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REPORT NO. 07250/91

YOUR REFERENCE:	Letter dated 7 February 1991
MATERIAL:	Tasmanian magnesite - low and high SiO_2
WORK REQUIRED:	Calcination tests

Investigation and Report by: J.R. Tuffley

Acting Manager, Mineral Processing Division: R. Phillips

91-3271-R

The results contained in this report relate only to the sample(s) submitted for testing. Amdel Ltd accepts no responsibility for the representivity of the samples submitted.

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CALCINATION TESTS

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CONTENTS

1. INTRODUCTION

CRA Limited has a major interest in a very large magnesite resource in Tasmania. It is envisaged that the material could be calcined to produce caustic magnesia for use in such applications as gas desulphurisation and treatment of effluent liquors for acid neutralisation and heavy metal removal.

In a letter dated 15 January 1991, CRA requested a proposal for calcination testwork aimed at determining optimum operating conditions for the commercial production of a highly reactive calcined magnesite. Amdel's proposal was accepted in a letter dated 7 February 1991 and the magnesite samples were received on 11 February 1991. Extra testwork was also approved during a meeting at Amdel on 26 February 1991 and on an ad hoc basis as the programme proceeded.

2. MATERIAL EXAMINED

2.1 Sample Description

A complete list of the drill core samples forwarded to Amdel are listed in Table 1. These samples were described by CRA as follows:

"The magnesite samples available appear to comprise intimate mixtures of micro-crystalline and macro-crystalline magnesite with a pseudo breccia texture. It typically contains about 60=70% of extremely fine grained, cream coloured magnesite fragments (0.5 to 3.0 cm) enclosed within a greyish matrix of coarser magnesite and variable amounts of silica."

The samples were combined to form two composites as follows:

i) A "low silica" composite comprising samples LR1 and LR2.

ii) A "high silica" composite comprising samples LR5, LR6 and LR7.

iii) At a later date, about 200 kg of surface samples was forwarded for use in kiln calcination trials. These would have come from boulders within the Pinner Pit at approx. 366500mE & 436 100mN.

Analyses of the two composites and the surface sample are listed in Table 2.

2.2 Mineralogy

Two samples were chosen by the client for mineragraphic examination as follows:

a) A very white sample from LR1 which was assumed to have a very low silica content.

b) A cream coloured sample from the high silica composite with a pseudo breccia texture.

The full report is enclosed in Appendix A. The mineragraphic examination found that each sample contained 50% crypto-crystalline carbonates and lesser amounts of crystalline material with an average grain size of around 100 microns. The silica was present as quartz which was concentrated in the crystalline carbonates.

No calcite was present, so the calcium content of the material was assumed to be dolomite.

2.3 Differential Thermal Analysis

The lead samples were further characterised by carrying out differential thermal analysis (DTA) tests. A full report on these is included in Appendix B.

These showed that magnesite decomposed in the range 570 to 710°C. However, the $MgCO_3$ component of the dolomite present in the sample decomposed at 710 to 780°C while the $CaCO_3$ decomposed at 925 to 960°C. The total $MgCO_3$ contents of the low and high silica samples were estimated from the DTA curves to be 89.5% and 85.5% respectively. This compares with figures of 86.3% and 81.9% respectively derived by the analyses listed in Table 2.

3. EXPERIMENTAL PROCEDURE AND RESULTS

3.1 Sample Preparation

A small quantity of -25 +19 mm and -19 +12.7 mm material was required for laboratory calcination tests. However, because of the long thin nature of the half and quarter drill cores provided, it was difficult to crush the samples at a coarse size. As a result, the coarse samples were obtained in the following manner. One length of drill core was taken from each small calico bag and broken manually with a hammer to produce material in the above size fractions.

The remaining drill core was combined into two composites and crushed to pass a 12.7 mm screen. Samples were riffled out of each composite to obtain a head sample for analysis and samples sized at -12.7 +6.3 mm, -6.3 mm and -0.5 mm for laboratory calcination tests.

The surface sample was stage crushed to pass 6.3 mm and a head sample obtained for analysis.

3.2 Laboratory Calcination Tests

a) Procedure

A laboratory muffle furnace was preheated to the required temperature. One sample of each composite (150 g of -6.3 mm material) was placed in a silica dish and the two dishes were placed side by side in the furnace. The samples were removed after the required time and allowed to cool in a desiccator. Products were then analysed as required.

b) **Weight Loss - Temperature - Time Curves**

Weight loss as a function of time was investigated for temperatures from 600 to 900°C using -6.3 mm feed. The results are listed in Table 3 and illustrated graphically in Figure 1. The apparent specific gravities in these graphs were calculated from the following feed specific gravities which were determined using an air picnometer.

Sample	SG
Low silica	3.07
High silica	3.02

The results show that calcination does not proceed at a fast rate below about 700°C. At 800 and 900°C most of the weight loss occurs in the first 30 minutes. Most of the difference between weight losses at 700 and 800°C after 2 hours is attributable to the $MgCO_3$ in the dolomite which decomposes above 700°C. There were no signs of decrepitation or other size degradation in any of the products.

c) **Effect of Temperature**

This series of tests was designed to establish an optimum temperature at which to carry out later tests. Material sized at -6.3 mm was calcined for one hour at temperatures from 500 to 750°C. The products were analysed for MgO and CO_2, and the iodine number was determined as a guide to reactivity.

Initially, the iodine number determination was carried out using product crushed to -2 mm. This was done to prevent any possibility of destruction of the internal pore structure by fine grinding. To check the effect of fine grinding, iodine numbers were also determined on finely ground products from calcination at 700, 725 and 750°C.

All results are listed in Table 4. These show that fine grinding of the products did not destroy the internal pore structure as evidenced by very similar iodine numbers for the -2 mm and finely ground products. As a result, calcined product can be marketed in any convenient size range without affecting reactivity.

The iodine number was a maximum for a calcination temperature of 700°C. However, the iodine number was still reasonably high at 725 and 750°C and the CO_2 levels were much lower. A few extra tests were carried out at 750 and 775°C for shorter times to see whether a higher iodine number could be obtained.

Results of these tests are also listed in Table 3. These confirmed that the highest iodine number was obtained at 700°C after one hour of calcination. All the products at 725 to 775°C had very similar iodine numbers but these were all less than the result at 700°C. The high silica material was less affected by the high temperatures than was the low silica material.

All further tests were then carried out at 700°C.

d) **Effect of Calcination Time**

The effect of calcination at 700°C on the iodine number was determined by calcining -6.3 mm material for times ranging from 0.5 to 2.0 hours. The results are listed in Table 5. These show that the iodine number decreased after one hour even though the degree of calcination (as measured by the weight loss) increased with time. Once again, the high silica material appeared to be less affected by the longer times and maintained iodine numbers above 100.

e) **Effect of Feed Size**

The effect of feed size on iodine number was determined by calcining a series of size ranges from -.05 mm to -25 +19 mm at 700°C for one hour. The results are listed in Table 6. These show that the weight loss decreased as the particle size increased. However, the finest particle size did not yield the highest iodine number. This may indicate that it is easy to over calcine the very fine material.

f) **Sample LR1**

Some very white lumps were selected by the client from sample LR1. These match one of the samples examined mineralogically. This material was crushed to -6 mm and calcined at 700°C for one hour. The weight loss obtained was 34.8% which was lower than that for the composite low silica sample.

The surface area of the product was determined by the B.E.T. method and the acid reactivity was also determined. These results are listed in Table 7 along with the results for several other products. This shows that it had a slightly lower surface area and was slightly less reactive than both the low and high silica composites.

g) **Surface Area**

A selection of products which had high iodine numbers was submitted for B.E.T. surface area determinations and acid reactivity tests. These were the products from calcination of -6.3 mm feed at 700, 725 and 750°C for 1 hour and 775°C for 40 minutes, and the -12 +6.3 mm feed at 700°C for one hour. The product from sample LR1 and the two -0.5 mm samples were also included. The surface area results are listed in Table 7.

These show some surprising differences to the iodine numbers. The highest surface area was obtained at 775°C for both composites. Acid reactivity tests (see next section) confirmed that 775°C produced the most reactive product.

h) **Acid Reactivity**

Acid reactivity was determined by reacting finely ground calcine with 0.1 N sulphuric acid (pH ≈ 1.26) containing about 10 ppm each of copper and zinc as sulphates. An initial amount of 5 grams of solids was added to 2 litres of acid in an agitated beaker and the pH was allowed to stabilise. Further additions of around 0.5 gram each were made until the pH reached 7.5 within a 2 hour period. In some of the tests the pH rose to 9 or above because only a very small excess (< 0.1 g) of calcine addition was sufficient to cause this to happen. The total weight of solids required was taken as a measure of reactivity, with the lowest weight representing the highest activity. These results are listed in Table 7 and show that the most reactive calcines were produced at 775°C. The residual carbonates in the calcine did not cause any bubbling or frothing due to their relatively low reactivity compared with the oxide product.

In the initial batch of reactivity tests, a liquor sample was taken every 30 minutes and analysed for Mg, Cu and Zn. These results are listed in Table 8. The rate of increase of pH in each sample was a function of the rate of addition of calcine only. It does not indicate the relative reactivity of the sample. For each sample the magnesium dissolved was in excess of 95%. The relationship between pH and the amounts of copper and zinc remaining in solution are illustrated graphically in Figure 2. All the copper was precipitated by pH 7 and all the zinc by pH 9 to 9.5.

3.3 Rotary Kiln Calcination

Calcination was carried out in a rotary kiln, 3.6 m long and 0.23 m internal diameter. The first two-thirds of the kiln was lined with high alumina bricks, while the last third was lined with "Super Hi-Cast" castable refractory. Labyrinth seals were provided at each end of the kiln to minimise ingress of air.

Air was drawn through the kiln using an induced draft fan. The suction of the fan could be varied by the use of dampers on bleed lines into the main suction line. Dust was removed from the off-gases in a 150 mm diameter cyclone.

The kiln was fired using a propane burner, and the kiln temperature was measured with a type K thermocouple located in the solids in the hottest section of the kiln. The speed of rotation was fixed at 2 rev/min and the slope was varied to alter the residence time. A variable speed belt feeder was used to feed the solids.

For each test, the kiln was operated at steady conditions for a time in excess of the total residence time in the kiln. Product was then collected for analysis, surface area determination and acid reactivity tests. There was no noticeable size degradation of the magnesite during calcination and very little dust was removed from the kiln (about 200 g/h for 15 kg/h feed rate). The product was quite weak and could be broken manually and hence would be easy to crush. However, no noticeable degradation occurred during handling of the product and presumably it could be transported without degradation.

It is interesting to note that the low and high silica composites calcined to a brown colour, while the surface sample calcined to a pink colour. This was probably due to a lower iron content in the surface sample. The head analyses (Table 2) also indicate that the surface sample had a much lower calcium content than the other two, while the silica content was similar to that of the high

silica composite.

1st Series

The first series of tests used low silica magnesite crushed to pass 12.7 mm. The calcination conditions used were 800°C with a residence time in the hot zone of about 25 minutes, 775°C/25 minutes and 775°C/40 minutes. These conditions were based on the best results obtained in the laboratory. Shorter residence times were investigated because there is a long heating up time in the kiln which effectively increases the total calcination time. The results of tests on the products are listed in Table 9.

The MgO contents in these products were higher than in any of the laboratory tests and hence the products had been calcined to a greater extent. The surface areas were lower than the best laboratory ones, but it is significant that the highest surface area corresponded to the lowest MgO content. This suggested that a better result may be obtained with a shorter residence time or a lower temperature.

On the other hand, the acid reactivities for all of the kiln samples were better than for the best laboratory samples. Copper and zinc contents of the solutions after 2 hours were each less than 0.2 ppm.

2nd Series

The second series of tests used the surface samples crushed to pass 12.7 mm. The calcination conditions were chosen with the aim of decreasing the amount of calcination taking place. The conditions used were 700°C/40 minutes, 750°C/25 minutes, 750°C/15 minutes and 775°C/15 minutes. The results of these tests are also listed in Table 9.

In the test at 700°C the product was undercalcined as evidenced by the low MgO and high CO_2 contents. At 775°C the product was overcalcined. Each test at 750°C gave a product with a surface area in excess of 90 m^2/g with a high MgO and low CO_2 content.

On the basis of these results, it was decided to process all of the remaining surface and high silica magnesite at 750°C/15 minutes.

Production Runs

The two feed materials were processed in separate campaigns using feed rates of around 15 kg/h. After removing representative sample from each product, the nett weights produced for return to CRA for client evaluation were as follows:

Surface	46.0 kg
High Silica	63.5 kg

The results of tests on the products are listed in Table 10. The results for the surface material were virtually identical to those obtained in Test 6 (see Table 9). The results for the high silica material were not as good as for the surface material. This indicates that either the conditions used were not optimum for that material, or that it has a lower inherent reactivity.

By comparison of the two MgO and CO_2 assays in Table 10, it would appear that the high silica composite was undercalcined and that more CO_2 should have been removed.

However, if the assays for the high silica composite are compared with those in Table 4 for calcination at 775°C for 40 minutes (conditions which gave the highest surface area in laboratory tests), it would appear that the kiln product was over calcined. This could only be resolved by kiln trials with the high silica material at a series of conditions.

Acid reactivity tests confirmed that both products were very reactive and that the weight of surface material required was less than that for the high silica. In both cases, almost 100% of the magnesia was dissolved.

Reactivity may be a function of the quantity of $CaCO_3$ present in the magnesite. This does not decompose during calcination and does not appear to react with the acid during reactivity trials. The low silica composite had the highest lime content (4.12% CaO), followed by the high silica composite (2.99% CaO), while the surface material contained only 1.22% CaO.

Throughout the laboratory testwork, the high silica composite was more reactive than the low silica material. The kiln production runs show that surface material is the most reactive.

Heat Requirement

The heat required for calcination has been calculated in Appendix C. Based on the assumptions made in these calculations, the heat requirement is 1955 MJ per tonne of feed. Since some assumptions may not be correct, it would be more realistic to assume a range of 1900 to 2000 MJ/tonne.

4. CONCLUSIONS

The following conclusions may be drawn from the testwork.

1. The magnesite deposit consists of a mixture of crystalline and crypto-crystalline magnesite with some free quartz. A small amount of $CaCO_3$ is present in the form of dolomite.

2. A minimum calcination temperature of 700°C is required to obtain a reasonable decomposition rate. However a temperature in excess of 710°C is required to decompose the $MgCO_3$ content of the dolomite, while the $CaCO_3$ decomposes about 925°C.

3. The magnesite can be calcined to form a very reactive product with a surface area of 75 to 95 m^2/g which reacts very quickly with acidic liquors, including very weak acids with pH values of 5 and above. Heavy metals such as copper and zinc can be virtually completely precipitated.

4. The reactivity appears to be highest when the $CaCO_3$ content is lowest.

5. The optimum calcination conditions in a rotary kiln are approximately 750°C with a residue time of 15 to 25 minutes in the hot zone. The time may vary with the overall length of kiln and the amount of time the ore spends at temperatures about 650°C during heating up.

6. Heat requirements for calcination are approximately 1900 to 2000 MJ per tonne of feed.

5. RECOMMENDATION

Since different parts of the deposit exhibit different reactivities, it is recommended that further kiln tests be undertaken with either low and high silica composites or with a representative mixture to confirm optimum calcination conditions for the total orebody.

TABLE 1

Magnesite Samples for AMDEL Tests

	From	To	Metres	Bags	Weight Kg	MgO%	CaO%	SiO_2%	LOI
LR1	245.8	267	21.2	3	24	41.6	4.6	2.3	48.9
	296.6	317.1	20.5	2	12	45.0	1.9	1.1	50.1
	341.5	358	16.5	2	15)	44.3	2.6	1.1	49.1
	358	369	11	1	8)				
					59				
$LR2_{(A)}$	250	335	85	18	114)	41.6	4.7	3.7	49.1
(B)	370	380	10	2	12)				
					126				
LR5	263	332	69	13	78	38.3	3.6	12.3	44.8
	400	423	23	4	24	37.7	6.4	6.8	46.8
					102				
LR6	81	104	23	2	10	41.9	1.2	8.6	46.6
	144	180	36	5	24	40.5	4.5	6.2	46.6
					34				
LR7	55	108	53	17	100	42.1	1.6	8.4	47.2

The above samples have been packed into 14 bags for transport, each weighing about 25 kilograms.

LR1 246 - 267 (3) and LR1 358 - 361 (1)	1
LR1 297 - 317 (2) and LR1 341 - 358 (2)	1
LR2 250 - 335 (16) Packed into 3 bags	3
LR2 370 - 380 (2) [Bags 9 & 10] and LR2 235 - 335 (2) [Bags 17 & 18]	1
LR5 263 - 332 (13) Packed into 3 bags	3
LR5 400 - 423 (4)	1
LR6 81 - 104 (2) and LR6 144 - 180 (5)	1
LR7 55 - 108 (17) Packed into 3 bags	3
	14

TABLE 2: HEAD ANALYSES (%)

Components	Low Silica Composite	High Silica Composite	Surface Sample
MgO	41.1	39.0	41.6
CaO	4.12	2.99	1.22
Fe_2O_3	1.31	0.88	0.53
Al_2O_3	0.13	0.06	0.11
SiO_2	3.43	8.92	7.72
CO_2	50.6	49.2	48.0

TABLE 3: WEIGHT LOSS AS A FUNCTION OF TIME AND TEMPERATURE

	Weight Loss, %			
Time, Hours	0.5	1.0	1.5	2.0
Low Silica				
Temp, °C				
600	3.7	6.7	11.4	24.7
700	19.5	36.7	40.1	43.9
800	39.6	45.4	47.3	48.2
900	48.0	48.2	-	-
High Silica				
Temp, °C				
600	3.8	8.8	13.1	24.7
700	22.0	37.5	40.1	42.8
800	38.0	43.9	45.4	46.3
900	46.0	46.2	-	-

TABLE 4: EFFECT OF TEMPERATURE ON IODINE NUMBER

Temp °C	Time min	Wt Loss %	MgO %	CO_2 %	Iodine No. -2 mm	Iodine No. Fines
Low Silica						
500	60	1.5	39.9	49.5	5	-
550	60	4.9	41.7	47.8	20	-
600	60	6.7	47.5	43.6	35	-
650	60	29.2	58.0	32.4	85	-
700	60	36.7	62.6	23.2	105	105
725	60	39.1	63.9	18.0	95	100
750	40	37.5	61.7	20.0	85	-
750	50	41.8	68.0	14.4	85	-
750	60	44.2	74.5	10.3	90	90
775	40	39.7	64.6	16.8	100	-
High Silica						
500	60	1.5	40.7	48.0	5	-
550	60	5.5	42.0	46.3	15	-
600	60	8.8	46.4	40.1	50	-
650	60	25.3	53.0	32.0	75	-
700	60	37.5	61.2	18.8	115	120
725	60	39.9	62.4	13.7	105	115
750	40	37.1	60.8	16.6	110	-
750	50	39.8	63.7	12.5	100	-
750	60	42.8	66.5	8.3	105	105
775	40	40.7	64.5	10.8	100	-

TABLE 5: EFFECT OF CALCINATION TIME AT 700°C ON IODINE NUMBER

Time Hours	Wt. loss %	Iodine No.
Low Silica		
0.5	19.5	50
1.0	36.7	105
1.5	40.1	95
2.0	43.9	85
High Silica		
0.5	22.0	70
1.0	37.5	115
1.5	40.1	105
2.0	42.8	105

TABLE 6: EFFECT OF FEED SIZE ON IODINE NUMBER (700°C - 1 HOUR)

Feed Size mm	Wt. loss %	Iodine No.
Low Silica		
-0.5	41.8	80
-6.3	36.7	105
-12.7+6.3	36.0	105
-19+12.7	31.5	95
-25+19	31.1	85
High Silica		
-0.5	41.5	95
-6.3	37.5	115
-12.7+6.3	35.7	95
-19+12.7	36.8	95
-25+19	34.2	85

TABLE 7: SURFACE AREA MEASUREMENTS AND ACID REACTIVITIES

Product	Iodine No	Surface Area m^2/g	Acid Reactivity wt of solids, g
Low Silica			
700°C, 1 h, -6.3 mm	105	65	7.80
725°C, 1 h, -6.3 mm	95	53	-
750°C, 1 h, -6.3 mm	90	50	-
775°C, 40 min, -6.3 mm	100	91	6.75
700°C, 1 h, -12+6.3 mm	105	75	7.70
700°C, 1 h, -0.5 mm	80	43	-
LR1, -6.3 mm	nd	62	8.25
High Silica			
700°C, 1 h, -6.3 mm	115	63	8.00
725°C, 1 h, -6.3 mm	105	71	-
750°C, 1 h, -6.3 mm	105	60	-
775°C, 40 min, -6.3 mm	100	92	6.45
700°C, 1 h, -12+6.3 mm	95	88	7.95
700°C, 1 h, -0.5 mm	95	44	-

TABLE 8: ACID REACTIVITY - SOLUTION ASSAYS

Sample	Time min	Analyses, ppm Mg	Cu	Zn	pH
Acid liquor	-	-	11.4	11.3	1.26
LS 700°C, 1 h -6 mm					
	30	1420	1.3	7.7	5.3
	60	1380	0.2	1.4	7.8
	90	1400	<0.2	<0.2	9.0
	120	1390	<0.2	<0.2	9.3
LS 775°C, 40 min					
	30	1330	10.9	10.9	3.2
	60	1360	5.5	9.5	5.2
	90	1350	<0.2	6.3	6.6
	120	1360	<0.2	2.2	7.9
LS 700°C, -12+6mm					
	30	1310	11.0	11.5	2.5
	60	1380	5.9	9.5	4.5
	90	1350	0.6	6.8	6.8
	120	1340	<0.2	<0.2	9.7
LR1, 700°C					
	30	1370	5.7	10.1	4.0
	60	1370	1.3	7.9	5.6
	90	1380	0.3	5.5	6.1
	120	1360	<0.2	<0.2	8.5
HS 700°C, 1 h -6 mm					
	30	1420	<0.2	0.8	7.0
	60	1430	<0.2	<0.2	9.6
	90	1420	<0.2	<0.2	9.8
	120	1420	<0.2	<0.2	10.0
HS 775°C, 40 min					
	30	1350	10.2	10.9	3.1
	60	1370	0.8	7.7	5.7
	90	1380	<0.2	1.2	8.8
	120	1350	<0.2	0.8	9.6
HS 700°C, -12+6 mm					
	30	1380	10.5	11.6	3.1
	60	1410	1.6	7.7	5.5
	90	1370	<0.2	1.0	8.8
	120	1360	<0.2	<0.2	9.6

LS = Low silica, HS = High silica

TABLE 9: KILN CALCINATION RESULTS

	1st Series			2nd Series			
Test No	1	2	3	4	5	6	7
Feed	Low Silica Comp			Surface Material			
Temperature, °C	800	775	775	700	750	750	775
Residence time, min	25	25	40	40	25	15	15
Reactivity, g solids	5.60	5.85	6.50	-	-	-	-
Surface area, m^2/g	57	70	56	83	92	96	72
Analyses, %							
MgO	77.7	74.8	77.5	67.2	77.2	76.8	79.8
CaO	7.55	7.25	7.90	2.38	2.24	2.15	2.36
Fe_2O_3	2.24	2.30	2.16	0.89	0.87	0.89	0.94
Al_2O_3	0.30	0.20	0.19	0.18	0.18	0.18	0.14
SiO_2	6.60	6.75	7.35	11.6	13.4	14.1	13.9
CO_2	8.30	10.7	8.00	18.7	7.50	7.00	3.65

TABLE 10: KILN PRODUCTION RUNS

Sample	Surface	High-Silica
Temperature, °C	750	750
Residence time, min	15	15
Reactivity, g solids	5.95	6.40
Surface area, m^2/g	94	78
Analyses, %		
MgO	76.2	67.8
CaO	2.12	4.41
Fe_2O_3	0.84	1.41
Al_2O_3	0.06	0.05
SiO_2	13.0	16.3
CO_2	7.05	8.20

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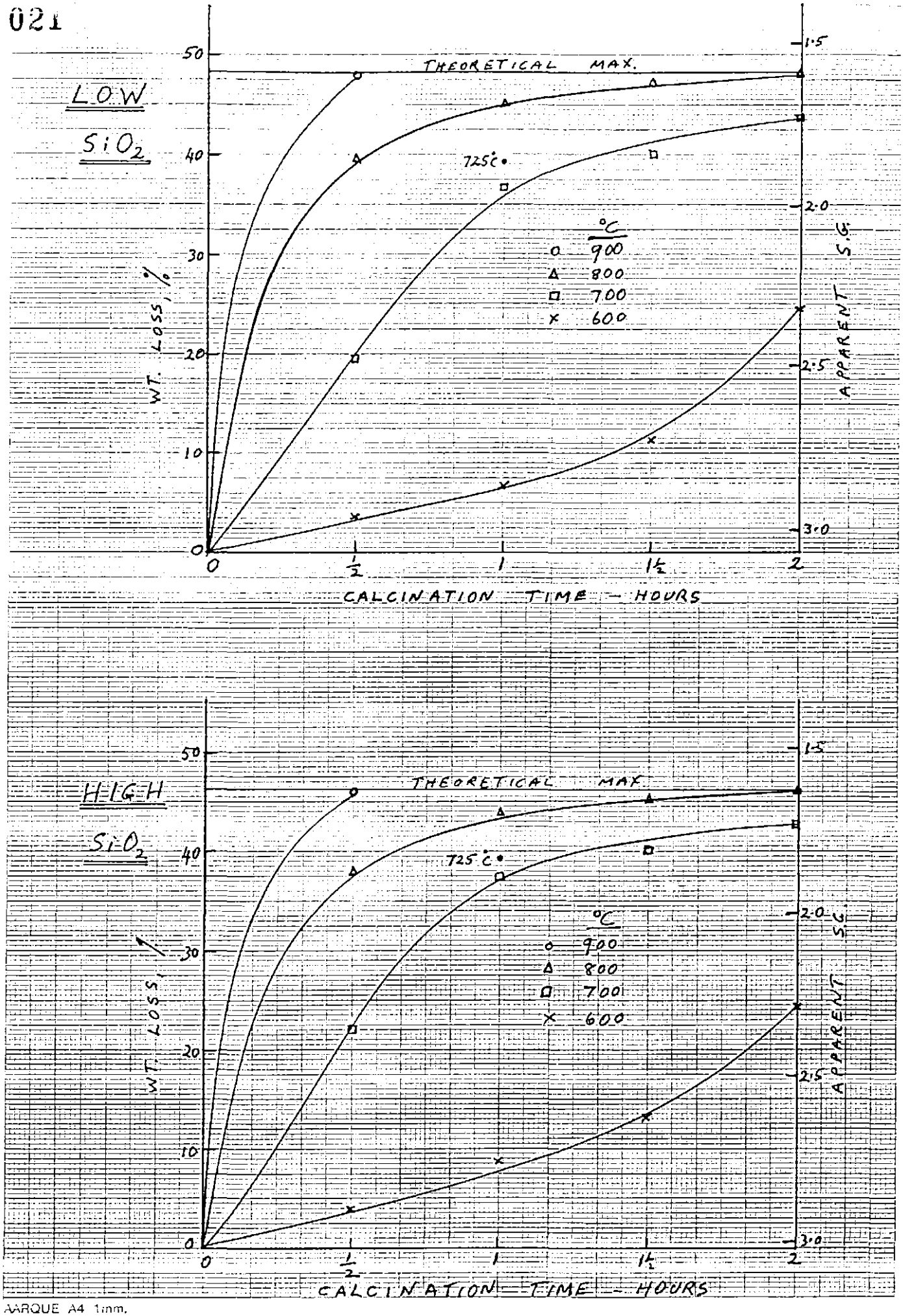

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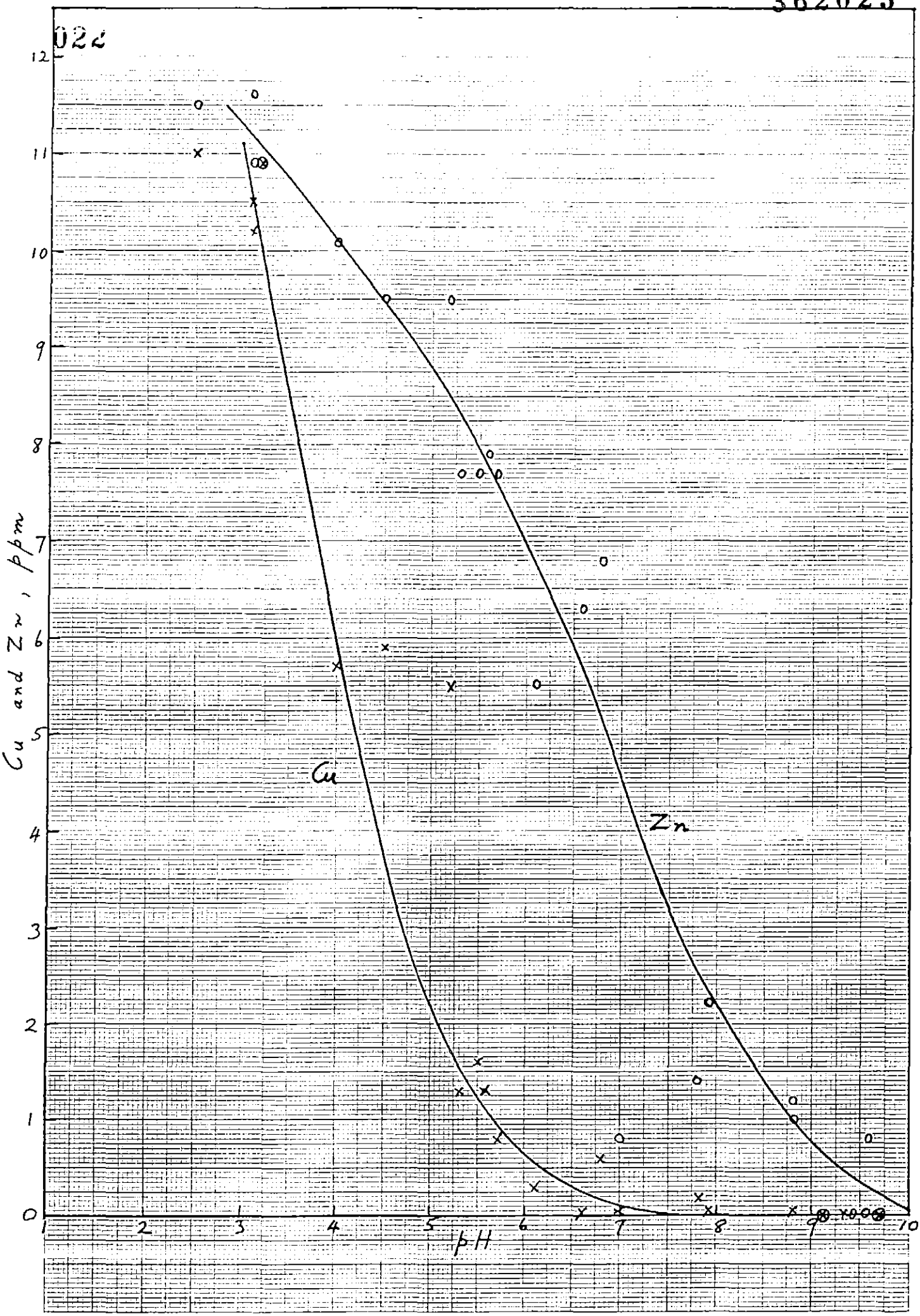
FIGURE 1: WEIGHT LOSS AS A FUNCTION OF TIME



AARQUE A4 1mm.

FIGURE 2: METAL PRECIPITATION AS A FUNCTION OF pH

APPENDIX A

MINERAGRAPHIC REPORT

PETROGRAPHIC DESCRIPTIONS FOR TWO MAGNESITE SAMPLES

1. INTRODUCTION

Two (2) samples described as magnesite were received from Mr. John Tuffley (Amdel Mineral Products Division, Thebarton) on 27 February, 1991.

The samples were labelled "L" (a white sample, with low SiO2), and "H" (a cream sample, with high SiO2 ~5%).

Specific requests were:

1. To prepare a routine petrographic description for each sample;
2. In particular, note the grain sizes present in each sample, especially "crystalline" versus "crypto-crystalline".

This report presents the results of this work.

2. METHODS

Standard thin sections (C55043, -044) were prepared from the samples provided. Prior to cover-slipping, the sections were stained for calcite using alizarin red-S solution.

Routine petrographic descriptions were prepared using conventional transmitted polarised light microscopy.

3. PETROGRAPHIC DESCRIPTIONS

The routine petrographic descriptions follow.

* 'L' C55044 Most probably came from the hole LR1 at the interval 358 - 369

C55043 'H' Most probably came from the hole LR5 at the interval 8263 - 332.

SAMPLE: Magnesite "H"

Thin Section: C55043

Rock Name:
Magnesian carbonate rock

Hand Specimen:
The fragment of drill core is composed of subequal proportions of very fine-grained, massive cream carbonate that is cut by irregular patches and veinlets of translucent grey crystalline material.

Petrography:

Mineral	**Vol.%**	**Origin**
Carbonate (crypto-cryst.)	50	sedimentary
Carbonate (crystalline)	35	diagenetic
Quartz	15	diagenetic
Goethite	Tr	alteration (weathering)

In thin section, this sample displays a very fine-grained massive sedimentary texture with auto-breccia structure, that has been modified by subsequent partial recrystallisation and veining.

Carbonate dominates the rock. It occurs in two forms: massive crypto-crystalline patches, and crystalline veins and patches.

The crypto-crystalline patches are massive in structure, and exceptionally fine-grained (< = 1 micron). The patches range in size from <0.5 mm to >3 mm, and in places contain angular fragments of similar texture, lending a brecciated texture to the rock.

The crystalline carbonate forms irregularly shaped patches and veins that cut the crypto-crystalline carbonate. Grain size varies widely (~2-5μm to ~200μm), but much is ~100μm in size.

The identification of the carbonate is uncertain: it is not calcite, as it has not accepted the pink stain, and it is therefore likely to be Mg-rich carbonate phases.

Quartz occurs in moderate amount as anhedral to euhedral grains, commonly located within the crystalline carbonate areas. Grain sizes of the quartz lie in the range ~0.1-1.0 mm.

Goethite occurs in trace amount as dark reddish brown patches that appear to have pseudomorphed a precursor euhedral phase (possibly sulphide).

The sample represents a fine-grained magnesian carbonate sedimentary rock that has suffered partial recrystallisation in patches and veinlets, generating coarser-grained carbonate patches accompanied by quartz.

SAMPLE: Magnesite "L"

Polished/Thin Section: C55044

Rock Name:
Magnesian carbonate rock

Hand Specimen:
The drill core rock fragment presents an overall white colour, and is composed of irregularly shaped, very fine-grained massive white areas that are cut by translucent grey patches and veinlets.

Petrography:

Mineral	Vol.%	Origin
Carbonate (crypto-cryst.)	50	sedimentary
Carbonate (crystalline)	45	diagenetic
Quartz	5	diagenetic
Opaques (sulphide?)	Tr	diagenetic

In thin section, this sample displays a fine-grained massive sedimentary texture that has been modified by later recrystallisation.

Carbonate dominates the mineralogy. It occurs in two forms, similar to the previous sample ("H"): crypto-crystalline carbonate, and crystalline carbonate.

The crypto-crystalline carbonate occurs in massive, irregularly shaped patches composed of minute (micron-sized) granules. It is identical in texture to the previous sample.

Crystalline carbonate occurs as patches and veinlets that cut the massive crypto-crystalline carbonate. The grain size varies from ~2-5 μm to ~3 mm. The coarsest grains are restricted to small patches, and most of the crystalline carbonate lies in the range ~0.05-0.10 mm.

Quartz occurs as anhedral to euhedral crystals ranging ~0.05-2.0 mm in size, but commonly ~0.1-0.3 mm. It tends to be concentrated in the patches of crystalline carbonate, but also occurs within the crypto-crystalline areas.

Opaque crystals of euhedral form are disseminated in trace amount through both types of carbonate. It may be a sulphide (pyrite?).

The sample represents a fine-grained magnesian sedimentary carbonate rock that has suffered partial recrystallisation to patches of coarser-grained carbonate and quartz with trace opaques.

APPENDIX B

DIFFERENTIAL THERMAL ANALYSIS

1. INTRODUCTION

Two samples of magnesite were submitted to the Materials Services Section, for thermal analysis. The principal objectives were to determine the proportion of magnesium carbonate in each sample, and the temperature required for complete removal of carbon dioxide from magnesium carbonate.

2. PROCEDURE

The samples were subjected to simultaneous differential thermal analysis (DTA) and thermogravimetric analysis (TGA) using the Stanton Redcroft Model STA-781 instrument, under the following conditions;

Sample	20 mg, as received
Reference	calcined alumina powder, 20 mg
Recorder Sensitivities	DTA $\pm$ 25 μV full scale
	TGA 10 (or 20) mg full scale
Heating Rate	10°C per minute
Atmosphere	carbon dioxide, 50 mL per minute.

3. RESULTS

The thermal analysis traces are reproduced in Figures B1 and B2. The principal features of the curves are as follows:

- a large endothermic DTA peak (heat absorption) accompanied by a substantial weight loss over the range 570 to 710°C. This is attributable to loss of CO_2 from magnesite.

- two smaller endothermic DTA peaks, with similar small weight losses, 710 to 780°C, and 925 to 960°C, respectively. These effects are due to CO_2 loss from dolomite ($MgCO_3$ and $CaCO_3$ components, respectively).

From the above, the temperature required to remove CO_2 completely from magnesite and the $MgCO_3$ in dolomite was around 780°C. The weight losses from the TGA curves were used to calculate the $MgCO_3$ contents (in magnesite plus dolomite) below:

Sample	$MgCO_3$, %
Low SiO_2 magnesite	89.5
High SiO_2 magnesite	85.5

In the high silica magnesite, a very small endothermic DTA peak at 575°C indicates the presence of a small amount of free quartz (α-ß phase transition). This is not evident on the DTA curve for the low silica magnesite.

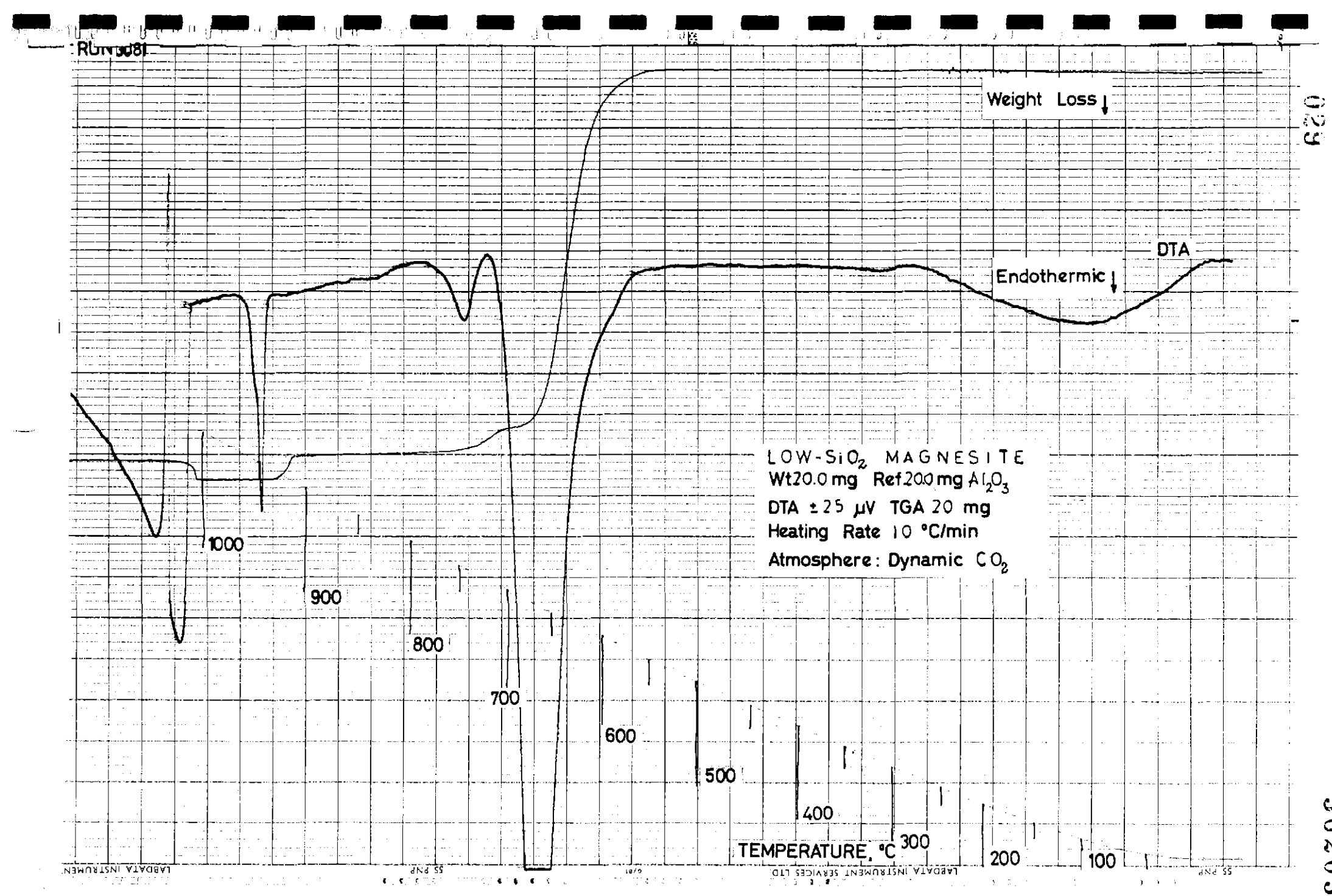


FIGURE B1: THERMAL ANALYSIS OF LOW SILICA MAGNESITE IN CO_2 ATMOSPHERE

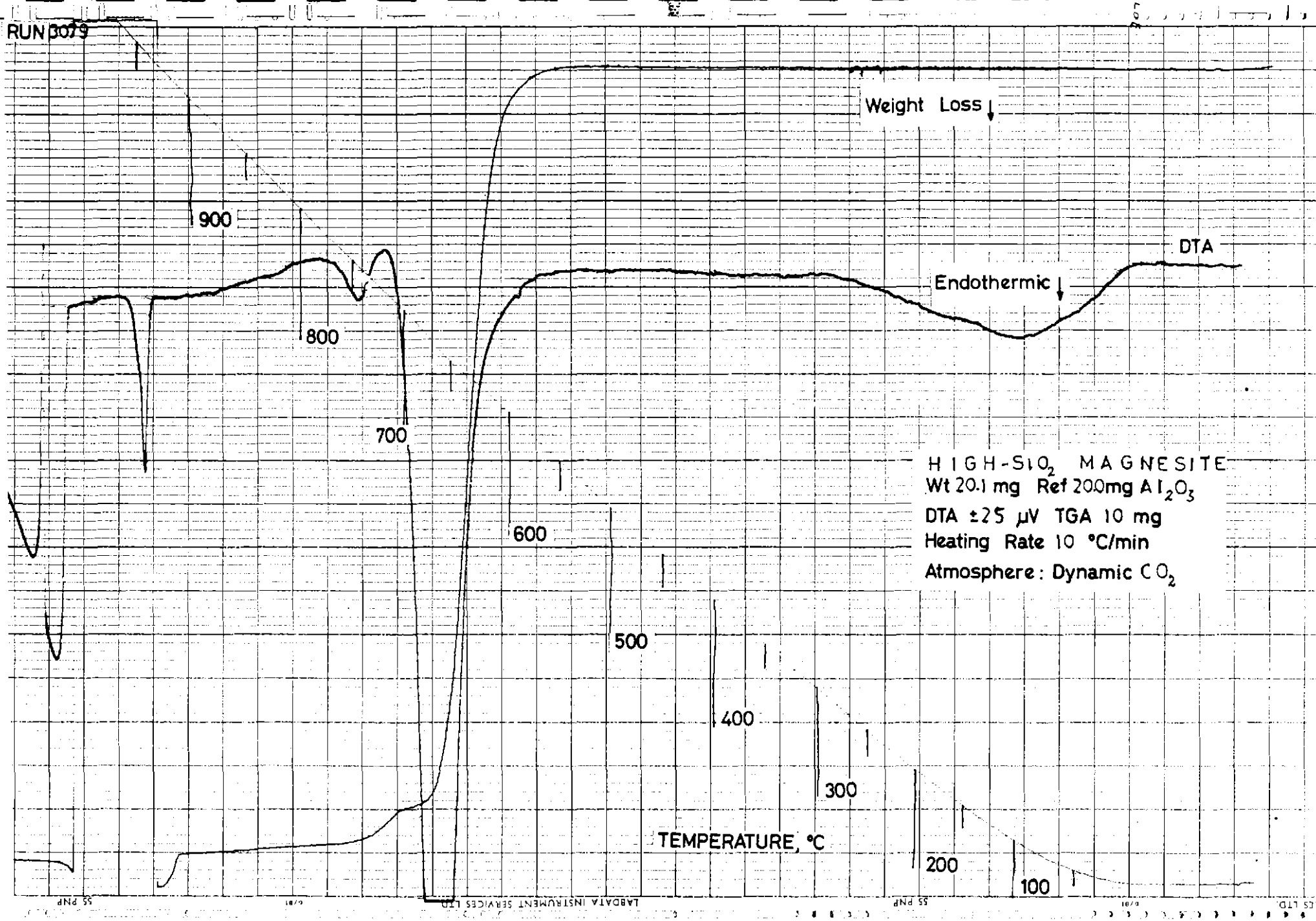


FIGURE B2: THERMAL ANALYSIS OF HIGH SILICA MAGNESITE IN CO_2 ATMOSPHERE

APPENDIX C

HEAT REQUIREMENT

Heat Requirement

The heat requirement for calcination of magnesite at 750°C has been estimated below using the following assumptions:

- Basis: 1 tonne of feed containing 40% MgO (84% Mg CO_3).
- Product discharged at 750°C containing 80% MgO, representing a 50% weight loss.
- Exit gases discharged at 300°C with a volume equivalent to 1000 std kl per tonne of feed.
- Ambient temperature is 10°C.
- Specific heats - product 0.17 k cal/kg
  Specific heats - exit gases 0.35 k cal/std kl
- Heat of decomposition = 258.7 k cal/kg Mg CO_3*
  = 258.7 x $\frac{84}{100}$ k cal/kg feed
  = 217.3 k cal/kg feed

* Kubaschewski O., et al, (1969) - "Metallurgical Thermochemistry" Pergamon Press.

1.	Sensible heat in solids	= 0.17 x 1000 x (750 - 10) x 4.19 KJ = 527 x 10^3 KJ
2.	Sensible heat in gases	= 0.35 x 1000 x (300 - 10) x 4.19 KJ = 425 x 10^3 KJ
3.	Heat of decomposition	= 217.3 x 1000 x 4.19 KJ = 910 x 10^3 KJ
4.	Sub total	= 1862 x 10^3 KJ or 1862 MJ
5.	Heat losses (say 5%)	= 93 MJ
6.	Total heat requirement	= 1955 MJ per tonne of feed