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- . Description of Operations and Order of Magnitude Cost Estimates for the Production of Magnesite and Magnesium. Mineral Resources Studies - April, 1984.
- . Tasmanian Magnesite Study  
Preliminary Cost Estimate for Process Plant  
Shedden Pacific Pty. Limited
- . Tasmanian Magnesite Beneficiation  
Progress Report on Test Work  
Zinc Corp. Ltd., Broken Hill - May, 1984.
- . Specification

SECTION 1REPORTS PREVIOUSLY SUBMITTEDTO DEPARTMENT OF MINESCRAE Report No. 12283

V. A. Williams "EL 43/70 Arthur River Area, Report on Exploration for 12 Months to 15th October, 1983."

Covers first 5 drill holes (1557.5m) at Lyons River and Arthur River with detailed petrological and initial beneficiation tests.

CRAE Report No. 12828

P. MacKenzie "EL 43/70 Arthur River Area, Report on Exploration for 12 Months to 15th October, 1984."

TCR 84-2214

Covers 7 holes (LR5-LR11) at Lyons River, 5 holes (LR3 to 7) at Arthur River and one hole at Cann Creek. Detailed mapping at all 3 locations and initial bulk sample tests at Pinner outcrop.

CRAE Report No. 12999

T. W. Dickson "EL 43/70 Arthur River Area, Report on Exploration for 12 Months to 15th October, 1984."

TCR 85-2498

Second diamond drill hole at Cann Creek and bulk sample tests at Humboldt Wedag A.G. in Germany.

1985 Metallurgical Reports

Submitted as Annual Report for 1985

Report 1: Process Engineering tests carried out with magnesite for CRA, KDH Humboldt Wedag AG, 25th July, 1985.

TCR 86-2593

Report 2: Process Engineering tests carried out with magnesite for CRA, KDH Humboldt Wedag AG, 6th August, 1986.

Report 3: Process Engineering tests carried out with magnesite for CRA, KDH Humboldt Wedag AG, 23rd August, 1986.

Refractory tests with magnesite floatation concentrate carried out for KDH Humboldt Wedag AG by Refractories Consulting and Engineering AG, Austria, 25th February, 1986.

CRAE Report No. 14728

F. R. Funnell "EL 43/70 Arthur River Area, Report on Exploration for 12 Months to 15th October, 1986."

Costeaming and collection of bulk samples for metallurgical test work.

TCR 87-2716

SECTION 2

GEOLOGY

**LYONS RIVER - ARTHUR RIVER**  
**MAGNESITE DEPOSITS**  
**N.W. TASMANIA**

**CRA EXPLORATION PTY. LIMITED**

### LOCATION AND ACCESS

Located at  $145^{\circ}24'$  East and  $41^{\circ}13'$  South (Lyons River) approximately 35km south-west of Wynyard in North-West Tasmania.

Access is via the Waratah Highway to Yolla and then by sealed and gravelled minor roads to the old saw-milling centre of West Takone. An all weather forestry road continues beyond West Takone, over the Arthur and Keith Rivers and almost to the Lyons River. This road ends at the Lyons River deposit and the road distance from Wynyard is 50km and 55km from the port of Burnie.

### TITLE

Area is held under Exploration Licence No. 43/70 owned 75% by CRA Exploration Pty. Limited and 25% by Mineral Holdings Australia Pty. Ltd. The Licence can be converted to either a series of Mineral Leases or to a Retention Licence to allow additional test work and evaluation.

### HISTORY

Magnesite first identified in 1925 by P. B. Nye who assayed "dolomite" outcrops on the Arthur River during dam site investigation. Mineral Holdings Australia Pty. Ltd. have held the area since 1970 and BHP, A.O. (Australia) and Osterreichish Americkanische Magnesite A.G. (OAMAG) explored the area north of Arthur River in the period 1971 to 1973.

Mineral Holdings also located a number of isolated outcrops in the Lyons River area and in 1982 CRAE recognised the potential for large magnesite bodies and joint ventured the area.

The first drill hole in December, 1982, intersected 369 metres of magnesite and dolomite and additional drilling confirmed a large magnesite body at Lyons River.

Mapping in the Keith-Arthur River suggested a second large body covered by alluvium and subsequent drilling has confirmed this.

### GEOLOGY

The magnesite deposits in the Arthur River region are situated in a north-northeast striking belt of highly deformed Precambrian rocks known as the Arthur Lineament. The Arthur Lineament varies from 8km to 15km wide and extends from Wynyard on the north-east coast to Granville Harbour on the west coast. The Savage River iron ore deposit occurs within the lineament 35km to the south-west of the Lyons River.

The area north of the Arthur River is largely occupied by Basal Permian tillites and mudstones and by Tertiary basalts. These rocks effectively bury the Precambrian rocks of the Arthur Lineament. A block of down faulted Permian mudstones occurs to the west of the Lyons River - Arthur River magnesite deposits.

The magnesite horizon is thought to be a conformable stratigraphic unit with a thick sequence of quartz schist and quartz-mica schists forming the hanging wall to the east. The western footwall sequence is dominated by amphibolite and pyritic siltstones. The Keith River gossan zone, which occurs between the two magnesite bodies, is situated within this sequence. Dips range from vertical to 70 degrees to the south-east.

The northern Keith to Arthur River deposit is covered by a veneer of alluvial gravels from 6-20m thick. It occurs over a strike length of 3,500 metres and ranges in thickness from 150-400 metres. It has been tested by seven diamond drill holes (1,642.8 metres) and the resource figure is approximately 3 million tonnes/vertical metre. It extends to at least 300 metres depth in drilling. High grade zones of +40% magnesite within the deposit have average  $\text{Fe}_2\text{O}_3$  1.57%, CaO 2.17% and  $\text{SiO}_2$  6.35%.

The Lyons River deposit occurs 4km along strike to the south. This body is up to 400 metres thick over a strike distance of at least 2,000 metres. The body grades to dolomite to the south and pinches out to the north under basalt cover. Magnesite is exposed over a vertical interval of at least 130 metres and has been proved to a further depth of 300 metres. Available tonnage is in the order of 2 million tonnes/vertical metre. The average of all +40% MgO material contains 1.09%  $\text{Fe}_2\text{O}_3$ , 3.4% CaO and 7.2%  $\text{SiO}_2$ .

The Lyons River deposit has been tested by 11 holes totalling 2,635 metres. A number of bulk samples have been taken for metallurgical evaluation.

Magnesite commonly constitutes 70% of the rock in the bodies and is usually creamy white and has the texture of a fine grained dense marble. The magnesite is easily distinguishable from dolomite which is dark grey in colour. The dolomite occurs as distinct bands or as the matrix of dolomite-magnesite breccias.

Much of the dolomite bands could be removed by selective mining and, apart from bands of high grade magnesite, the dolomite from dolomite breccias can be easily floated to produce a high grade magnesite concentrate.

Metallurgical testing is currently underway and our future programme is to open up a large face across the body to test selective mining and provide additional selective samples for evaluation.

DRILL RESULTS - LYONS RIVER

<u>Hole No.</u>	<u>Depth in Metres</u>	<u>Metres +35% MgO</u>	<u>Metres +40% MgO</u>
DD 82 LR 1	389.0	217.6	198.6
DD 83 LR 2	418.5	269.7	189.7
DD 83 LR 3	367.5	15.0	5.2
DD 83 LR 4	37.0 ABANDONED	-	-
DD 83 LR 5	452.5	217.5	72.3
DD 84 LR 6	223.0	101.4	58.5
DD 84 LR 7	176.0	131.0	76.1
DD 84 LR 8	59.0	-	-
DD 84 LR 9	209.0	79.1	34.6
DD 84 LR 10	138.0	31.0	7.1
DD 84 LR 11	37.0 ABANDONED	3.7	0.7
DD 84 LR 11 A	128.0	25.1	1.6
	<hr/>		
	2634.5		

9 EFFECTIVE  
DIAMOND DRILL HOLES.

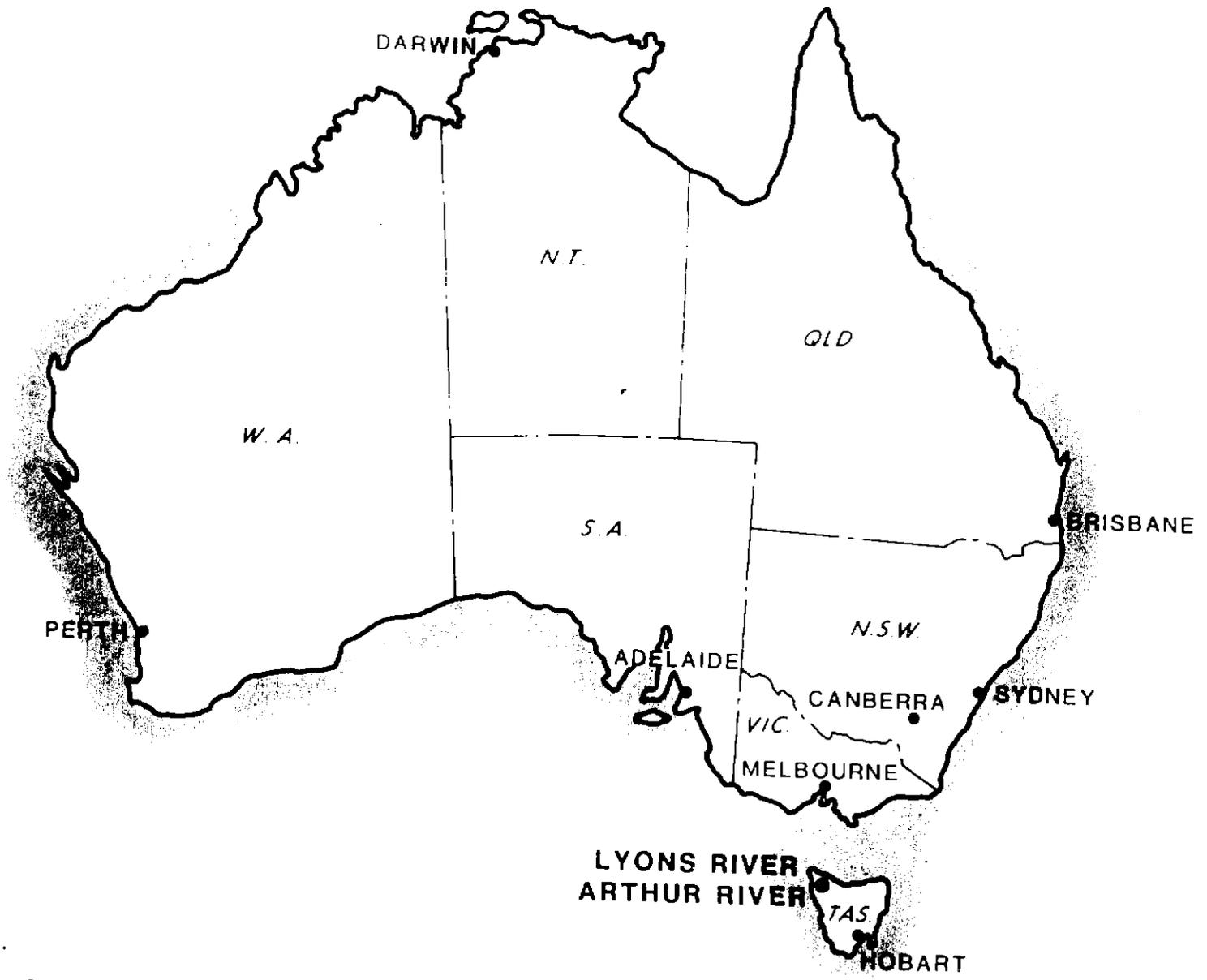
DRILL RESULTS - ARTHUR RIVER

<u>Hole No.</u>	<u>Depth in Metres</u>	<u>Metres +35% MgO</u>	<u>Metres +40% MgO</u>
DD 83 AR 1	138.0	-	-
DD 83 AR 2	244.5	120.0	105.0
DD 83 AR 3	408.0	180.0	86.6
DD 84 AR 4	32.0 ABANDONED	-	-
DD 83 AR 5	156.2	27.6	15.0
DD 83 AR 6	382.0	236.8	93.1
DD 83 AR 7	282.1	194.8	153.0

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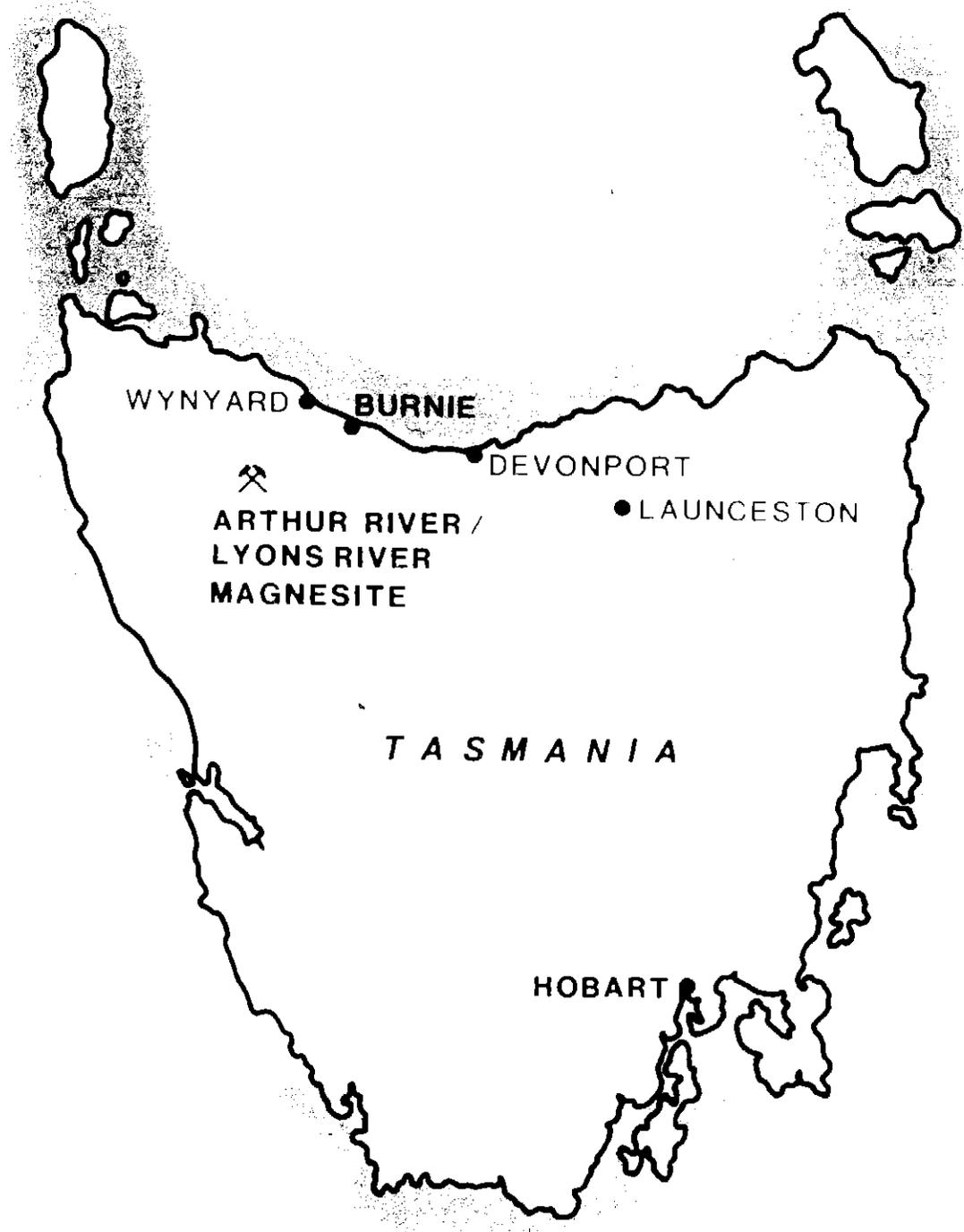
1642.8

5 EFFECTIVE  
DIAMOND DRILL  
HOLES.

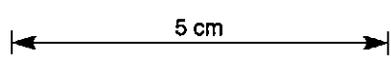


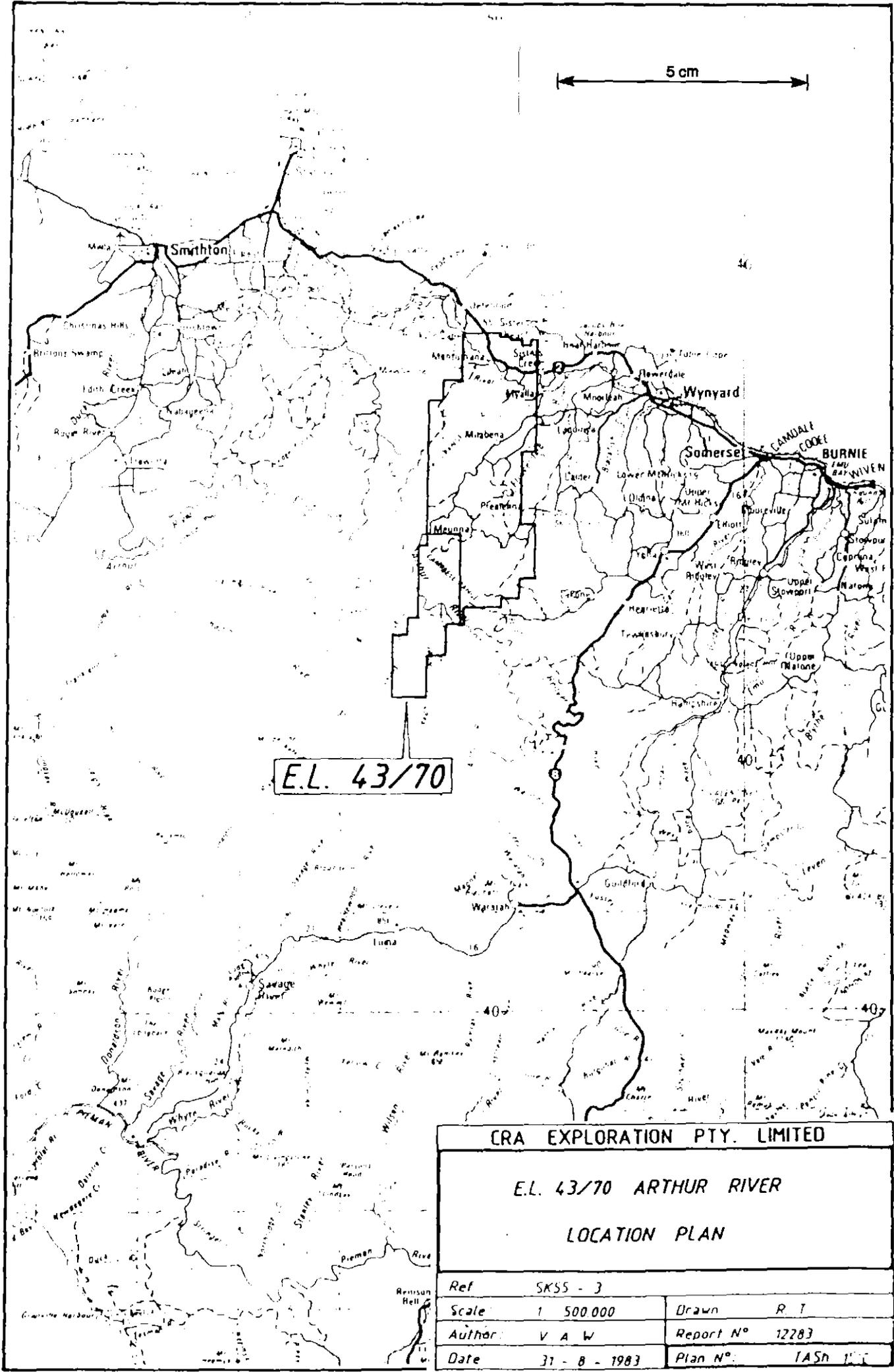
0 1000  
KILOMETRES

781011



# LOCATION DIAGRAM

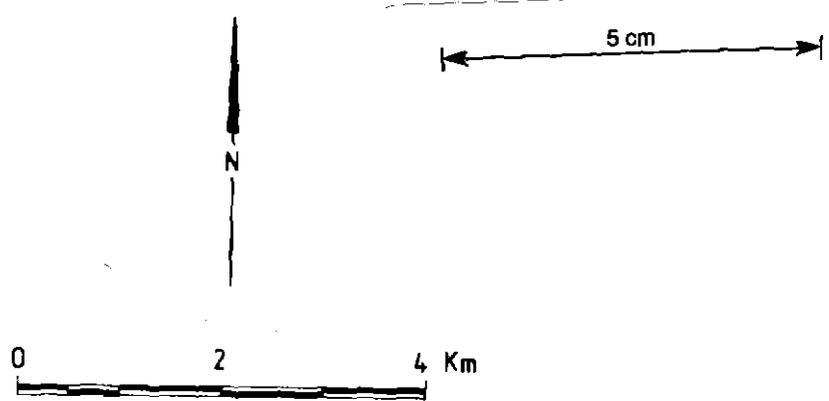
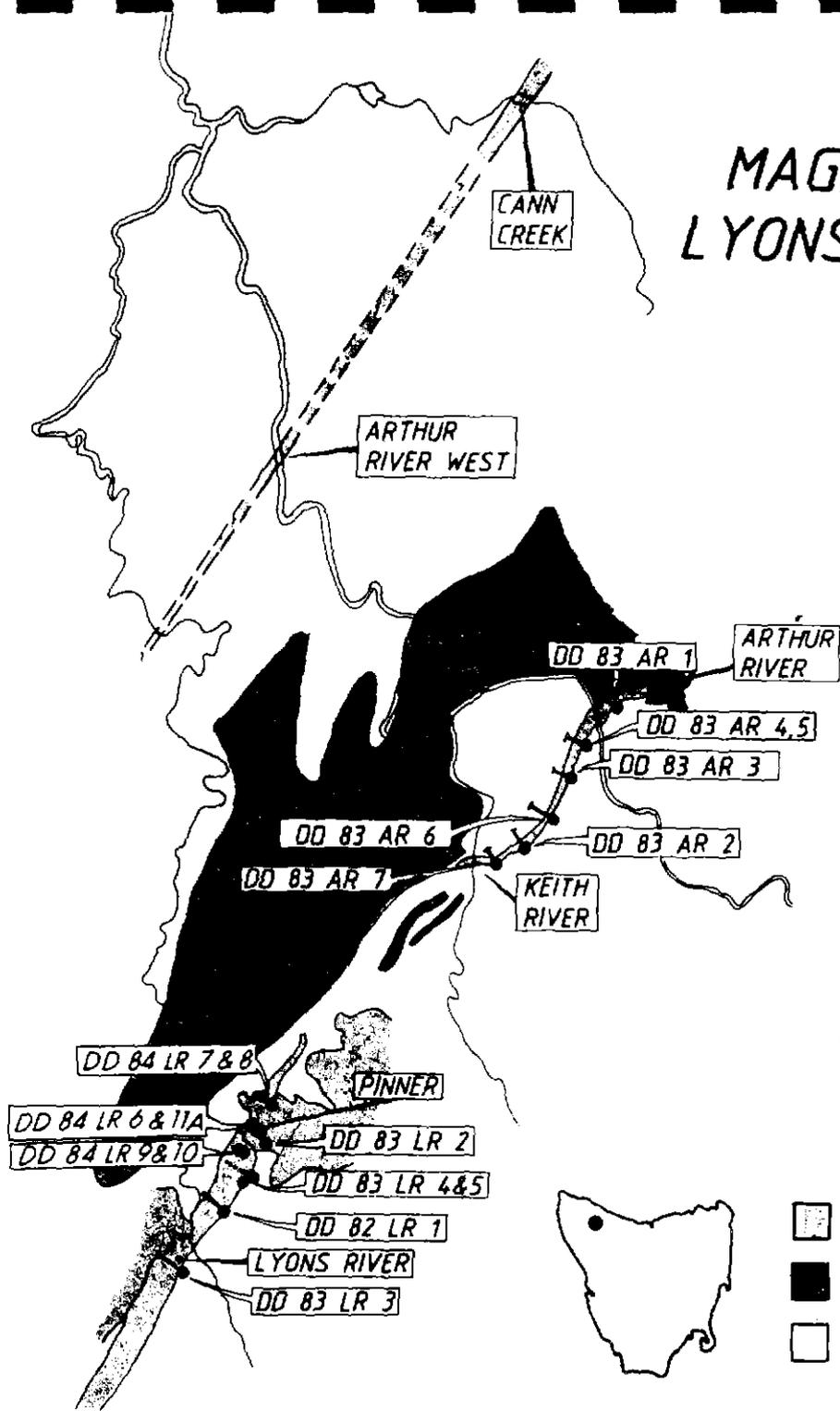




E.L. 43/70

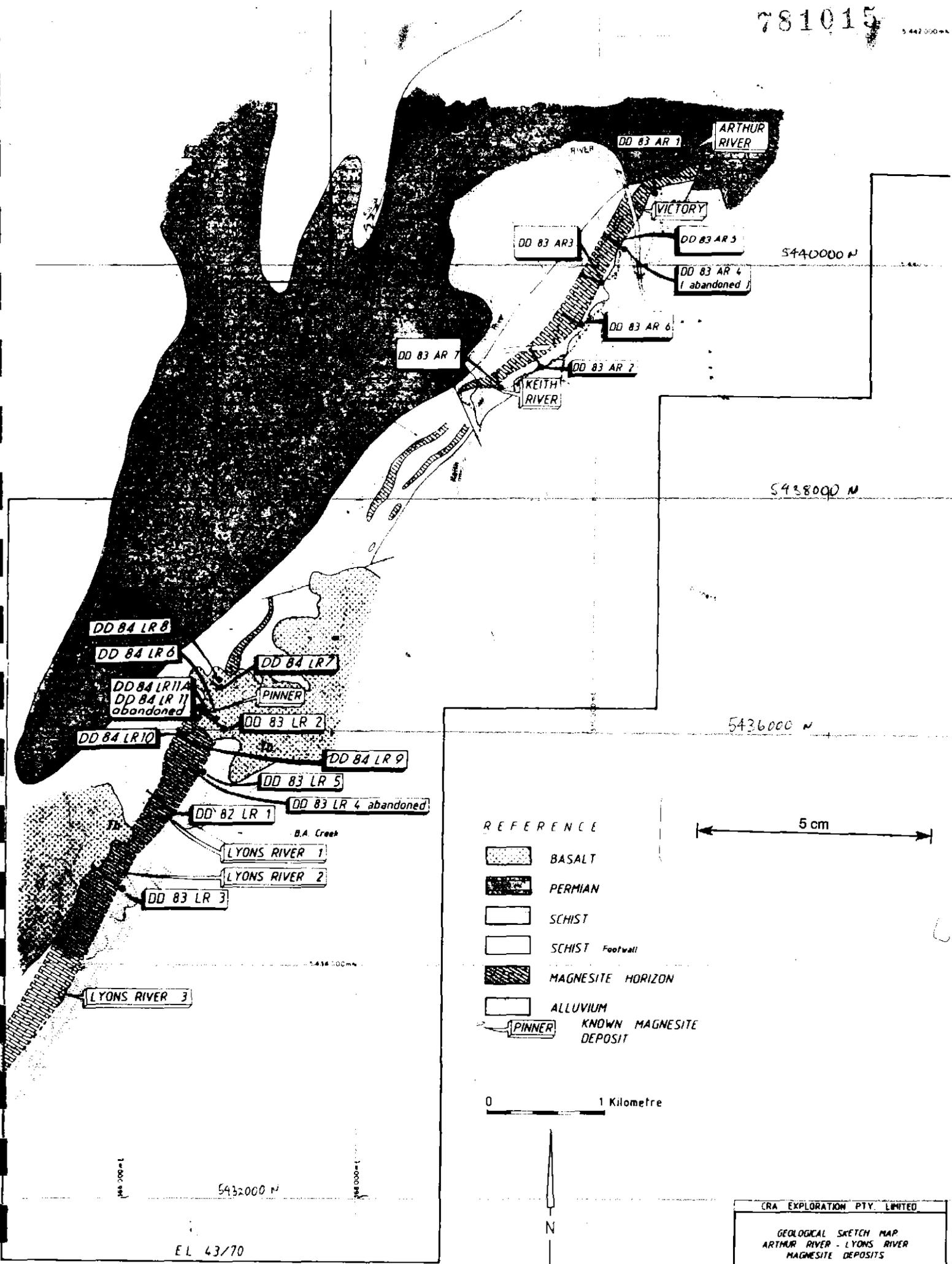
<b>CRA EXPLORATION PTY. LIMITED</b>	
<b>E.L. 43/70 ARTHUR RIVER</b>	
<b>LOCATION PLAN</b>	
Ref	SKSS - 3
Scale	1 500 000
Author	V A W
Date	31 - 8 - 1983
Drawn	R. T.
Report N°	12283
Plan N°	TASh 111

# MAGNESITE DEPOSITS LYONS - ARTHUR RIVER AREA



- |                                                                                       |         |                                                                                       |           |
|---------------------------------------------------------------------------------------|---------|---------------------------------------------------------------------------------------|-----------|
|  | BASALT  |  | MAGNESITE |
|  | PERMIAN |  | ALLUVIUM  |
|  | SCHISTS |                                                                                       |           |

781014



5436000 N

5 cm

- REFERENCE
- BASALT
  - PERMIAN
  - SCHIST
  - SCHIST Footwall
  - MAGNESITE HORIZON
  - ALLUVIUM
  - PINNER KNOWN MAGNESITE DEPOSIT

0 1 Kilometre



CRA EXPLORATION PTY. LIMITED

GEOLOGICAL SKETCH MAP  
ARTHUR RIVER - LYONS RIVER  
MAGNESITE DEPOSITS

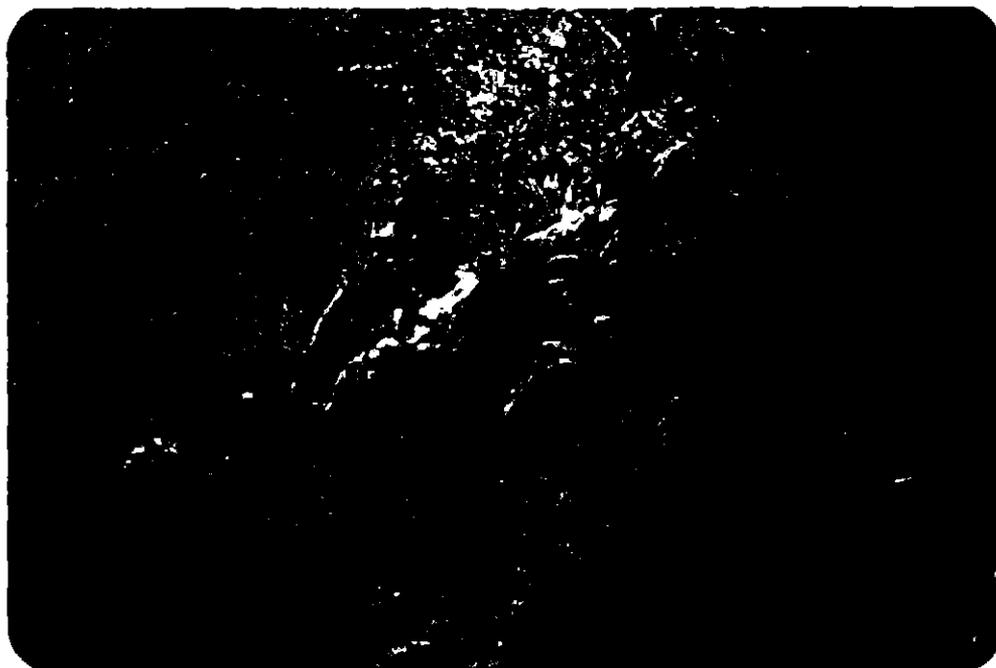
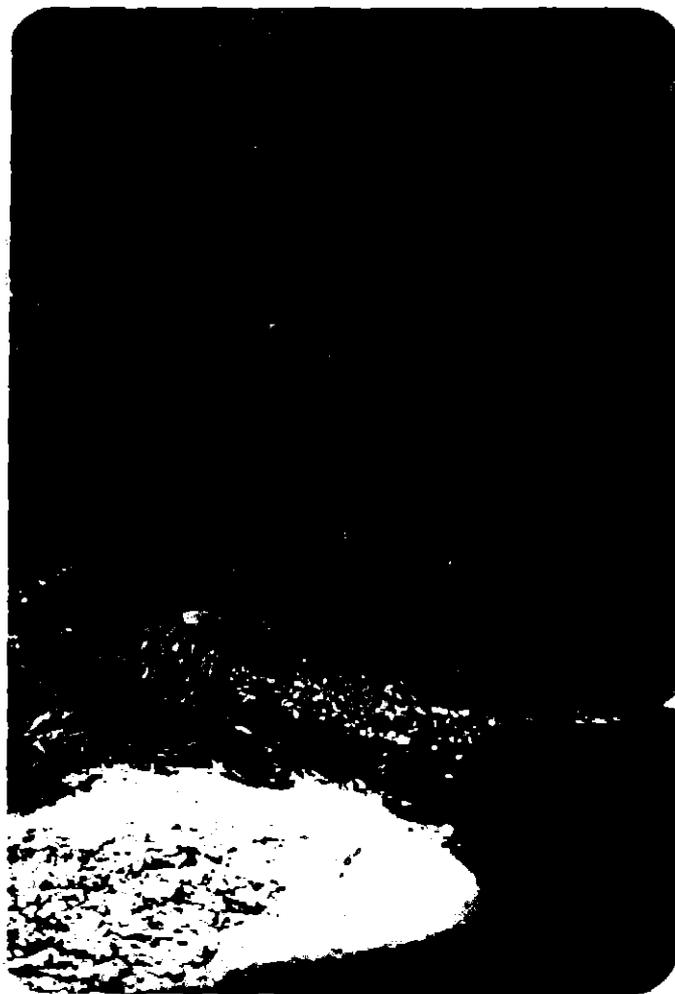
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EL 43/70

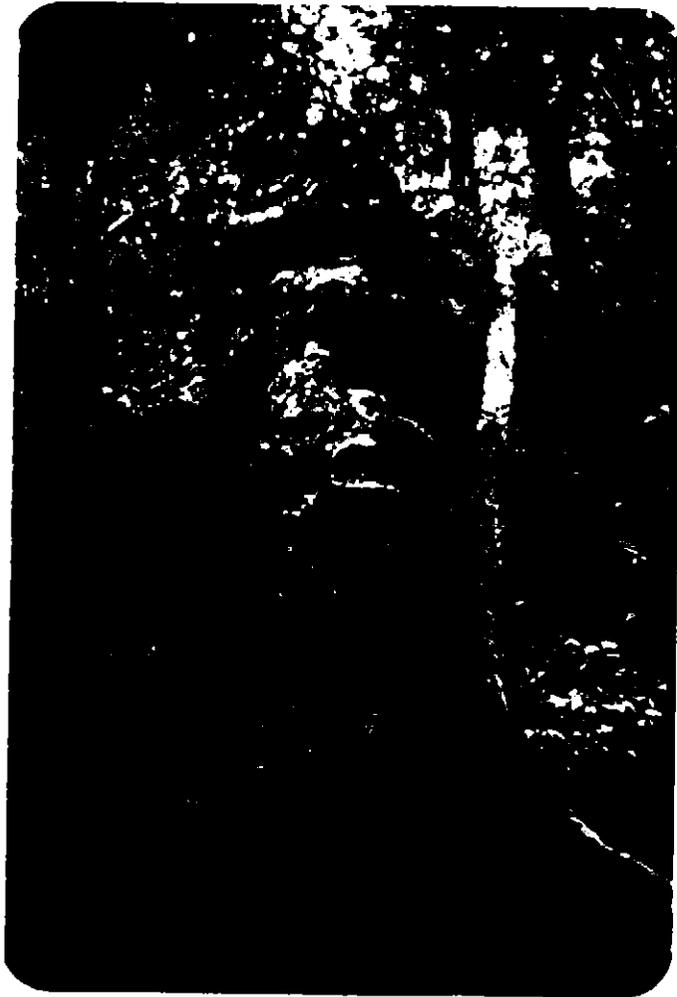
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266

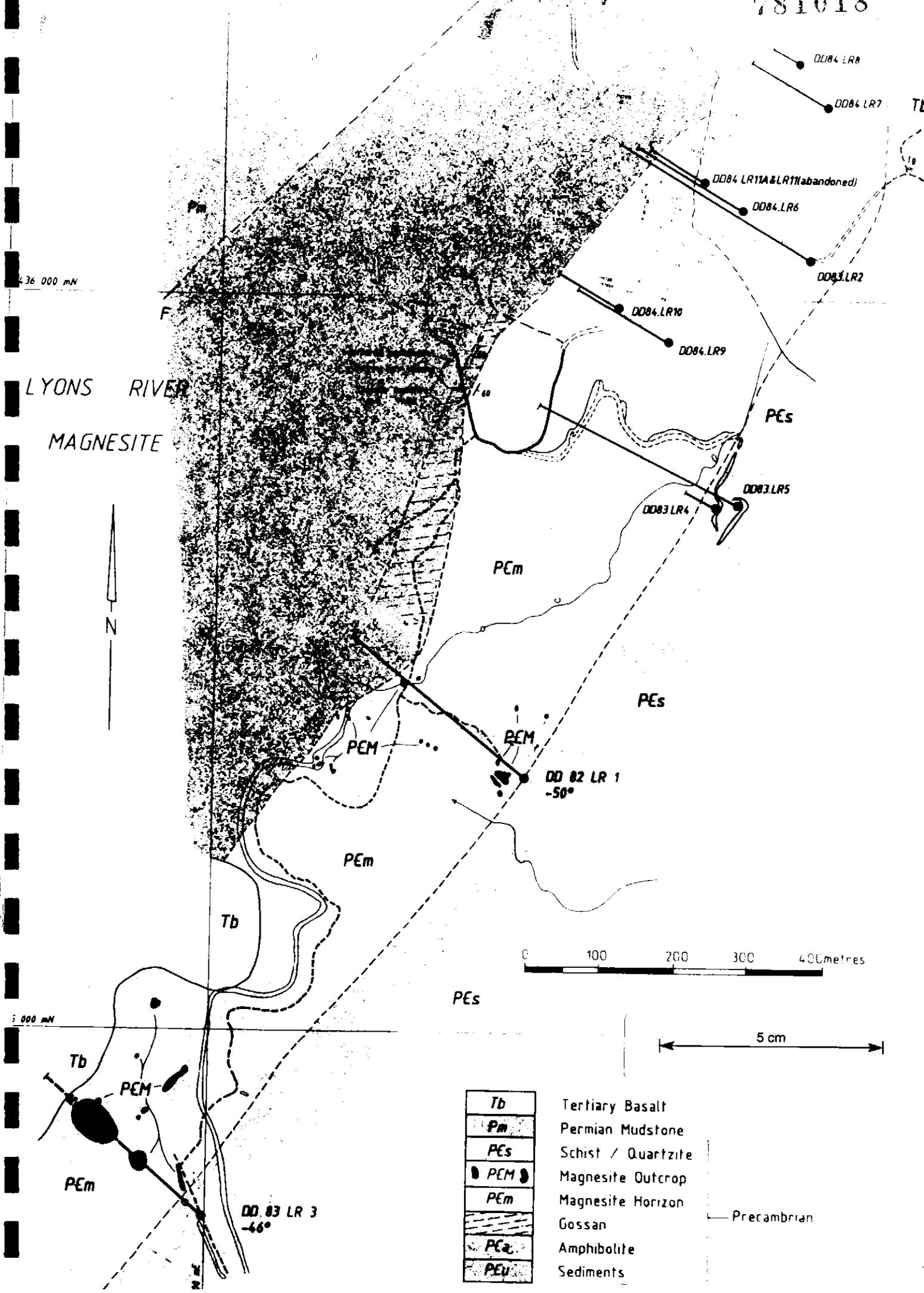
266



LYONS RIVER AND MAGNESITE OUTCROP



OUTCROP AND CONTACT OF WEATHERED  
MAGNESITE (BROWN CLAY) AND FOOTWALL  
SCHISTS



LYONS RIVER  
MAGNESITE



0 100 200 300 400metres

5 cm

Tb	Tertiary Basalt
Pm	Permian Mudstone
PEs	Schist / Quartzite
PEM	Magnesite Outcrop
PEm	Magnesite Horizon
Gossan	Gossan
Amphibolite	Amphibolite
Sediments	Sediments

Precambrian

36 000 mN

3 000 mN

DD 83 LR 3  
-46°

DD 82 LR 1  
-50°

DD84 LR8

DD84 LR7

DD84 LR11A & LR11 (abandoned)

DD84 LR6

DD84 LR2

DD84 LR10

DD84 LR9

PEs

DD83 LR5

DD83 LR4

PEm

PEs

PEM

PEM

PEm

Tb

PEs

Tb

PEM

PEm

320° AMG

140° AMG

DD 82 LR 1

E.O.M.  
389.0m

FW CONTACT

LEGEND

-  Tertiary Gravel
-  Pyritic Calc - Siltstone
-  Amphibolite

CARBONATE TYPES

-  Massive Grey Dolomite
-  Angular Magnesite Breccia
-  Whispy Magnesite Breccia
-  Luneform Magnesite

Magnesite Textures are dominated by sparry (i.e. recrystallized) material obscuring any previous textures

5 cm

0 10 20 30 40 50 100 metres

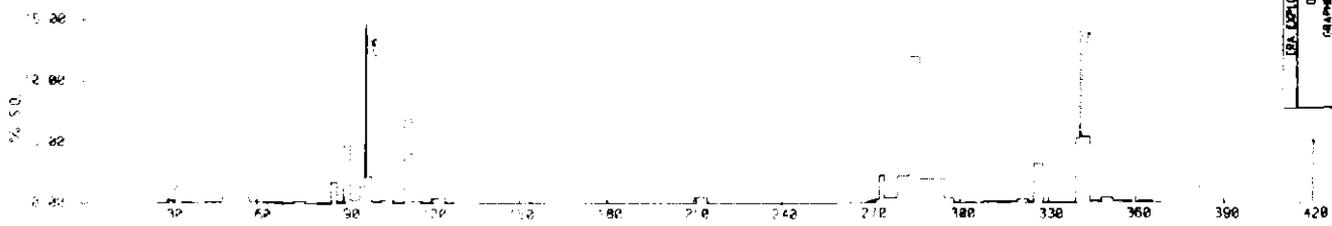
GRA EXPLORATION PTY. LIMITED

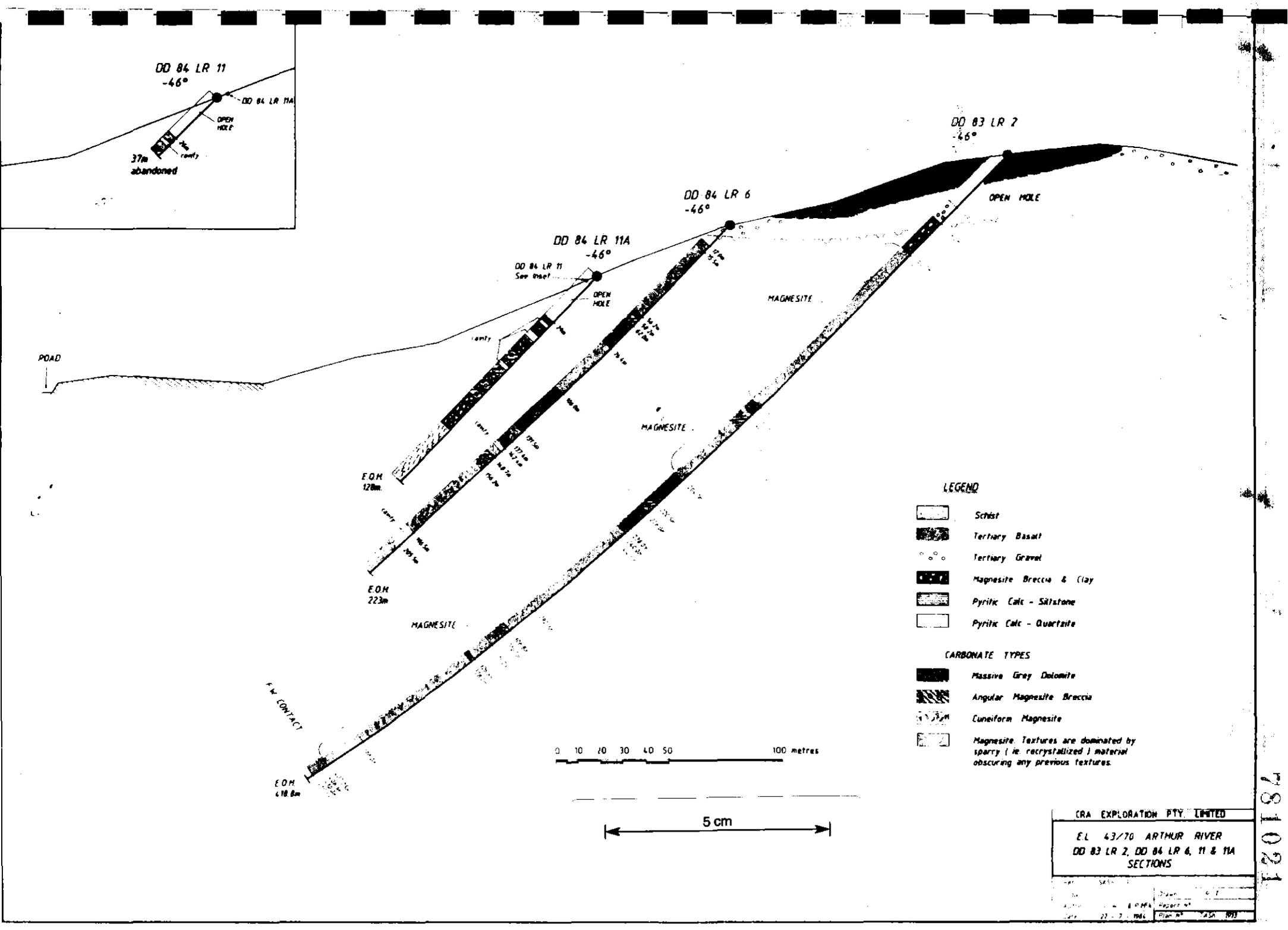
FL 43/70 ARTHUR RIVER

DD 82 LR 1 SECTION

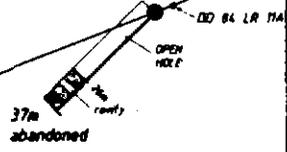
781019

EPA EXPLORATION PVT. LTD.  
 00 41 81  
 GRAPHIC LOG AND ASSAYS





DD 84 LR 11  
-46°



DD 83 LR 2  
-46°

DD 84 LR 6  
-46°

DD 84 LR 11A  
-46°

DD 84 LR 11  
See inset

ROAD

E.O.H.  
128m

E.O.H.  
223m

E.O.H.  
418.8m

0 10 20 30 40 50 100 metres

5 cm

LEGEND

- Schist
- Tertiary Basalt
- Tertiary Gravel
- Magnesite Breccia & Clay
- Pyritic Calc - Siltstone
- Pyritic Calc - Quartzite

CARBONATE TYPES

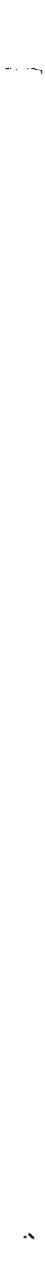
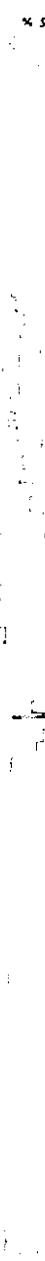
- Massive Grey Dolomite
- Angular Magnesite Breccia
- Cuneiform Magnesite
- Magnesite Textures are dominated by sparry (i.e. recrystallized) material obscuring any previous textures.

CRA EXPLORATION PTY. LIMITED  
EL 43/70 ARTHUR RIVER  
DD 83 LR 2, DD 84 LR 6, 11 & 11A  
SECTIONS

781021

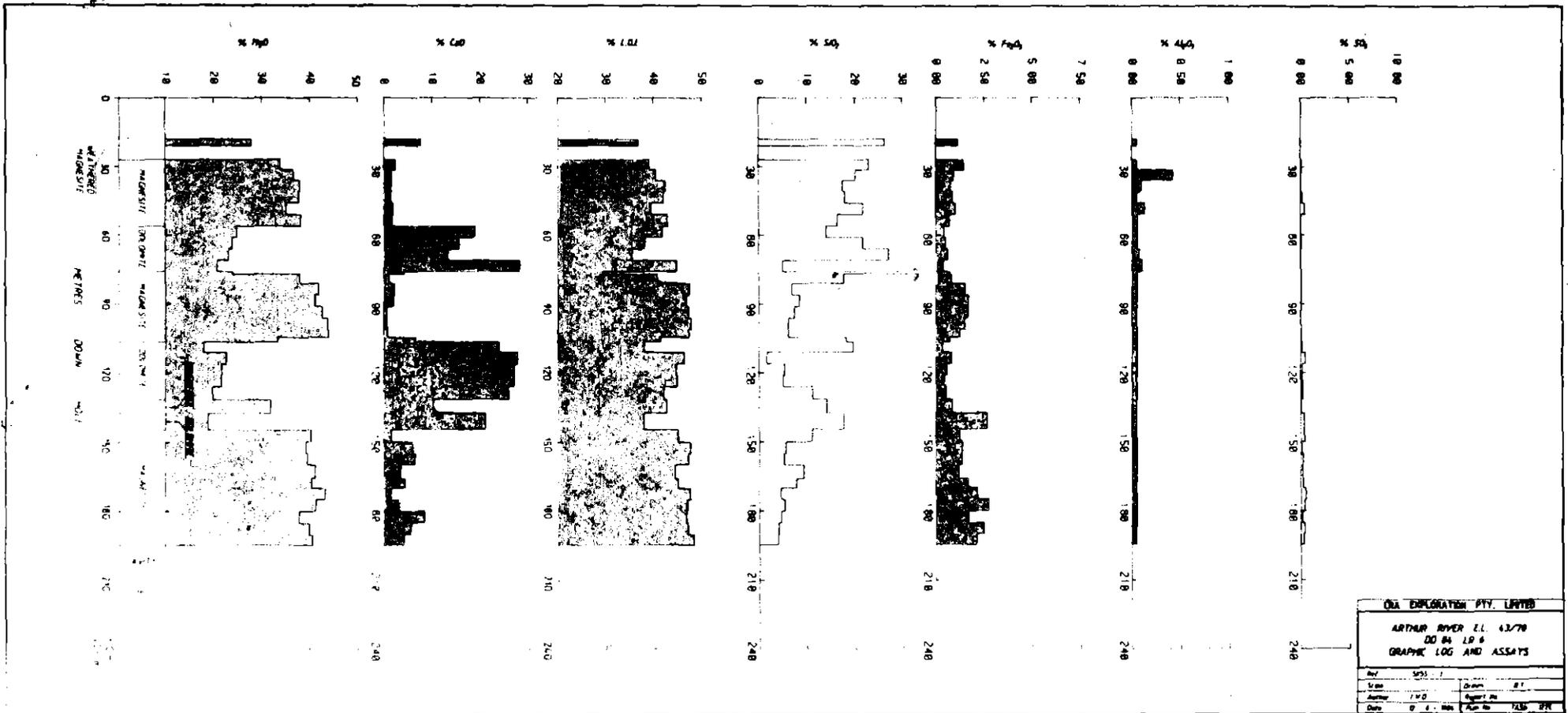
3300 4400 5300 6200

1000 2000 3000 4000 5000 6000



CRA EXPLORATION PTY LIMITED  
 EL 41/70 ARTHUR RIVER  
 DD 83 (B 7)  
 GRAPHIC LOG AND ASSAYS  
 15/11/83  
 4/83  
 3/83  
 2/83

781022



OIA EXPLORATION PTY. LIMITED			
ARTHUR RIVER E.L. 43/78			
DD 84 LR 6			
GRAPHIC LOG AND ASSAYS			
Drawn	SJS	Checked	BT
Author	140	Approved by	
Date	9.4.88	Scale	1:5000

781023

300° AMG

120° AMG

FOOTWALL CONTACT

FOREST PT  
PERMANENT  
SURVEY  
MARK  
D. 28

Siltstone  
Flot.

Siltstone  
Subcrop

Weathered  
Carbonate

Magnesite  
Outcrop

Magnesite  
Outcrop

Magnesite  
Outcrop

DD 83 LR 5  
-46°

Weathered Carbonate  
in road cutting  
(projected)

M.W. CONTACT  
INFERRED

LEGEND

-  Hanging Wall Schist.
-  Siltstone in Footwall Sequence.
-  Amphibolite

CARBONATE TYPES

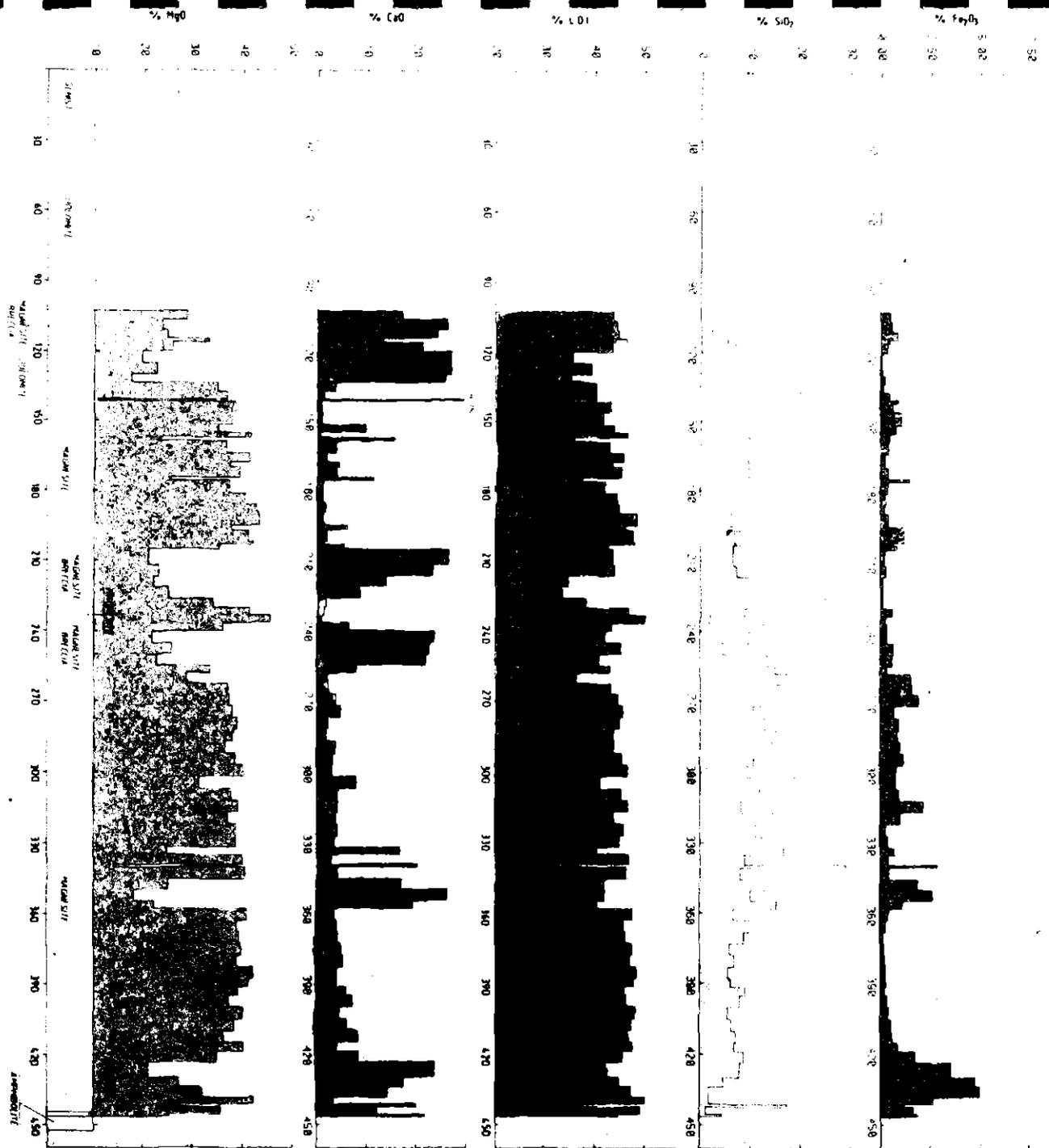
-  Sandy - Siliceous Dolomite
-  Magnesite. Minor sparry and/or sandy dolomite patches only.
-  Complex mixture of magnesite and sandy - siliceous dolomite. ( includes massive magnesite bands up to 1 metre thick in places )

EDM  
45245 m

444.0  
446.0  
447.5

GWA EXPLORATION PTY. LIMITED	
E.L. 43/70 ARTHUR RIVER	
DD 83 LR 5 SECTION	
Ref:	5155 - 1
Scale:	Drawn: A. I.
Author: V. A. V.	Checked: P.
Date: 22 - 9 - 1987	Plot No.: TADP 258

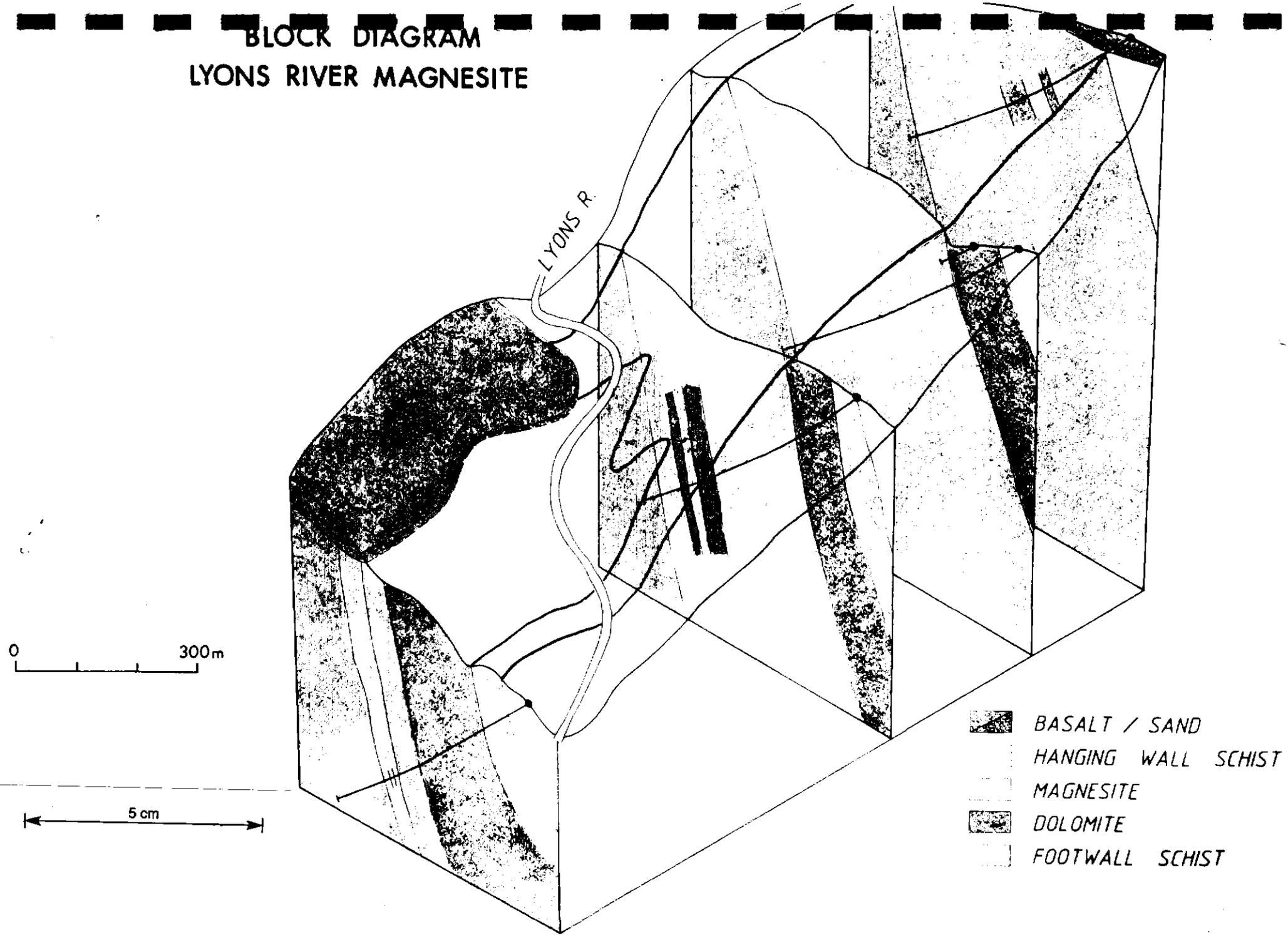
281024



GSA EXPLORATION PTY. LIMITED	
211, 43/70 ARTHUR AVENUE SUITE 105 WILLOWDALE, ONTARIO	
Job No.	W.M. - 1
Client	W.M. - 1
Date	1970
By	J. H. B. / J. H. B.

481023

BLOCK DIAGRAM  
LYONS RIVER MAGNESITE

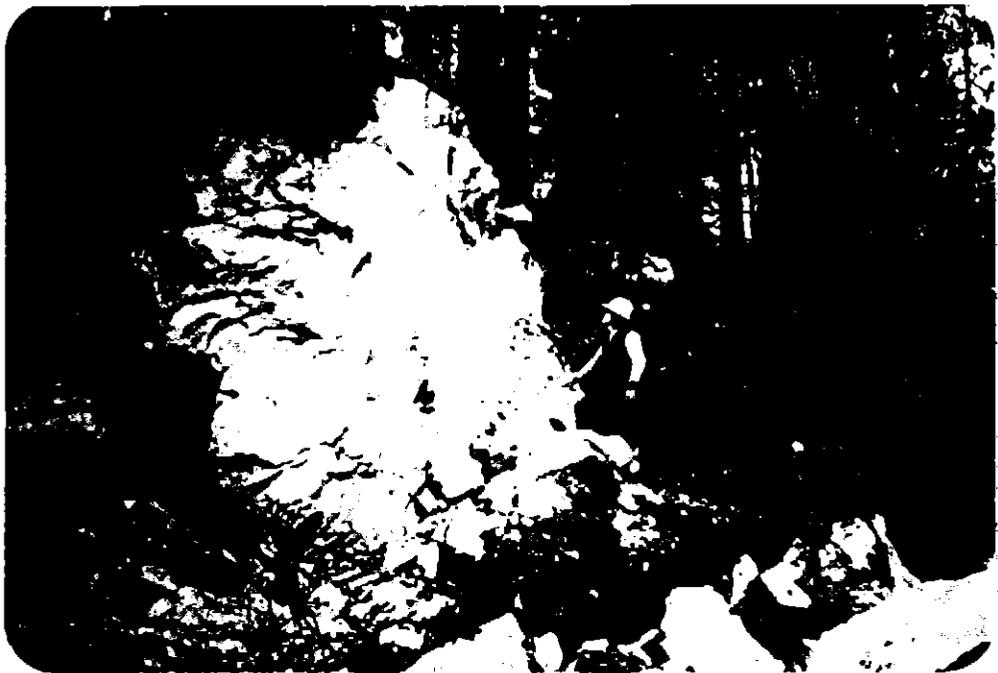


0 300m

5 cm

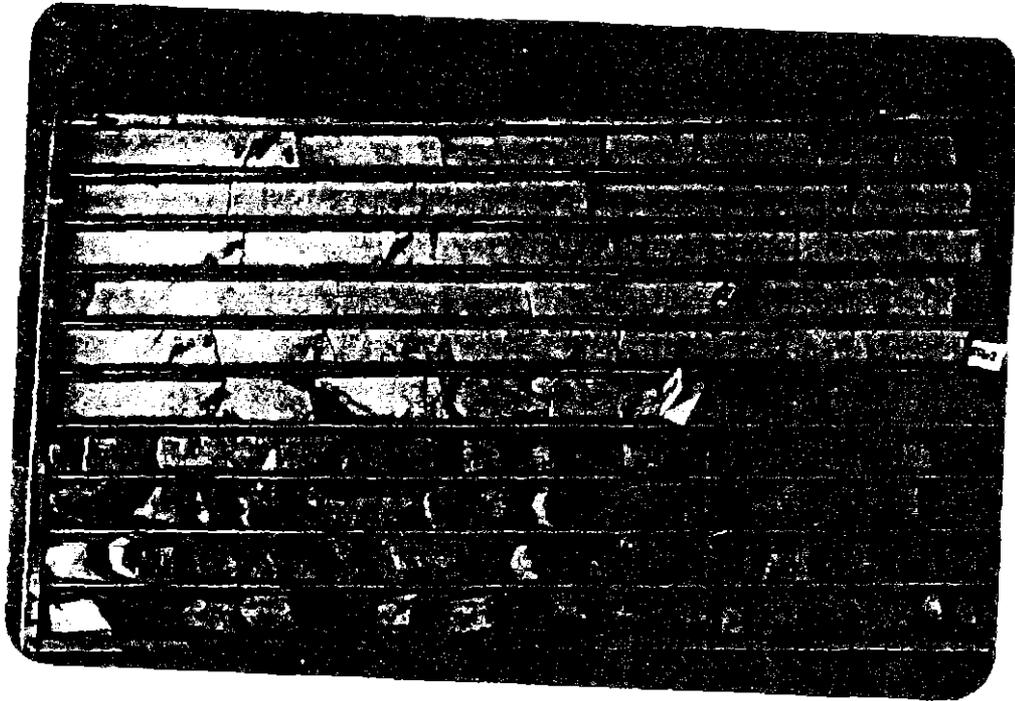
-  BASALT / SAND
-  HANGING WALL SCHIST
-  MAGNESITE
-  DOLOMITE
-  FOOTWALL SCHIST

781026



BULK SAMPLING LYONS RIVER

HIGH GRADE MAGNESITE IS AVAILABLE  
EG BOTTOM SECTION IN HOLE LR 1

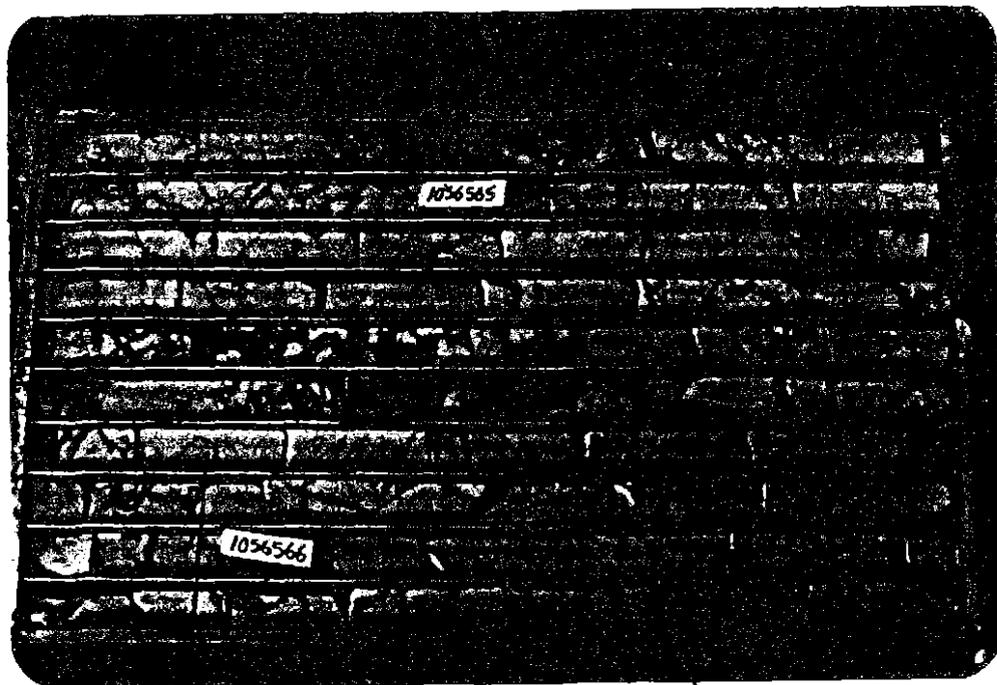


Sample	1055612	( 362.6 - 368.9m )
	MgO	46.99
	CaO	0.57
	SiO <sub>2</sub>	< 0.5
	Fe <sub>2</sub> O <sub>3</sub>	0.71
	L.O.I.	51.3

## EFFECTS OF UPGRADING

5 metre sample in photo 1056566 i 325 - 330metres  
returns

MgO	42.35
CaO	4.01
SiO <sub>2</sub>	3.87
Fe <sub>2</sub> O <sub>3</sub>	0.38
L.O.I	49.37



### White Magnesite (934762)

MgO	46.0
CaO	0.40
SiO <sub>2</sub>	0.74
Fe <sub>2</sub> O <sub>3</sub>	0.59
L.O.I.	51.6

### Grey Dolomite (934763)

MgO	25.2
CaO	17.7
SiO <sub>2</sub>	13.3
Fe <sub>2</sub> O <sub>3</sub>	0.43
L.O.I.	41.1

High grade Magnesite ( +45% MgO ) can be produced  
by floating out Dolomite and Quartz

SAMPLE 934762 DD83 LR2 317.0 Metres

White magnesite - minor dolomite veining.



A. ANALYSIS %  
(ICP analysis by Amdel)

SiO <sub>2</sub>	0.74
Al <sub>2</sub> O <sub>3</sub>	<0.10
Fe <sub>2</sub> O <sub>3</sub>	0.59
MgO	46.0
CaO	0.40
SO <sub>3</sub>	<0.10
LOI	51.6
Boron	

B. QUANTITATIVE MINERALOGY %  
(from XRD and chemical analysis)

Magnesite	95.6
Dolomite	1.3
Quartz	0.7
Talc	
Chlorite	
Tourmaline	
[Fe <sub>2</sub> O <sub>3</sub> ]	0.6
[SO <sub>3</sub> ]	

C. PETROLOGY W.H.Fander Central Mineralogical Services

Carbonate - Dense, ultrafine (<5u) ? magnesite or magnesite - dolomite; thin pygmatic dolomite veins, 20-300 u, 2-4% of rock.

Quartz - Granular to euhedral, dispersed and associated with veins; 20-500 u 1%.

Other Minerals None

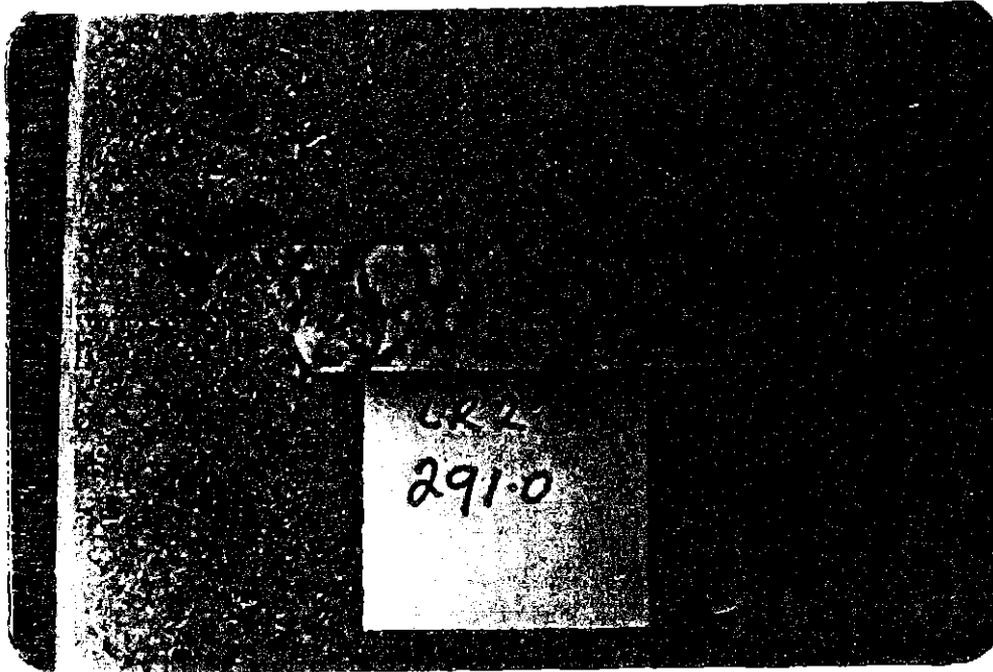
Comments - Magnesite shows breccia structure which resulted from tectonism prior to lithification.

SAMPLE 934762 (cont'd)OBSERVATIONS

The sample as it looks from the photograph is an almost pure magnesite with very little quartz or a trace of dolomite veining. Despite the white colour the 0.6% iron would appear to be held in the magnesite lattice. The surrounding rock sample 1056564 315 - 320 metres contains 8.8% dolomite (2.66% CaO) and up to 10% quartz which should like sample 934760 be contained in the dolomite veins. The iron content of the 5 metre zone is almost identical (0.61%) and although 0.04% of this can be accounted for as pyrite (0.081% SO<sub>3</sub>) the remainder 0.57% must occur in the magnesite/dolomite lattices.

SAMPLE 934760 DD83 LR2 291.0 Metres

Magnesite breccia with grey dolomite infil.



A. ANALYSIS  
(ICP analysis by Ardel)

SiO <sub>2</sub>	2.94
Al <sub>2</sub> O <sub>3</sub>	< 0.10
Fe <sub>2</sub> O <sub>3</sub>	0.57
MgO	36.8
CaO	10.4
SO <sub>3</sub>	0.02
LOI	48.4
Boron	Not tested

B. QUANTITATIVE MINERALOGY %  
(from XRD and chemical analysis)

Magnesite	61.3
Dolomite	34.2
Quartz	2.9
Talc	
Chlorite	
Tourmaline	
[Fe <sub>2</sub> O <sub>3</sub> ]	0.6
[SO <sub>3</sub> ]	

C. PETROLOGY W.H.Fander Central Mineralogical Services

Carbonate - Dense, ultrafine (< 5 u) ? magnesite replaced by patches  
veins of coarse, clear dolomite (30%) with associated  
quartz.

Quartz - Euhedral replacive crystals, and mosaics, in dolomite  
veins.

Other Minerals None

Comments - Coarse, clear carbonate in veins proved to be dolomite,  
based on stain tests and XRD.

SAMPLE 934760 (cont'd)OBSERVATIONS

In this case the abundant grey matrix of the "breccia" did prove to be dolomite. The quartz does occur in the dolomite and therefore could be easily sorted from the white magnesite fragments. - see photomicrograph below.

It was originally thought that the black rims to the dolomite veins and patches could be chlorite and that this would account for most of the iron oxide. The rims actually contain traces of heavy hydrocarbons which give the dark colour but this material would burn up on calcining.

The composition of the surrounding interval - sample 1056559 290 - 295 metres is very similar to sample 934760 - a little extra quartz and approximately 0.2% pyrite are the only real changes.

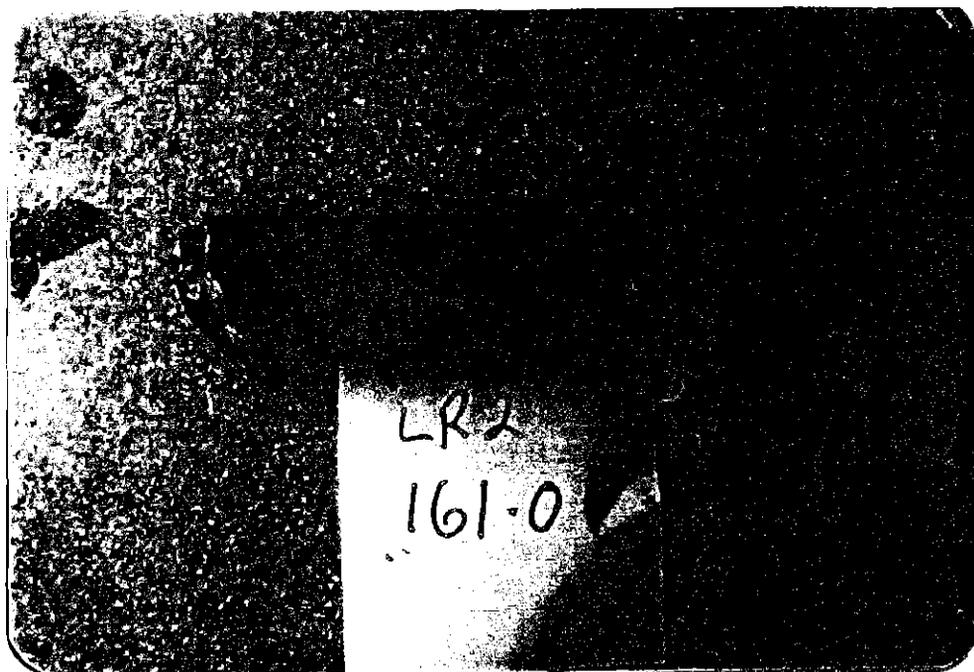
330  $\mu$ 

934760 Magnification 30x

Dolomite progressively replacing magnesite (dark), with euhedral quartz crystals containing zones of carbonate inclusions.

SAMPLE 934756 DD83 LR2 161.0 Metres

Dark grey weakly banded dolomite



A. ANALYSIS %  
(ICP analysis by Amdel)

SiO <sub>2</sub>	0.19
Al <sub>2</sub> O <sub>3</sub>	< 0.1
Fe <sub>2</sub> O <sub>3</sub>	0.2
MgO	21.4
CaO	30.2
SO <sub>3</sub>	0.02
LOI	47.1
Boron	37 ppm

B. QUANTITATIVE MINERALOGY %  
(from XRD and chemical analysis)

Magnesite	-
Dolomite	99.3
Quartz	0.2
Talc	-
Chlorite	-
Tourmaline	-
[Fe <sub>2</sub> O <sub>3</sub> ]	0.2
[SO <sub>3</sub> ]	0.02

C. PETROLOGY W.H.Fander Central Mineralogical Services

Carbonate - Finely crystalline dolomite (XRD) with coarser cloudy crystals; grain sizes average 25 u and 150 u. Dolomite veins (clear).

Quartz - Scattered crystals and mosaics, 50 u to 1 mm.  
1%

Other Minerals None.

Comments - No magnesite detected by XRD. Quartz is authigenic

SAMPLE 934756 (Cont'd)

OBSERVATIONS

A pure dolomite sample. The interval surrounding it (sample 1056525 160 - 162.6 ) contains much more silica (6.65%) while other section of dolomite, samples 1056526, 1056527, contain 16 to 24% SiO<sub>2</sub>. The SO<sub>3</sub> content in sample 1056525 (0.06%) also indicates a trace of pyrite. The boron content of 37 ppm indicates elevated but insignificant tourmaline content in this sample, other dolomites however do contain significant tourmaline (see sample 934763).

AmdeI originally reported "clay" in this sample and to evaluate this Fander crushed and dissolved the sample in dilute HCl. He reported:-

The residue comprised 1.5% of the sample and consists dominantly of colourless tourmaline (elbaite) and quartz, with very minor illite-sericite. The elbaite generally occurs as small needles and as aggregates of minute ( 10 u) stubby crystals. Dispersed fine colourless tourmaline is very difficult to detect in a carbonate host, and thin-section observations suggest that the tourmaline is erratically distributed, which inevitably causes various sampling problems.

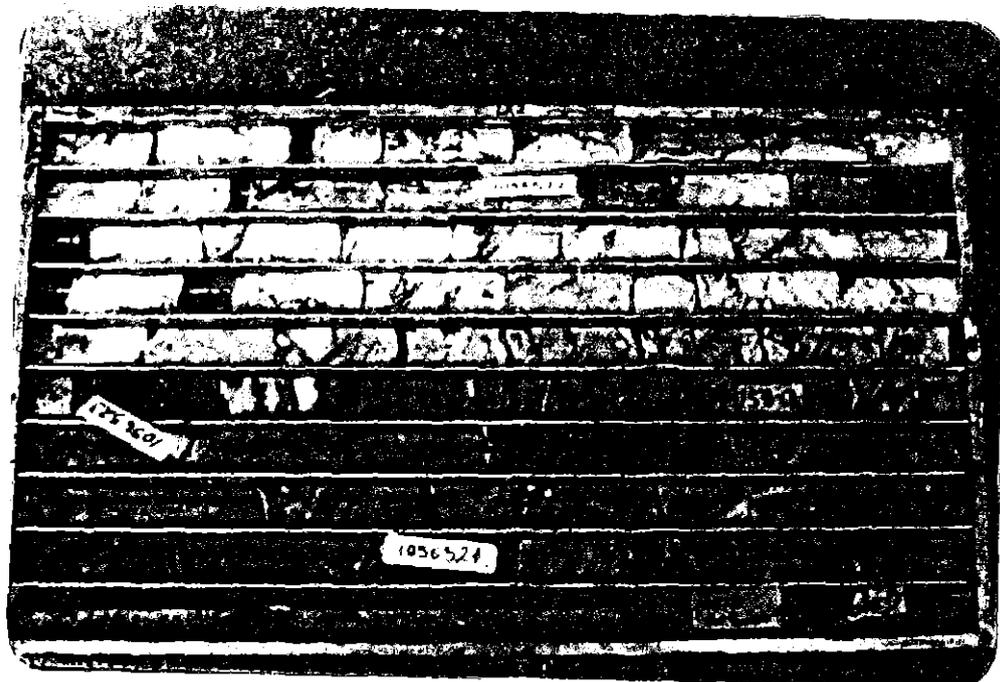
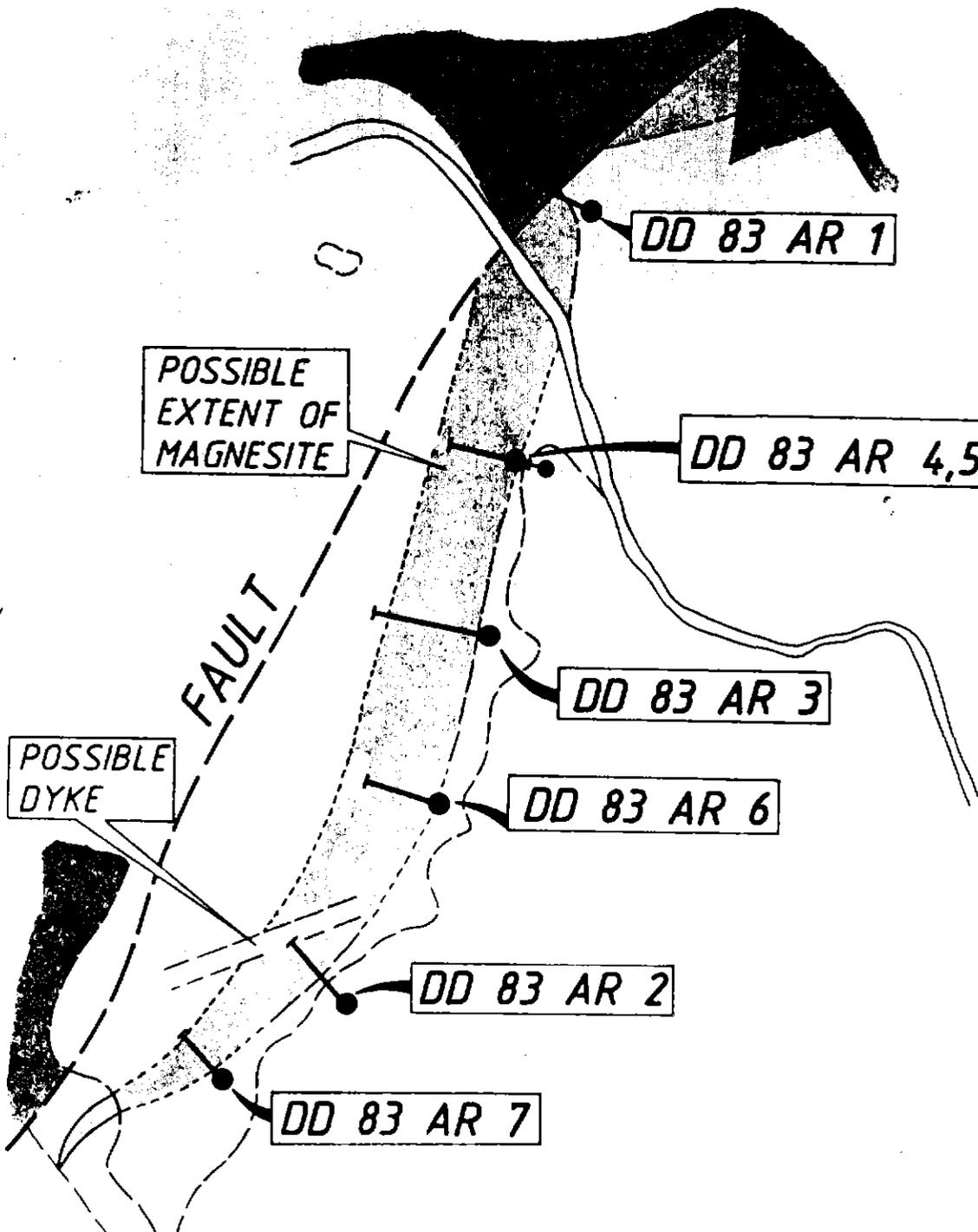
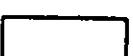
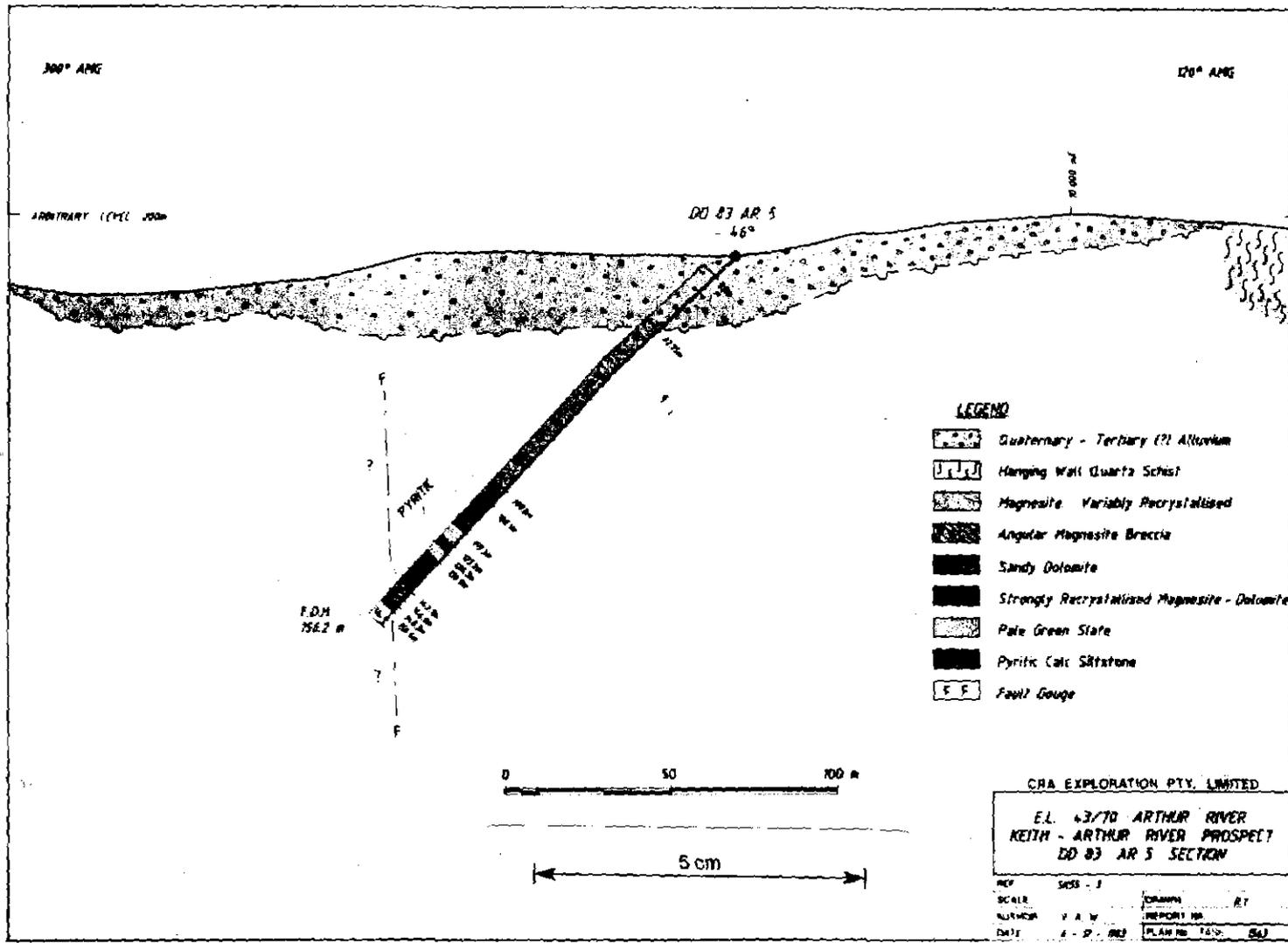


Photo demonstrating sharp contact and contrast between dolomite (grey) and magnesite (buff) in DD83 LR2.

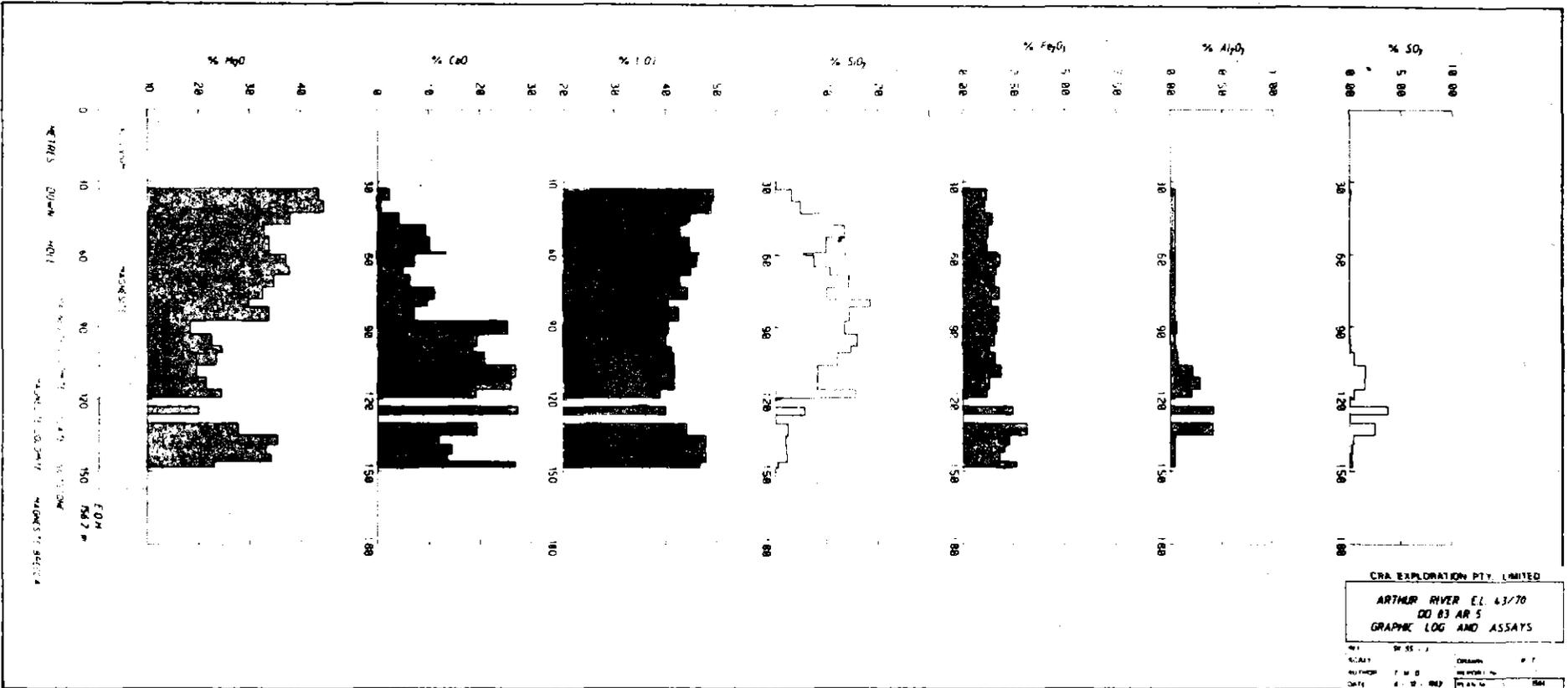
# KEITH RIVER MAGNESITE



-  MAGNESITE
-  SCHIST
-  PERMIAN
-  ALLUVIUM



781037



781038

9750 mE 9800 mE 9850 mE 9900 mE 9950 mE 10000 mE 10050 mE 10100 mE 10150 mE

3015° AMG

1215° AMG

DD 83 AR 3  
- 46°

700m RL

Inferred  
Siltstone

LEGEND

-  QUATERNARY - TERTIARY (?) ALLUVIUM
-  FINE SAND - PROBABLY WEATHERED MAGNESITE KARST FILL
-  HANGING WALL QUARTZ SEMI
-  HEAVILY RECRYSTALLIZED VARIABLY WEATHERED MAGNESITE DOLOMITE
-  ANGULAR MAGNESITE BRECCIA
-  LAMBY DOLOMITE
-  QUARTZ SANDSTONE
-  HYDRATED LIME LESTONE
-  AMPHIBOLITE

0 50 100 metres

5 cm

10M  
408.0 m

CRA EXPLORATION PTY. LIMITED

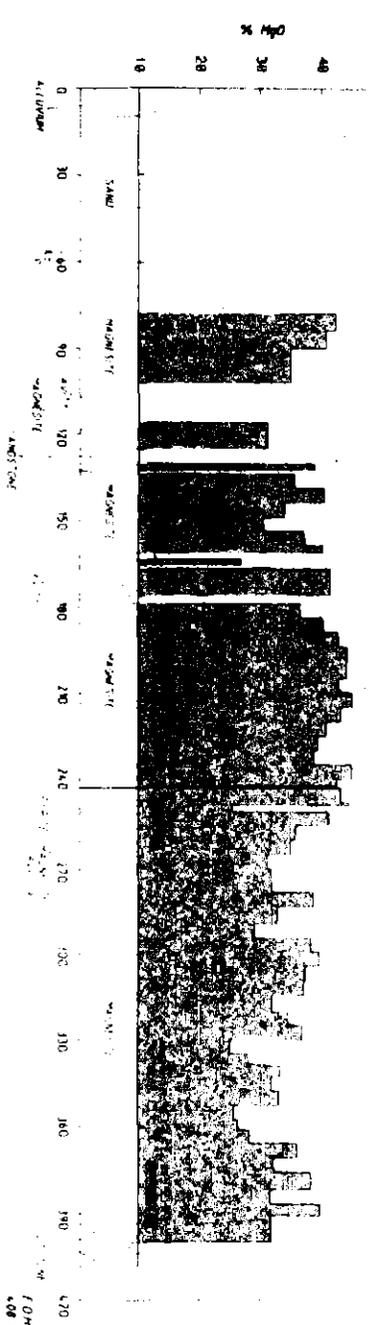
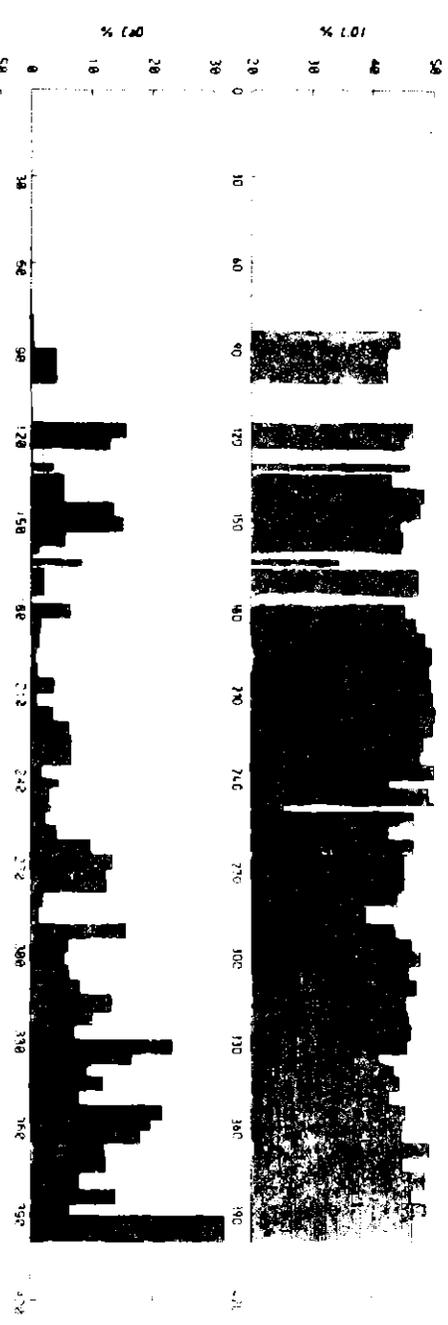
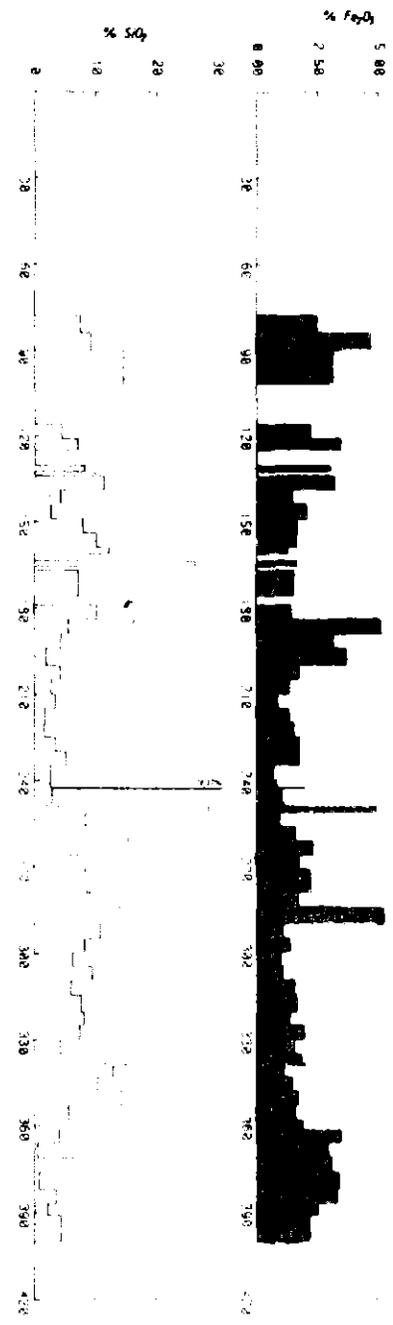
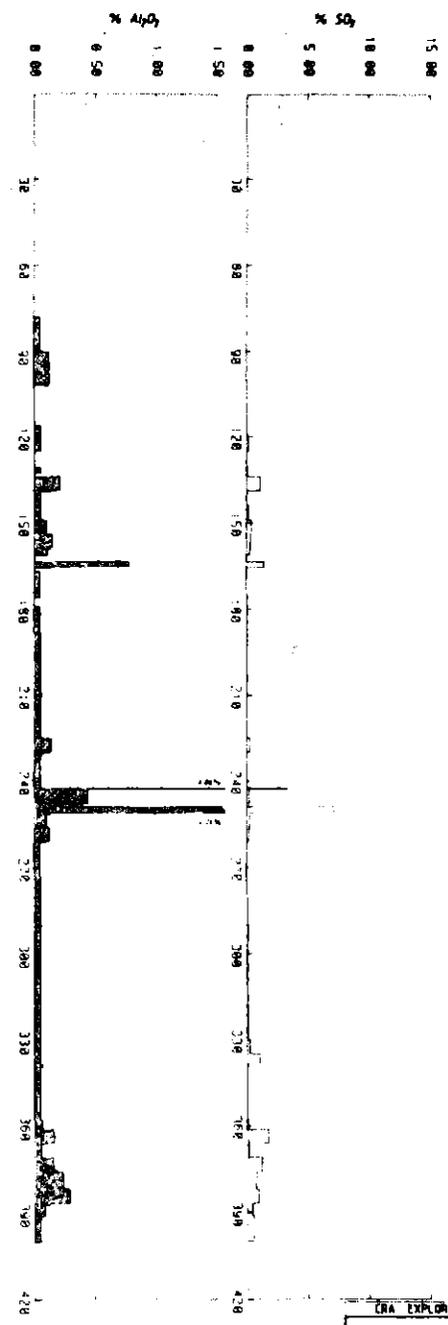
ARTHUR RIVER EL. 43/70  
KEITH - ARTHUR RIVER PROSPECT  
DD 83 AR 3 SECTION

281039

781040

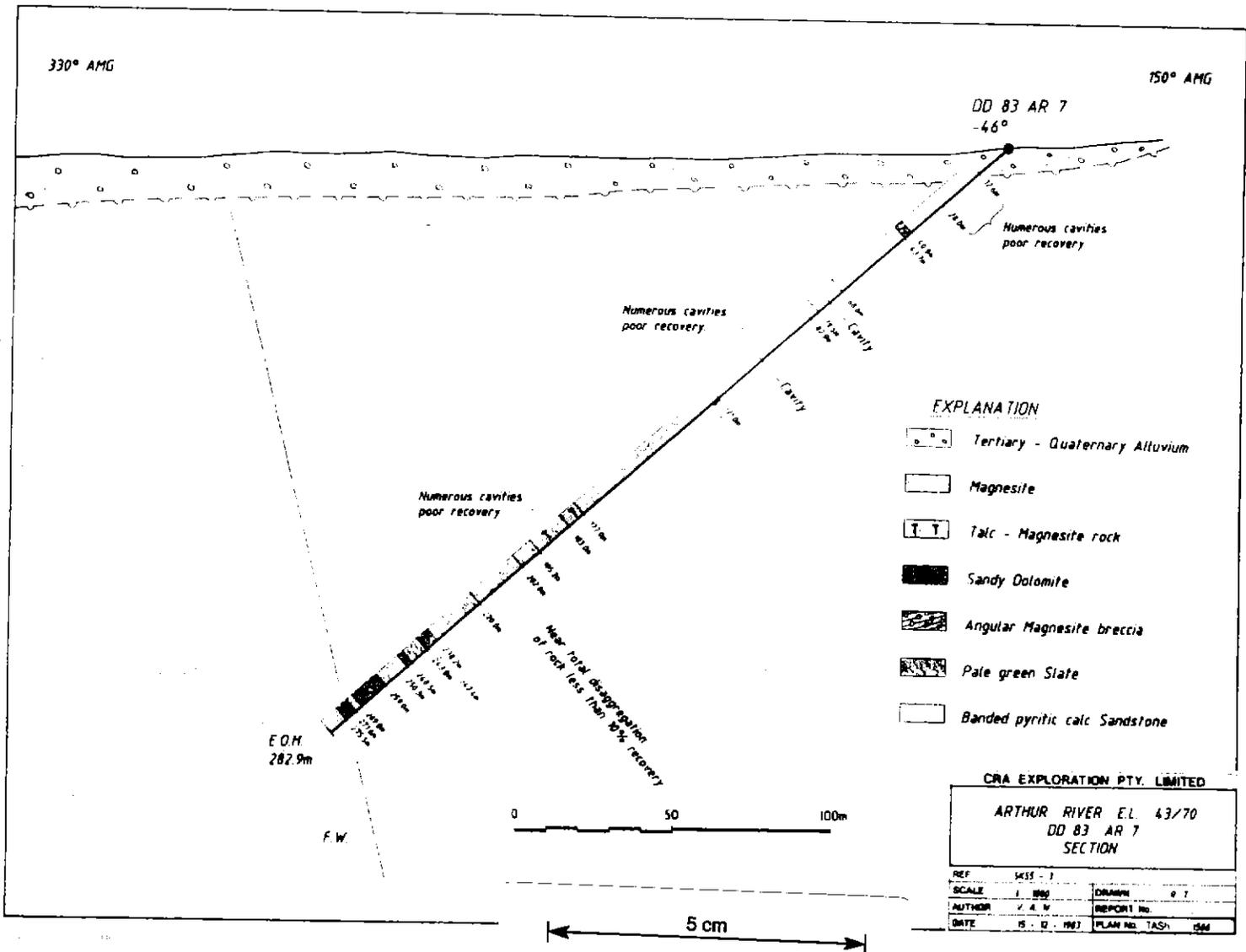
ORA EXPLORATION PTY. LIMITED  
 ARTHUR RIVER EL. 4379  
 DD 83 AD 3  
 GRAPHIC LOG AND ASSAYS

DATE	NO.	DEPTH	ASSAY



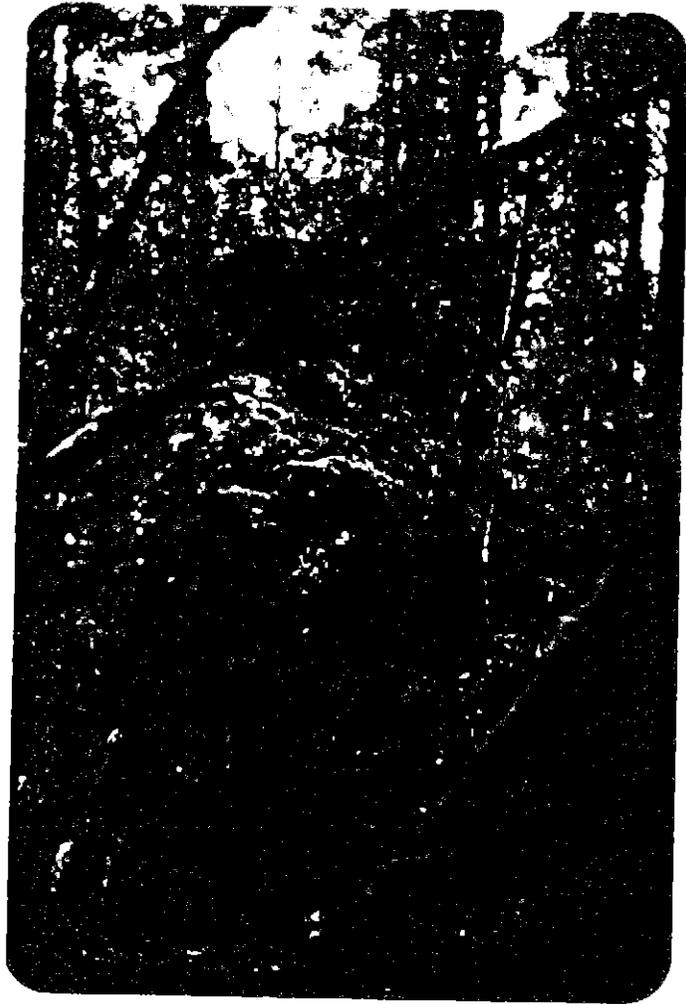
MINES DOWN 101

101



781041





TOS CORRESP. File



## CRA EXPLORATION PTY. LIMITED

(INC IN N.S.W.)

54 RAGLAN STREET, PRESTON, VICTORIA 3072, AUSTRALIA

P.O. BOX 91  
 NORTHLAND CENTRE 3072  
 TELEGRAMS: CRAEX  
 TELEX: AA17478  
 TELEPHONE: 480 1866  
 AREA CODE 031

IN REPLY PLEASE QUOTE:

10th August, 1987

NOTE TO: File

FROM: T. W. Dickson

Cann Creek Magnesite

Neil Thomas has recently opened up the largest and highest grade of the Cann Creek magnesite outcrops. The outcrop is approximately 10 metres north of Cann Creek and has been exposed over a distance of 18 metres along an access track. Dolomitic talc schist is exposed for 15m to the west and 30 metres to the east of the outcrop.

A costean was constructed 40 metres north of the track, but only a very thin 0.2 metre section of badly weathered carbonate was exposed in the 100m trench.

The amount of high grade magnesite available is therefore severely limited and extends no more than 30 metres north of the creek or approximately 1500 tonnes/vertical metres north of the creek. This material averages 44.2% MgO, 3.6% CaO and 1.0% SiO<sub>2</sub>. Iron is very low and averages 0.06% Fe<sub>2</sub>O<sub>3</sub>.

The magnesite does not outcrop south of Cann Creek, but a drill hole (DD 85 CC 2) traverses the section 20m south of the creek and at 100m depth. Only two thin dolomitic magnesite sections, 35-37% MgO, 13-10% CaO and 6-8% SiO<sub>2</sub> were intersected. There is no doubt that CC 1 traversed the full section even if the dip is slightly to the west. A second hole, DD 84 CC 1, a further 450 metres to the south, intersected only dolomite. It would appear that the good grade magnesite facies changes to lower grade magnesite and dolomite with depth and to the south.

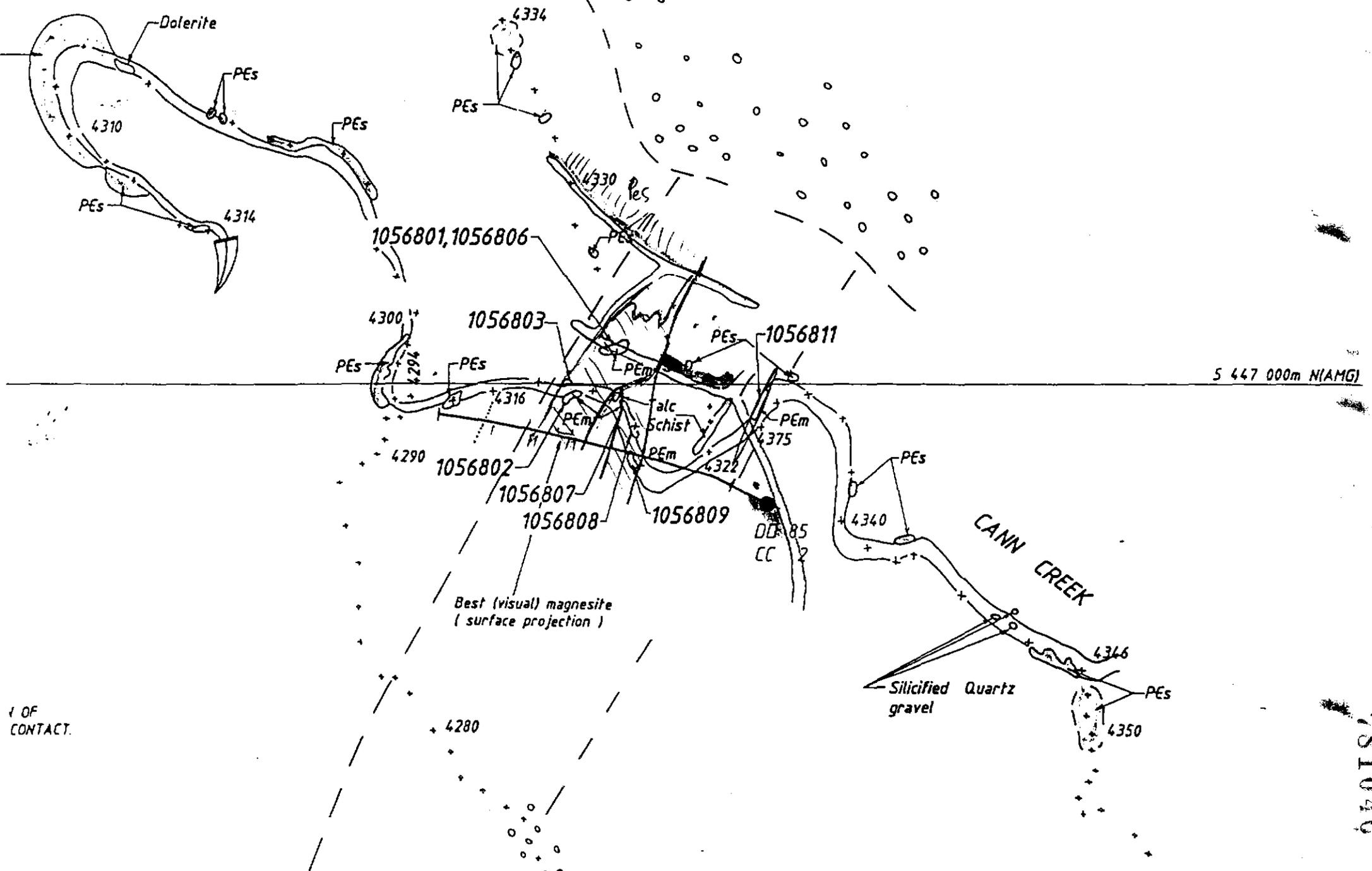
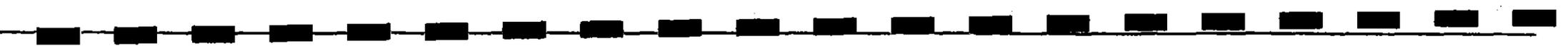
It is probably very unlikely but even if the magnesite were to extend to 100 metres south of the creek and could be worked to a depth of 40 metres (a waste to ore ratio of 2.2 to 1) then a maximum of 220,000 tonnes could be available (very optimistic).

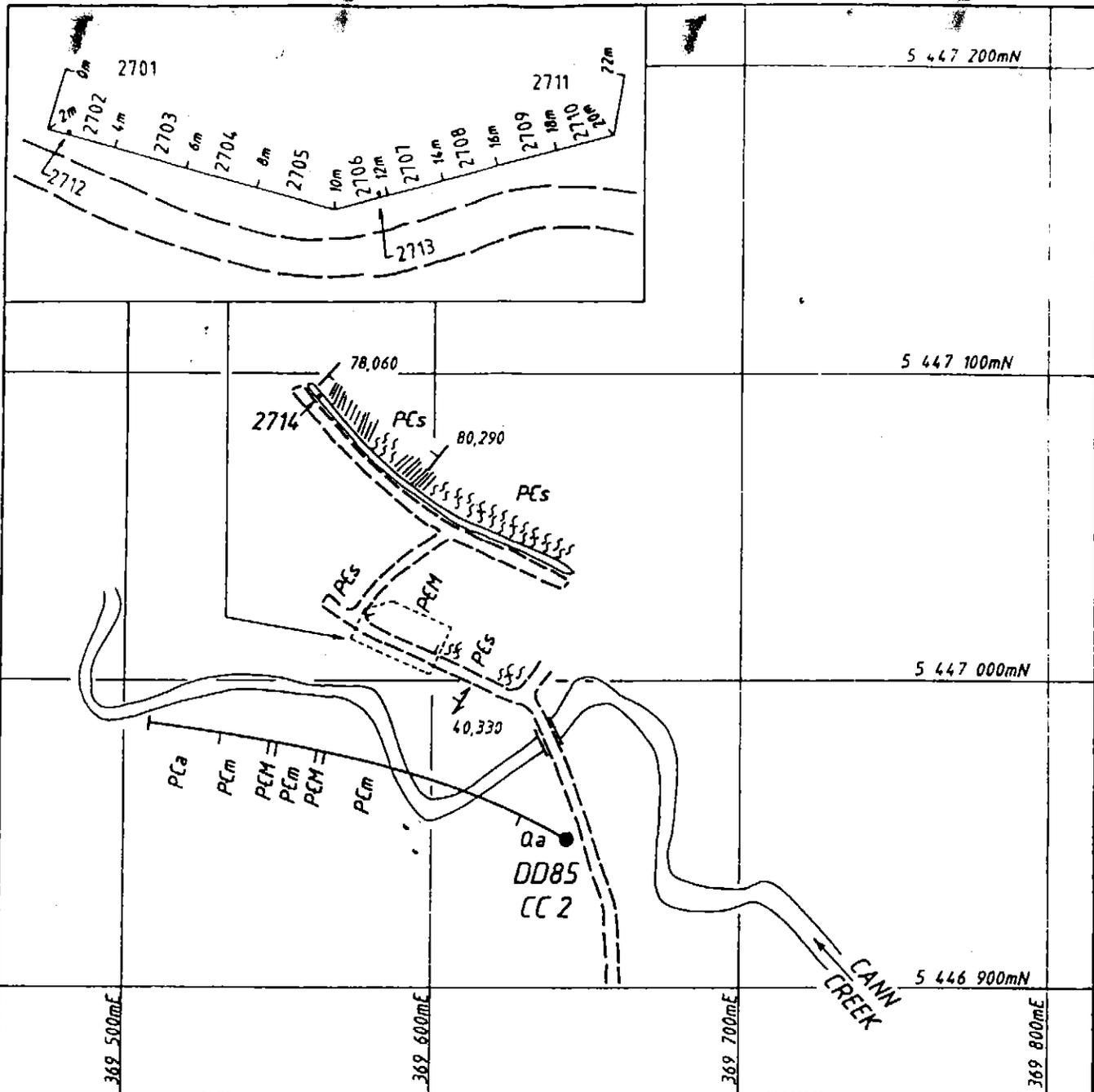
If the material north of the creek could also be worked to 40 metres below creek level, then an additional 65,000 tonnes of magnesite could be available.

The extent of magnesite south of the Cann Creek could best be checked by a series of back hoe trenches at 40, 100 and perhaps 150m south of the creek.



T. W. DICKSON

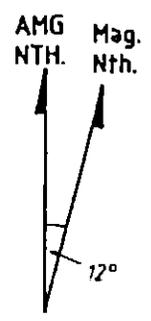




REFERENCE

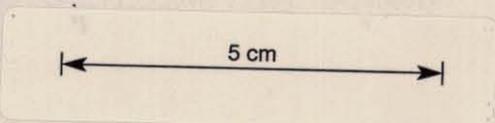
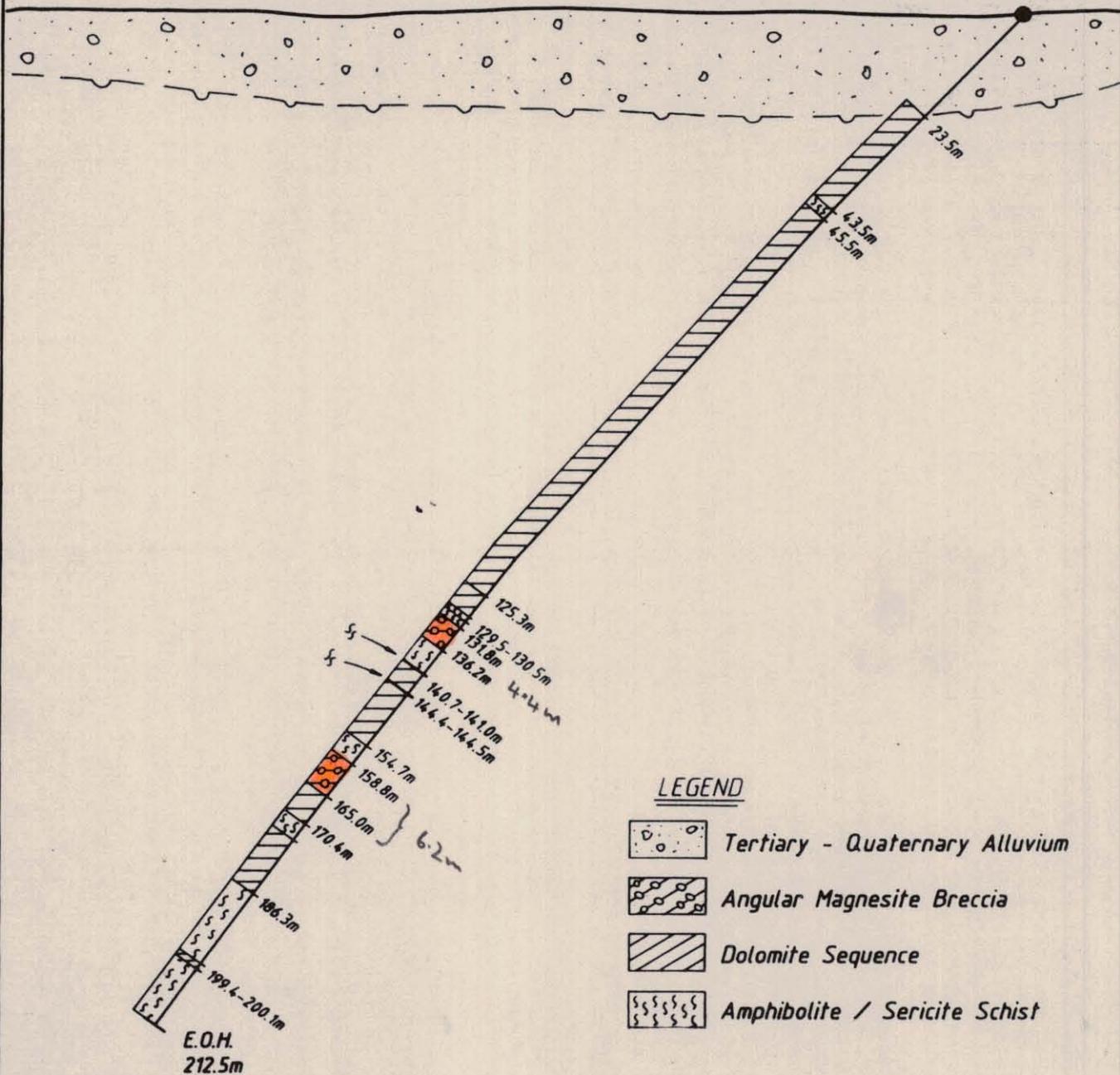
- Qa Quaternary alluvium
- PCm Interpreted magnesite. In CC2 is nearly entirely Dolomite
- PEM Magnesite
- PEa Amphibolite
- PEs Keith Beds
- Shear Zone
- Approximate dip of bedding
- Shear schistosity: dip, dip direction
- Bedding: dip, dip direction

All sample numbers prefixed by 165 .....



CRA EXPLORATION PTY. LIMITED		
ARTHUR RIVER E.L. 43/70 CANN CREEK PROSPECT GEOLOGY & SAMPLE No. LOCATION PLAN		
REF	SK55 - 3	( 7915 )
SCALE	1 : 2000	DRAWN R.T.
AUTHOR	F.R.F.	REPORT No.
DATE	8 7 1987	PLAN No. 1A(1) 2/CC

DD85 CC 2  
 Inclination : -46°  
 Azimuth : 285° (mag)



<b>CRA EXPLORATION PTY. LIMITED</b>	
ARTHUR RIVER E.L. 43/70 DD85 CC 2 SECTION	
REF.	SK55 - 3
SCALE	1 : 1000
AUTHOR	S.J.C.
DATE	25 - 6 - 1985
DRAWN	R.T.
REPORT No.	14728
PLAN No.	TASH 2664

SECTION 3

FEASIBILITY STUDIES

781050

*Arthur River - Metallurgy*

ARTHUR RIVER JOINT VENTURE

DESCRIPTION OF OPERATIONS AND ORDER OF  
MAGNITUDE COST ESTIMATES  
FOR THE PRODUCTION OF MAGNESITE AND MAGNESIA

Mineral Resource Studies

August, 1984

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## FIGURE

Figure 1	Location Plan
Figure 2	Lyons River DDH Location Plan
Figure 3	Magnesia Flowsheet and Material Balance.

## 1. SCOPE

This paper describes the conceptual operations and associated costs involved in the production of magnesite ( $MgCO_3$ ) and the production of magnesia ( $MgO$ ) from the Arthur River magnesite deposit.

It assesses within the limits of present knowledge;

- (a) the establishment of a small open pit at Lyons River;
- (b) for a magnesite operation, the establishment of a portable crusher at Lyons River;
- (c) for a magnesia operation, the establishment of a beneficiation and calcification plant at Lyons River;
- (d) the provision for a bulk storage facility within immediate locality of Burnie;
- (e) the provision for utilizing the Emu Bay Railway's bulk ship loading facility at Burnie port;
- (f) order of magnitude costs for the delivery of magnesite f.o.b. Burnie port based on 250,000 t.p.a. sales;
- (g) order of magnitude costs for the delivery of magnesia f.o.b. Burnie port based on 100,000 t.p.a. sales;

## 2. CONCLUSION

Based on present knowledge and assumptions;

- (a) an order of magnitude operating cost of \$30.00 per tonne of saleable product is estimated for the supply of 250,000 t.p.a. of magnesite product f.o.b. Burnie port. No capital expenditure is envisaged;
- (b) an order of magnitude operating cost of \$155.00 per tonne of saleable product is estimated for the supply of 100,000 t.p.a. of magnesia product f.o.b. Burnie port. A capital expenditure of around \$30,000,000 is estimated.

## 3. TENEMENT

## 3.1 Mineral Title

Exploration License No. 43/70 of 310 sq. km. is located in northwest Tasmania (refer figure 1).

In September 1984 E.L. 43/70 is to be reduced to 125 sq. km.

## 3.2 Title Holder/Land Ownership

Mineral Holdings Australia Limited is the current title holder of E.L. 43/70. Crown land (mainly forestry) covers the immediate area of interest at Lyons River. Arrangements to register CRAE's title ownership has been initiated.

## 4. PROJECT TYPE

A joint venture between CRA Exploration Pty. Limited and Mineral Holding Australia Pty. Ltd. commenced on 8th April 1982.

As at 30th June 1984, CRAE's cumulative total programme expenditure was \$737,161.00 earning 75% equity.

If MHA failed to contribute, CRAE could earn up to 90% equity.

## 5. GEOLOGY

## 5.1 Location and Access

Access to the main area of interest is via the Waratah Highway to Henrietta then by sealed and gravelled minor roads to the former saw-milling centre at West Takone. An all weather forestry road continues beyond West Takone over the Arthur and Keith Rivers and almost to the Lyons River. The road terminates at the Lyons River magnesite deposit.

The overall distance by road from the Lyons River magnesite deposit to Burnie is 62 kilometres.

Topography in the area is rugged, with relief up to 400 metres and slopes locally up to 50 degrees. Vegetation consists of horizontal scrub and valley slopes and myrtle and churchwood forests on ridge tops.

## 5.2 General

The magnesite deposits in the Arthur River region are situated in the N/NE striking belt of highly deformed Precambrian rocks known as the Arthur Lineament (8km to 15km wide). The Savage River iron ore and magnesite deposits occur within the Arthur Lineament and are thought to be correlatives of similar rocks within the Arthur/Lyons River region.

The eastern hanging wall is underlain by quartz and quartz mica schists, known as the Keith Schists and the western footwall sequence is dominated by amphibolite and pyritic siltstone.

The magnesite is considered to be derived by magnesium metasomatism of dolomite. Magnesium rich solutions generated during metamorphism, result in the replacement of limestone and dolomites by magnesites which have  $\text{SiO}_2$ ,  $\text{Fe}_2\text{O}_3$ ,  $\text{Al}_2\text{O}_3$  impurities inherent in the original carbonates in addition to the varying proportions of unreplaced dolomite.

Detail geological mapping has shown the magnesite is not continuous between the Lyons River and Arthur River locally, but occurs in discrete intervals along the magnesite/dolomite horizon.

## 6. DIAMOND DRILLING PROGRAMMES

As at December 1984, five diamond drill holes involving 1627.75 drilled metres were completed within the Lyons River locality and seven diamond drill holes, involving 1,611.6 drilled metres were completed within the Arthur River locality.

During 1984 six diamond drill holes involving 970 drilled metres were completed within the immediate area of DDH LR2 at Lyons River, and one diamond drill hole involving 289 metres was completed at Camm Creek.

## 7. RESOURCE

### 7.1 Tonnes

A potentially large deposit of moderate to high grade magnesite has been identified by geological mapping and diamond drilling at Lyons River.

Evaluation of the deposit as delineated by the "fill in" 1984 six hole diamond drill programme is pending analytical analysis. (refer fig. 2)

It is assumed a plus 25 million tonne magnesite resource amenable to open-pit mining is delineated.

### 7.2 Grade

Based on a 40% MgO cut-off grade at a minimum five metre interval the average analyses reported by each diamond drill hole follows:

## Lyons River Locality

D.D.H.	Cumulative Interval	MgO %	Fe <sub>2</sub> O <sub>3</sub> %	CaO %	SiO <sub>2</sub> %	Al <sub>2</sub> O <sub>3</sub> %
DD82 LR 1	198.6	42.97	1.71	3.07	3.07	0.06
DD83 LR 2	189.7	42.15	0.68	3.21	5.48	0.06
DD83 LR 3	5.2	44.98	1.04	2.52	0.50	0.05
DD83 LR 5	57.4	41.52	0.51	2.89	7.36	0.06
DD84 LR 6	68.5	41.41	1.71	3.08	6.61	0.05
DD84 LR 7	78.8	42.07	0.53	2.03	7.59	0.05
DD84 LR 8		Awaiting assays				
DD84 LR 9	20.5	41.59	2.20	2.34	5.75	0.05
DD84 LR10	Nil					
DD84 LR11A	Nil					

## Arthur River Locality

D.D.H.	Cumulative Interval	MgO %	Fe <sub>2</sub> O <sub>3</sub> %	CaO %	SiO <sub>2</sub> %	Al <sub>2</sub> O <sub>3</sub> %
DD83 AR2	105.0	41.61	0.70	2.60	8.12	0.05
DD83 AR3	81.0	42.39	2.16	2.24	4.47	0.11
DD83 AR5	10.0	43.94	1.12	1.55	4.02	0.05
DD83 AR6	79.1	41.40	1.46	2.61	7.86	0.07
DD83 AR7	155.8	42.52	1.64	2.22	5.88	0.05

Typical grades of other oxides within the intervals of interest report as -

B <sub>2</sub> O <sub>3</sub>	less than 0.05%
MnO and Na <sub>2</sub> O	less than 0.10%
SO <sub>3</sub> , K <sub>2</sub> O, TiO <sub>2</sub> , P <sub>2</sub> O <sub>5</sub> , PbO, ZnO, CuO, NiO and BaO	less than 0.01%

## 8. MAGNESITE OPERATION:

## 8.1 Description

## 8.1.1 Commodity

A natural cryptocrystalline magnesium carbonate MgCO<sub>3</sub> called magnesite, is the saleable product. Product quality is assumed to be satisfactory.

## 8.1.2 Production Schedule

Annual sales of 250,000 tonnes of crushed magnesite product f.o.b. Burnie Port are envisaged.

### 8.1.3 Mining Method

Open pit mining techniques are to be employed. A mining contractor will be engaged to conduct all aspects of the mining operation inclusive of site clearing and preparation, drilling and blasting, loading and hauling and waste dump maintenance.

Based on a waste to ore mining ratio of 1:1 the following annual material movement schedule is required:

Waste Material	300,000 tonnes per annum
Magnesite Material	300,000 tonnes per annum
Total Material Movement	600,000 tonnes per annum

### 8.1.4 Processing

A self-powered portable crushing and screening plant is to be installed, operated and maintained by a mining contractor. Run-of-mine magnesite is crushed to minus 50mm plus 3mm product size. An undersize reject of one tonne from every six tonnes crushed is estimated.

### 8.1.5 Transportation

The crushed product is loaded into 20 tonne trucks and hauled the 62 kilometres to Burnie, where the product is stored in an appropriate storage facility provided by the haulage contractor.

On demand the product is reclaimed from the storage facility and hauled by 20 tonne trucks to the bulk loading facility owned and operated by the Emu Bay Railway at the Burnie port.

### 8.1.6 Shiploading

The Emu Bay Railway's bulk loading facility at Burnie Port is available.

The product is stockpiled adjacent to the external bulk loader feeder system (south of the existing base metal concentrate storage shed). Front end loaders will feed onto the main conveyor system. A maximum loading rate of 500 tonnes per hour is estimated for magnesite.

Vessels of 25,000 tonne capacity can be accommodated.

## 8.2 Operating Costs

### 8.2.1 Mining

Based on Brambles indicative quotation.

## 8.2.1.1 Waste Mining

Unit activities include site preparation, (removal of vegetation and topsoil) drilling, blasting, loading and hauling to waste dump, and maintenance of waste dump.

300,000 t.p.a. @ \$3.30 per tonne mined.

## 8.2.1.2 Magnesite Mining/Processing

Unit activities include drilling, blasting, loading and hauling to portable crusher, feeding portable crusher, crushing to minus 50mm plus 3mm, stockpiling, and disposed of minus 3mm undersize.

300,000 t.p.a. @ \$7.36 per tonne crushed.

## 8.2.2 Haulage

Based on Brambles indicative quotation. Unit activities include reclaiming crushed product from portable crusher stockpile, haul 62 kilometres to storage facility at Burnie, store, and on demand reclaim and haul to Emu Bay Railway bulk loading facility at Burnie Port. (Involves double handling.)

250,000 t.p.a. of saleable product @ \$11.20 per tonne, i.e. around 18 cents per tonne per kilometre.

## 8.2.3 Bulk Loading

Based on Emu Bay Railway's indicative quotation. The product is reclaimed from the temporary stockpile adjacent to the base metal concentrate storage facility and fed to the bulk loader at around 500 tonne per hour discharge rate.

250,000 t.p.a. of saleable product @ \$3.00 per tonne.

A \$1.05 per tonne bulk loading charge is payable to the Marine Board of Burnie.

250,000 t.p.a. of saleable product @ \$1.05 per tonne.

## 8.2.4 Administration

Maintenance of the mining leases, administration of the mining contract, preparation of mine planning schedules/budgets/product specifications, drilling and sampling analytical requirements, survey computations and environmental monitoring requirements requires the following J.V. work force and equipment:

- 7 -

1 x J.V. Manager/Geologist	\$100,000 per annum
2 x Field Assistant	\$ 60,000 per annum
Drilling and analytical work	\$ 50,000 per annum
Surveys	\$ 25,000 per annum
General Administration inclusive of provision for office and vehicles	\$100,000 per annum
Assistance re forestry road maintenance	\$100,000 per annum

## 8.2.5 Operating Cost Summary

Activity	Unit Cost \$ per tonne	Annual Cost \$
Mining - waste	\$ 3.30	\$ 990,000
Mining and processing magnesite	\$ 7.36	\$2,208,000
Road haulage - mine site to Burnie	\$11.20	\$2,800,000
Bulk loading - Burnie Port	\$ 3.00	\$ 750,000
Bulk wharf charge - Marine Board of Burnie	\$ 1.05	\$ 262,500
Project Administration		\$ 435,000
Total		\$7,445,500
Per tonne saleable product f.o.b. Burnie		\$ 30

## 9. MAGNESIA OPERATION

## 9.1 Description

## 9.1.1 Commodity

A calcinated magnesium oxide MgO called magnesia (dead burned magnesite) is the saleable product. Product quality is assumed to be satisfactory.

## 9.1.2 Production Schedule

Annual sales of 100,000 tonnes of magnesia product f.o.b. Burnie Port are envisaged.

## 9.1.3 Mining Method

Open pit mining techniques are to be employed. A mining contractor will be engaged to conduct all aspects of the mining operation inclusive of site clearing and preparation, drilling and blasting, loading and hauling and waste dump maintenance.

Based on a waste to ore mining ratio of 1:1, the following annual material movement schedule is required:

Waste Material	300,000 tonnes per annum
Magnesite Material	300,000 tonnes per annum

Total Material Movement 600,000 tonnes per annum

## 9.1.4 Processing

The process flowsheet and material balances involving crushing, screening, precalcination, beneficiation and final dead burning calcination is summarized in Figure 3.

## 9.1.4.1. Crushing and Screening Plant

The following major equipment items are included in this plant;

Truck dump hopper with grizzly	10m <sup>3</sup> capacity
Primary (jaw crusher)	760mm x 510mm
Single Deck Screen	50mm screen
Secondary (Gyratory) crusher	710mm
Single Deck Screen	6mm screen
Hammer Mill	1270mm x 900mm
Rock breaker for lump ore	
5 x conveyors	600mm width
Radial stacker	15 metres
Front end Loader	Cat 920

## 9.1.4.2 Precalcination Plant

The precalcination plant comprises 2 x fluidized bed calciners. Each calciner has preheating calcining (750°C) and cooling sections and external ancillary equipment, including feed and discharge conveyors, surge bin fuel system and fluidized bed/water tube, final cooler, dust cyclones, induced draft fan and stack. Feed material is reclaimed from the crushed ore stockpile by front end loader.

## 9.1.4.3 Beneficiation

A range of physical beneficiation process are applicable to magnesite, from the conventional such as optical sorting, magnetic separation, flotation and H.M.S. to the advanced, such as pressure leaching. For this study recognition of an undefined beneficiation unit activity is included.

## 9.1.4.4 Dead Burning Plant

The dead burning plant comprises 2 x fluidized bed calciners 2.27m diameter and approximately 16m high operating in parallel.

## 9.1.4.5 Product Handling and Storage

Dead burned products are stored in silos from which they are loaded by conveyor onto trucks for road haulage.

## 9.1.4.6 Tailings Disposal

The tailings disposal system includes tailings pumps and pipeline, initial dam construction decant tower and outfall pipes.

## 9.1.4.7 Service Facilities

Provision is made for;

- (a) 10km of new 22kv overhead power line and 22kv switchroom, sub-stations at the major plant locations and a 2km 22kv overhead line to the water supply pump station;
- (b) a 4150 kl per day water supply facility;
- (c) an appropriate compressed air facility;
- (d) heavy fuel oil storage facility;
- (e) cooling water system;
- (f) sewage treatment plant;
- (g) buildings and equipment associated with;

Administration  
Laboratory  
Workshop/Warehouse  
Mobile Equipment Service  
Magazines  
Fire Station/Equipment  
Change Room/Crib  
Gale House/Weighbridge

## 9.1.5 Transportation

The magnesia product is loaded into 20 tonne trucks and hauled the 62 kilometres to Burnie where the product is stored in an appropriate storage facility provided by the haulage contractor.

On demand the product is reclaimed from the storage facility and hauled by 20 tonne trucks to the bulk loading facility owned and operated by the Emu Bay Railway at the Burnie port.

## 9.1.6. Shiploading

The Emu Bay Railway's bulk loading facility at Burnie port is available.

The product is stockpiled adjacent to the external bulk loader feeder system (south of the existing base metal concentrate storage shed). Front end loaders will feed the product onto the main conveyor system. A maximum loading rate of 500 tonnes per hour is estimated for magnesia.

Vessels of 25,000 tonne capacity to be accommodated.

## 9.2 Operatint Costs

## 9.2.1 Mining

Based on Brambles indicative quotation.

Unit activities include site preparation (removal of vegetation and topsoil) drilling, blasting, hauling to crusher and waste dump, and maintenance of waste dump.

600,000 t.p.a. @ \$3.30 per tonne mined

## 9.2.2 Processing

Basis: Sheddon Pacific Pty. Ltd. cost estimate.

	Annual Costs
Personnel	\$ 2,000,000
Fuel	\$ 3,950,000
Power	\$ 500,000
Operating Supplies	\$ 200,000
Maintenance Supplies	\$ 500,000
Contingency @ 25%	\$ 1,850,000

- 11 -

Sub Total	\$ 9,000,000
-----------	--------------

plus

Beneficiation Allowance (\$10.00 per tonne)	\$ 1,000,000
------------------------------------------------	--------------

Total	\$10,000,000
-------	--------------

Per tonne of saleable product	\$ 100
-------------------------------	--------

## 9.2.3 Haulage

Based on Brambles indicative quotation.

Unit activities include reclaiming crushed product from silos, haul 62 kilometres to storage contents at Burnie, store and on demand reclaim and haul to Emu Bay Railway bulk loading facility at Burnie port.

100,000 t.p.a. of saleable product @ \$11.20 per tonne, i.e. around 18 cents per tonne per kilometre.

## 9.2.4 Bulk Loading

Based on Emu Bay Railway's indicative quotation. The product is reclaimed from the temporary stockpile adjacent to the base metal concentrate storage facility and fed to the bulk loader at around 500 tonnes per hour.

100,000 t.p.a. of saleable product @ \$3.00 per tonne.

A \$1.05 per tonne bulk loading charge is payable to the Marine Board of Burnie.

## 9.2.5 Project Administration

A provision of \$2,000,000 (\$10.00 per tonne of saleable product) is estimated for general project administration and management.

## 9.2.6 Operating Cost Summary

Activity	Unit Cost \$ per tonne	Annual Cost \$
Mining	\$ 3.30	\$ 1,980,000
Processing	\$ 100.00	\$10,000,000
Road haulage - mine site to Burnie	\$ 11.20	\$ 1,120,000

Bulk loading - Burnie Port	\$ 3.00	\$ 300,000
Bulk wharf charge - Marine Board of Burnie	\$ 1.05	\$ 105,000
Project Administration	\$ 20.00	\$ 2,000,000
Total		\$15,505,000
Per tonne of saleable produce f.o.b. Burnie		\$ 155

## 9.3 Capital Costs

Basis: Sheddon Pacific Pty. Ltd. cost estimate.

## Process Facilities

	\$
Crushing and Screening	900,000
Precalcination	5,700,000
Beneficiation	5,000,000
Dead Burning	4,400,000
Storage and Handling	600,000
Tailings Disposal	400,000

## Service Facilities

Power supply and distribution)	
Water supply )	350,000
Compressed Air	100,000
Fuel Storage	120,000
Cooling Water System	60,000
Sewage Treatment	80,000
Communication	100,000

## Site Works

Building and Equipment	2,200,000
Roads and Civil Works	600,000
Mobile Equipment	400,000

## Other

Engineering Procurement and Construction Management	2,290,000
Working Capital	1,500,000
Contingency @ 25%	4,800,000

Total	\$29,600,000
-------	--------------

say	\$30,000,000
-----	--------------

Figure 1

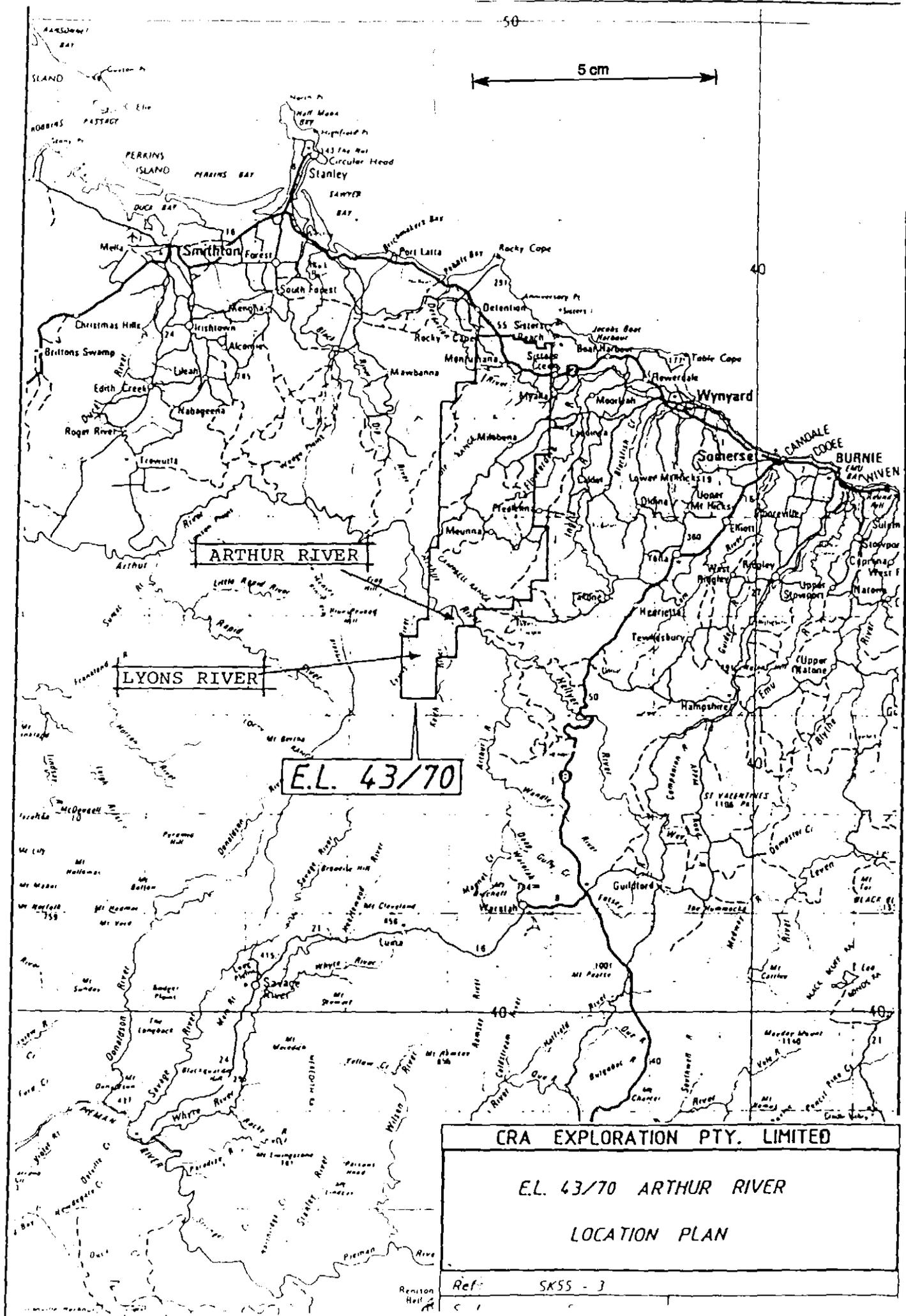


Figure 2

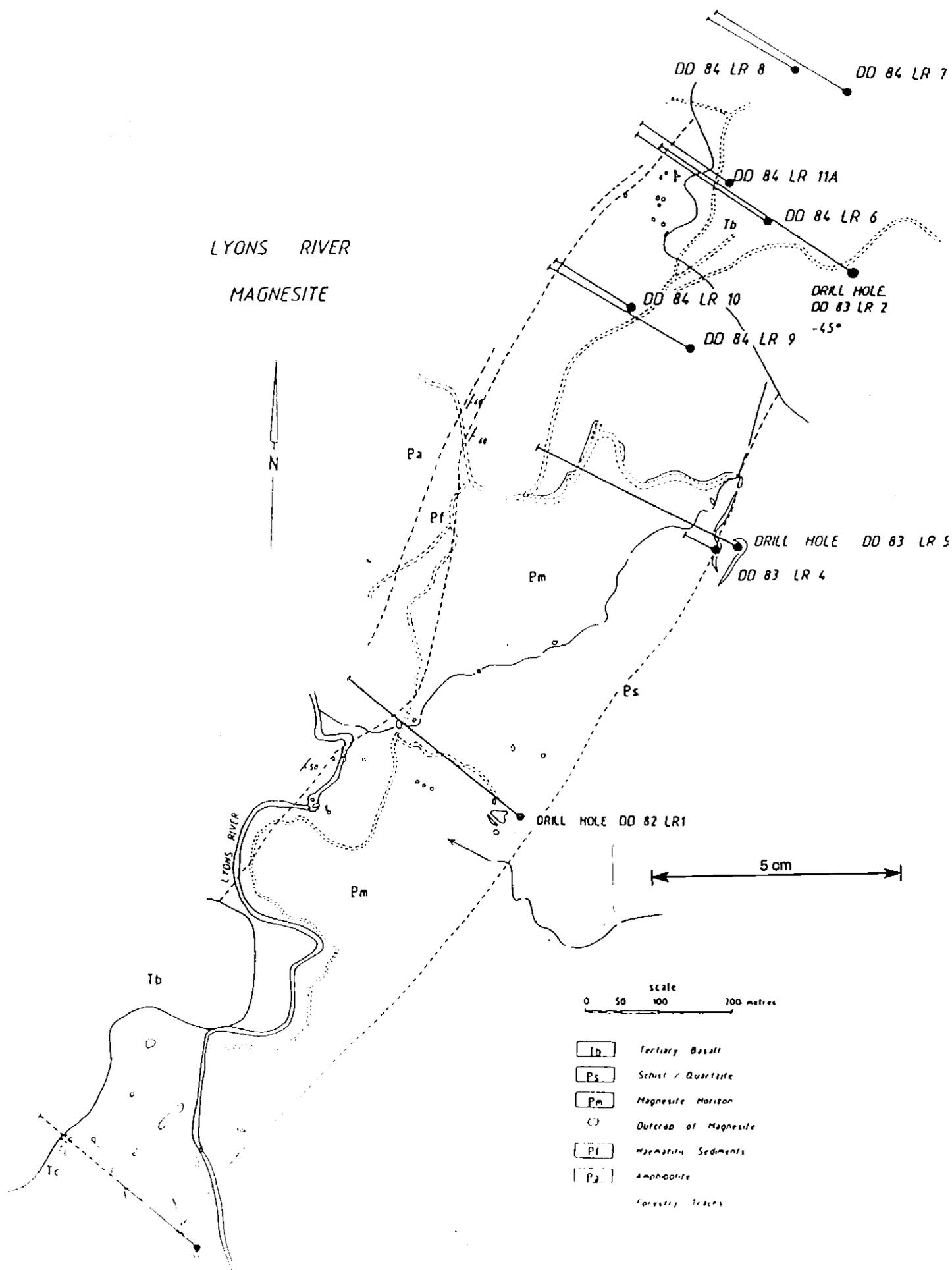
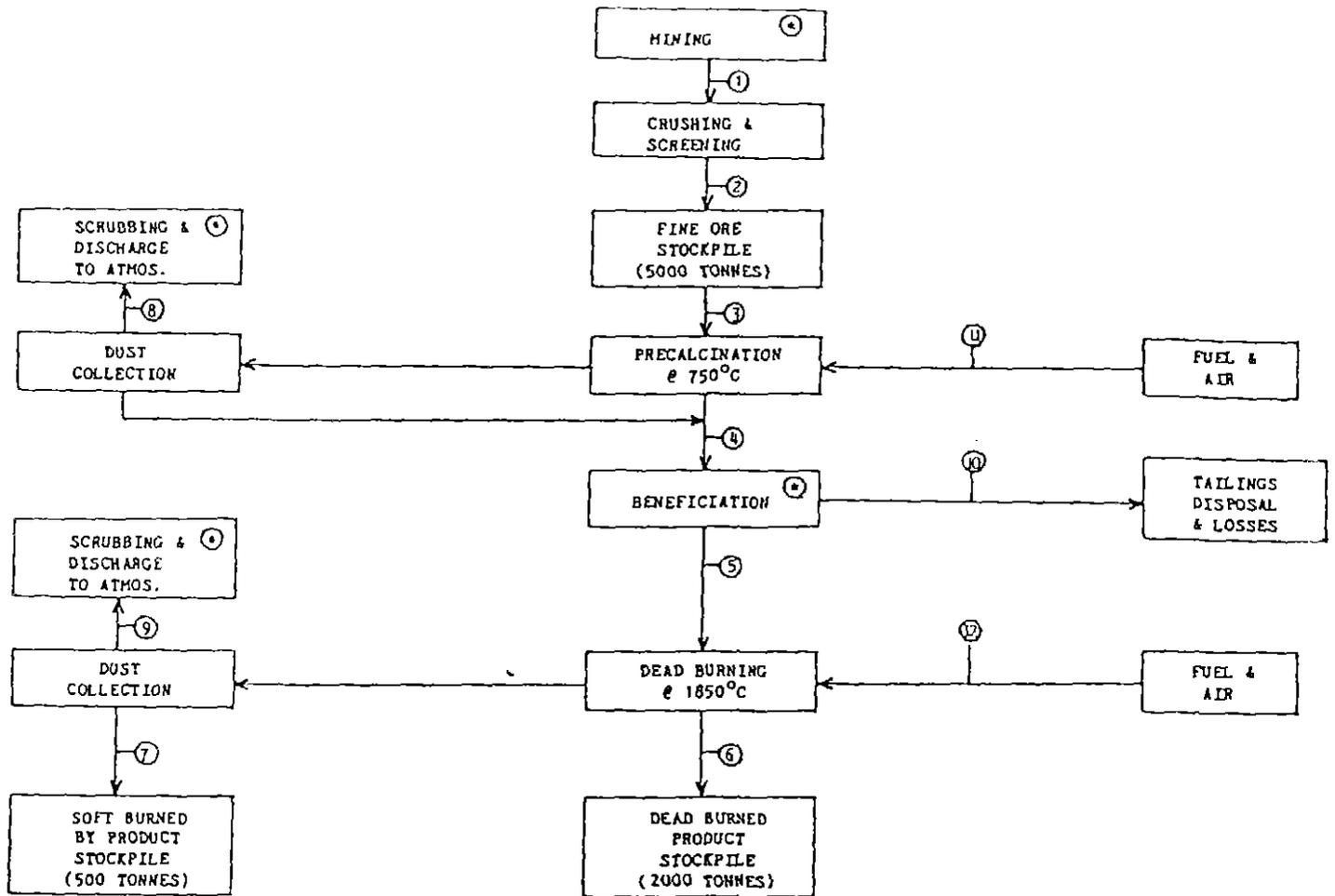


Figure 3

FLWSHEET & MATERIAL BALANCE



STREAM	1	2	3	4	5	6	7	8	9	10	11	12
TONNES x 1000/YEAR												
- MgCO <sub>3</sub>	251	251	251	17	12	-	1.5	-	-	5	-	-
- GANGUE	49	49	49	49	3	3	0.5	-	-	46	-	-
- MgO	-	-	-	112	106	97	14	-	-	6	-	-
- CO <sub>2</sub>	-	-	-	-	-	-	-	122	5	-	-	-
- PRODUCTS OF COMBUSTION	-	-	-	-	-	-	-	214	69	-	-	-
- HEAVY FUEL OIL	-	-	-	-	-	-	-	-	-	-	13	4
- AIR	-	-	-	-	-	-	-	-	-	-	201	65
TOTAL	300	300	300	178	121	100	16	336	74	57	214	69
SIZE												
MC:	-1000	-6	-6	-6	-6	-6	-6	-	-	-	-	-

TABLE 4

BEST RESULT FROM TESTWORK ON  
THE BASIS OF SIMPLICITY, SELECTIVITY,  
GRADE AND RECOVERY (TEST 59)

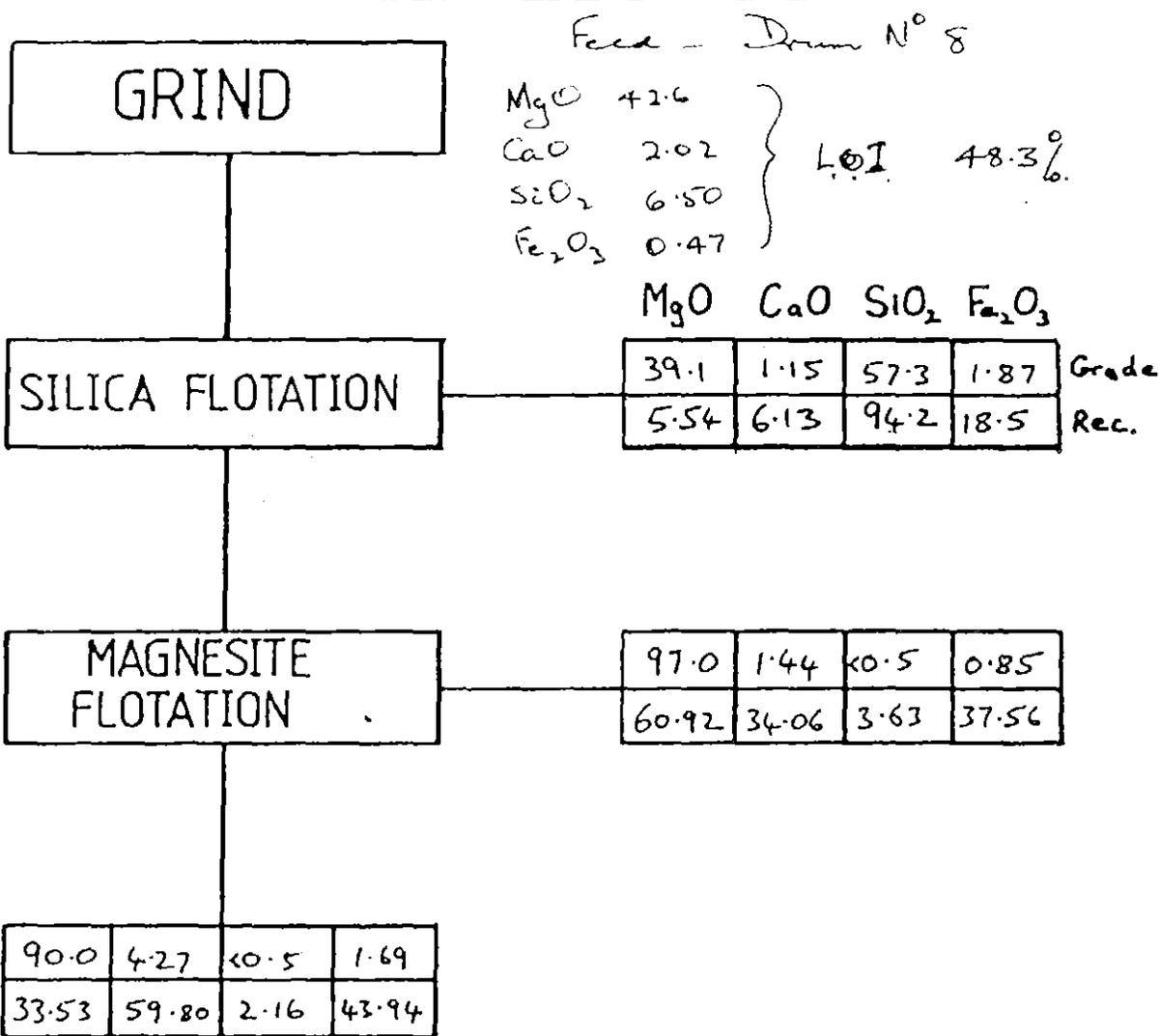


Table 6. Installed Magnesium Production Capacity (1978)

Country	Producer	Production capacity, metric tons/yr	Type of production process <sup>a</sup>	Magnesium source
United States	The Dow Chemical Co., Freeport, Texas	115,000	E	seawater, dolomite
	NI. Industries, Rowley, Utah	22,000	E	brine
	American Magnesium, Snyder, Texas	5,000	E	brine
	Northwest Alloys, Addy, Washington	22,000	T	dolomite
Norway	Norsk Hydro, Porsgrunn	50,000	E	seawater, brine, dolomite
France	Société Française d'Electrometallurgie, Marignac	10,000	T	dolomite
Italy	Sta. Italiana Per Il. Magnesio E Leghe Di Magnesio, Bolzano	12,000	T	dolomite
Japan	UBE Industries Ltd., UBE	6,500	T	seawater
	The Furukawa Magnesium Co., Ltd. Tochigi	6,500	T	dolomite
Canada	Chromasco, Haley, Ontario	9,000	T	dolomite
USSR		72,000 <sup>b</sup>	E	carrollite

<sup>a</sup> E = electrolysis, T = thermal reduction

<sup>b</sup> Estimated

duction for sale to magnesium consumers for a wide variety of uses. Table 5 gives the production statistics of various countries in recent years. Table 6 gives production capacities.

Magnesium is the world's most readily available metal. The ocean is an enormous reservoir of magnesium, whereas other engineering metals face the eventual exhaustion of their most economical ore bodies. Thus, it may be expected that magnesium could become increasingly more important in the future as costs of production of other structural metals increase.

Because of magnesium's low density, the unit volume cost of magnesium has often been lower than that of other common structural metals such as aluminum and zinc. In 1915, the price of magnesium in the United States was \$11/kg; it was reduced steadily until it reached \$0.45/kg in 1943. From 1950 to 1973, prices increased gradually and reached \$0.83/kg for primary ingot. The price of magnesium began to escalate appreciably in 1974 as a result of increased energy costs. The price history of magnesium from 1943 to 1979 is shown in Table 7.

The U.S. magnesium industry serves a wide variety of structural and nonstructural uses. Consumption by principal uses is given in Table 8.

### Specifications

Commercial primary magnesium has a typical purity of ca 99.8%, which is sufficient for most chemical and metallurgical uses. A typical analysis might be expected to show about 0.003% each of aluminum and copper, 0.03% iron, 0.08% manganese,

Table 1

## World Magnesium Production Capacity

	<u>Company</u>	<u>Process</u>	<u>Annual Capacity (tons)</u>
<u>Brazil</u> <sup>+</sup>	<u>Brasileiro de Magnesio</u>	<u>Magnethermic</u>	<u>6,000</u> ✓
<u>Canada</u>	<u>Chromasco Limited</u>	<u>Silicothermic</u>	<u>11,000</u> ✓
<u>France</u>	<u>Societe Francaise d'Electrometallurgie (SOFREM)</u>	<u>Magnetherm</u>	<u>9,900</u> ✓
<u>Italy</u>	<u>Societe Italiana per il Magnesio e Leghe di Magnesio</u>	<u>Silicothermic</u>	<u>12,700</u> ✓
<u>Japan</u>	<u>Furukawa Magnesium, Ltd.</u>	<u>Silicothermic</u>	<u>7,200</u> ✓
	<u>Ube Industries, Ltd.</u>	<u>Silicothermic</u>	<u>7,200</u> ✓
<u>Norway</u>	<u>Norsk Hydro</u>	<u>Electrolytic</u>	<u>55,000</u>
<u>U.S.S.R.</u>	<u>Various</u>	<u>Electrolytic</u>	<u>(71,000)*</u>
<u>United States</u>	<u>Dow Chemical Company</u>	<u>Electrolytic</u>	<u>125,000</u>
	<u>AMAX</u>	<u>Electrolytic</u>	<u>28,000</u>
	<u>Northwest Alloys (Alcoa Subsidiary)</u>	<u>Magnetherm</u>	<u>24,000</u> ✓
	<u>American Magnesium Company</u>	<u>Electrolytic</u>	<u>10,000</u>
<u>Yugoslavia</u>	<u>Magnohron Oour Bela Stena</u>	<u>Magnetherm</u>	<u>5,000</u> ✓
	<b>TOTAL</b>		<b>301,500</b>

*of which  
Thermal*

*83,000 t/a  
(28/6)*

<sup>+</sup> Expected to begin production in 1982.

\*Estimate not included in total.

Sources: U.S. Bureau of Mines Minerals Yearbook, Canadian Department of Energy, Mines and Resources, International Magnesium Association, and Personal Communication.

Table 2

## Comparison of Electrolytic and Metallothermic

## Process for Magnesium Production



	Electrolytic	Metallothermic
Current world capacity (tons)	218,500	<u>83,000</u>
Maximum plant size (tons)	125,000	<u>26,000</u>
Average plant size	54,625	<u>10,375</u> *
Energy requirements (kwh thermal/lb Mg)	42.8	<u>41.1</u>
Electrical energy requirements	48%	<u>70%</u>
Estimated capital cost for new plant (\$/annual ton capacity) Sample plant size: 20,000 annual tons	4,500	3,500

\* A 25,000 t/a magnes<sup>ium</sup> plant would represent 9.3% of current world capacity; it would be a relatively large plant.

Assuming 77% overall recovery of Mg, such a plant would use about 115,000 t/a

Table 6. Installed Magnesium Production Capacity (1978)

Country	Producer	Production capacity, metric tons/yr	Type of production process <sup>a</sup>	Magnesium source
United States	The Dow Chemical Co., Freeport, Texas	115,000	E	seawater, dolomite
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France	Société Française d'Electrometallurgie, Marignac	10,000	T	dolomite
Italy	Sta. Italiana Per Il Magnesio E Leghe Di Magnesio, Bolzano	12,000	T	dolomite
Japan	UBE Industries Ltd., UBE	6,500	T	seawater
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CRA SERVICES LIMITED

TASMANIAN MAGNESITE STUDY  
PRELIMINARY COST ESTIMATE  
FOR  
PROCESS PLANT

PREPARED BY

SHEDDEN PACIFIC PTY. LIMITED

## SHELDON PACIFIC PTY. LIMITED

TABLE OF CONTENTS

1. INTRODUCTION
  2. PROCESS FLOWSHEET & METALLURGICAL PARAMETERS
  3. DESCRIPTION OF FACILITIES & BASIS FOR CAPITAL COST ESTIMATES
  4. OPERATING COST BASIS
  5. CAPITAL COST SUMMARY
  6. OPERATING COST SUMMARY
- ATTACHMENT A. CRA Services Ltd. letter dated  
25 November 1983
- ATTACHMENT B. "New Process for Recovery of Magnesite  
from its Ores by Calcination"  
by Frangiskos and Kontopoulos

## SHEDDEN PACIFIC PTY. LIMITED

CRA SERVICES LIMITED  
TASMANIA MAGNESITE STUDY  
PRELIMINARY ESTIMATES FOR PROCESS PLANT

## 1. INTRODUCTION

CRA Services Ltd., in its letter dated 25th November 1983 (Refer Attachment A), issued a study brief relating to the early investigation of a magnesite prospect in Tasmania. The study, which was subsequently awarded to Shedden Pacific Pty. Limited, required preparation of order of magnitude capital and annual operating cost estimates for the crushing, screening and calcining plant and related services and facilities.

The nature of the required study was further defined in later discussions with CRA staff to the extent that it should be based on a "standard" process flowsheet which assumes that the ore behaves in an extremely favourable manner. CRA further required that mining, beneficiation, atmospheric pollution control facilities and all housing and community facilities be excluded from the study. Other capital items for the plant such as crushing and screening, fuel supply, civil works, electric power, tailings disposal, product storage are all included.

## SHELDON PACIFIC PTY. LIMITED

## 2. PROCESS FLOWSHEET AND METALLURGICAL PARAMETERS

The stated criteria for the study include feed to the crusher of +40% MgO magnesite ore at a rate of 300,000 tpa and a product of 100,000 tpa of +97% MgO dead burned magnesite. The implication of these figures is that the ore contains some 16% gangue material and that a beneficiation stage is necessary.

Although process selection and estimates of costs for the beneficiation stage were excluded from the scope of the study, it was necessary to briefly consider this process step in order to determine the most appropriate approach to staging of the calcination process.

A range of beneficiation processes are applicable to magnesite ore and the selection of the appropriate process can only be made at a much later stage in the project development. Such processes depend on the difference in properties of the magnesite and the gangue material. Processes can range from the conventional (such as optical sorting, magnetic separation, flotation, and HMS or air classification) to the advanced (such as pressure leaching).

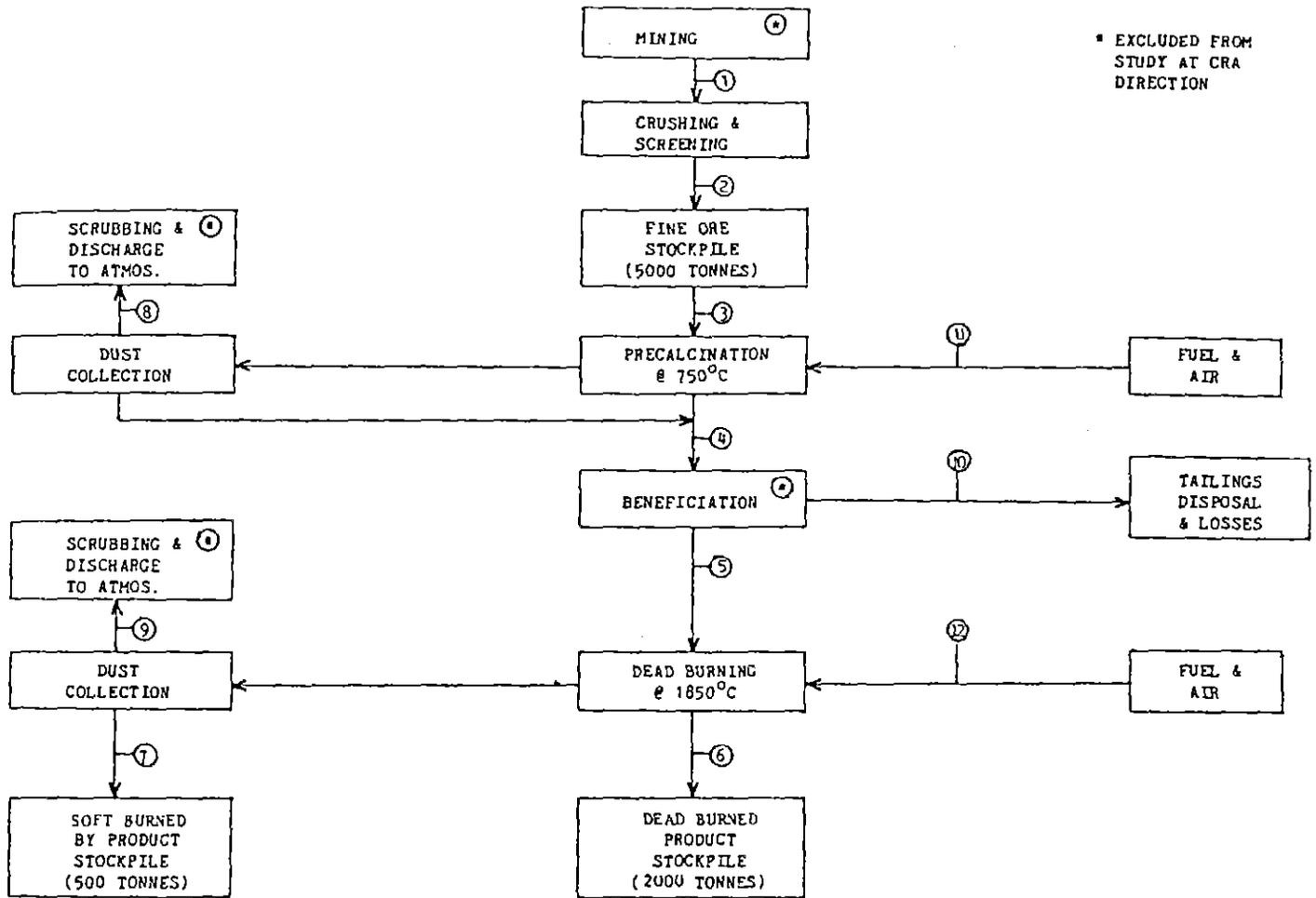
Beneficiation may be carried out before or after dead burning but the former is recommended as the gangue material would most certainly cause sintering and reaction problems at the high temperature of the dead burning process.

There would appear to be some advantage in recovery and operating economies if a dry process achieves the required beneficiation as compared with wet heavy medium separation or flotation. (Ref. Attach. B describing the process selection for the FIMISCO plant in Greece). However, for the purpose of developing a "standard" flowsheet, it has been assumed after discussions with CRA staff, that a wet beneficiation process be assumed and that allowance be made in the estimates for wet tailings disposal.

The process flowsheet, selected for this study, includes a precalcining stage (750°C) followed by beneficiation and then by the dead burning stage (1850°C). See Fig. 1. The precalcining step has been included for the following reasons:

- Depending on the beneficiation process, there may be significant advantage in the fact that precalcining increases the difference in specific gravity between gangue and the magnesite thereby improving separation efficiency. Typically the SG of magnesite and gangue in the raw ore are 2.7-2.8 and 2.4-2.6 respectively. After precalcining (soft burning) the SG's are 1.3-1.6 and 2.2-2.3 respectively.

TASMANIAN MAGNESITE STUDY  
 FIG. 1 FLOWSHEET & MATERIAL BALANCE

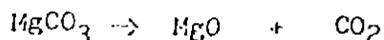


EXCLUDED FROM STUDY AT CRA DIRECTION

STREAM	1	2	3	4	5	6	7	8	9	10	11	12
TONNES x 1000/YEAR												
- MgCO <sub>3</sub>	251	251	251	17	12	-	1.5	-	-	5	-	-
- GANGUE	49	49	49	49	3	3	0.5	-	-	46	-	-
- MgO	-	-	-	112	106	97	14	-	-	6	-	-
- CO <sub>2</sub>	-	-	-	-	-	-	-	122	5	-	-	-
- PRODUCTS OF COMBUSTION	-	-	-	-	-	-	-	214	69	-	-	-
- HEAVY FUEL OIL	-	-	-	-	-	-	-	-	-	-	13	4
- AIR	-	-	-	-	-	-	-	-	-	-	201	65
TOTAL	300	300	300	178	121	100	16	336	74	57	214	69
-----												
SIZE												
MM	-1000	-6	-6	-6	-6	-6	-6	-	-	-	-	-

## SHEDDEN PACIFIC PTY. LIMITED

- Approximately 80% of the heat required for the overall process is required for the endothermic reaction



If this is achieved at 750°C the kiln size is smaller and the fuel consumption less than if the process is carried out in a single stage at 1850°C.

- It is preferable for operating and maintenance reasons to have two kilns operating at 750°C and two kilns at 1850°C rather than four kilns at 1850°C.

Table 1 indicates the order of magnitude estimates of capital cost for calciners and the respective fuel consumptions for a number of schemes considered.

Table 1: Comparison of Beneficiation/Hard Burning Schemes

Schemes	Calciners	Approx. Total Cost \$ million (Jan. 1984)	Heavy Fuel Oil Consumption (tpa)
<u>Selected Scheme</u>			
Precalcining	2x2.78m dia.	9.55	16,800
Beneficiation	-		
Hard Burning	2x2.27m dia.		
<u>Alternative Scheme A</u>			
Hard Burning	4x3.35m dia.	17.0	17,580
Beneficiation	-		
<u>Alternative Scheme B</u>			
Beneficiation	-	15.0	15,600
Hard Burning	4x3.14m dia.		

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The following additional assumptions have been made in the selection of the flowsheet:

- . The beneficiation process will be able to achieve the required degree of gangue rejection.
- . Carryover product from the dead burning stage will be saleable as a soft burned by-product. It would alternatively be possible to consider pelletizing this material and re-feed it to the dead burning stage.

## SHELDEN PACIFIC PTY. LIMITED

## 3. DESCRIPTION OF FACILITIES &amp; BASIS FOR CAPITAL COST ESTIMATES

3.1 Crushing and Screening Plant

The crushing and screening plant has been assumed to operate on the same shift cycle as the mine, i.e. 2x10 hr. shifts per day, 5 days/week. Throughput rate is therefore 1200 tpd. The crushed ore is delivered to a 5000 tonne stockpile (4 days capacity). The following major equipment items are included in this plant:

- . Truck Dump Hopper with Grizzly - 10m<sup>3</sup> capacity
- . Primary (Jaw) Crusher - 760mmx510mm
- . Single Deck Screen - 2400mmx1200mm, 50mm screen
- . Secondary (Gyratory) Crusher - 710mm
- . Single Deck Screen - 3000mmx1200mm, 6mm screen
- . Hammer Mill, Centre Feed - 1270mmx900mm
- . Rock Breaker for Lump Ore
- . 5 x Conveyors - 600mm width, varying length
- . Radial Stacker - 15m
- . Front End Loader - Cat 920 or equiv.

The capital cost estimate for this plant is based on factoring of current budget prices received from equipment vendors.

3.2 Precalcination Plant

The precalcination plant comprises 2 x fluidized bed calciners, 2.78m dia x approx. 16m high, operating in parallel. Each calciner has preheating, calcining (750°C) and cooling sections and external ancillary equipment including feed and discharge conveyors, surge bin, fuel system, a fluidized bed/water tube final cooler, dust cyclones, induced draft fan and stack. Feed material is reclaimed from the crushed ore stockpile by front end loader.

This plant has been assumed to operate on 3x8 hr shifts/day, 7 days/week with the feed rate consequently being 860 tpd.

The capital cost estimate for this plant is based on factoring from a recently completed more detailed study.

## SHELDEN PACIFIC PTY. LIMITED

3.3 Dead Burning Plant

The dead burning plant comprizes 2 x fluidized bed calciners 2.27m. dia and approximately 16m high, operating in parallel. Each calciner has preheating, dead burning (1850°C) and cooling sections and external ancillary equipment including surge bin, fuel system, a fluidized bed/water tube final cooler, dust cyclones and induced draft fan and stack.

The capital cost estimate for this plant is based on factoring from a recently completed more detailed study.

3.4 Product and By-Product Handling & Storage

Dead burned product and soft burned by-product are stored in silos from which they are loaded by conveyor into trucks for road haulage out. A storage capacity of 7 day's production of dead burned magnesite has been allowed (i.e. 2000 tonnes) and 11 days of soft burned magnesite (i.e. 500 tonnes). The following items of major equipment are included in this plant.

- . Product & by-product transfer conveyors from the dead burning plant.
- . 4 x Product silos - 6m dia. x 16m high
- . 1 x By-Product silo - 6m dia. x 16m high
- . Reclaim conveyor and loadout facility.

The capital cost estimate for this plant is based on current budget prices from equipment vendors.

3.5 Tailings Disposal

CRA Services requested an indication of capital costs for a tailings disposal system as may be associated with a wet beneficiation process. The capital costs associated with such a system will vary considerably with the process and the terrain.

The costs included herewith are factored from those previously developed for a base metals beneficiation process in Tasmania. This tailings disposal system typically included the tailings pumps and pipeline, initial dam construction, decant tower and outfall pipes.

## SHELDEN PACIFIC PTY. LIMITED

3.6 Service Facilities3.6.1 Power Supply & Distribution

The estimate of the cost of the power supply line has been based on 10 km of new 22 kV O.H. line connecting to the HEC grid at West Takone. No allowance has been made for upgrading the existing line between Somerset and West Takone although some upgrade would most probably be necessary.

Distribution facilities covered in the estimate include a 22 kV switchroom, cabling, sub-stations at the major plant locations and a 2 km 22 kV O.H. line to the water supply pump station.

3.6.2 Water Supply, Treatment & Distribution

It has been assumed that a wet beneficiation process will be used and the water supply system has been based on a typical water usage for such a process. The water requirements for beneficiation significantly dominate the total water requirements as indicated in the following assumptions:

Beneficiation	4000 kl/day
Precalcining & dead burning	50 kl/day
Domestic/general	50 kl/day
Mine area	50 kl/day

The estimated capital cost of the water supply as included herein is for the total water supply system and was factored from a previous study.

3.6.3 Compressed Air Supply & Distribution

The capital cost estimate includes an allowance for a small compressed air facility. It is assumed that any major compressed air requirement for beneficiation will be included in the beneficiation plant estimate.

3.6.4 Fuel Storage

The estimate includes a storage facility for 2 week's supply of heavy fuel oil (approx, 700 tonnes).

The facility comprizes 4 x 6m dia x 5.5m high storage tanks, banded enclosure, a pumping and distribution system and a small diesel fueled steam generator to provide heating for the storage tanks and tracing of the oil lines. It is assumed that diesel fuel storage would be included as part of the mine facilities.

## SHEDDEN PACIFIC PTY. LIMITED

3.6.5 Cooling Water System

Cooling towers are included to provide the cooling water requirements for the precalcined and hard burned products.

3.6.6 Sewage Treatment

Allowance has been made for sewage collection and treatment in a small package unit.

3.6.7 Communication

Allowance has been made for connection to the Telecom network and for an in-plant VHF radio communications system.

3.6.8 Buildings, Fittings and Service Equipment

The estimate has been based on the following assumption of building requirements:

Administration	-	400 m <sup>2</sup>
Laboratory	-	100 m <sup>2</sup>
Workshop/Warehouse	-	1200 m <sup>2</sup>
Mobile Equipment Service	-	200 m <sup>2</sup>
Magazines	-	50 m <sup>2</sup>
Fire Station	-	35 m <sup>2</sup>
Change Room	-	400 m <sup>2</sup>
Crib	-	100 m <sup>2</sup>
Gatehouse		

Allowance is also made for the following fittings and equipment:

Office Furnishings & Equipment  
 Laboratory Equipment  
 Workshop Equipment  
 Fire Equipment  
 Mobile Maintenance Equipment  
 Vehicles  
 Weighbridge

3.6.9 Roads and Civil Works

Allowance has been made for site clearance earthworks, drainage, roads and hard standing, and for fences and landscaping. The assumption has been made that 3 km only of access road will have to be constructed.

## SHEDDEN PACIFIC PTY. LIMITED

3.6.10 Other Costs

The allowance for engineering, procurement and construction management has been included as 14% of the capital cost. Working capital requirements have been calculated as equal to two (2) months operating cost.

## SHEDDEN PACIFIC PTY. LIMITED

4.2 Fuel Costs

Fuel costs were calculated on the basis of a delivered cost of heavy fuel oil of \$220 per tonne. The diesel fuel requirements for steam generation and front end loader operation are based on a delivered cost of 40c/litre.

4.3 Power Costs

The power costs as estimated in this study include the following:

	<u>Operating</u> kW	Hrs/year	<u>kWh/yr.</u>
Crushing & Screening	270	250x20	1.4x10 <sup>6</sup>
Precalcining	800	350x24	6.7x10 <sup>6</sup>
Dead Burning	150	350x24	1.3x10 <sup>6</sup>
Site Services (Process Plant only)	200	365x24	1.8x10 <sup>6</sup>
Water Supply (Process Plant only)	5	365x24	.05x10 <sup>6</sup>
		<u>Total</u>	<u>11.3x10<sup>6</sup></u>

Alternative Tariffs for power supply are:

Tariff 86 - Demand  
Costs per quarter

Supply charge	\$142.50
Demand	\$21.10/kW
Energy	3.06 cents/kWh

Tariff 11 - Energy  
Costs per quarter

1st 150,000 kWh	13.2 c/kWh
Remainder	7.5 c/kWh

with an 8% rebate

Tariff 86 has been used in calculating the power costs for this study.

4.4 Operating and Maintenance Supplies

Operating supplies have been allowed at 10% of personnel costs and maintenance supplies at 2% of capital cost.

## SHEDDEN PACIFIC PTY. LIMITED

## 5. CAPITAL COST SUMMARY

	<u>\$A'000</u> (Jan. 1984)
<u>Process Facilities</u>	
Crushing and Screening	900
Precalcination	5,700
Dead Burning	4,400
Storage and Handling	600
Tailings Disposal	400
<u>Services Facilities</u>	
Power Supply & Distribution (All facilities)	
Water Supply, Treatment & Distribution (All facilities)	350
Compressed Air Supply	100
Fuel Storage (HFO only)	120
Cooling Water System	60
Sewage Treatment	80
Communications	100
<u>Site Works</u>	
Buildings and Equipment	2,200
Roads and Civil Works	600
Mobile Equipment	400
<u>Other Costs</u>	
Engineering, Procurement & Construction Management	2,290
Working Capital	1,500
Contingency @ 25%	4,800
Estimated Total Capital Cost	<hr/> 24,600 <hr/>

## SHEDDEN PACIFIC PTY. LIMITED

## 6. OPERATING COST SUMMARY

The following annual operating costs relate to the process plant only:

	<u>\$A'000/year</u> (Jan. 1984)
Personnel	2,000
Fuel	3,950
Power	500
Operating Supplies	200
Maintenance Supplies	500
Contingency @ 25%	1,850
Estimated Total Annual Operating Cost	<u>9,000</u>



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In Reply Please Quote

File: 7.2.7

25th November 1983

Mr Ken Mason  
Manager Minerals & Energy  
Sheddon Pacific Pty Ltd  
18-20 Thomas Street  
SOUTH MELBOURNE VIC 3205



c R Kay

Dear Ken

RE: TASHANIAN MAGNESITE STUDY

As discussed during our meeting on 24th November, 1983, please find attached a brief technical information note elaborating on the nature and scope of the envisaged magnesite process plant.

An order of magnitude capital and annual operating cost estimate (January 1984, Australian Dollars) for the process plant, and necessary facilities and services is requested.

The study should include:

- (a) A brief description of the proposed plant facilities and services.
- (b) Significant metallurgical parameters and consumable usages.
- (c) Manpower requirements.
- (d) An appropriate breakdown of the capital and operating costs.

Given the terms of reference of the study, we estimate that approximately 5 man days will be involved.

We look forward to receiving confirmation of your company's interest re this enquiry together with industrial experience details of those persons who may be assigned to complete the order of magnitude cost estimate. Construction and operating experience with large calcining kilns is essential.

Please do not hesitate to contact me regarding any aspect of this enquiry.

Yours sincerely

*[Handwritten signature]*  
c R Kay

TASMANIAN MAGNESITE STUDYTECHNICAL INFORMATION

To accompany letter of enquiry  
to Mr K Mason of SPPL

1. Location

Mine and Process Plant : Approximately 60 kms south  
west of the Port of Burnie  
Remote area: no local infra-  
structure.

2. Climate

Av max winter day temp : 7°C  
Av max summer day temp : 24°C  
Av Annual rainfall : 2024 mm

3. Process Plant: Unit activities

Crushing, grinding, screening, calcining stockpiling.

4. Production schedule

Ore type : Magnesite  
Ore delivered to crusher : 300,000 tpa (minus 1 metre)  
Product produced : 100,000 tpa (dead burned)

5. Product Grade

Premium grade magnesium : +97% MgO

6. Operation

Continuous process : calcining at 1500° to 1800°C

7. Tailings Disposal

Distance from plant : approx 1 km

8. ServicesWater Supply

Distance : Plant to source approx 2 km  
Height : Plant above source approx 100  
metres

Power supply

Source : State grid  
Transmission ext : Provide by State Government

9. Dollar Terms

Costs to be expressed in January 1984 Australian Dollars.

10. Capital Cost Estimate

To reflect the design construction and commissioning of the process plant, facilities required to maintain the process plant and services necessary to operate the process plant. The capital cost estimate will not include mine equipment and mine facilities or the general site administration facilities and services

11. Operating Cost Estimate

To reflect annual operating costs associated with the operation and maintenance of the process plant. Labour up to the Process Superintendent level is to be included.

12. General

Assume the +40% MgO magnesite ore behaves in an extremely favourable manner. The ore crushes and grinds with relative ease and is thermally efficient during calcining.

For this exercise, no allowance should be made to environmentally control gas and noise emissions.

# New process for recovery of magnesite from its ores by calcination

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FIMISCO, Athens, Greece

A. Koutopoulos Dipl. Eng., Ph.D.,  
National Technical University of Athens, Greece

661.891.622.782-622.7-367.1

## Synopsis

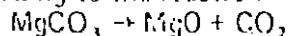
A new process for the recovery of magnesite from its ores is described. The ore contains magnesite and a siliceous gangue; after an optional preconcentration step, it is calcined at a temperature ranging between 600 and 900°C. During this treatment, magnesite decomposes partly or wholly to porous caustic-calced magnesite, and attains an apparent specific gravity (bulk density) of 1.3–1.6 g/cm<sup>3</sup>; the gangue loses mainly the combined water, and attains an apparent specific gravity of 2.2–2.3 g/cm<sup>3</sup>. Separation is thus easily effected by the usual gravity concentration methods. Pneumatic gravity methods are preferable, because full exploitation of the difference in the apparent specific gravities is effected. Gravity separation in water (flotation, jigging, dense media) results in hydration of the caustic-calced magnesite, whose apparent specific gravity is thus raised to 1.9–2.1 g/cm<sup>3</sup>; separation is more difficult, but still gives quite acceptable results. Laboratory, pilot-plant and full scale tests of the method are presented.

Pure natural magnesite is one of the most important raw materials for the production of dead-burnt magnesia, which is used in the manufacture of basic refractory bricks. Purity of the magnesite is necessary for this purpose; the beneficiation of magnesite ores is an important step. Such ores usually contain a siliceous gangue material – serpentine, dunite, pargasite, free silica, etc. Dense magnesite has an apparent specific gravity (ASG) (bulk density) of 2.7–2.8 g/cm<sup>3</sup>; the siliceous gangue has a lower ASG, generally 2.4–2.6 g/cm<sup>3</sup>. Gravity concentration methods can therefore be employed: the most commonly used is the dense-media process, applied either in cyclones or in static separators.

Some magnesite ores are not amenable to gravity concentration, because the contained magnesite is porous and has an ASG very near that of the gangue. No general method is applicable in this event. A preliminary, or even in some cases final, concentrate can be obtained by magnetic separation, whereby the gangue is collected as the magnetic portion. It is possible to enhance the magnetic properties of the gangue by calcination under reducing conditions.<sup>1,2</sup> Flotation is another possible method, but it requires rather expensive grinding; the concentrate obtained by flotation requires calcination and briquetting steps in order to

yield a product suitable for dead-burning.

A new and inexpensive process, by which caustic-calced magnesite of high quality is recovered from magnesite ores, has been developed\* and is described here; it is generally applicable to all magnesite ores. By this process, the ore is calcined at a temperature of 600–900°C; magnesite undergoes partial or complete decomposition to caustic-calced magnesite according to the reaction



The temperature of calcination is low enough for the material to suffer no shrinkage due to sintering; its ASG is thus very low – 1.3–1.6 g/cm<sup>3</sup>

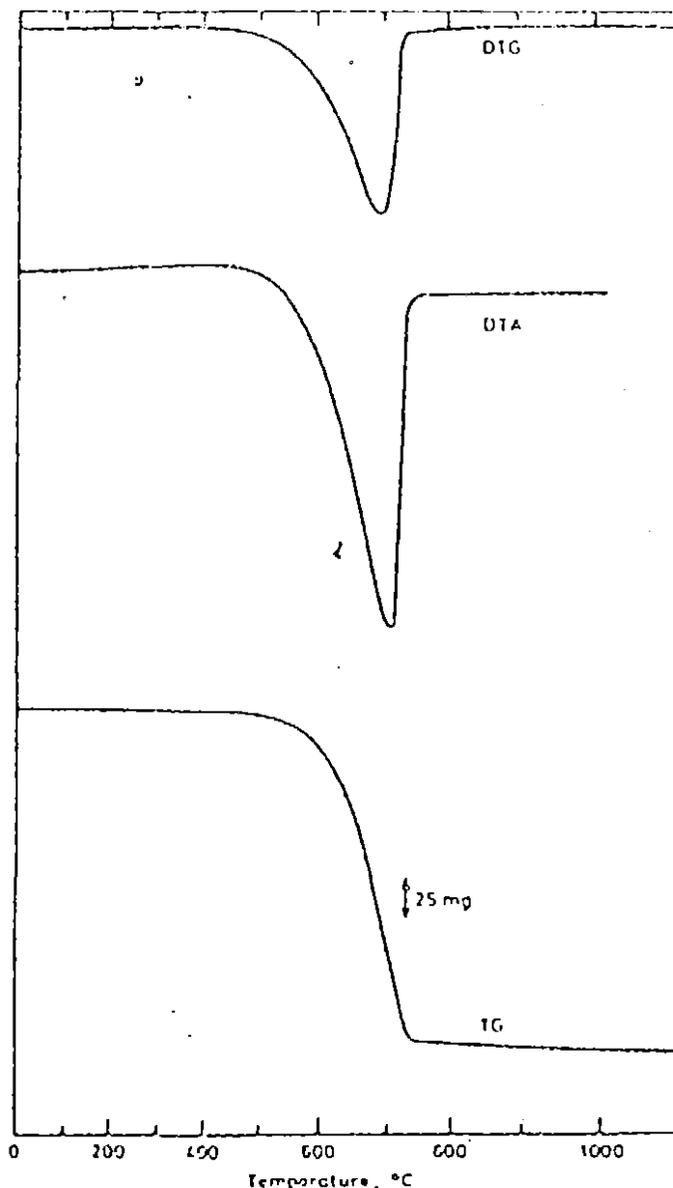


Fig. 1 Combined DTA-DTG-TG diagram for pure magnesite: initial weight of sample, 416 mg

is typical, depending on the degree of decomposition. On the other hand, the gangue does not undergo any significant change, apart from losing the bound water. Its ASG, only slightly affected by the calcination process, becomes 2.2–2.3 g/cm<sup>3</sup>. Magnesite, or rather caustic-calced magnesite, is then easily separable by dry or wet gravity methods.

Attenuation of the physical characteristics of a constituent of an ore by calcination, in order to effect separation, is not new. Faulkner<sup>3</sup> described a process by which borates are separated from the gangue by heating at a temperature high enough to dehydrate the borates to such an extent that their ASG was altered, so that separation from the gangue was achieved. Bieneck and Schroth<sup>4</sup> described a process whereby crude magnesite was suddenly subjected to a temperature somewhat above the  $\beta$ - to  $\alpha$ -quartz conversion temperature ( $575^{\circ}\text{C}$ ); the increase in volume that accompanied the quartz

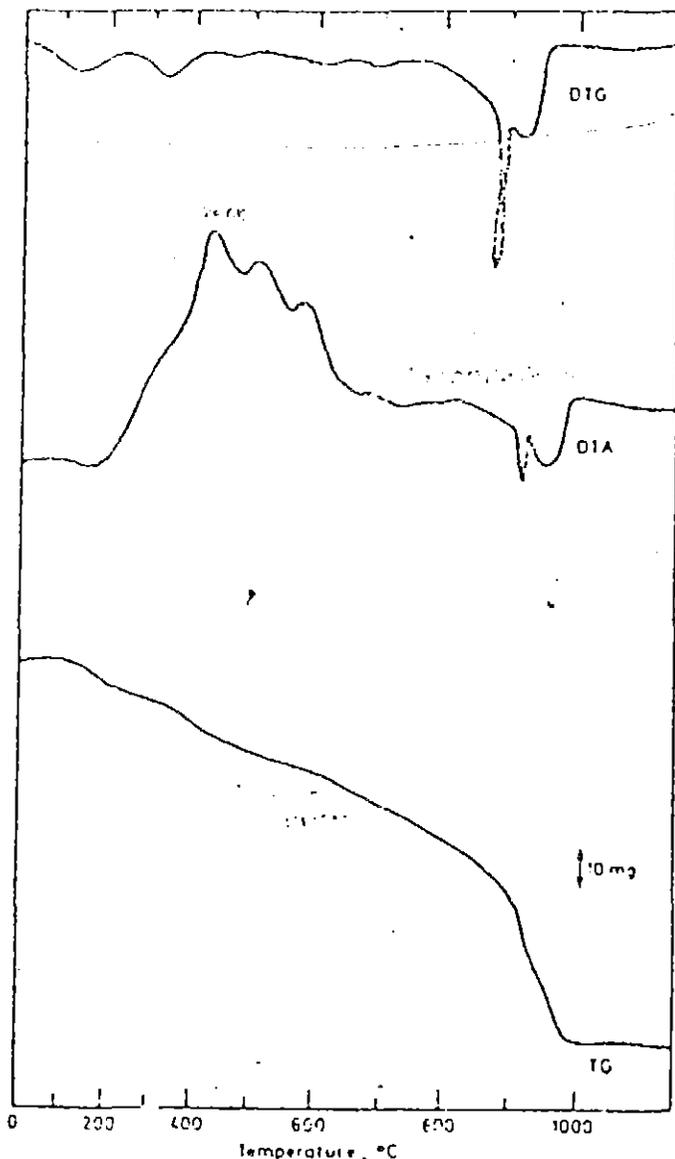


Fig. 2 Combined DTA-DTG-TG diagram for gangue; initial weight of sample, 375 mg

conversion took place explosively, and resulted in bursting of the quartz grains and disintegration of the magnesite particles in which the quartz was embedded. The quartz dust thus formed was easily separated from the coarser magnesite particles. McLoughlin<sup>5</sup> described a process by which magnesite and the silica gangue were heated at  $500^{\circ}\text{C}$  to decompose magnesite. The calcined material was rapidly cooled in water; the difference in contraction between silica and MgO caused a disintegration of the material, and effected at the same time detachment of MgO from silica. The product then passed through an agitator, where further liberation was achieved, due to attrition of the particles together. After the

rest was ground down to 30 mesh, and the  $\text{MgO}$  (of ASG 3–3.6  $\text{g}/\text{cm}^3$ ) was separated from the silica (of ASG 2.2  $\text{g}/\text{cm}^3$ ) by hydraulic classification. The process is interesting, but had the drawback that the  $\text{MgO}$  was recovered as hydrated fine particles, and required dehydration and briquetting steps before dead-burning.

## Experimental

### LABORATORY TESTS

It is well known<sup>6,7,8</sup> that, on heating to  $500$ – $700^{\circ}\text{C}$ , magnesite decomposes to  $\text{MgO}$  and  $\text{CO}_2$ ; the reaction absorbs approximately 24 kcal/mol. A 52% loss of weight accompanies this

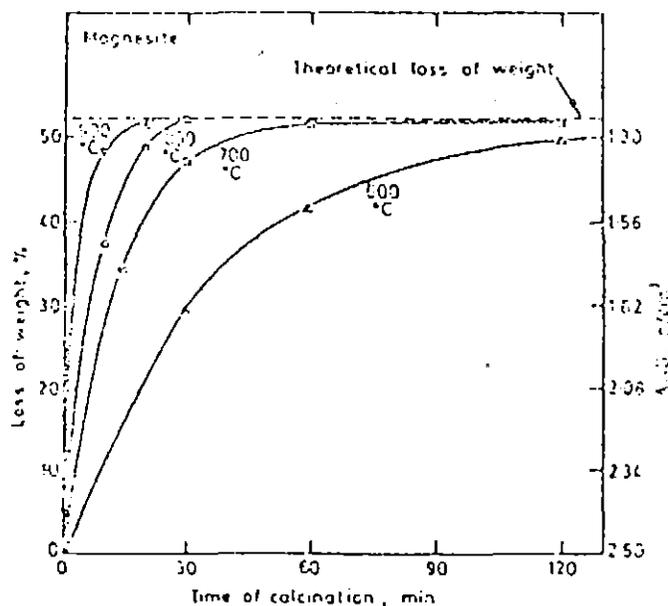


Fig. 3 Loss of weight and apparent specific gravity as functions of time and temperature of calcination for pure magnesite

decomposition. The ore tested by us was from Ormelia, northern Greece, and had a stockwork structure; it consisted of magnesite, serpentine or dunite with veins of pegmatite (secondary formations), free filmlike quartz and silicified material (magnesite, serpentine, or dunite). Magnesite specimens from the ores tested showed the typical DTA-TG-DTG diagram (Fig. 1); peak temperature is at  $630$ – $700^{\circ}\text{C}$ , in agreement

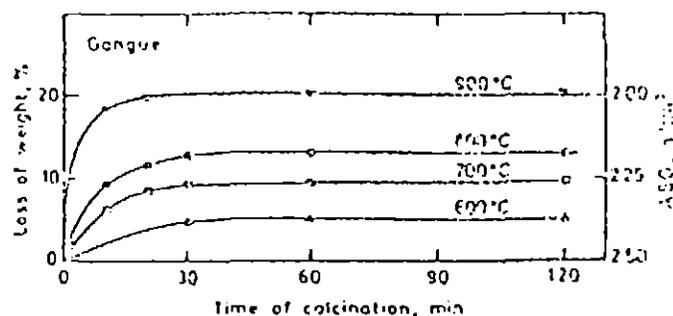
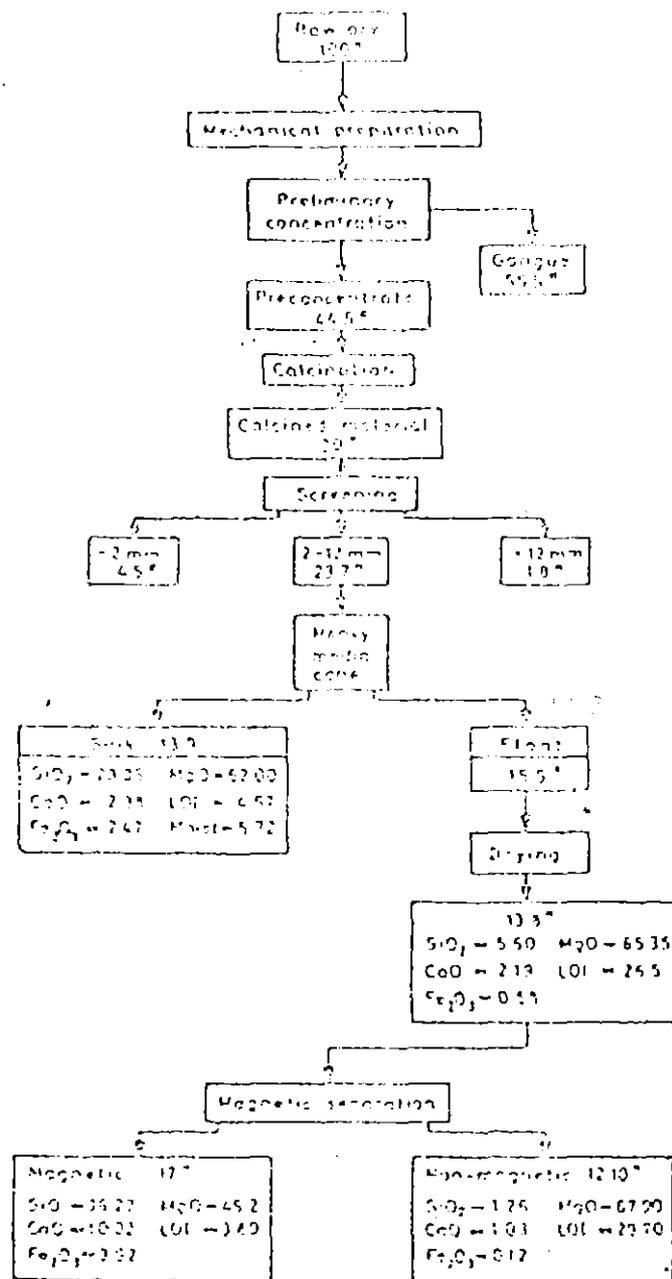


Fig. 4 Loss of weight and apparent specific gravity as functions of time and temperature of calcination for gangue

with the generally reported values.<sup>6</sup> The dunite, which constituted the major part of the gangue, showed the typical DTA-TG-DTG diagram (Fig. 2); as seen from the TG curve, a gradual loss of weight, mainly due to dehydration, was

the rate is increased until the reaction is completed at 900°C. The total loss of weight was approximately 20%.



\* Arbitrary weight units  
LOI Loss on ignition  
Moist Moisture  
Analyses are given in wt. %

Fig. 5 Flowchart for dense-media separation

Figs. 3 and 4 show the experimentally determined loss of weight and the ASG as functions of time and temperature of calcination for pure magnesite and gangue, respectively. It was found that there is no difference in the decomposition curves for various size fractions examined. It is obvious that the optimal difference in the ASGs is obtained by calcining for 30 min at 700–800°C, when magnesite attains an ASG of 1.3–1.4 g/cm<sup>3</sup> and the gangue 2.25 g/cm<sup>3</sup>. Calcining at higher temperature lowers the latter figure to 2.0 g/cm<sup>3</sup>, without affecting the former. Of course, here the optimal difference is obtained in the dry state. If wetted calcined magnesite is treated with water and

the typical decomposition of Mg(OH)<sub>2</sub>, with peak temperature at 440°C, in agreement with the published values.<sup>9</sup> Examination by X-ray diffraction reveals that the hydrated product consists of Mg(OH)<sub>2</sub> with only minor amounts of MgO. It can therefore be concluded that on wetting the bulk of MgO is hydrated to Mg(OH)<sub>2</sub>, and only a small portion remains unchanged. On the other hand, the wetted gangue absorbs only 5–10% by weight of water, and its ASG is only slightly increased. There is then an overall decrease in the difference of the ASGs and separation is more difficult in the wet state. A dry gravity separation method, such as pneumatic separation, is thus highly desirable.

#### PILOT-PLANT TESTS - SEPARATION IN DENSE MEDIA

After the preliminary laboratory investigation, pilot-plant tests were conducted with the use of dense-media separation in a cone (Fig. 5). The run-of-mine ore, after a mechanical preparation and preliminary concentration step as described below, was crushed and screened to -17 +2 mm (where the upper limit was decided on the basis of liberation considerations and the lower on rotary kiln feed requirements), and calcined in a rotary kiln of length 3 m and diameter 0.6 m, fired with diesel oil. The temperature was kept at 700–750°C. The calcined material was then screened to produce three fractions, -2, 2–12 and +12 mm. The +12-mm fraction was very lean in calcined magnesite and was rejected. This apparently happened because the larger MgO particles, being friable, were autogeneously ground by the hard gangue particles in the rotary kiln. The -2-mm fraction was quite rich in calcined magnesite, which could be recovered either on a Kelly-type pneumatic table for fine particles or by flotation.

However, this fine fraction would create difficulties during the subsequent firing to produce dead-burnt magnesite, and therefore it was excluded from the total recovered magnesite. The 2–12-mm fraction was treated by the dense-media process in a cone. A suspension of FeSi and magnetite in water, with specific gravity 2.10 g/cm<sup>3</sup>, was used as the dense medium; its settling and viscosity characteristics were improved by small additions of bentonite. The weights and chemical analyses of the products of the separation are given in Fig. 5.

The analysis of the float material in the sink–float separation could be considerably upgraded by use of a lower-density medium. This generally resulted in low recoveries, however, and it was not practised, because it was observed that nearly all the impurities in the float fraction were magnetic and could be removed by a magnetic separation, to give the final concentrate shown in Fig. 5. As mentioned above, the concentrate is mainly in the form of Mg(OH)<sub>2</sub>. The equivalent amount in MgO is 8.5% of the original, with chemical analysis referred to MgO as follows: SiO<sub>2</sub>: 1.75%, CaO: 1.47%, Fe<sub>2</sub>O<sub>3</sub>: 0.17%. The magnesite recovery from the ore is approximately 83%.



CaO, the recovered weight was 10.26% of the original, with the following equivalent chemical analysis: SiO<sub>2</sub>, 1.50%; CaO, 1.46%. When these figures are compared with the pilot-plant results of the wet separation, it is obvious that both recovery

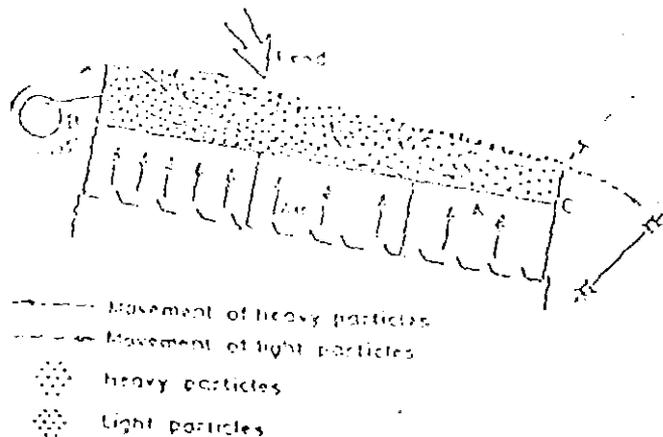


Fig. 2 Principle of pneumatic table

and chemical analysis of the product are better with the pneumatic separation, as expected. Overall magnesite recovery is approximately 90%.

#### Conclusions

The recovery of magnesite from its ores as caustic-calined magnesite by calcination, followed by gravity separation, appears to be an attractive and feasible process.

Technically, the process proved quite successful and stable. In the full-scale tests, the rotary-kiln temperature could not be very closely controlled, owing to the relatively small quantity of ore calcined. Consequently, the calcine contained material with varying degrees of decomposition. Despite this, the subsequent pneumatic-table separation was very stable, and with only minor adjustments gave the required concentrate.

Economically, the process compares favourably not only with flotation, which is the only other method applicable to the porous ore treated here, but also with the conventional sink-float separation: it generally provides higher recoveries.

#### References

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## TASMANIAN MAGNESITE BENEFICIATION

A PROGRESS REPORT ON TESTWORK AS CONDUCTED

BY THE METALLURGICAL RESEARCH DEPARTMENT

THE ZINC CORPORATION, LIMITED

BROKEN HILL

1st May, 1984

## 1. INTRODUCTION

This report summarises testwork conducted by the Metallurgical Research Department of The Zinc Corporation, Limited at Broken Hill for CRA Resource Studies between 18th April, 1983 and 1st May, 1984.

At this time work is continuing on the development of flotation techniques to provide a magnesite concentrate to meet specifications as outlined by M.D. Lavery and detailed in the text of this report.

The work performed at Broken Hill has been in two parts, the first being a study examining ore characteristics to select possible concentration routes and the second concentrating on beneficiation by flotation. Other test programs on gravity beneficiation and *what?* hydrometallurgical refining have been conducted by separate organisations without the involvement of this laboratory.

## 2. SUMMARY OF RESULTS

The work conducted by this laboratory to date has covered three major areas; evaluation of the available mineralogical data, a broad study to indicate possible beneficiation methods and the development of a flotation process to produce the desired magnesite concentrate.

Examination of the mineralogical data indicated that the grain size of the ore is too fine for heavy media separation methods. With the majority of grains in the size range of 100 to 200 micrometres ( $\mu\text{m}$ ) either gravity separation or flotation would be applicable. Although some iron sulphides had been observed in the ore the quantity present was not sufficient to account for the iron values given by chemical analysis.

Combining the mineralogical data with information from the literature, bench scale heavy liquid separation tests were performed to confirm the grain size at which liberation took place, indicate the feasibility of gravity separation and to gain further information on the presence of the iron. This testwork indicated that gravity separation may be possible even though it is probable that only a small specific gravity differential exists between dolomite and magnesite and further testwork by Mineral Deposits Limited was recommended. It is believed that this testwork indicated that this treatment method would be unsuccessful. The presence of iron within the magnesite either as solid solution or submicroscopic inclusions was confirmed.

Consequently development of a flowsheet for beneficiation by flotation has proceeded. Testwork in this area has progressed to the stage where approximately 17% of the new feed material has been concentrated into a fraction containing 97.6% MgO, 1.29% CaO, less than 0.5% SiO<sub>2</sub> and 1.29% Fe<sub>2</sub>O<sub>3</sub>. Methods of increasing the recovery of magnesite to the concentrate by increasing selectivity in the primary float are being investigated. Future work will include cleaning and upgrading of intermediate products to increase recovery, optimisation of grade and recovery, and budget type economic evaluation of alternative flowsheets.

2.

### 3. BROAD EVALUATION

#### 3.1 The Aim of the Testwork

The testwork as initiated was conducted under the following aim:

"The objective of the initial metallurgical testwork is to determine whether or not by applying bulk flotation or heavy media techniques, a substantial upgrading in MgO content can be achieved with a resultant dramatic decrease in SiO<sub>2</sub>, Al<sub>2</sub>O<sub>3</sub>, Fe<sub>2</sub>O<sub>3</sub>, and CaO: i.e. is it possible by simple beneficiation methods to produce a magnesite concentrate that when dead burned at approximately 1700°C will report the following order of assay values:

plus 95% MgO  
 less than 2.5% SiO<sub>2</sub>  
 less than 1.0% Al<sub>2</sub>O<sub>3</sub>  
 less than 1.0% Fe<sub>2</sub>O<sub>3</sub>  
 less than 2.0% CaO

The ability to produce a range of products at less stringent assay values will also be studied. The above order of assay values represent the top quality, highest value product type. We must be able to produce this type of product".

Twelve samples from DDH1 and DDH2 were specified for testing and are listed below:

<u>DDH1</u>	<u>DDH2</u>
1055545	1056512
1055568	1056523
1055577	1056553
1055606	1056563
1055608	1056567
1055612	1056576

These samples were chosen by CRA Resource Studies to represent the variability of the orebody as it was known at that time.

#### 3.2 Interpretation of the Data Available

The mineralogical and analytical data presented in AMDEL reports GS4660/83 and AC4660/83 and Central Mineralogical Services report CMS 83/3/8 were examined. Examination of the sample in hand specimen was not possible for although some chemical analyses had been conducted at the ZC Assay Office all of the material available had been crushed to minus 1.68 mm (10 mesh BSS).

A literature survey indicated that magnesite is recovered commercially from ores with silica, dolomite and calcite by both heavy media separation and flotation. In general heavy media separation is applied to ores where satisfactory beneficiation can be achieved at a particle size of 3 mm or greater. Finer grained ores are ground and separated by selective flotation of first the silica and then the magnesite leaving a calcite/dolomite tail.

The above information can be summarised in the following manner:

- (a) In most cases the grain size of the magnesite and other minerals in the Lyon's River Ore is less than 2 mm with the majority being between 100 and 200 microns. Heavy media separation is not feasible for materials of this size.
- (b) Gravity separation is applicable in the size range we are looking at and although it is possible to test upgrading of a magnesite product on both table and spiral, the small SG differential between dolomite (2.85 - 3.0) and magnesite (3.0 - 3.2) may not be sufficient for good separation.
- (c) In all of the 12 samples of direct interest magnesite is the major component. Therefore, it will be preferable to remove the undesirable minerals from a high grade magnesite tailing. There does not appear to be a commonly used flowsheet for dolomite flotation with magnesite depression although technical literature on flotation fundamentals would suggest that it is possible.
- (d) There is no positive information which would indicate the form of mineral containing the Al or the Fe. Analytical work at Broken Hill suggests that in all but a very few samples iron sulphides are not present in significant quantities. It is possible that most of the iron is part of the magnesite structure and therefore is not amenable to beneficiation. The form of the Al is not clear with some suggestion of clays but there has been no positive identification of clay minerals. To our knowledge there has been no work to determine the Mg:Ca ratio of the dolomite and so it is hard to predict how much Mg would be rejected with the calcareous gangue. Results and assays are therefore reported in two forms, as dead burnt products and as reconstituted minerals where it has been assumed that all Mg occurs as magnesite and all Ca is calcite.

Beneficiation of the Lyons River Ore could therefore be possible by either gravity separation using equipment typically used in the beach sand mining industry or by flotation. In the latter case it would be preferable to use a reverse flotation process where the gangue minerals are floated from the desired product giving a magnesite rich tail as the "final concentrate".

### 3.3 Testwork

Because of the relatively small quantity of material available in each of the twelve specified samples it was decided to prepare a bulk sample to be used for flowsheet development. When a feasible process had been developed for treatment of the representative bulk testing of the individual samples could be undertaken to indicate variability within the orebody. Two bulk samples were prepared from 52 samples originating in DDH 1 and 28 samples from DDH 2 as recommended by CRA Resource Studies and as shown in Appendix 1.

While preparation of the bulk samples was taking place heavy liquid separation (HLS) testwork commenced on two samples from the twelve initially selected. The first sample No. 1055545 (see Table 3.1 below) was chosen as being fairly typical of the ore while the second, No. 1056576 was chosen because of its relatively high dolomite : magnesite ratio. For comparison the testwork conducted on these samples was repeated on the two bulk samples.

TABLE 3.1

SAMPLES SELECTED FOR HEAVY LIQUID SEPARATION

Identification	Sample 1	Sample 2	Bulk 1	Bulk 2
	1055545	1056576		
	DDH 1	DDH 2	DDH 1	DDH 2
	161-164m	375-380m		
<u>Chemical Analysis</u>				
SiO <sub>2</sub>	4.98%	3.02%	3.03%	4.96%
Al <sub>2</sub> O <sub>3</sub>	0.05	0.05	0.05	0.05
Fe <sub>2</sub> O <sub>3</sub>	0.534	0.92	1.721	0.721
MgO	44.20	41.32	43.13	42.73
CaO	1.311	5.45	2.61	3.02
LOI	49.02	49.35	49.38	48.44
<u>Dead Burn Assay</u>				
Magnesite	86.7%	80.9%	85.4%	82.9%
Calcite	2.57	10.7	5.2	5.9
Quartz	9.8	5.9	6.0	9.6
[Fe <sub>2</sub> O <sub>3</sub> ]	1.0	1.8	3.4	1.4
Other	0	0.7	0	0.2

The specific aims of this testwork were to:

- (a) Indicate the grain size at which liberation of magnesite from the other gangue minerals occurred.
- (b) Indicate if sufficient specific gravity differential existed between the magnesite and the other minerals to allow gravity separation to take place.

This initial series of tests used tetrabromoethane (TBE) at SG 2.95 in an effort to separate quartz and calcite (2.7) and dolomite (2.8 - 2.9) from the magnesite (3.0 - 3.2). The samples were sized on a total of 11 screens in a  $\sqrt{2}$  series with apertures ranging from 1680  $\mu\text{m}$  to 53  $\mu\text{m}$ . The individual fractions were subjected to HLS and the recovery of the mineral species to the sinks fraction is summarised as Figures 1-4. The following conclusions were drawn from this data:

- (a) A good separation between magnesite and the gangue minerals can be achieved with HLS at SG 2.95. Separation is most efficient between quartz and magnesite in all samples because of the significant SG differential. Carry over of calcareous gangue into the sink fraction was significantly greater in both the selected sample and the bulk sample from DDH 2. This is probably due to a higher proportion of dolomite to calcite and/or to a higher SG of a Mg rich dolomite.
- (b) High recovery of iron to the sinks can be explained in two ways: pyrite identified as being present by microscopic examination, and solid solution Fe as seen in the Savage River deposits. It was felt that some Fe could be removed by HLS at SG 3.25 indicating the quantity of Fe present in each of the above forms.
- (c) To ensure that liberation had occurred it would be necessary to grind the ore so that most individual mineral grains were less than 600  $\mu\text{m}$ . At sizes above 600  $\mu\text{m}$  selectivity decreased in both the No. 1 sample and the No. 1 bulk. Although grinding to 600  $\mu\text{m}$  gave reasonable liberation in the No. 2 sample, the No. 2 Bulk sample needed further grinding to 425  $\mu\text{m}$  to release both calcareous and siliceous gangue. The decrease in selectivity below 75 microns in the individual and bulk samples from No. 1 DDH is due mainly to the very slow rates of settling and rising of these small particles. The apparently consistent recovery of calcareous material to the sink fraction in the No. 2 and No. 2 Bulk sample tests can only be explained by extremely fine intergrowth of the mineral species or the presence of a Mg rich dolomite.

The concentrates produced, although not to specification, were encouraging when the performance was considered over the size range most suitable for gravity separation, i.e. when the very fine and the very coarse particles were disregarded. The dead burn assays of simulated gravity concentrates are compared in Table 3.2 below while full test data is shown in Appendix 2.

TABLE 3.2

SIMULATED GRAVITY CONCENTRATES FROM HLS

<u>Analysis</u>	<u>No. 1</u>	<u>No. 2</u>	<u>No. 1 Bulk</u>	<u>No. 2 Bulk</u>	<u>Specification</u>
MgO	95.77	92.29	93.07	94.5	95.0
CaO	1 35	4 42	1 32	1 93	2 0

A series of HLS tests using Diiodomethane (SG 3.35) diluted with benzene to produce a varying heavy liquid S.G. was conducted on the No. 1 Bulk sample. The aim of this work was to optimise magnesite concentration and to improve iron rejection. The results, summarised in Figure 5 show that although it is possible to reject both silica, calcareous gangue and a proportion of the iron minerals from the magnesite by gravity methods it is unlikely that these methods will successfully reduce the level of iron in the magnesite concentrate. The minegraphic testwork reported in the following section confirmed this point of view.

### 3.4 Mineragraphic Investigation

The search for iron bearing minerals was carried out on a small scale. Samples of four different mineral groups were hand-picked from a sample of No. 1 Bulk and tested for composition and S.G. The results of these tests are shown in Table 3.3.

As expected, the darkest mineral contained the most iron but there was also significant iron in the almost "pure" magnesite samples. Inclusions of iron sulphides were not visible indicating submicroscopic particles or solid solution as the source of Fe. The levels of iron in these minerals were more than double the 1% limit set for the dead burned concentrate. This suggests that will be impossible to produce a magnesite concentrate to iron specifications by physical means.

Specific gravity determinations on these minerals showed the dark orange-brown mineral to be only marginally lighter than the high magnesite minerals. The difference in specific gravity is not large enough to allow effective separation of the minerals.

TABLE 3.3

#### MINEGRAPHIC EXAMINATION OF HAND-PICKED MINERALS

Mineral Group Characteristic	S.G.	Mineral Assays				Dead Burnt Mineral Assays			
		$\text{Fe}_2\text{O}_3$	% MgO	% CaO	% $\text{SiO}_2$	% $\text{Fe}_2\text{O}_3$	% MgO	% CaO	% $\text{SiO}_2$
1. Translucent White	2.997	1.153	45.91	0.621	1.519	2.34	91.66	1.26	3.08
2. Clear-White, Crystalline	2.90	1.926	37.69	6.28	7.41	3.60	70.51	11.75	13.86
3. Translucent, Coloured	2.975	1.230	46.06	0.569	1.037	2.52	94.39	1.17	2.13
4. Orange-Brown	2.987	2.93	42.51	2.98	1.707	5.81	84.36	5.91	3.39

### 3.5 Conclusions

The first stage of the testwork indicated the following:

- (a) Some of the iron in the Lyon's River Ore is present as a sulphide mineral but in general this is only a minor quantity. Most of the iron is present in intimate association with the magnesite.
- (b) Liberation of the individual mineral species takes place at sizes ranging from 425 to 600 microns. At this size both gravity separation and flotation are applicable.
- (c) Heavy liquid separation indicates that gravity separation may be feasible for the rejection of siliceous and calcareous gangue and pilot scale studies were recommended. This testwork was conducted by another laboratory under the direction of CRA Resources and the results reported independantly. It is believed that this testwork was unsuccessful.
- (d) The production of a magnesite concentrate by flotation should be possible although a flowsheet for the flotation of dolomite calcite and silica from magnesite was not found in the literature. A report of this testwork follows in Section 4.

## 4. FLOTATION TESTWORK

Following the initial testwork and confirmation that the Fe content of the ore is primarily associated with the magnesite, revised target specifications were advised by CRA Resources. A magnesite concentrate with plus 97% MgO, 1.0% SiO<sub>2</sub> and CaO:SiO<sub>2</sub> 2.0 was sought. Secondary products would also be of interest if the above target could be reached.

### 4.1 Literature Survey

As previously stated the literature has indicated that the flotation of magnesite away from the calcareous gangue minerals is being commercially practised but a method for the flotation of the gangue minerals from the magnesite has not been found.

Because the Lyon's River deposit is a high grade magnesite ore it will probably be preferable to upgrade the magnesite by reverse flotation if a significant recovery of material to the magnesite concentrate is possible. This will minimise the size of equipment needed for flotation product handling and alleviate the problems associated with the flotation of a large quantity of material from a relatively small gangue component. Testwork however, has included schemes which do float magnesite. It may be preferable to use direct flotation if the specified concentrate can only be produced at low recovery of magnesite.

#### 4.2 Testwork

Because of the better knowledge of the composition of the No. 1 Bulk sample it was selected for the preliminary testwork however, the second phase of the study has been conducted on material from the No. 2 Bulk as supplies of the No. 1 bulk were depleted. Grinding one kilogram of No. 1 Bulk sample at 50% solids by weight in the laboratory rod mill for four minutes gave the size distribution shown in Table 4.1. Testwork has indicated that a grind of eight minutes is necessary to give an equivalent product when using the No. 2 Bulk samples. An 80% passing size (P80) of 150 microns was selected as a starting point because it placed the bulk of the material into a size ideally suited for flotation and gave good liberation while minimising the production of fines.

TABLE 4.1

SIZE DISTRIBUTION OF MAGNESITE AFTER GRINDING IN  
THE LABORATORY ROD MILL AT 50% SOLIDS BY WEIGHT

Screen Aperture ( $\mu\text{m}$ )	% Weight Retained	Cumulative % Passing
420	0.01	99.99
300	0.43	99.56
210	4.55	95.01
150	16.29	78.72
105	18.56	60.16
75	10.79	49.37
-75	<u>49.37</u>	
	100.00	

Once an initial grind had been selected flotation testwork commenced to test the flotation response of the three basic mineral species with a large number of possible reagents. This initial period required that tests be performed in batches so that work could progress at a reasonable rate in spite of long sample turnaround times. However, conscious effort was made to balance the number of tests and therefore cost, with the rate of progress. Initially a total of fourteen tests was performed to examine the flotation rates of the individual minerals both in single-stage and multi-stage selective schemes.

Examination of the assays from the initial tests indicated two silica collectors which appear effective. Tests with these collectors, Aeromine 3037 and DUOMAC T, gave immediate success resulting in greater than 90% recovery of silica in a relatively clean concentrate. For all tests using these reagents de-silicated tail grades were less than 0.5% silica.

9.  $\text{CaO} \xrightarrow{\text{MgO}}$  dolomite

Separation of calcite and magnesite is more difficult. Numerous collectors and depressants were tried with limited success. The latest tests, however, have met with some success and selective collectors for both calcite and magnesite have been found. Naphthenic acid has proven moderately successful in producing magnesite concentrates of 95% MgO and approximately 2.5% CaO but the recovery to these concentrates was small.

The only reagent that has shown any selectivity for the flotation of calcite is dodecylamine. In the best test to date a calcite concentrate was produced with the dead burnt analysis of 81.4% MgO, 16.7% CaO, 0.5% SiO<sub>2</sub> and 1.57% Fe<sub>2</sub>O<sub>3</sub>. Respective recoveries of MgO and CaO from the test feed were 15.75% and 46.35%. This represented 48.7% and 92.5% recovery respectively from the feed to the calcite flotation stage of the test. In terms of magnesite concentration the test is seen to be successful in that it produces a magnesite rich tailing which meets specification as well as a slightly lower grade magnesite concentrate. Full details of this test are shown as Figure 6.

The areas which offer the greatest chance of improved performance are the rejection of magnesite from the silica concentrate where approximately 20% of the magnesite has been recovered, and rejection if possible of the large quantity of calcareous material which has reported to the intermediate magnesite concentrate i.e. greater than 34% CaO recovery. This latter area may be difficult with the No. 2 Bulk samples and its higher dolomite content.

Some 13 tests concentrating on these areas and investigating the affect of changing variables such as grind and reagent addition rates have been completed and the test samples submitted for assay. Analysis of these results will indicate the possibility of improving performance and give more information on the possible grade-recovery relationship for magnesite by direct and/or reverse flotation.

#### 4.3 Future Work

To date all flotation testwork has been conducted as a simple grind and float procedure. It is probable that the latest batch of tests will show improved performance in the areas investigated but it is still likely that further improvements could be achieved by regrind and cleaning of the individual concentrates. Although this is not always easy with small samples on a laboratory scale it will provide useful information should pilot plant evaluation follow.

Once the technically feasible flowsheets have been outlined it will be necessary to evaluate the economics and give some indication as to which one, if any, can be expected to be successful in commercial operation. Base data is being collected to enable this study to proceed as soon as the laboratory testwork has reached a suitable stage.

APPENDIX 1 - SAMPLESCOMPOSITION OF BULK SAMPLES

The bulk samples were produced by combining material from the following samples with the weight of sample used being determined by the length of core it represented.

Bulk 1 : DDH Number 1

Sample Interval		Sample Numbers
From	To	From      To
metres	metres	
139.0	170.2	1055537 - 1055547
182.9	267.0	1055552 - 1055578
296.9	317.1	1055589 - 1055594
341.5	369.4	1055605 - 1055613

Bulk 2 : DDH Number 2

100.0	120.0	1056509 - 1056512
175.0	200.7	1056530 - 1056535
250.0	265.0	1056551 - 1056553
325.0	370.0	1056566 - 1056574
375.0	403.0	1056576 - 1056581

## APPENDIX 2 - HEAVY LIQUID SEPARATION TEST DATA

TABLE 1: Sink Product For HLS of No. 1 Magnesite Sample with TBE at SG=2.95

SIZE	WT%	WT FRACTION TO SINKS	MgO	CaO	SiO <sub>2</sub>	Fe <sub>2</sub> O <sub>3</sub>
1680	1.45	0.896	89.32	1.565	6.837	1.436
1200	7.42	0.863	93.32	1.463	3.407	1.136
850	17.64	0.858	92.54	1.368	3.862	1.162
600	22.26	0.820	94.99	1.266	1.984	1.185
420	13.73	0.860	95.25	1.280	1.920	1.158
300	9.37	0.850	94.65	1.298	1.691	1.233
210	6.82	0.850	95.61	1.284	1.471	1.193
150	4.66	0.862	95.74	1.312	1.491	1.275
105	3.41	0.627	93.06	2.711	1.009	2.426
75	1.90	0.846	94.77	1.591	1.495	1.440
53	1.20	0.827	85.02	3.302	10.12	1.509
-53*	10.14	1.000*	85.7	3.054	9.304	1.385

\* Fine material not treated by HLS but included for information.

TABLE 2: Sink Product for HLS of No. 2 Magnesite Sample with TBE at SG=2.95

SIZE	WT%	WT FRACTION TO SINKS	MgO	CaO	SiO <sub>2</sub>	Fe <sub>2</sub> O <sub>3</sub>
1680	5.70	0.785	90.96	4.654	2.049	1.966
1200	16.40	0.771	91.47	4.744	1.451	1.970
850	16.70	0.786	91.57	4.336	1.339	1.960
600	13.45	0.800	92.53	4.124	1.056	2.019
425	9.20	0.533	93.78	3.004	1.019	2.118
300	7.00	0.807	91.62	4.790	1.149	2.078
210	5.45	0.768	90.51	5.798	1.061	2.093
150	4.20	0.702	90.74	5.603	1.011	2.217
105	3.40	0.787	95.27	1.836	1.570	1.311
75	2.15	0.783	90.09	6.054	1.009	2.426
53	1.60	0.648	90.92	4.974	1.011	2.768
-53*	14.75	1.000*	81.07	12.02	4.579	1.970

TABLE 3: Sink Product For HLS of No. 1 Bulk with TBE at SG=2.95

SIZE	WT%	WT FRACTION TO SINKS	MgO	CaO	SiO <sub>2</sub>	Fe <sub>2</sub> O <sub>3</sub>
1680	0.73	0.887	90.53	1.895	4.062	2.864
1200	5.42	0.884	91.14	1.601	3.703	3.120
850	16.10	0.888	91.79	1.548	3.027	3.246
600	21.55	0.873	92.57	1.220	2.283	3.408
425	13.17	0.876	92.57	1.309	2.200	3.471
300	9.03	0.876	92.96	1.305	1.991	3.486
210	6.62	0.868	93.10	1.303	1.663	3.609
150	4.61	0.839	93.09	1.124	1.584	3.725
105	3.64	0.859	91.74	1.916	1.870	4.014
75	2.32	0.828	91.81	1.835	1.384	4.371
53	1.60	0.807	89.82	3.460	1.462	4.571
-53*	15.19	1.000	85.75	4.704	4.685	4.171

TABLE 4: Sink Product for HLS of No. 2 Bulk with TBE at SG=2.95

SIZE	WT%	WT. FRACTION	MgO	CaO	SiO <sub>2</sub>	Fe <sub>2</sub> O <sub>3</sub>
1680	5.95	0.802	92.02	2.406	3.901	1.455
1200	18.46	0.811	92.31	2.614	3.335	1.420
850	17.98	0.795	92.55	2.400	3.059	1.522
600	13.44	0.815	92.81	2.281	2.894	1.497
425	8.74	0.813	94.05	1.905	2.125	1.491
300	6.54	0.827	94.60	1.840	2.025	1.528
210	5.14	0.807	94.26	1.919	1.949	1.554
150	3.88	0.788	94.76	1.737	1.554	1.706
105	3.15	0.771	94.04	2.304	1.434	1.790
75	2.20	0.730	94.28	2.052	1.159	1.911
53	1.41	0.678	94.46	1.974	1.022	1.970
-53*	13.11	1.000	83.67	6.816	7.383	1.555

FIGURE 1: Heavy Liquid Separation of Individual Size Fractions  
From Sample 1 Using Tetrabromoethane (SG = 2.95)

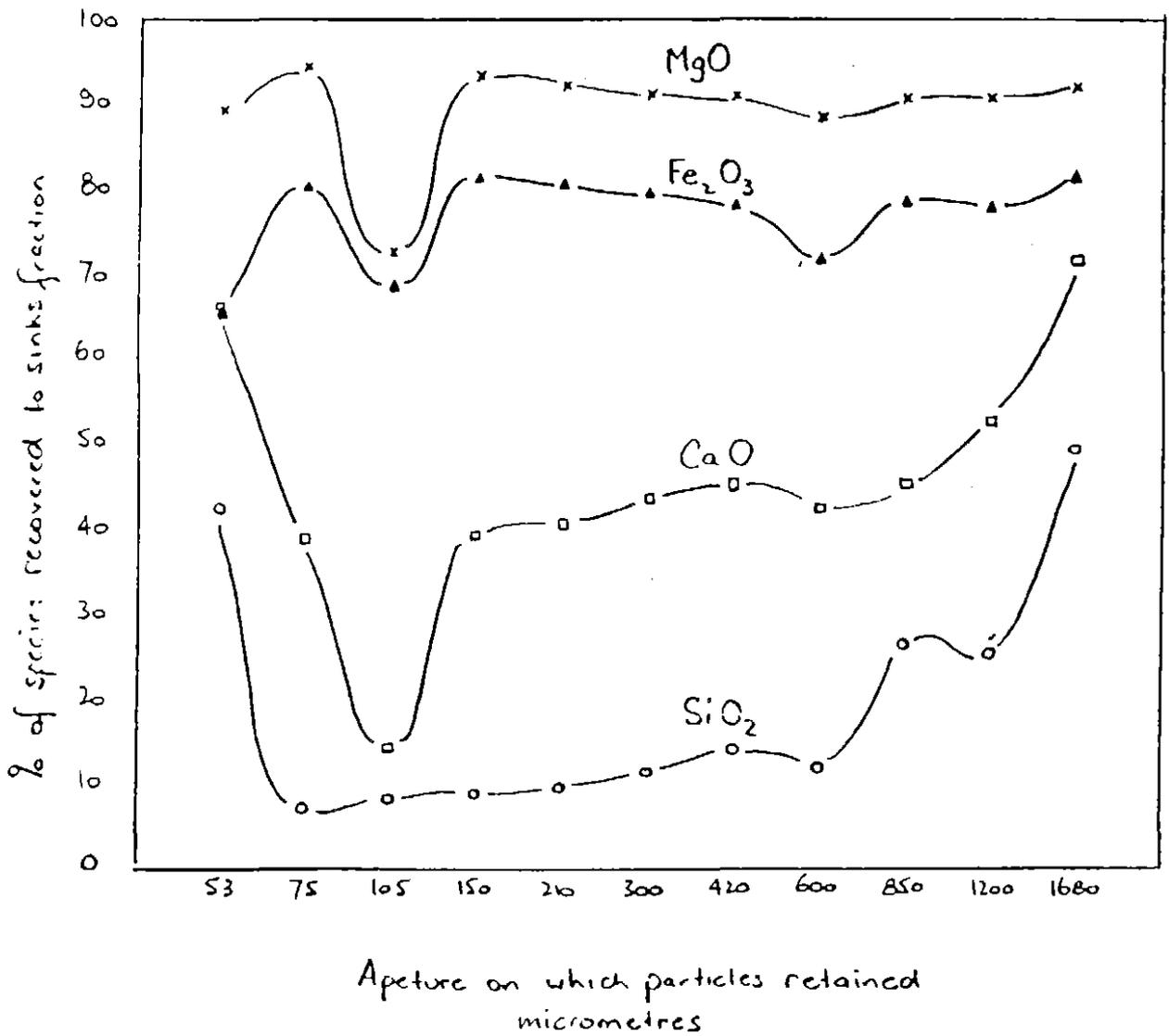


FIGURE 2: Heavy Liquid Separation of Individual Size Fractions  
From Sample 2 Using Tetrabromoethane (SG = 2.95)

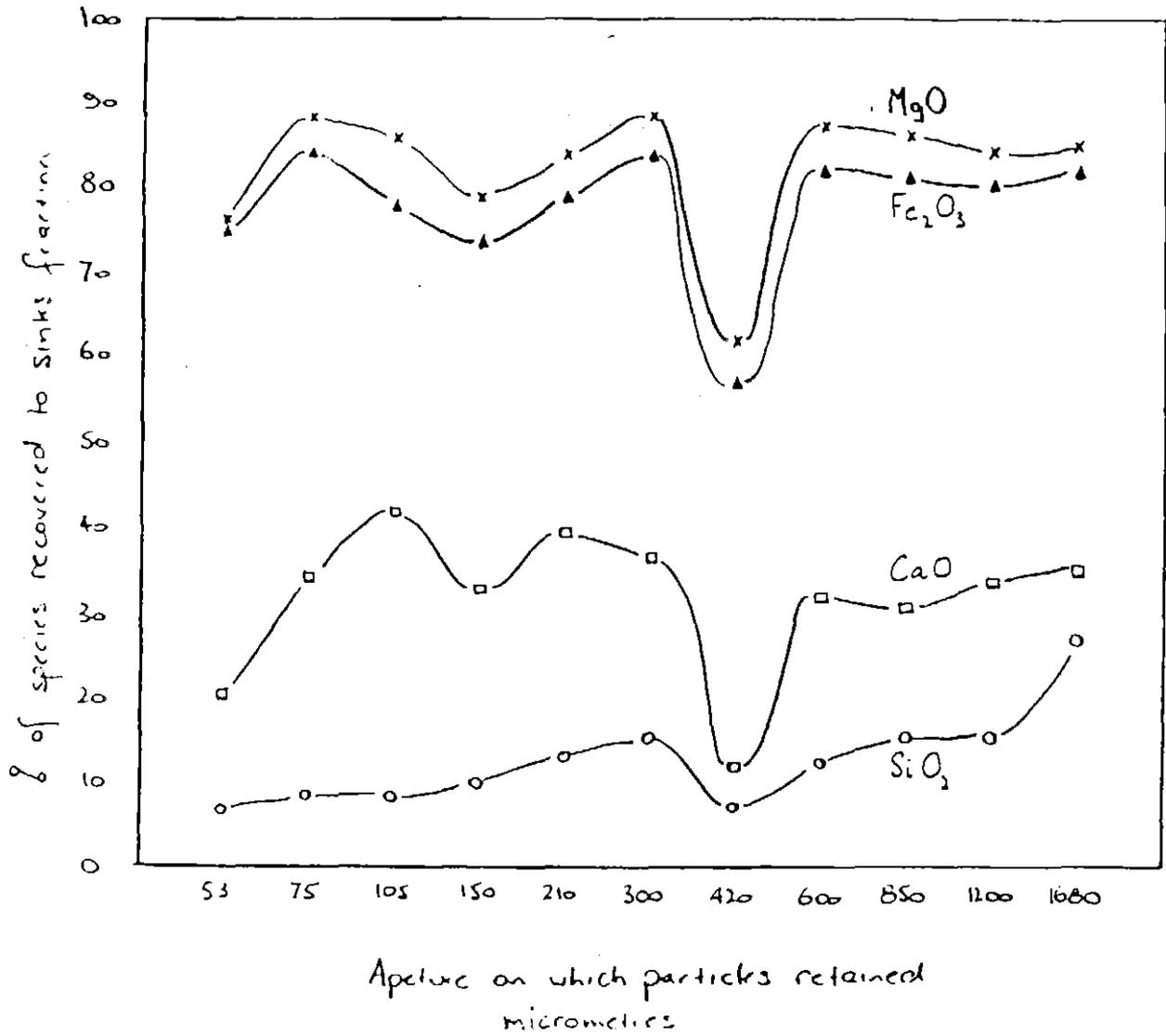


FIGURE 3: Heavy Liquid Separation of Individual Size Fractions  
From No. 1 Bulk Using Tetrabromoethane (SG = 2.95)

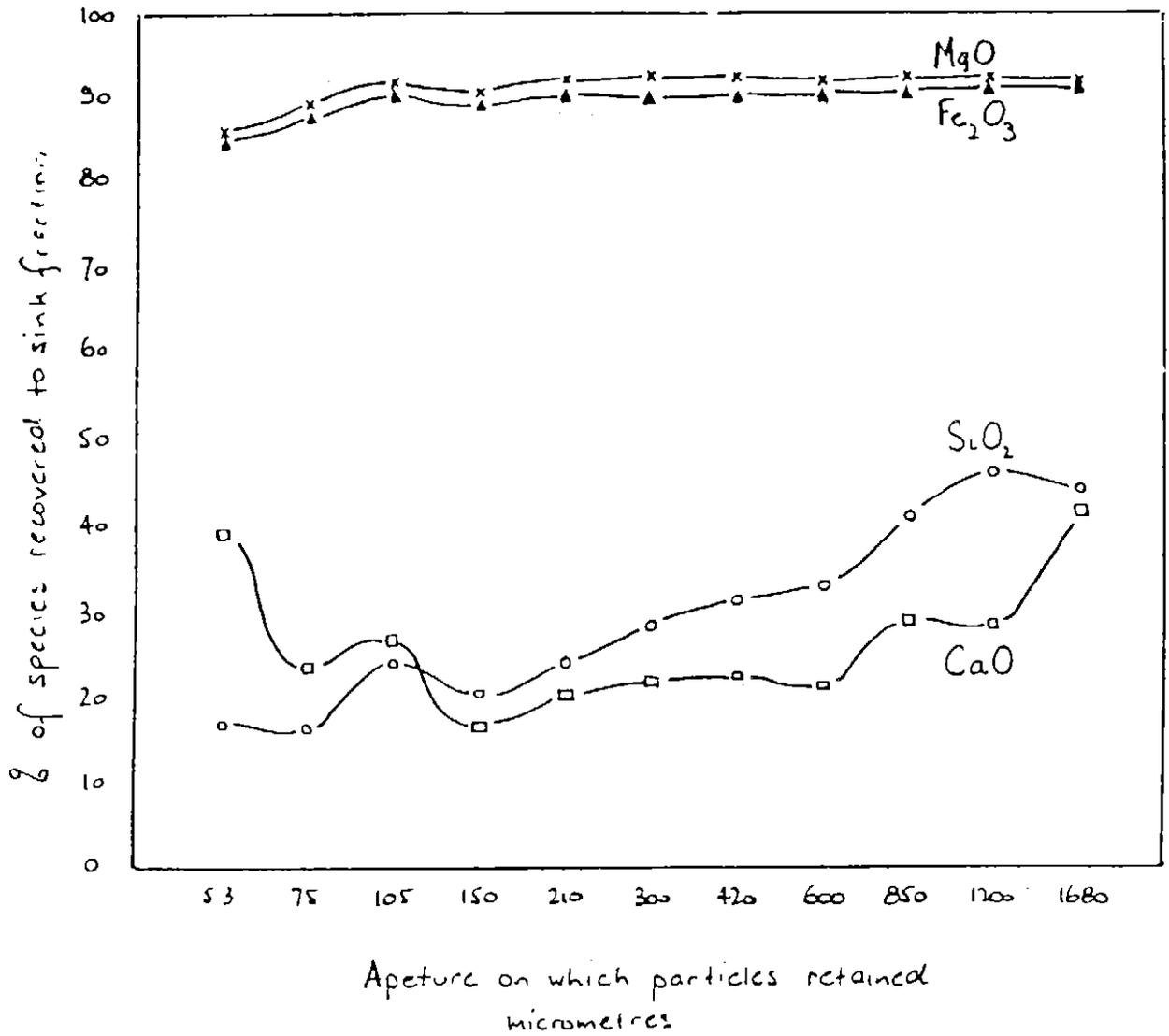
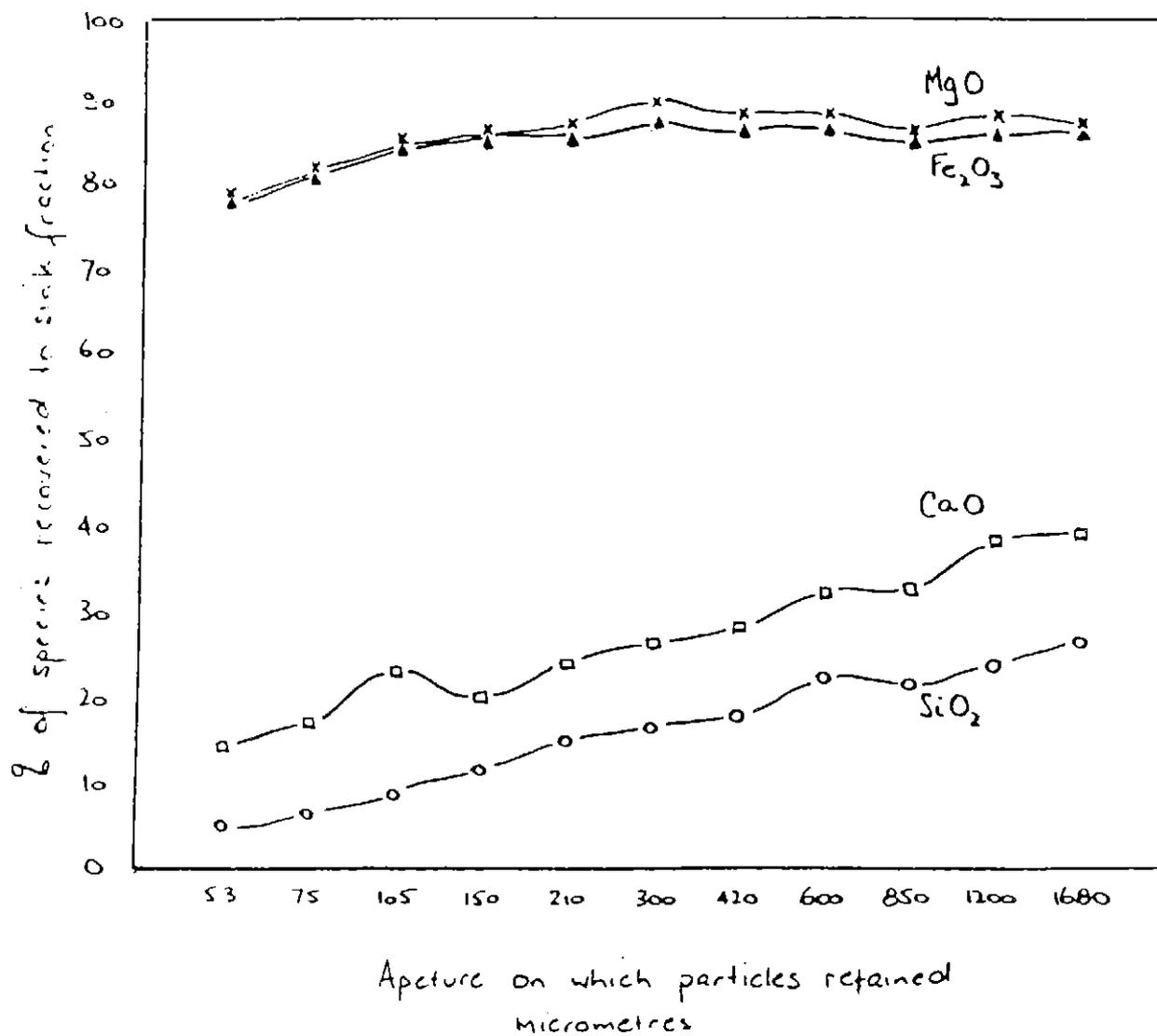


FIGURE 4: Heavy Liquid Separation of Individual Size Fractions  
From No. 2 Bulk Using Tetrabromoethane (SG = 2.95)



**FIGURE 5:** Recovery of Mineral Species to Sinks with HLS AT SG 2.95 and to the Floats with Cleaning at Higher SG's using Bulk Sample 1 Used

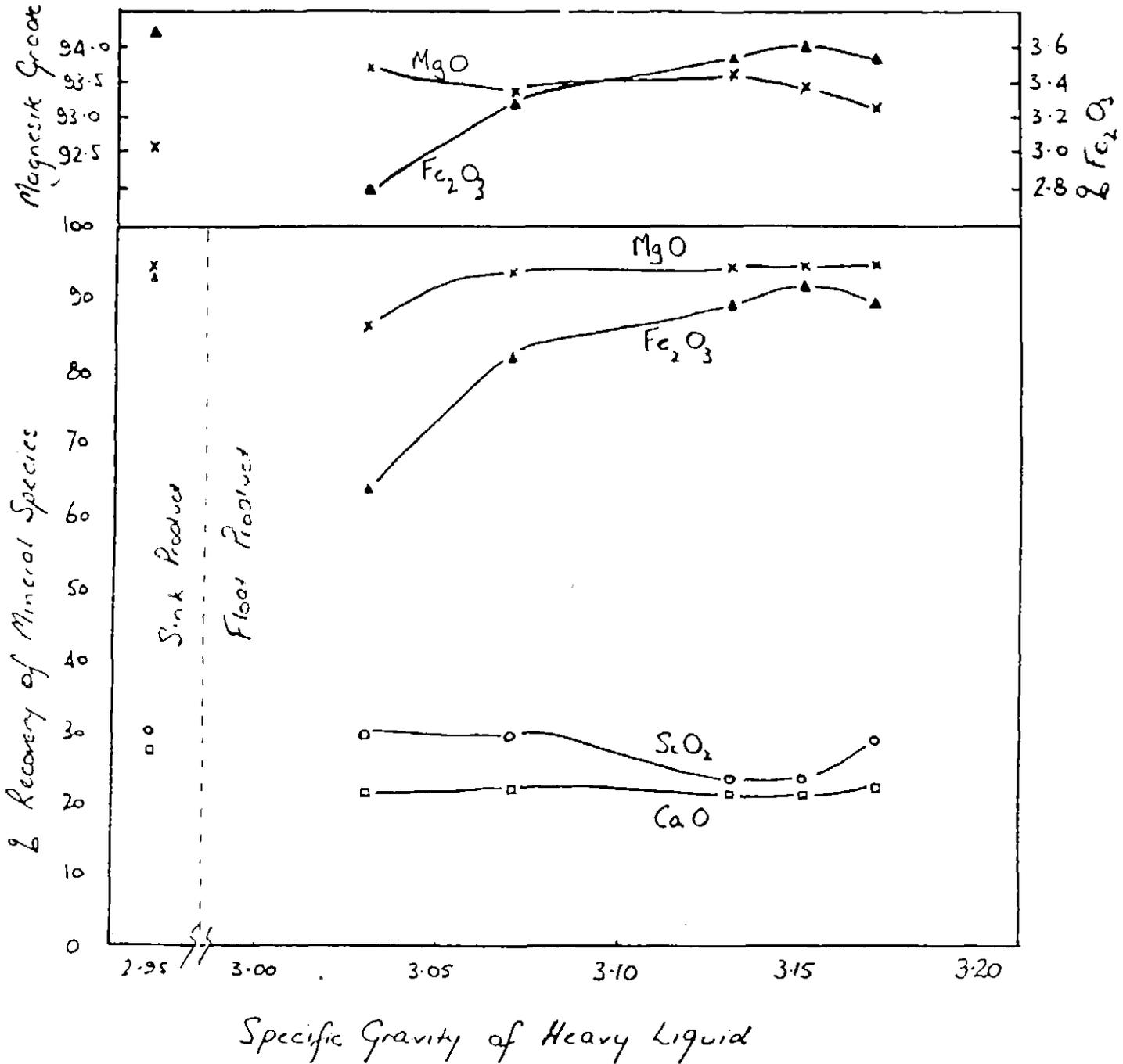
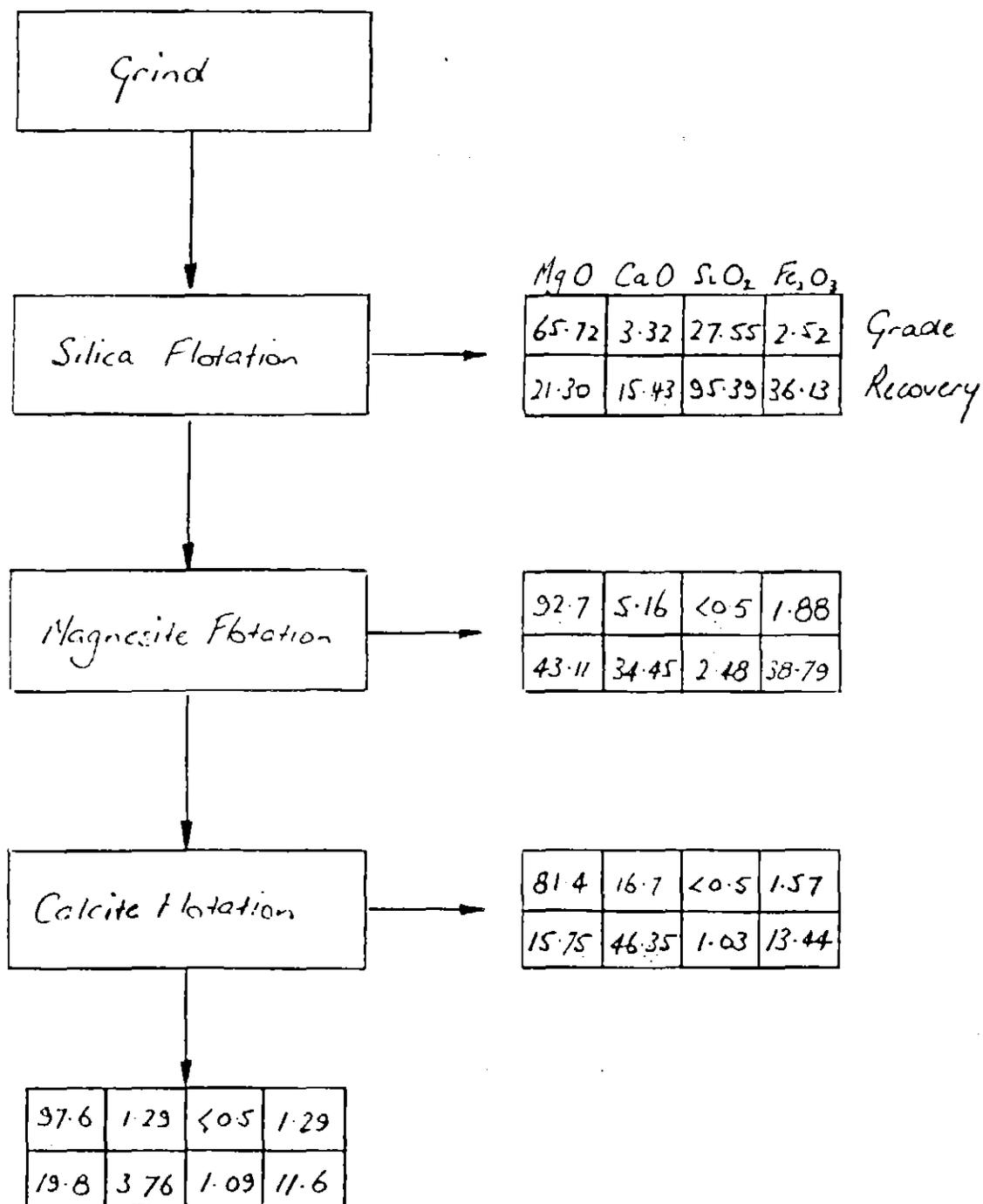


FIGURE 6: Selective Flotation giving a Magnesite Rich Tail and an Intermediate Magnesite Concentrate



FILE NOTE 7.2.6

MAGNESITE SPECIFICATION - Meeting with Tore Vraalstad, Norsk Hydro

Dated 12/11/86. New process, in Canada.

CaO less than 0.025 ratio but as low as possible  
MgO

Acid soluble silicon - as low as possible

MgO greater than or equal to 46%

Fe  
+ ) less than 1% combined  
Al

Ni less than 2 gm/tonne; less than, ideal

S less than 40 ppm

Mn less than 250 ppm

B less than 40 ppm

Ti, no definite figure, goes with iron?

Cu)

Pb) not sensitive except effluent discharge - so as

Zn) low as possible, less than 20ppm each

Cr)

P no edict

Zn less than 200ppm

BATH FORMULA

$$\frac{\text{NaCl} - \text{KCl}}{\quad} = 0.8 \text{ to } 1.0$$

CaCl<sub>2</sub> (+BaCl<sub>2</sub>)

SIZING 5mm to 50mm initial  
5mm to 100mm is possible  
5mm to 25mm maybe

will advise what optimum is.

*Murray Knott*

MJK

CC: Tom Dickson  
John Danbar  
JKH

