloric acid, in the presence of a 50% excess of calcined residue (with the object of preparing a neutral solution), the following percentages of Al_2O_3 were extracted at 95°C. (Percentages reckoned on the amount theoretically extractable by the acid).

1 hr.	2 hrs.	3 hrs.	4 hrs.	5 hrs.
25%	75%	90%		95%

THE COMPOSITION OF THE ACID EXTRACTS:

The following is a typical complete analysis (by the Government Chemical Laboratory) of a solution obtained by extraction of the calcined residue with sulphuric acid, and subsequently diluted for submission to the Government Analyst :-

TABLE 111

	mg./ml.	Constituents expressed as % of Al_2O_3 content (approx.)
Al_2O_3	34.5	100
Fe_2O_3	2.5	7.5
K_2O	2.3	6.9
Na_2O	0.6	1.8
MgO	0.1	0.3
SiO_2	0.1	0.3
TiO_2	0.2	0.6
CaO	Nil	Nil
MnO	Nil	Nil
P_2O_5	0.1	0.3
SO_3	not determined (solution is aluminium sulphate)	

No analyses are yet available for the solutions obtained by extraction with hydrochloric acid.

THE PURIFICATION OF ALUMINIUM SULPHATE AND ALUMINIUM CHLORIDE:

Owing especially to the high Fe_2O_3 content, a salt prepared by evaporation of a solution such as that in Table 111 would be unsuitable for the manufacture of pure alumina. Various methods of purifying the solutions were therefore investigated.

Owing to the relatively high Fe_2O_3 content and the expectation that acid extraction processes would lead to a product relatively low in SiO_2, all of the methods that have been tried at the University of Western Australia have been with the object of removing Fe_2O_3. These methods have included:-

(a) Recrystallisation of Aluminium Sulphate or Aluminium Chloride: Since it was found that the Fe_2O_3 content of the solids obtained by evaporation of the leached solutions was largely there as a film on the surface of the crystals and not as part of the structure of the crystals themselves, recrystallisation presented itself as an obvious method, providing it would not have to be carried too far.

(b) Treatment of solutions with excess of the calcined residues.

(c) Treatment of the solutions with alunite that has been dehydrated by heating to 500 - 550°C.

Of these three methods, the last named has turned out to be the most attractive.

The results presented below are preliminary results only, since the experimental work has not yet been completed and several samples are still undergoing analysis:-

(i) Using a solution of aluminium sulphate that was about one-fifth saturated and in which the ratio of Fe_2O_3/Al_2O_3 was 2.4%, treatment with dehydrated alunite reduced the Fe_2O_3 content to 0.03% in half an hour.

(ii) Using a sulphate solution that was about half saturated, the Fe_2O_3/Al_2O_3 ratio was reduced in half an hour from 6.4% to 0.2%.

(iii) With a practically saturated solution of aluminium sulphate, two consecutive treatments with dehydrated alunite are required to reduce the Fe_2O_3/Al_2O_3 ratio from 6% to under 0.1%.

(iv) In the case of aluminium chloride solutions, three successive treatments with dehydrated alunite, each of one hour, have reduced the Fe_2O_3/Al_2O_3 ratio from 6% to 0.1%.

The rate of removal of ferric oxide from the chloride solutions is apparently somewhat slower than is the case with the sulphate solutions, mainly owing to the greater amount of colloidal ferric hydroxide that is present.

(Sgd.) N. S. Bayliss.

PROFESSOR OF CHEMISTRY.

22nd September, 1941.

(COPY) "D"

A. F. B. NORWOOD
CONSULTING METALLURGICAL
ENGINEER.

A.M.P. Buildings,
Maritana Street,
KALGOORLIE.

Edmond J. Martin, Esq.,
Manager,
Potash Alumina Development Syndicate,
42 St. George's Terrace,
PERTH.

Dear Mr. Martin,

I enclose herewith estimates of operating and capital costs for the production of potash from Lake Campion alunite, on the bases of the treatment of both 130 and 390 tons per day.

General. The figures are conservative, but at this stage it would be unwise to underestimate either operating or capital costs. As we agreed during our conversation, this is particularly the case while the Syndicate's application for some form of protection or bounty is being considered by the Commonwealth. However, while the figures are conservative, they are not duly so, and I am sure to responsible engineer could materially reduce any of the individual cost items given at this stage.

Operating Costs. For your own personal information, I think we can hope for (but not estimate on) a material reduction in the estimated production costs when the plant has been operating for a while and all "teething troubles" have been overcome. Principally, the factor which might lower costs is the possibility of treating more than 130 tons per day through the kiln and a fuel consumption for calcination somewhat lighter than given.

Another point where economy may be possible is that I have given power costs at 1d. per kilowatt hour and steam for the evaporators at .05d. per lb., which is the cost of generation if we use steam engines, and their exhaust steam for the evaporator, there should also be a marked economy at this point. When the War is over, the cost of bagging should be reduced, and now that you have these estimates available, it should be possible to obtain a reduction in the freight rate from Weria to Fremantle.

Capital Costs. As stated in the notes, there is a possibility of an economy of £10,000 by using a secondhand machinery for some of the main items, and of a further £20,000 if it is found possible to dispense with the forced circulation evaporator.

I have just received a quotation for a secondhand steam engine set from New South Wales, as follows:-

1 - 325 K.W. Steam Driven Alternating Set. With Brownett-Lindley Vertical Compound Enclosed High Speed Engine, Cylinders 16" and 26" dia. x 11" stroke, direct coupled to British Westinghouse Alternator 325 K.W. 415v. 3 phase 50 cycles, 375 r.p.m. With exciter mounted on end of rotor shaft. With Regulator; all mounted on one C.I. base plate.
Overhauled and in good order.

PRICE .. .. £1700. 0. 0 on Wharf.,
Sydney.

This unit would be very suited to our requirements if the Kestner type evaporator is installed.

I understand these estimates are required for the final negotiations with the State and Commonwealth Governments and I presume the condensed estimates for the prospectus will not be required for a while. With the figures I have available in my office, I can now give you these at a day or two's notice. I will defer them until I hear from you, so that some of the various alternatives at present existing will have been settled one way or the other.

With reference to my remarks on leaching the calcines in vats, I have a batch of the last roast treated in Kalgoorlie. With a two stage leach, the total extraction was 15% solids. I should be glad to learn what was the extraction obtained by the University from this calcine. The solution obtained was quite clear, so that the proposal looks very promising from the point of view of capital and operating costs.

With kind regards,

Yours faithfully,

(Sgd.) A. F. B. NORWOOD.

(COPY)

ESTIMATED OPERATING COSTS OF PRODUCING POTASH FROM LAKE CAMPION ALUNITE.

OPERATING-LABOUR	130 tons day		390 tons day	
Digging & Loading	2 men @ 24/-		4 men @ 24/-	
Crushing	1 " " "		2 " " "	
Calcining	3 " " "		3 " " "	
Gas Producer	6 " " "		18 " " "	
Classifiers and/or Filters	3 " " "		3 " " "	
Crystallisers and Centrifugues	3 " " "		3 " " "	
Residue Disposal	1 " " "		2 " " "	
Bagging and/or Loading Potash	1 " " "		2 " " "	
Shift Bosses	3 " " 40/-		3 " " 40/-	
Total:	23 men	-£30.0.0	40 men	- £50.0.0
REPAIR LABOUR				
Tradesmen	5 men @ 28/-		8 men @ 28/-	
Foreman	1 " " 40/-		1 " " 40/-	
Total	6 men	- £9.0.0	9 men	- £13.0.0
		£39.0.0		£63.0.0
POWER HOUSE LABOUR				
Included in power and steam costs.				
SUPPLIES				
Diesoline for Tractor	£1.0.0		£2.0.0	
Lubricants	2.0.0		3.0.0	
Water: 500 gals. per ton of alunite @ 2/6d. per 1,000	8.0.0		24.0.0	
Wood fuel for calcining 50% of weight of alunite @ 12/- per ton of wood	39.0.0		117.0.0	
	£50.0.0	£39.0.0	£146.0.0	£63.0.0
POWER				
300 h.p. for 24 hrs. @ 1d. per kilowatt hr.				
100 h.p. for 8 hrs. @ 1d. per kilowatt hr.	25.0.0			
400 h.p. for 24 hrs. @ 1d. per kilowatt hr.				
100 h.p. for 8 hrs. @ 1d. per kilowatt hr.			35.0.0	
Steam for Evaporators				
4,000 lbs. per hours @ .05d. per lb.	20.0.0			
10,000 lbs. per hour @ .05d. per lb.			50.0.0	
Repair Materials				
@ 4/- per ton	26.0.0			
@ 3/- per ton		121.0.0	59.0.0	290.0.0
C/Forward		£160.0.0		£353.0.0

B/Forward

		£160.0.0		£353.0.0
Miscellaneous Charges				
Chemical Laboratory	10.0.0		10.0.0	
Superintendence	8.0.0	18.0.0	8.0.0	18.0.0
GRAND TOTAL:		£178.0.0		£371.0.0
Overheads @ 8%		14.0.0	O/hds.5%	18.0.0
TOTAL COST PER DAY:		£192.0.0		£389.0.0
COST PER TON OF ALUNITE:		£1.10.0		£1.10.0

COST PER TON OF POTASH:
(@ 10% recovery)

Plant cost of Potash	15.0.0	10.0.0
Cost of bags per ton of potash	1.0.0	1.0.0
Freight to Weira & Loading	7.6	7.6
Freight to Fremantle	1.0.0	1.0.0
TOTAL COST OF POTASH IN FREMANTLE.	£17.7.6	£12.7.6

Note: (i) No cost has been allowed in the above estimates for the separation of glaserite and sodium sulphate. (To produce a high grade potassium sulphate). It has been stated that a market is available for sodium sulphate. The value received for this material would considerably exceed the cost of flotation or re-crystallisation of the crude potash.

(ii) In the case of the 130 tons/day unit, part of the potash would be used in the State and the freight would then be only 13/8d. per ton. It is also possible that requirements in this State could be shipped in bulk.

(Sgd.) A. F. B. Norwood.

Consulting Engineer.

COPY

PROPOSED PLANT FOR PRODUCTION OF POTASH FROM LAKE CAMPION ALUNITE

ESTIMATED CAPITAL COSTS

Winning Equipment:	130 tons/day £	390 tons/day £
One 110 h.p. Tractor	3,900	3,900
One Le Tourneau model "F" Scraper	4,000	4,000
One Le Tourneau model "H" Rooter	1,300	1,300
42" x 24" Swing Hammer Mill	2,500	2,500
Feeder, Conveyors and Storage Bins for crushed alunite	6,000	8,500
Rotary Kiln 150' x 7' complete with flues and stack	18,000	54,000
Cooling and Discharge conveyor	1,000	1,500
(i) Potash extraction plant	5,700	8,000
(ii) Thompsons forced circulation evaporator	13,000	13,000
Centrifuges or filtration plant	2,400	3,600
Conveyor for waste material	1,800	1,800
Conveyors, Potash storage, packing machine and loading equipment	4,000	5,000
Buildings, roads and services	7,000	12,000
Power House Equipment		
(ii) Boilers	14,000	21,000
Engine with alternator and all auxilliaries but no boilers	6,000	9,000
Chemical control laboratory, equipped	2,500	2,500
	93,100	151,600
Contingencies 10%	9,310	15,160
TOTAL CAPITAL COST	102,410	166,760
Reserve for plant modification, etc.	10,000	20,000
Working Capital for six months	36,000	72,000
	£148,410	£258,760

N.B. (i) This sum would cover the installation of agitators and two stages of filtration; or classifiers and filters for the classifier overflow. Cost of leaching vats would be much lower.

(ii) The evaporator estimated would take care of the full tonnage, even in the case of the 130 tons a day unit. The boilers installed in the 130 tons per day unit would be sufficient to run the evaporator on the full tonnage, but there would be no spare. If no evaporation were carried out, and the solutions were crystallised in the Swenson-Walker crystallisers, there would be an economy of approximately £20,000 in the case of the 130 tons/day unit and £25,000 in the case of the 390 tons/day unit.

(Sgd.) A.F.B. NORWOOD
CONSULTING ENGINEER.

(COPY) "E"

REVISED ESTIMATES OF CAPITAL COST OF PLANT INSTALLED.

DETAILS OF PLANT.	ESTIMATED COST
Swing-hammer mill	£ 3,200
Receiving hopper, conveyors and storage bins	6,000
Rotary Kiln	18,000
Cooling and vat charging conveyors	1,000
Potash extraction plant	5,000
Conveyors for waste material	1,800
Crystallisers	4,000
Centrifuges and drier	3,200
Conveyors for potash and potash storage	4,000
Buildings, roads and services	7,000
Power House	10,000
Chemical control laboratory	2,500
	£65,700
Contingencies estimated on 10% basis	6,570
TOTAL PLANT COST	£72,270
Working Capital including stores, 5 months @ £5,500 per month	27,500
	£99,770
Reserve for plant modifications	10,000
TOTAL	£109,770
TOTAL CAPITAL REQUIREMENTS	£110,000

NOTE: This is considered to be the smallest part unit that should be installed for the production of potassium sulphate on a commercial basis.

ESTIMATED OPERATING COSTS OF PRODUCING POTASH FROM LAKE CAMPION ALUNITE.

		130 tons/day
OPERATING - LABOUR		
Contract price for winning ore @ 1/6 per ton		9. 15. 0
Crushing	1 man @ 24/-	
Calcining	3 men @ 24/-	
Gas Producer	6 " " "	
Classifier	3 " " "	
Crystalliers & centrifuges	3 " " "	
Residue Disposal	1 " " "	
Bagging and/or Loading Potash	1 " " "	
Shift Bosses	3 " " 40/-	
TOTAL	21 men -	27. 12. 0
REPAIR LABOUR		
Tradesmen	5 men @ 28/-	
Foreman	1 man @ 40/-	
TOTAL	6 men -	9. 0. 0
POWER HOUSE LABOUR		
(Included in power costs)		
SUPPLIERS:		
Lubricants	£2. 0. 0	
Water 375 gals. per ton of alunite @ 2/6 per 1,000	6. 1.10	
Wood fuel for calcining 50% of weight of alunite @ 12/- per ton of wood	39. 0. 0	
Power 300 h.p. for 24 hrs. @ 1d. per kilowatt hour 100 h.p. for 8 hrs. @ 1d. per kilowatt hour 400 h.p. for 24 hrs. @ 1d. per kilowatt hour. 100 h.p. for 8 hours @ 1d. per kilowatt hour.	25. 0. 0	
REPAIR MATERIALS:		
@ 4/- per ton		
@ 3/- per ton	26. 0. 0	
TOTAL STORES EXPENDITURE		98. 1.10
MISCELLANEOUS CHARGES		
Chemical Laboratory	10. 0. 0	
Superintendence	8. 0. 0	18. 0. 0
	GRAND TOTAL	£162. 8.10

Estimated operating costs (Contd.)

	130 tons/day.
FORWARD:	£162. 8. 10
Overheads @ 8%	12. 19. 10
TOTAL COST PER DAY	£175. 8. 8
COST PER TON OF ALUNITE	1. 6. 11
COST PER TON OF POTASH (@ 10% recovery)	
Plant cost of Potash	13. 9. 2
Freight to Weira & Loading (5/7 per ton glaserite or 7/6 per ton Potash)	7. 6
DEPRECIATION @ 10% on £72,270 or £600 per month on 400 tons K_2SO_4 per ton	1. 10. 0
TOTAL COST OF POTASH ON RAIL	£15. 6. 8

NOTE: Cost of bagging charged
(bags at Purchasers cost)