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INDIAN AND NORTHERN AFFAIRS CANADA
NORTHERN AFFAIRS: YUKON REGION

Open File 1995-4(T)

BENEFICIATION OF BARITE ORE

By

D. B. CRAIG, PH.D., PENG

FOR

H. COYNE & SONS LIMITED

14-51

Canada

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Government

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CONTENTS

I INTRODUCTION

High grade, bedded barite deposits occur in upper Palaeozoic sedimentary rocks of the Earn Group in south-eastern Niddery Lake map-area. Following discovery and initial exploration of the TEA claims, the present owners have carried the property to the production stage through the construction, machine assembly and test operation of a beneficiation mill at Ross River.

II TEA PROPERTY

1.0 HISTORY

The TEA claims were staked in 1975 by Welcome North Mines Limited, geologically mapped, trenched and diamond drilled then and in succeeding years by Yukon Barite Limited. Test mining was done in 1982, with some 8000 tons being trucked to Ross River.

H. Coyne and Sons Ltd., the present owners, since 1990 have concentrated efforts on readying a grinding mill and beneficiation circuit at Ross River, using as feed the mine run material brought from the property in 1982. They have done considerable analysis of the market for barite as an oilfield drilling mud additive.

2.0 LOCATION AND ACCESS

The TEA property is found in south-eastern Niddery Lake map-area (NTS 105 O - 2) at Latitude 63° 01' N, Longitude 130° 37' W (Fig.1). It lies in the north-western Selwyn Mountains 160 kilometres north-east of Ross River and is reached by vehicle via an 11 kilometre haulage road which turns off the North Canol Road at Kilometre 408 (Mile 253).

3.0 GEOLOGY AND RESERVES

The TEA property is underlain by a sequence of marine sedimentary rocks having a barite rich zone some 100 meters thick in a shale member of the Earn Group of Devono-Mississippian age (Figure 2). The main showing grades from a carbonate-rich base with grey, baritic and carbonaceous shale, to a sulphate-rich top (bedded barite). Minor interbedded chert occurs throughout the section but is more common towards the base. The probable origin of the deposits was barium rich exhalative activity in marine basins. Drilling in 1986 returned intersections of up to 30 meters, true thickness, of nearly massive barite.

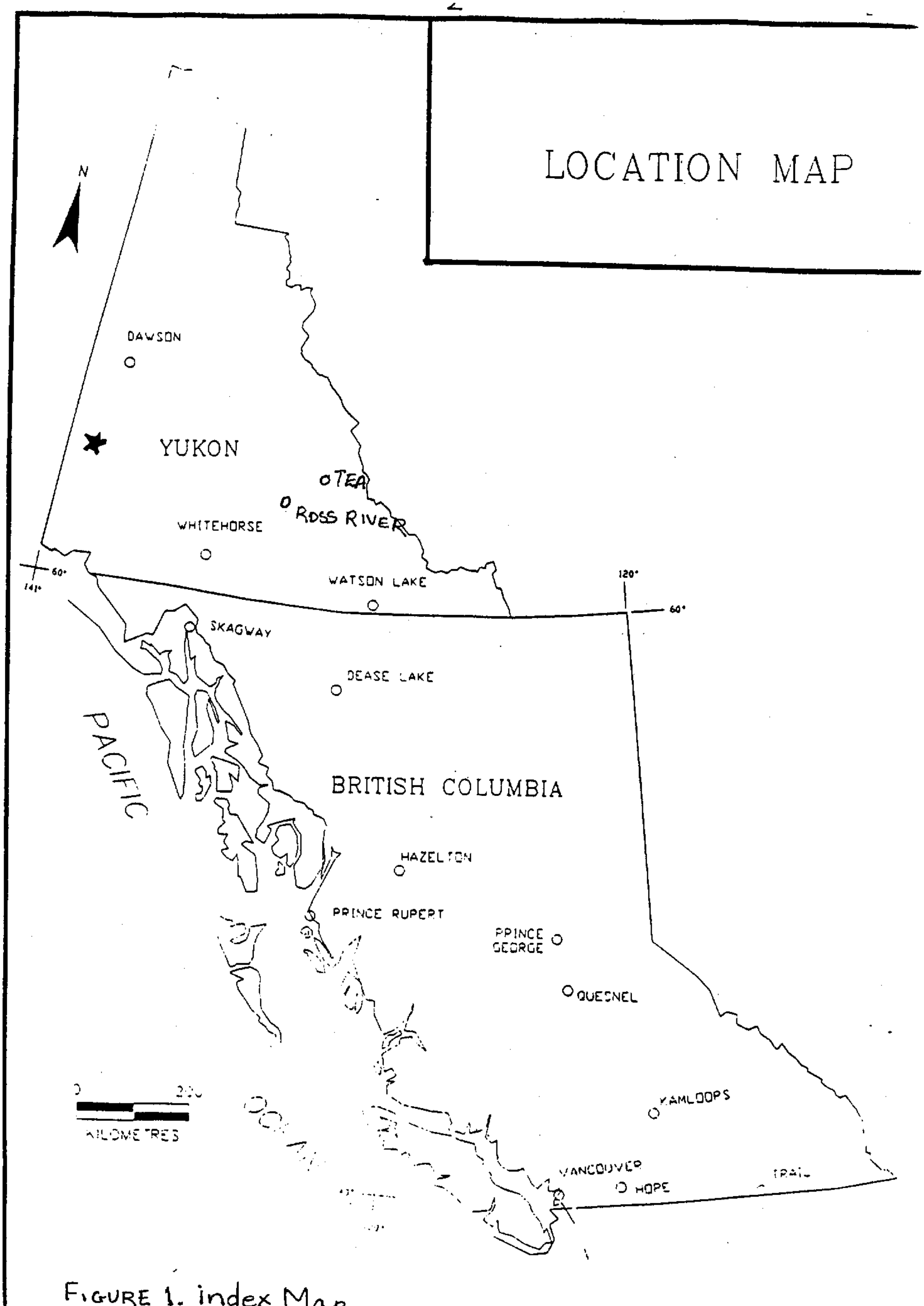


FIGURE 1. index Map

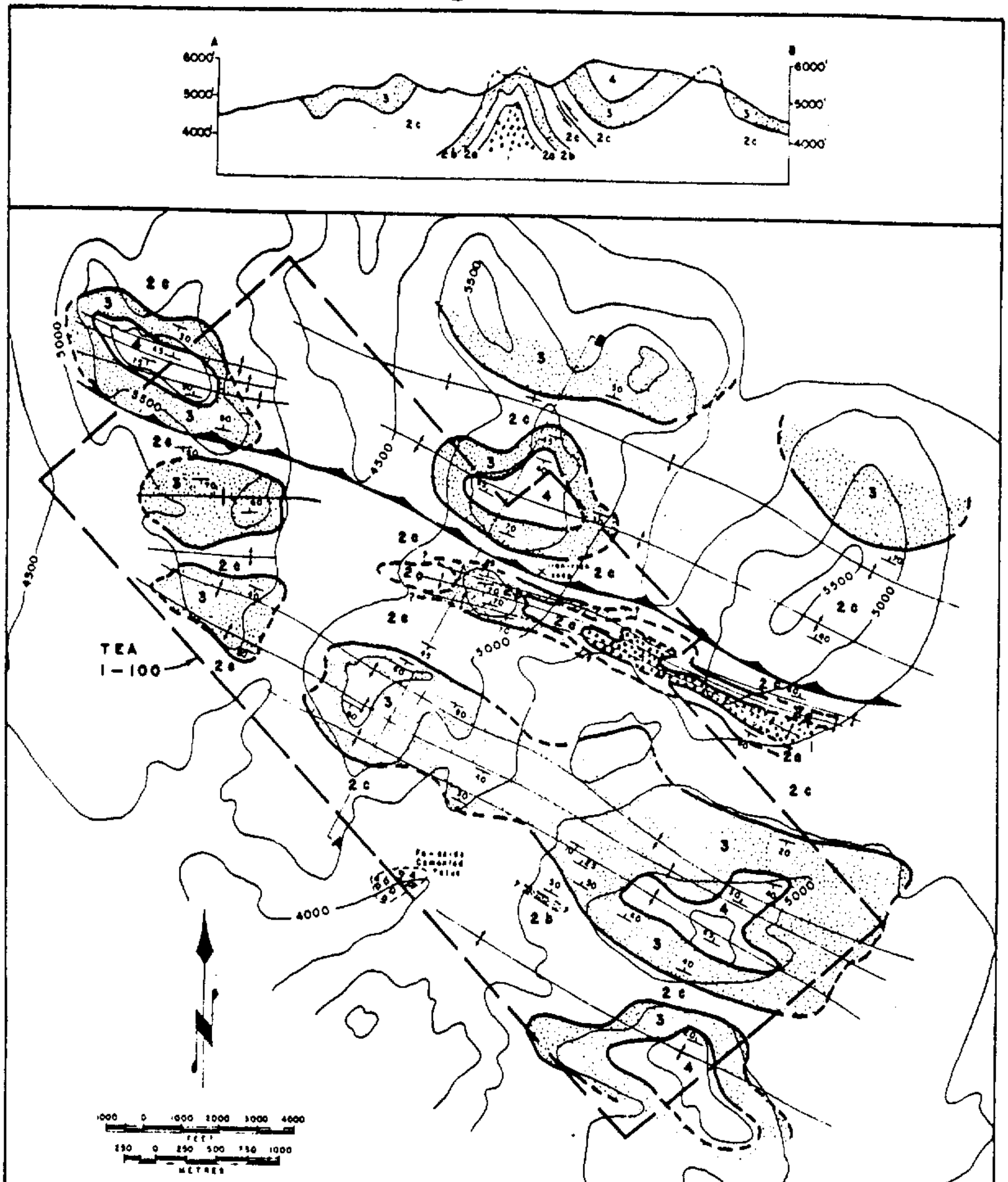


FIG. 2

GEOLOGY OF THE TEA BARITE PROPERTY
105 O-2
LEGEND

4	Banded grey quartzite, brown mudstone brown-grey shale, nordular barite		Geological boundary (defined, assumed)
3	Banded black-grey quartzite, calcareous sandstone and shale, nordular barite		Bedding (inclined, horizontal, vertical)
2c	Carbonaceous shale, siliceous shale, chert		Thrust fault (teeth indicate direction of dip)
2b	Bedded barite, baritic shale, barite, limestone, shale		Syncline
2a	Siliceous pyritic shale, minor siliceous siltstone and siliceous silty shale, chert and cherty argillite		Anticline
3D	Chert pebble conglomerate, greywacke, chert sandstone		

Reserves have been calculated with the data from successive trenching and diamond drilling programs. Some 68,000 tonnes were identified by 1976 (Carne, 1976), then 250,000 tonnes with a specific gravity of 4.24 by 1982. Then, greater than 800,000 tonnes, with a specific gravity of 4.22, but including a higher grade zone of approximately 90,000 tonnes of 4.27 specific gravity, were established by 1990.

Since the key criterion for market acceptance for drilling mud is a specific gravity of 4.20 or greater, these promising figures suggested that a saleable product would be easily achieved. Simple grinding would produce a direct shipping product.

However, as progress was made towards milling, it was realised, by 1992, that inevitable dilution of the barite ore in mining and handling would result in the specific gravity falling below 4.20. (J. Coyne reported 4.15 specific gravity as an average grade for 8000 tons mined.) Accordingly, any milling process would have to include some beneficiation to bring the product to marketable grade.

III BARITE BENEFICIATION

1.0 <u>BARITE MILL</u>

The mill established to process barite ore from the TEA property is on Whiskers Lake, four kilometres south-west of Ross River, Yukon, adjacent the South Canol Road. It is in north-eastern Quiet Lake map-area (NTS 105 F - 15) at Latitude 61 58' N, Longitude 132 31' W.

The mill equipment is housed in a modern, Butler type, steel frame, galvanised steel clad building 50 meters long by 20 meters wide, with large overhead doors providing ready access for heavy equipment, such as front end loaders. The main components - feed hopper, ABB Raymond roller mill with whizzer classifier, cyclone separator, bag house and final product bin, but excluding the mechanical air separator, are mounted on a common skid system consisting of two I - beams 14 meters long. The milling process is dry, with heated air entrainment of particles for both size classification and gangue-product separation. The mill has a nominal capacity of 10 metric tons per hour.

2..0 PHYSICAL AND CHEMICAL REQUIREMENTS FOR DRILLING MUD

The American Petroleum Institute has specified the standards which barite must meet in order to be certified by the Institute. Purchasers, even if not requiring certification, typically require the same standards.

The API standards are:

a)	Density	4.20 gm./ cubic cm. minimum
b)	Water soluble alkaline earth metals as Calcium	250 mg/kg maximum.
c)	Residue greater than 75 micrometers (200 mesh)	3% wt maximum.
d)	Particles less than 6 micrometers in equivalent spherical diameter	30 % wt maximum.

3.0 LAKEFIELD RESEARCH

Lakefield Research, a Division of Falconbridge Limited, was contracted, in 1993, to produce a barite concentrate of 4.20 or greater specific gravity. They accomplished this by roll crushing a bulk sample to -35 mesh, wet screening over 100 mesh with both the oversize fraction and the -100 + 325 fraction being passed over Wilfley tables and each concentrate being upgraded twice. The results were that the -325 mesh had a 4.25 specific gravity, represented 53 percent by weight of the original sample and met other API specifications listed above. When the Wilfley table concentrates for the other two size fractions were added, the composite had a specific gravity of 4.23 and represented 80 percent, by weight, of the original sample. Thus the amenability of TEA property barite to beneficiation to drilling mud specifications was proven. The appropriate milling techniques and economics were still to be worked out.

4.0 MILLING PROCESS

The process applied at Ross River mill (see Figure 3) involves feeding of three-quarter inch (1.9 cm) crushed barite ore by front end loader from a stockpile to a hopper and feed conveyor. This conveyor discharges into the feed hopper of the roller mill where the material is ground. Above the grinding rolls and ring is the whizzer classifier consisting of shaft mounted steel paddles. The material from below, air entrained, passes through the whizzer, is drawn to the cyclone separator and from there is moved by a screw conveyor to the bucket elevator. Air and fine barite is drawn from the air stream returning to the roller mill, through the bag house where the barite is extracted. The clean air is vented to the atmosphere and the barite fraction is fed to the screw conveyor. From the screw conveyor, material goes by bucket conveyor to the mechanical air separator where an accept line delivers beneficiated commercial barite to the final product bin from which it is bagged and weighed. The reject fraction from the separator, some barite, some chert and other gangue minerals, goes to a waste pile for possible future recovery of the contained barite.

5.0 PILOT PLANT OPERATIONS

The ABB Raymond roller mill is a general purpose mill which can operate on a variety of mineral (and even non-mineral) feed materials. The operating parameters or settings and individual components are adjusted or changed to bring the performance to an acceptable level for the particular material being milled.

Under the guidance or direction of S. Syed of ABB Raymond of Chicago, a series of nine test runs were made during the period June 25 - 30, 1994. These runs involved changes in the number of whizzer blades, whizzer shaft speed in RPM, the temperature, air flow in the system and the air pressure (partial vacuum). Attempts were being made to obtain a suitable proportion of the material in the -325 mesh range, both for freeing the barite from the chert gangue and to achieve the size range requirement of the market specifications. Also, the mill was brought to smoother operation, with necessary adjustments made or identified to match the output of the roller mill with the capacity of the screw conveyor and bucket elevator.

At the same time as the mill test runs were being conducted, R.G. Irwin of Lakefield Research of Lakefield , Ontario and K. Coyne of H. Coyne and Sons Ltd., operated a laboratory scale mechanical air separator on the mill products to achieve a separation into a beneficiated barite fraction and a barite - chert reject fraction. They determined specific gravity of both barite and reject fraction using the Le Chatelier Flask method as outlined in the American Petroleum Institute specifications.

On the basis of the above work, H. Coyne and Sons Ltd., purchased and installed a mechanical air separator in the mill system.

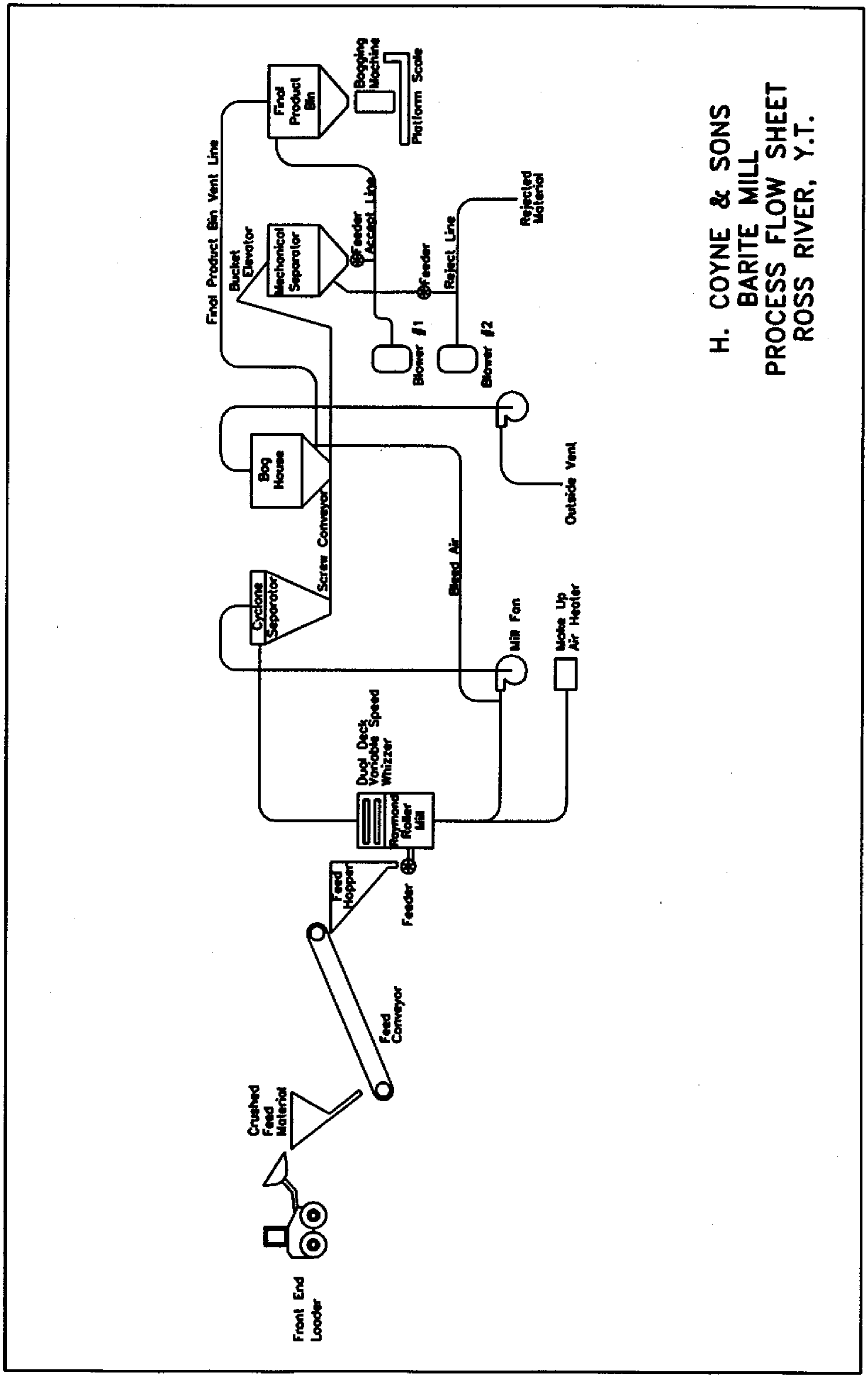


FIGURE 3. Barite Mill Process Flow Sheet

VI CONCLUSIONS

1.0 A bedded barite deposit has been identified on the TEA property in the Selwyn Mountains of the Yukon. It is of suitable tonnage to support any likely scale of production (5000 to 10,000 tonnes per year) for at least 25 years.

2.0 The barite is of suitable grade such that with moderate beneficiation (from a mine run grade of approximately 4.15 S.G., to drilling mud grade of 4.20) it should find a market in both northern Canada or Alaska, enjoying a transportation cost advantage over materials presently brought from Nevada.

3.0 The ore is amenable to beneficiation, based both on the preliminary laboratory work by Lakefield Research of Ontario and on the production scale test runs by H. Coyne and Sons Ltd., with the mill at Ross River.

4.0 Laboratory equipment techniques of types approved by the American Petroleum Institute are being used for quality control of product at the Ross River mill. A barite standard of known and accepted specific gravity is used to check the calibrations and performance of this quality control system.

5.0 A determined market analysis has been conducted. The requested production samples are being provided to prospective purchasers in Alaska.

VII REFERENCES

Carne, R.C. The TEA Barite Deposit, 1976: Preliminary Geological Report in Indian and Northern Affairs Open File Report EGS 1976-16.

VII APPENDIX

Barite Analyses

Summary

Since the lab work on the specific gravity was showing an adequate grade above 4.2 using the air comparison pychnometer method, the first 16 runs were ground too fine for the MAS to beneficiate the product.

Runs 17 and 18 were ground coarse with three whizzer blades in the mill so that the product was coarse enough for the separator to work (63.8% passing the 200 mesh). After 12 tests in which we varied the whizzers, voltage and feed rate, it was determined that the highest recovery with an acceptable grade was achieved using a combination of low voltage and the least number of whizzer blades possible. From July 11 through August 9, 1994, 16 tonnes of coarse feed product was run through the lab separator with a recovery of approximately 67% with a specific gravity between 4.22-4.28.

During the milling of Run 17 and 18, the coarse product was going through the mill too fast for the dust collection and conveying system to handle. We had two alternatives, A) to slow down the mill to what the conveying system could manage, or B) increase the conveying and dust collection systems. We decided to change the mill shieve to slow the mill down and install a production separator.

All the results from the mill with the production separator have been above the required specific gravity of 4.2 (4.21-4.33) and the recovery has been above 75%. During the course of this work we have ground approximately 800 tonnes.

Ground Product Analyses

To sample the product from the grinding circuit the sampling procedure was as follows:

1) Samples were taken of the filled bags.

2) The bags were sampled by grabbing handfuls of material at various depths and surface points. The bags' content was voluminous (2 metric tonnes) and easy to penetrate by inserting ones hand. A minimum of 10 grab samples were removed from each bag.

3) The sample removed was mixed by rolling.

4) A sample of 50 or 100 grams was removed for size analysis by wet screening on a 200 Tyler mesh and a 325 Tyler mesh. The oversize was dried and weighed.

5) Initially, a 200 gram sample was removed for moisture determination. These samples were dried for 2 hours at 220°C in a gas oven.

6) S.G. determinations were conducted on the dried sample.

7) For test runs 8/9 and 10 equal weight composites were prepared for analysis.

Summary of Ground Products from Mill

Run Number	2MT Bag Number	Size % 200	Plus Mesh 325	Specific Pycnometer Method	Gravity Flask Method	Alkalinity Ca (mg/L)
Run 1	Bag 1	0	0.2	4.22		
Run 2	Bag 1	0	0.6	4.19		
	Bag 2	0	0.5			
Run 3	Bag 1		3.0	4.23		
Run 4	Bag 1	16.6	24.3	4.12		
Run 5	Bag 1	1.48	5.08	4.07		
Run 6	Bag 1	6.42	12.22	4.20		
	Bag 2	5.10	12.32			
Run 7	Bag 1	5.10	12.32			
Run 8	Bag 1	2.09	3.00			
	Bag 2	0.22	1.39	4.23		40
	Bag 3	1.43	4.68			
Run 8/9	Bag 1	0.22	1.27			36
	Bag 2	0.06	0.70			
	Bag 3	0	0.65			29
	Bag 4	0	0.71			
Composite	(8+ 8/9)				4.13	
Run 10	Bag 1	0	0.7			
	Bag 2	0	0.9			37
	Bag 3	0	0.7			
	Bag 4	0	0.9			42
	Bag 5	0	0.6			
	Bag 6	0	0.5			40
	Bag 7	0	1.3			
	Bag 8	0	1.0			29
	Bag 9	0	1.5			
	Bag 10	0	0.7			32
	Bag 11	0	0.6			
Run 11	Mill unstable	No samples	taken			
Run 12	Bag 3	0.3	3.03			
Run 13	Bag 3	0.04	1.5			
Run 14	Bag 3	0.9	7.3			
Run 15	Bag 3	1.6	10.4			
Run 16	Bag 3	2.3	11.9			

Summary of Mechanical Air Separator Tests

Test Numbers MAS 1 to MAS 12

Procedure:

A representative 200 lb sample was removed from the following product bags:

a) Run 4 Bag 1 Size
b) Run 8 Bag 3
c) Run 10 Bag 10

These samples were individually mixed by coming and quartering, and then split into equal quarter fractions. One quarter was further mixed by coning and quartering and a hard sample removed for size distribution and S.G. The tests were conducted with the 10 inch Raymond air separator. All tests were conducted with a 6 bladed fan, a 6 bladed upper wizzer and a 3 bladed lower wizzer. The variable in all tests was the feed rate. The test procedure was to

1) fill the feed hopper with sample,
2) start the air separator, start the feeder noting its setting and time.

The fine fraction was collected in a plastic bag sealed to the exit part. The coarse fraction dropped by gravity into a pail. All products were weighed, and sampled for S.G. and size.

Test Conditions:

Feed	Test #	Feeder			Product Weight (lbs)			Product Weight %		
		Setting	Time mins.	Rate lb/min	Fine	Coarse	Total	Fine	Coarse	Total
R4-B1	1	79	16	2.9	46	0.25	46.25	99.5	0.5	100
	12	85	11	4.9	36	18	54	67	33	100
	4	89	5	8.4	30	12	42	71	29	100
	9	100	6.5	5.5	23	13	36	64	36	100
R8-B3	3	89	7	6.0	36	7	42	86	14	100
	11	95	7.5	6.8	35	16	51	69	31	100
	5	100	6	7.2	29	14	43	67	33	100
	7	110	5.5	9.3	19	32	51	37	63	100
R10-B10	2	89	9	4.1	37	0.25	37.25	99.3	0.7	100
	10	95	7.5	5.3	33	7	40	83	17	100
	6	100	6	7.7	35	11	46	76	24	100
	8	110	4.5	11.5	29	23	52	56	44	100

(Test Conditions Cont'd)

Feed	Test Number MAS	Product	% Weight	% Passing Mesh 200	325	S.G. Flask
R4-B1		Feed		95.7	90.7	4.14
R4-B1	1	Fine	99.5	99.2	95.4	4.13
		Coarse	0.5	92.5	82.0	4.03
			100.0			
	12	Fine	67	99.6	98.9	4.15
		Coarse	33	94.8	79.9	4.07
			100.0			
	4	Fine	71	99.9	99.7	4.15
		Coarse	29	95.1	82.7	4.11
			100.0			
	9	Fine	64	99.9	99.0	4.18
		Coarse	36	95.6	82.7	4.14
			100.0			
R8-B3		Feed			95.3	4.16
	3	Fine	86	99.0	98.0	4.11
		Coarse	14	91.9	83.2	4.10
			100.0			
	11	Fine	69	99.8	99.1	4.18
		Coarse	31	99.6	98.9	
			100.0			
	5	Fine	67	99.9	99.2	4.14
		Coarse	33	95.5	86.7	4.09
			100.0			
	7	Fine	37	100	99.7	4.17
		Coarse	63	96.5	91.9	4.14
			100.0			
R10-B10		Feed		100.0	99.4	4.15
	2	Fine	99.3	99.9	99.3	4.14
		Coarse	0.7	99.7	99.2	4.12
			100.0			
	10	Fine	83	100.0	99.6	4.12
		Coarse	17	99.8	97.6	4.14
			100.0			
	6	Fine	76	99.8	99.6	4.12
		Coarse	24	99.7	96.3	4.13
			100.0			
	8	Fine	56	99.9	99.8	4.16
		Coarse	44	99.7	98.2	
			100.0			

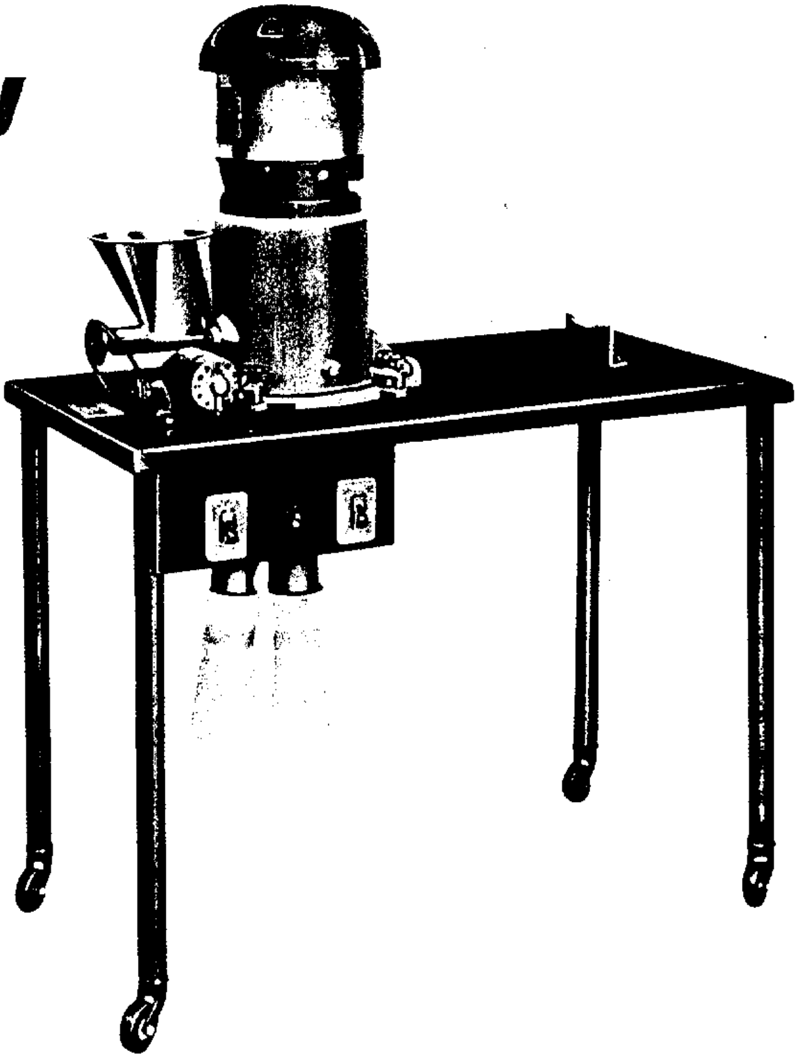
MAS Analysis

Feed	Test # MAS	Product	% Weight	Weight 200 (g)	325 (g)	% 200	Passing 325	S.G. Flask	Ca (mg/l)
R17-B3	Feed			36.2	0.80	63.8	99.2	4.15	
	19	Fine	43	0.00	0.00	100.0	100.0	4.19	44.0
		Coarse	57	44.30	3.50	56.70	96.50	4.13	
	20	Fine	29	0.20	0.15	99.80	99.85	4.22	
		Coarse	71	48.40	10.50	51.60	79.50	4.07	
	21	Fine	18	0.09	0.11	99.91	99.89	4.28	40.0
		Coarse	82	46.90	8.60	53.10	91.40	3.72	
	22	Fine	36	0.60	1.80	99.40	98.20	4.24	
		Coarse	64	53.80	9.30	46.20	90.70	4.07	
	23	Fine	36	0.40	1.70	99.60	98.30	4.23	
		Coarse	64	44.60	14.13	55.40	85.87	4.06	
	24	Fine	40	0.07	2.10	99.93	97.90	4.22	37.9
		Coarse	60	56.40	0.90	45.60	99.10	4.14	
R18-B3	Feed			14.10	8.80	85.90	91.20	4.14	
	25	Fine	35	0.00	0.05	100.0	99.95	4.19	
		Coarse	65	22.30	21.60	81.70	80.40	4.09	
	26	Fine	39	0.10	0.30	99.90	99.70	4.17	33.0
		Coarse	61	26.60	29.70	74.40	70.30	4.15	
	27	Fine	30	0.20	0.00	99.80	100.0	4.17	
		Coarse	70	35.20	12.70	64.80	81.30	4.16	
	28	Fine	50	35.60	13.00	64.40	87.00	4.21	27.
		Coarse	50	0.80	2.40	99.20	82.60	4.08	
	29	Fine	52	0.50	1.90	99.50	98.10	4.18	
		Coarse	48	37.80	18.0	69.20	82.0	4.08	
	30	Fine	56	0.48	2.30	99.60	97.70	4.25	
		Coarse	44	31.32	21.30	86.68	78.70	4.06	

Production Separator Analysis

Sample#	Specific Gravity	Mesh 325 Retention	Mesh 200 Retention	Mesh 325 % Passing	Mesh 200 % Passing
21A	4.32	7.89	1.20	92.11	98.80
21B	4.24	9.79	2.22	90.21	97.78
21C	4.27	7.50	0.74	92.50	99.26
21D	4.23	8.03	0.98	91.97	99.02
22A	4.25	7.63	1.31	92.37	98.47
23D	4.22	6.68	0.88	93.32	99.12
22C	4.28	8.37	1.64	91.63	98.36
22D	4.29	6.70	1.12	93.30	98.88
22E	4.24	14.43	2.09	85.57	97.91
25A	4.25	9.36	2.88	90.64	97.12
25B	4.28	8.44	1.68	91.56	98.32
25C	4.30	8.00	1.20	92.00	98.80
25D	4.28	13.06	1.78	86.94	98.22
26A	4.27	8.71	1.48	91.29	98.52
26B	4.29	9.00	2.80	91.00	97.20
27A	4.29	7.05	1.77	92.95	98.23
27B	4.23	10.03	2.12	89.97	97.88
27C	4.26	8.73	1.20	91.27	98.80
27D	4.28	8.82	1.47	91.18	98.53
28A	4.30	11.07	1.68	88.93	98.32
28B	4.27	7.32	0.91	92.97	99.09
28C	4.30	10.43	2.11	89.57	97.89
28D	4.28	7.62	1.81	92.38	98.19
29A	4.28	10.17	1.57	89.83	97.43
29B	4.26	9.44	2.54	90.56	97.46
29C	4.26	8.44	1.97	91.56	98.03
29D	4.28	9.40	2.14	90.60	97.86
30A1	4.21	9.86	1.57	90.14	98.43
30B2	4.33	8.76	1.49	91.24	98.51

Raymond® Laboratory Separator



The *Raymond®* laboratory separator is a small capacity air classifier, especially suited for fines extracting operations, and offering other benefits:

- Self contained, dustless operation.
- Easy to adjust for desired changes in fineness.
- Easy to clean when changing materials.
- Same operating principle as standard size *Raymond®* mechanical air separators.
- Works in combination with any pulverizer, including the *Raymond* laboratory mill and *the Raymond®* 8-inch screen mill.

The laboratory separator is a completely self-contained unit. Product classification occurs in an enclosed double chamber with air constantly circulating for dustless operation and uniform separation.

Fineness is controlled by changing fan and whizzer combinations. The fan, whizzers and distributor plate in the separating chamber rotate on the long shaft extension of the motor. They are easily removed for fineness adjustments and cleaning by loosening the nut at the end of the shaft.

The separator is supplied with two different size fan wheels and four whizzers with 6, 12, 16 and 24 blades. Fineness adjustments are made by simply varying the fan size and whizzer combinations and placement.

The separator is driven by a ½ HP 3600 rpm motor which can be furnished either as a single phase 60 hz 115 volt capacitor start motor or a 3 phase 60 hz 230/460 volt motor of the open drip-proof type.

The laboratory separator is shipped completely assembled on a metal base with corner sockets. Pipe legs are supplied to support the unit at the desired height above the floor.

Note: While the laboratory separator is very effective in fines extracting operations, it is not suitable for dividing a product into several different fractions within close limits on the fines and coarse ends. It will do an excellent job of classifying a material of medium fineness, such as 75% to 80% passing 200 or 325 mesh, and in delivering the finished product testing practically all through 200 or 325 mesh.

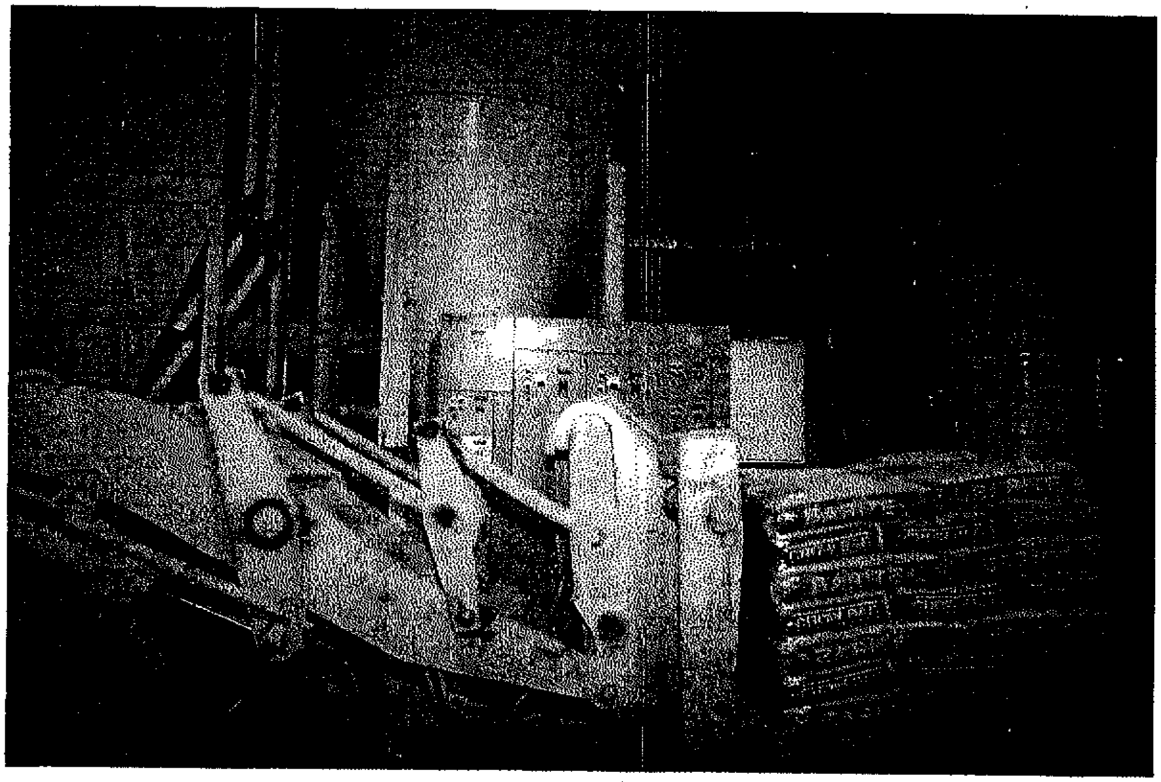


Plate 1.
Raymond Roller Mill (right), Cyclone Separator (centre), Baghouse (left).

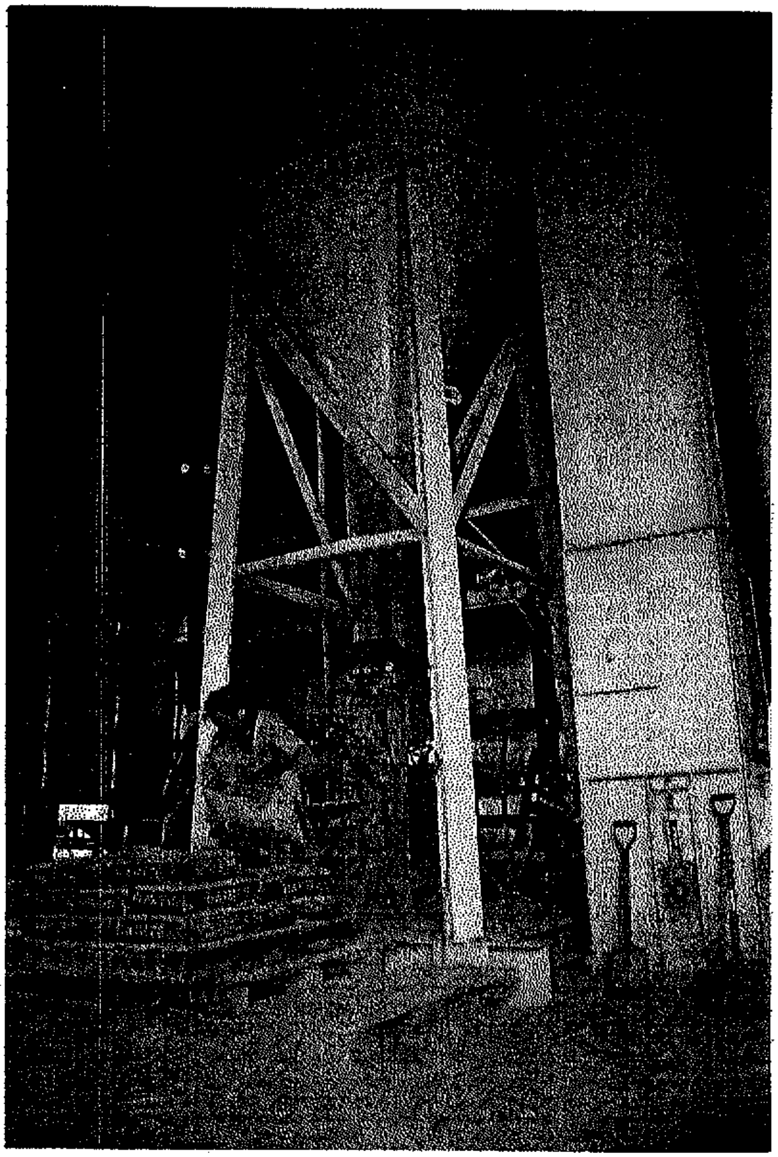


Plate 2.
Final Product Bin, Bagging Machine, Platform Scale.