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P R O P O S A L

FOR A

FEASIBILITY STUDY

INTO

THE PRODUCTION OF MAGNESIUM METAL

FROM ORES IN NORTHERN TASMANIA

13 June, 1993.

ELs 25/89, 31/90, 32/90
33/90, 25/88

AMG REFERENCE POINTS ADDED

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PROPOSAL FOR A FEASIBILITY STUDY INTO THE PRODUCTION OF MAGNESIUM METAL FROM ORES IN NORTHERN TASMANIA

A. MAGNESIUM METAL

1. INTRODUCTION

The western world production of magnesium is about 250,000 tonnes per annum and there is maybe another 70,000 tonnes production in the former Communist countries. Australia does not produce any magnesium in spite of the presence of several world class ore deposits. It has a consumption of about 5000 tonnes per annum.

For decades, there have been predictions that magnesium "is about to take off". The 20 kg of magnesium used by the Volkswagon "Beetle" for die cast crankcase and transmission housings was often quoted as "proof" that the metal had penetrated the automotive industry but in fact it had not. There was, however, an increase of 35% in the use of magnesium in the U.S. auto industry over the past three years (1).

What has held back the growth of magnesium consumption ? It has not been

- the scarcity of magnesium ores
- excessive energy consumption
- difficult casting and fabrication technologies
- flammability problems
- environmental restrictions

The answer to the question is firstly price relative to aluminium and secondly (to some extent) the structure of the industry.

The principal object of this Proposal is to suggest that improved technology to which Mineral Holdings Australia (MHA) has access, together with the availability of excellent ores of magnesium and silicon in coastal deposits of Northern Tasmania, may offer a cost competitive entry into magnesium production.

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2. THE PRICE REDUCTION REQUIRED

The principal competitor of magnesium is aluminium and the early growth of magnesium will depend largely on its ability to displace some of the aluminium and also zinc die castings currently used in the automotive industry. Magnesium has this potential because it is only 67% of the weight of aluminium for the same volume and 24% of the weight of zinc. Replacement of ferrous materials is even more favourable but the cost differential is of course greater.

A prediction by M. Holland of Ford Motor Co. in 1980 (2) was that magnesium could begin to displace aluminium in minor automotive applications when the Mg/Al price ratio was 1.7, a figure related to the difference in density. The aluminium price is depressed at present (US$1.15 - 1.20/kg) but with a more realistic figure of say $1.50, a price of $2.55/kg ($1.15/lb.) would be required for magnesium to satisfy the ratio of 1.7.

The current price of magnesium is about $3.15/kg ($1.43/lb.) which is 60 cents/kg or 23.5% above $2.55. Dr. A.M. Cameron, the inventor of the new technology to be described, is confident that his improvements to the conventional Magnetherm process of Societe Francaise d'Electrometallurgie (SOFREM), a subsidiary of Pechiney, will yield savings of much more than 20% in the cost of magnesium production (see later).

3. ENVIRONMENTAL PRESSURE FOR INCREASED MAGNESIUM PRODUCTION

After many years of speculation about the future of magnesium, there are now positive indications that governments are moving faster to reduce the weight of automobiles for environmental reasons. The Japan Government now requires the average weight per car to be reduced to 1,200 kg by 1995 and 850 kg by 2000. The Japanese Automotive Association consequently expects the weight reduction to require the amount of magnesium used per average car to increase by 3900% between 1989 and 2000.

While it has become fashionable to predict the western world consumption of magnesium to be "1 million tonnes by the year 2000", these forecasts now raise the prediction to "1.6 million t.p.a. over the next 10 years" (3). Be that as it may, there is little doubt that the consumption of magnesium will grow and that Australia is well placed to play a significant part in this growth.

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4. TECHNOLOGY FOR MAGNESIUM REDUCTION

The western world magnesium industry has a relatively small output of primary metal which is currently valued at about US$0.8 billion p.a. It consists of some large producers using the chloride electrolysis route technology and a larger number of smaller producers using the thermal route. Most of the magnesium producers are also producers of aluminium and over half of the magnesium produced is later alloyed with aluminium. In most cases, the amount of magnesium in the alloy is small, being only one or two percent.

The chloride route technology is tightly held by those companies using it. This technology involves two distinct parts - the preparation of magnesium chloride from sea water, brine, dolomite or magnesite followed by its electrolysis and the recycling of chlorine. The producers will licence out part of their technology but not all of it. For example, Queensland Metals Corporation is reported to have an option to use an existing electrolysis cell but is developing its own anhydrous magnesium-chloride preparation technology which it is doing with the assistance of C.S.I.R.O , the government research organisation in Australia.

The thermal route technology can readily be purchased and is operated in 10 countries. The largest installation of 36,000 - 40,000 t.p.a. is at Northwest Alloys Inc., Washington, U.S.A., a subsidiary of ALCOA and consists of nine 4 MW Magnetherm units.

The improved technology that is the subject of this Proposal is a thermal process owned by the University of Manchester Institute of Science and Technology (UMIST). (There is a royalty arrangement with Royal Dutch Shell.)

An option agreement is held by MHA for Australia/New Zealand and all other countries with the exception of U.S.A. where the rights are held by Northwest Alloys Inc.

5. SELECTION OF REDUCTION TECHNOLOGY

The following is an extract from a report commissioned by the U.S. Dept. of Energy (DOE) dated February, 1981 entitled "An Assessment of Magnesium Primary Production Technology" by M.C. Flemings et al. of MIT (4).

"In the opinion of the writers, the current and potential costs of producing magnesium by the electrolysis versus the metallothermic route are sufficiently close that the optimum magnesium primary production process depends, not on the intrinsic technological advantage, but rather site selection with respect to the availability of raw materials, energy, labor and markets for both magnesium and process by-products. Given the variation in resources in industrial regions in the United States, electrolytic and metallothermic magnesium production technologies can both be expected to remain competitive for at least the medium term (20 years)."

The small number of producers and the low total production of magnesium have had the effect of limiting the amount of available information about the industry. The DOE report is probably still the best collective source even though it is over 12 years old, possibly because the industry has not changed much and the output has remained fairly constant.

Some figures quoted in the report are given in Table 1.

TABLE 1: MAGNESIUM INDUSTRY STATISTICS IN 1980

	Metallothermic	Electrolytic
1980 world capacity (tons)	83,000 (27.5%)	218,500 (72.5%)
Max. plant size (tons)	26,000	125,000
Average plant size (tons)	10,375	54,625
Total energy requirements (equiv. kwh thermal/lb Mg)	41.1	42.8
Estimated capital cost (US$/annual ton for a 20,000 tpa plant in 1980)	3,500	4,500

The proportions of capacity coming from the two routes have not changed much over the decade indicating that the metallothermic or thermal route is still viable in spite of its smaller unit capacity (Table 2.).

TABLE 2: **MAGNESIUM PRODUCTION: INSTALLED CAPACITY IN 1991 (5)**

Metallothermic		Electrolytic	
Country	m.t.p.a.	Country	m.t.p.a.
Brazil : Brasmag	6,000	Canada : Norsk Hydro	40,000
Canada : Timminco	12,000	Norway : Norsk Hydro	55,000
China (est.)	9,000	U.S.A. : Dow Chem.	90,000
France : Pechiney	18,000	U.S.A. : Mag. Company	36,000
India : Southern M & C	600	U.S.S.R.(est.)2 plants	90,000
Italy : SIM	12,000		
Japan : Japan Met. & Chem.	5,000		
Japan : Ube Industries	9,000		
USA : N.W. Alloys	36,000		
Yugoslavia: Magnorhom	5,000		
Total	112,600		311,000
Average plant size	11,260		51,830

There are many factors to be considered in the choice of the route to magnesium if a 60,000 tonne per annum plant were to be contemplated but for a plant with a final capacity of 5,000 to 10,000 t.p.a. the choice would certainly be thermal. That such plants outnumber electrolytic plants at low tonnages is "attributable to the simplicity of thermic reduction equipment design and ease of operation. Thermic facilities also have the advantages of less restrictive site selection criteria, low capacity economies of scale and consequently lower initial investment requirements" (6).

It is preferable, when commencing a new venture with a view to early entry into established world markets, to begin on a small scale and increase gradually. An acceptable procedure would be to start with a production of 5,000 t.p.a. from a single thermal furnace and increase it in similar increments when larger local and overseas markets become available. This would be particularly important in relation to a commodity like magnesium which has for decades defied predictions of rapid world growth.

The electrolytic process is not as amenable to low tonnage operation as the thermal route, providing other essential requirements can be satisfied.

6. THE MAGNETHERM PROCESS

Magnetherm is the most modern process for thermal production of magnesium. It is based on the reduction of magnesium oxide by silicon contained in ferrosilicon:

$$2MgO.CaO + (xFe)\ Si + nAl_2O_3 \rightarrow$$
$$2Mg + 2CaO.SiO_2.nAl_2O_3 + xFe$$

The slag composition is held close to 55% CaO by weight, 25% SiO_2, 14% Al_2O_3 and 6% MgO which at the operating temperature of 1550°C is not fully molten. The temperature cannot be allowed to go much higher because the graphite furnace lining will react to form CO which will oxidise the magnesium vapour produced. Nor can the silicon level in the residual ferrosilicon be allowed to go below about 20%.

The Magnetherm process is conducted in an AC arc furnace comprising an upper water-cooled electrode with current flow through the bath to the carbon hearth. The slag has to be electrically conducting so that the passage of current heats the bath. The reaction by which the magnesium is formed and released as a gas occurs at the surface and is strongly endothermic, requiring heat to be transferred there from the body of the melt.

Many improvements have been made to the Magnetherm process over the years but it still has the disability of operating under vacuum in order for the production of magnesium to proceed at an acceptable rate, a reasonable temperature, and with satisfactory silicon consumption. The sub-atmospheric operating pressure allows some leakage of air into the condenser and causes a loss of metal production. Also, it requires the vacuum to be broken twice per day to tap slag and to change the condenser.

According to Fleming et al: "conversion (of Magnetherm) to continuous operation at a positive pressure would significantly reduce energy consumption and labor requirements, substantially increase the production capacity of the reduction unit and reduce both capital and operating cost requirements" (7).

7. THE CAMERON PROCESS

7.1 Introduction

Several improvements of the Magnetherm process have been developed by Dr Andrew M. Cameron of UMIST. They are covered by International Patent WO89/00613 with a priority date of 10th July, 1987 and the following with the same content and priority date:

Granted: USA 5090 996
South African 88/4985
Australian Acceptance No. 618272;

Pending : South Korean Application No. 775/89.

In discussing the history of the development, Cameron said that he graduated from the Universities of Strathclyde and London (Royal School of Mines, Imperial College) in the mid-seventies and then joined the Thornton Research Centre, Chester of Shell Research Ltd. After several years he was transferred to Shell's Billiton laboratories in the Netherlands as officer-in-charge of pilot plant operations. He worked on the carbothermic reduction of magnesium using a D.C. plasma arc furnace but he had little confidence in this route. He took a position with UMIST where he had the opportunity to develop his improvement to the Magnetherm technology on the basis of detailed chemical thermodynamic studies.

The technology was subsequently piloted continuously at Billiton in a D.C. plasma arc furnace which had an input of 0.6 MW. Enough information was obtained to prove the thermodynamics and kinetics of the technology although further work is required to confirm the engineering, equipment and operational aspects (8).

The DC plasma transferred arc generator is constructed of graphite and is not water-cooled. Such equipment has so far only been used for melting and other 'unsophisticated' applications such as vaporising zinc from steel plant dusts. Intensities of 40 MW are possible with this type of equipment(9). The Cameron process would be the first to make full use of its unique characteristics for a metallurgical reduction process

Incidentally, the Council for Mineral Technology (Mintek), South Africa has patented the use of a DC plasma arc using the Magnetherm slag conditions but Cameron believes this is not practicable and that low silicon use and poor condensation efficiencies would result.

7.2 Basis of the Cameron Technology

Ideal conditions for the silicothermal reduction of magnesium according to the reaction:

$$2\ MgO + Si \longrightarrow SiO_2 + 2Mg(g)$$

include the following:

- a slag saturated with MgO
- a slag with a low activity of SiO_2
- molten reactants in the reaction zone
- the reaction zone located at the surface of the slag for ready Mg gas evolution
- a high temperature in the reaction zone.

Careful examination of the phase diagrams of the MgO, CaO, Al_2O_3, SiO_2 system indicates that the required conditions can be found in the periclase (MgO) region.

The conditions provide a strong thermodynamic driving force at temperatures of the order of 1600-1650°C which permits the reaction to proceed at a satisfactory rate at atmospheric pressure. Furthermore, it enables the silicon reductant to be used efficiently allowing the silicon in the residual ferrosilicon to be reduced to a very low level (provided a graphite furnace lining is not used as in Magnetherm).

The DC transferred arc operation does not require the bath composition to be governed by its ohmic resistance in order to generate heat as in Magnetherm. Most of the heat transfer from arc to bath is by convection and radiation. A magnesite refractory brick bonded with dicalcium silicate could be used as the furnace lining instead of carbon and it could be similar in composition to the bath and have a frozen wall. Only the area under the arc needs to be fully molten.

Reference to the phase diagram in the Cameron patent indicates that the level of MgO in the slag at operating temperature could be held at 13% or above compared with 6 to 8% in Magnetherm. The volume of slag produced per unit weight of magnesium produced will be 15% lower than the Magnetherm. It would be the ultimate objective that the process would operate with an invariant slag composition which would minimise refractory wear with continuous feeding and maybe continuous tapping of slag and continuous condensation. No maximum furnace size is indicated at the present time.

7.3 Improved Efficiencies and Cost of Production

UMIST claims that the successful 0.6 MW pilot plant trial in the Netherlands confirmed several predicted improvements to the Magnetherm process. Although magnesium was not actually condensed during the trial, analysis of the off-gas indicated that the efficiency of condensation of magnesium vapour to metal would improve because of the substantial reduction in the production of magnesium oxide and nitride. Ingress of air to the condenser was much reduced as the operation was under slightly positive rather than substantially negative pressure. The saving was believed to be equivalent to a 25% increase in magnesium production at no extra cost compared with Magnetherm.

The second source of saving resulting from atmospheric pressure operation was due to not having to break the vacuum to tap slag from the furnace and to replace the condenser. This will reduce daily downtime from 15% to 10%. Of course there would also be capital and operating cost savings by avoiding the need for vacuum pumps and related equipment.

Cameron estimates that the operating cost for the production of magnesium metal would be reduced from US$2.60 to less than US$2.00 per kg. Continuous operation would reduce this further.

7.4 Return on Investment

MHA is not able to make an estimate of the return on investment of the Cameron Process at this time because a detailed estimate of capital and operating costs cannot be made until after the proposed semi-commercial trial.

Published information on the cost of magnesium production is rare but a 1992 paper by Foley of Commodities Research Unit (CRU) and Gilbert of British Sulphur Consultants on the structural use of magnesium contains some interesting estimates of both capital and operating costs (10). These refer to a hypothetical 60,000 tpa chloride-route magnesium plant but MHA would expect that a plant such as the 40,000 tpa Magnetherm plant (such as that of Northwest Alloys Inc., Addy) when converted to the Cameron Process could well have comparable costs. (Note that future interest costs will be less than the 20% predicted in this article.)

MHA is particularly encouraged by the interest and enthusiasm for the Cameron Process by Northwest Alloys which operates the largest and most modern Magnetherm plant in the world and must be well aware of its position on the world cost curves.

8. RAW MATERIALS FOR CAMERON PROCESS MAGNESIUM PRODUCTION

The raw materials required for a 4 MW single furnace operation of the Cameron process producing 5,000 t.p.a. magnesium metal would depend on whether aluminium scrap was available at a suitable price to replace portion of the silicon reductant and to provide alumina to achieve the appropriate slag characteristics. Otherwise some calcined bauxite would be required. Two possible situations would be as follows:

For 5,000 t.p.a. Magnesium production

Option A: Aluminium Scrap		Option B: Bauxite
Calcined dolomite	20,400 tonnes	29,400 tonnes
Calcined magnesite	3,000	620
Aluminium metal	1,140	-
Alumina in bauxite	-	3,120
75% Si ferrosilicon	3,020	4,360
	27,560	37,500

The nature of the raw materials can be changed depending on local economics provided the specified MgO, CaO, Al_2O and SiO_2 contents of the slag were maintained. For example, dolomite could be replaced by a mixture of magnesia, lime or magnesia-enriched lime.

B. MAGNESIUM, CALCIUM AND SILICON ORE RESOURCES

1. INTRODUCTION

MHA's mineral exploration in N.W.Tasmania has been conducted for over 18 years. Exploration, testing, consulting and drilling costs have been substantial on a number of minerals. It is believed that these Tertiary and Precambrian prospects have indications on the surface of very large mineral bodies which will be economically mined as open-cut mines with little overburden.

Consideration of the establishment of a magnesium metal industry in northwest Tasmania provided an added incentive to evaluate deposits of high grade carbonate and silicate minerals which are likely to be of international significance for a number of markets. The potential of the magnesite, dolomite, limestone and silica has been recognized by MHA and others for some time but the available markets to date have not provided the necessary opportunity for their closer examination or development.

Recent further drilling programmes have delineated high grade metamorphosed carbonates and quartzites at depth.

The non-fragility of these ores ensures minimum dust and recent calcination tests have indicated that the ore would have excellent furnace performance with minimum decrepitation.

No.!

MHA has mineral leases in the following areas:

EL.25/89	:	Dolomite south of Smithton adjoining an existing small quarry (see map in Appendix).
EL.31/90, EL.32/90, EL.33/90	:	Limestone, magnesium-rich limestone, dolomite in three locations being west of Smithton near Redpa, Togari and Montagu.
EL.25/88	:	High grade quartzite rock at the Thomas Mountain Mine in the Dip Range.

In addition, CRA Limited (75%) and MHA (25%) hold very extensive magnesite leases near Arthur River and Lyons River west of Hellyer Gorge (RL.8717 and RL.8718).

It has not yet been possible to make detailed estimates of the tonnages available but the surface expressions and drilling already conducted leave no doubt that the exploration licences cover a huge carbonate resource which could support major export operations both in respect to quality and quantity. Some details are given in the Appendix.

2. LOCATION/INFRASTRUCTURE

The location of the deposits is excellent being on flat undulating cleared land with much of the deposit being mainly on private land with some Crown land. The near-seaboard carbonate deposit locations shown in the Appendix are serviced by the ports of Stanley (30,000 tonne vessels), Port Latta (110,000 tonne vessels) and Burnie (45,000 tonne vessels) with established bulk loading facilities. All ports have much free time. MHA has an option for rights to a non-metallic bulk storage area at Burnie Port. A full infrastructure exists nearby, including water, airport, labour, roads, railways, hydro-power and ready accommodation, as many employees would be resident at Smithton. These existing infrastructures should greatly enhance the viability of a mine with minimum capital costs.

3. ENERGY

The existing energy sources are generated by the State's low cost hydro-electricity plants.

A possible alternative for energy could be Amoco's recent Yolla discovery of natural gas, about 100 km offshore in shallow water in the Bass Basin, or B.H.P. gas from the Gippsland Basin field. MHA is hopeful that natural gas will become available on site at Port Latta - being the nearest on-shore site to Yolla - for calcining. These energy factors will enhance the viability of a substantial industrial development in this area. MHA has an assurance of an allocation of hydro-power from the Tasmanian Government and also of a site and some assurance of assistance with other development costs.

4. TRANSPORT - TASMANIA AND MAINLAND AUSTRALIA

The existing local rail and road infrastructure will be utilised for Tasmanian industries. The Federal Government Freight Interstate Equalisation Scheme is proving of benefit to Tasmanian industry by subsidising exports to all States on the mainland. This scheme covers any containerised materials and some bulk shipments with substantial subsidies ensuring that a Tasmanian industry is not at a disadvantage to a mainland industry, ie. basically it allows Tasmanian industry to transport its product at much the same road freight cost that exists between States, ie. Victoria to New South Wales, Queensland or Western Australia.

Hopefully reform on the waterfront will greatly reduce bulk transport costs to the mainland and overseas.

C. THE PROPOSALS
OPTION 1

1. INTRODUCTION

MHA wishes to find a Joint Venture Partner (JVP) to collaborate in the further evaluation in a step-wise manner of the economic potential of the Cameron Process and of the dolomite, limestone and silica deposits in its exploration leases.

MHA plans to pass over the management and 50% of the joint venture to JVP following a positive conclusion of a Feasibility Study.

The proposed Feasibility Study will include a trial of the Cameron Process in a full-size furnace. As mentioned earlier, the rights for the Process in USA are held by Northwest Alloys Inc. (NWA), a subsidiary of ALCOA, which operates nine 4 MW Magnetherm furnaces in its plant at Addy, Washington.

Because of the downturn in the world commodity markets several of the NWA furnaces are currently shut down. During visits to Addy by N.M. Thomas and J.C. Nixon in May and August, 1992, NWA advised that they were keen to convert an idle furnace to the Cameron technology and operate it in 1993 for a period of 6 months. They invited MHA to participate and to share the cost of the trial.

2. PROPOSAL FOR FEASIBILITY STUDY FOR MAGNESIUM PRODUCTION

The following steps are proposed:

2.1 Stage 1: Preliminary Study - 10 months

MHA will organize and manage a Feasibility Study with the assistance of geological, mining, engineering and metallurgical consultants in association with JVP, UMIST and the other licence holder of the UMIST technology.

The Study will consist of further explorational drilling and will recommend preferred mining and smelting sites, taking account of the available existing infrastructures. Some experimental work on calcination and other aspects is envisaged.

The costs will include further detailed mapping, drilling, assaying and testing of the mineral deposits; consulting fees; part of UMIST licence fees; part reimbursement of prior MHA costs; MHA administration; preliminary environmental studies, etc.

Cost: US$1.5 million.

2.2 Stage 2: Construction and Operation of Cameron Process - 10 months.

Concurrently with Stage 1, one 4 MW Magnetherm furnace at the Addy Smelter will be converted to the Cameron process and operated to produce over 2000 tonnes of refined magnesium for sale. Materials supplied by MHA and/or JVP will be used for prolonged tests.

Costs will include extensive alterations to an existing furnace including provision of new electric cabling and a transformer-rectifier, training of the metallurgical and engineering staff of MHA and JVP and preparation of drawings sufficient for orders to be placed for smelting equipment.

Net Cost:	US$7.0 million
Contingency:	US$1.0 million

2.3 Stage 3: Final Feasibility Study, Cost Estimates and Infrastructure Prepatation - 9 months.

Sufficient information should be available after 3 months operation of the Cameron furnace to enable a decision to be made whether to proceed with a smelter project. (The actual timing of Stages 3 and 4 will depend on when the transformer-rectifier can be ordered and delivered to the Northwest Alloys plant.)

Stage 3 will include the planning and selection of the smelter site; design of roads, storage and loading facilities for smelter feed; further environmental studies; MHA co-ordination and administration.

The JVP would have earned 50% equity in the project in this stage or possibly earlier and would have the option of taking over the management of the project.

Cost: US$1.5 million.

2.4 Stage 4: Construction of Cameron Smelter - 12 months.

Stage 4 will include the construction and completion of all facilities for calcination, smelting, refining, storage, shipping and administration.

Cost: not available until Stage 3.

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OPTION 2

3. INTRODUCTION

If it were not possible to trial the Cameron Process at Addy as described in Option 1, and if no other suitable furnace could be found elsewhere, the original plan of piloting the Process close to MHA's dolomite deposits in the Smithton area of Tasmania would be adopted. This would reduce the ultimate cost of the full development up to the construction of the first commercial furnace but the risk would be higher in the event of failure of the Process.

To lessen the risk, the trial furnace would be designed and constructed with a view to converting it to a conventional Magnetherm furnace i.e. the reverse of the Magnetherm-to-Cameron conversion planned for Addy. Pechiney, the developer of Magnetherm, have indicated that they would assist.

The following steps are proposed:

3.1 State 1: Preliminary Study - 10 months.

As for Option 1 (2.1). Estimate: US$1.5 million.

3.2 Stage 2: Design ~~of~~ and Construction of Facilities - 12 months.

The pilot plant furnace will have a capacity of 4 to 6MW which represents a reasonable scale-up from the 0.6MW Billiton furnace and which could be readily converted to a commercial unit. Ancillary equipment, although limited to essentials, would be planned and located as if it were the first unit of 5 or 10 Cameron Process furnaces.

The mining areas selected in Stage 1 would be opened up and contracts awarded for the construction of plant and buildings for ore storage, materials handling, calcination, smelting, product disposal, power and water supply, maintenance, etc. Mining and shipment of raw ores for sale could be expected to occur throughout Stage 2.

A further portion of the license fee would be paid to UMIST.

The costing of Stage 2 would form a significant part of Stage 1 and hence a detailed estimate is not available at present.

Indicative Estimate (without commitment): US$25 million.

Stage 3: Operation of Pilot Plant - 9 months.

Operation of smelter and detailed design of full commercial facilities:

Estimate: US$5 million.

Stage 4: Upgrading to a Commercial Plant: 7 months.

Completion of construction of mine roads and ore storage, materials handling, calcination, smelting, refining, product and waste disposal, maintenance, facilities, supply of services, etc.	US$10 million
Environmental assessments	US$ 0.5 million
TOTAL ESTIMATE	US$42.0 million

4. RIGHTS EARNED BY JOINT VENTURE PARTNER

As mentioned above, JVP will have earned, during Stage 3 of the Feasibility Study a 50% share in the information generated. This is expected to yield:

(a) sufficient information to construct a Cameron magnesium smelter;

(b) 50% ownership of the Cameron technology in a certain country or countries as agreed with MHA;

(c) an assurance that MHA would be able if required to supply Tasmanian feed materials for the Cameron Process delivered to international ports at competitive prices;

(d) sufficient information for JVP to decide whether to purchase a 50% share in the ownership of MHA Pty Ltd.

Note that all of the above have been agreed in principle with the particular owners but the details are subject to final confirmation.

5. PRODUCTION ROYALTIES

In consideration of past performance and expenditure, and the availability of substantial tax losses available to MHA, MHA will claim royalties as follows:

(a) if JVP decides not to purchase a 50% share in MHA, royalty charges on MHA's ores will be included in the sale price of ores to JVP but JVP will not be obliged to purchase same;

(b) if JVP decides to take 50% ownership of MHA Pty Ltd., MHA will be entitled to a royalty of 3.5% of the indexed sale price of any ore and 1% of the price of any processed product (except magnesium metal) arising from the current exploration leases;

(c) we believe that UMIST will charge a royalty of not more than 3.0% of the value of Cameron Process metal and MHA will charge an additional 1%.

N.M. Thomas
Chairman, Mineral Holdings Aus. P/L.
18 June, 1993.

J.C. Nixon
Consulting Metallurgist.

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APPENDIX

NOTES ON MINERAL HOLDINGS AUSTRALIA'S TASMANIAN LEASES BASED ON A REPORT BY MR V. THREADER, CONSULTING GEOLOGIST, HOBART.

DOLOMITE

1. Smithton Basin

Carey & Scott (1952) correlated all carbonate sequences in the *Smithton Basin* with the Smithton Dolomite, in the belief that there was only one carbonate succession in the Basin. More recent mapping and geophysical data has provided evidence that this original correlation is not valid. This work indicates that there are two carbonate sequences: an upper one - Smithton Dolomite of the Duck River and Montagu River drainage systems and a lower one - Black River Dolomite (a dominantly silicified carbonate sequence). These two carbonates are separated by the Crimson Creek Formation or its correlates (a sequence of volcaniclastics). For more detailed information see Brown A.V. in Burrett C.F. and Martin E.L. (eds) (1989) Geology and Mineral Resources in Tasmania Spec. Publ. Geol. Soc. Aust. 15.

The dolomite resource within the tenements EL.25/89 (Smithton), EL.31/90 (Redpa), EL.32/90 (Montagu Plains) and EL.33/90 (Brittons Swamp) are stratigraphically within the Smithton Dolomite.

2. EL.25/89

Twenty hammer holes were drilled in this tenement and 8 surface samples taken. The results indicated continuity of the high grade dolomite which was located by B.H.P. in ten diamond drill holes to the north of the area now occupied by the Circular Head Dolomite Company.

The area drilled was 100,000m² and the depth of drilling was 10m, i.e. 1,000,000m³ or 2.4 million tonnes (mt).

The licence area covers about 2km² south of Bass Highway which is small holdings farm land and has not been examined and would not be unless a mining venture could gain approval. A similar area, i.e. 2km², of high prospectivity lies to the west of 102m/71 (237 ha) held by the Circular Head Dolomite Company.

3. EL.31/90

The (Precambrian) Smithton Dolomite is over 1000m thick and covers 1km² (outcropping sporadically through the area). There is therefore a potential 2 million tonnes per metre depth in the licence and the depth would appear to be limited only by the practicalities of mining.

The quality of dolomite, from hammer drill and diamond drill samples is high, and in places is pure dolomite.

Analysis of surface samples gives around 20% MgO and in borehole samples the range is MgO 18.98-21.89% CaO 28.45-32.48% and LOI 41.97-46.91%.

The degree of solution cavity is unknown and could only be established by more drilling. Pattern drilling at say 100m centres for a start is required with a mix of open holing for sampling and core drilling for prevalence of voids (recovery).

In addition to pure or nearly pure dolomite there is a rock type which has been described as dolomitic limestone or magnesium limestone (which could be the result of de-dolomitisation). This occurs in the eastern portion of the licence and its precise stratigraphic position is not clear but it appears to be lower in the sequence (perhaps on the contact with the underlying Caroline Creek Formation). The composition of this rock is:

CaO	35.80-47.0%
MgO	4.77-16.4%
LOI	43.67-46.43%
Fe_2O_3	0.03- 0.1%
$SiO_2 + Al_2O_3$	0.19- 1.89%

This was examined in outcrop and borehole but more data is required to identify a resource.

4. EL's. 32/90 & 33/90 CARBONATE HILLS

These licence areas lie to the east of EL.30/90. The Smithton Dolomite is flatter dipping here than it is in EL.30/90 (which lies on the steeply dipping western limb of a syncline).

There has been no drilling in these areas as yet but the rock quality of surface samples indicates that it is consistently of high quality e.g. Montagu (32/90) - average of 4 samples.

MgO 20.64%; CaO 31.44%; SiO_2 0.25%; Al_2O_3 0.08%; $Fe_2O_3$0.43%.

A scout drilling is proposed for these areas when the most suitable areas have been identified (on the lines of landowner agreements, and environmental considerations).

These two areas combined cover some tens of square kilometres and have a very large potential resource.

5. DOLOMITE GENERAL

The former consultant of M.H.A., a one time Chief Government Geologist in Tasmania (and later Director of the Bureau of Mineral Resources for Australia until his retirement), Mr. P.B. Nye, long held the belief that the Smithton Dolomite was a huge resource of high quality and from the recent mapping by the Geological Survey of Tasmania and the exploration by M.H.A., this would appear to be the case.

The maximum suggested by R. Glenie for these licences:

31/90 - 200mt, 32/90 - 300mt, 33/90 - 1600mt, 25/89 - 200mt.

is about the right order of magnitude. There is no point at present of assuming a greater depth of resource than 20m although the greater potential is indicated by stating it as 20+.

MAGNESITE: RL.8717 & RL.8718

The magnesite resource (+40% MgO) at Lyons (30mt) and Keith Rivers (30mt) has been estimated to a nominal depth of 100m. Diamond drilling has established continuity of the deposit to much greater depth and so the reserves of magnesite would be correspondingly greater. There are also considerable tonnages of low grade magnesite - dolomite which could be beneficiated.

LIMESTONE RESOURCE: EL.31/90 CARBONATE HILLS, REDPA

An indicated resource of 3/4 million tonnes is estimated less solution cavities which may be a significant proportion judging by paucity of outcrop and lack of limestone intersections (open holes) drilled between outcrops.

A thickness of 5m only was applied in this estimate to allow for soft rock below the depth as in DD5 and 6.

A suggestion by R. Glenie that the limestone is thicker than indicated may be the case if the limestone was deposited on an uneven floor but the Geological Survey geologist who mapped the area does not support the view that the limestone extends below plains level.

The quality of the main limestone resource is high:

CaO 53-55%; Fe_2O_3 0.03-0.7%; MgO 0.5-1.75%; SiO^2 + Al^2O^3 0.5-2.9%.

The status of the resource must remain at an inferred level due to the lack of information between outcrops.

This estimate refers only to Michaels and Coffeys Hills. Outlying and prospective areas have the potential to double this reserve but more drilling is required to establish this and close pattern and deeper drilling is required to improve the status of the estimate.

Before any further drilling is done, a larger scale topographic map is required for more accurate plotting of data.

SILICA

Ferrosilicon is required as a reductant for magnesium oxide in the Cameron process. It was formerly manufactured by the BHP subsidiary TEMCO at Bell Bay on the north-east coast of Tasmania which is connected to the Smithton area by road and rail.

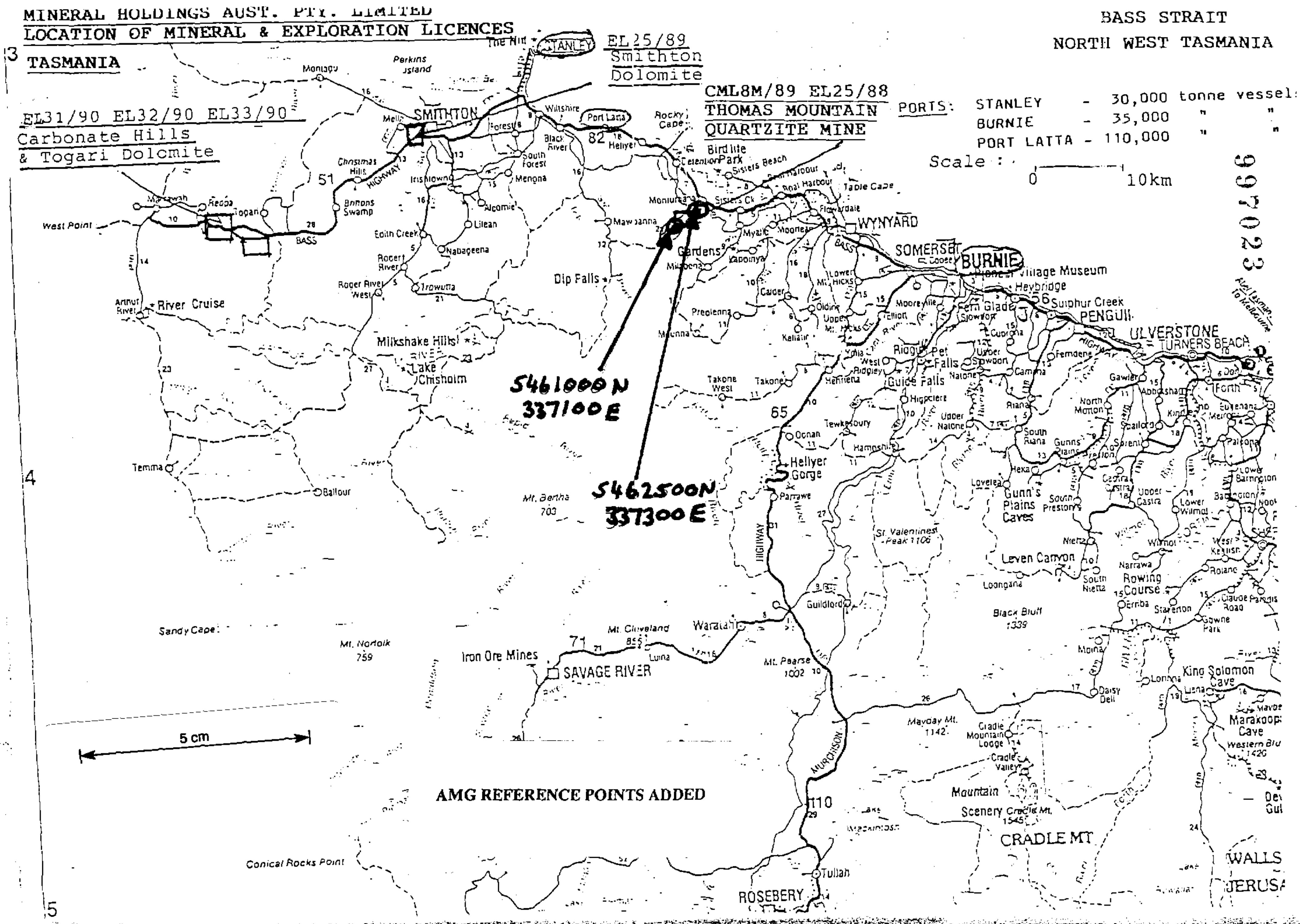
Substantial deposits of high grade quartzite rock are held by MHA at Thomas Mountain in the Dip Ranges, south of Rocky Cape about 80 km east of Smithton. This material would be suitable for the manufacture of ferrosilicon and silicon metal.

CASSITERITE

In the north-east of Tasmania, MHA holds two Retention Leases 8715 (6km^2) and 8723 (7km^2) which have been explored for alluvial tin in the Fosters Marsh area and a reserve of 45000m^3 of grade 450 grams per m^3 have been estimated. There is an area of higher grade cassiterite (tin) at "Bowlers Lagoon" in this licence with 850 grams per m^3 that would be "ideal" to commence dredging. A contiguous off-shore area which represents a northerly extension of this deposit into Ringarooma Bay has also been examined and reserves of 3300-4500t of tin metal (grade 80g per m^2) were estimated at depth of 20-40 metres. Associated rutile, zircon, gold and minor monazite were found which added approximately 20% to the resource value.

This prospect would be included in the 50% equity sale should the partner so desire.

28/5/93.



MINERAL HOLDINGS AUST. PTY. LIMITED
LOCATION OF MINERAL & EXPLORATION LICENCES
TASMANIA
BASS STRAIT
NORTH WEST TASMANIA
EL25/89
Smithton
Dolomite
CML8M/89 EL25/88
THOMAS MOUNTAIN
QUARTZITE MINE
EL31/90 EL32/90 EL33/90
Carbonate Hills
& Togari Dolomite
PORTS:
STANLEY - 30,000 tonne vessel
BURNIE - 35,000 " "
PORT LATTA - 110,000 " "
Scale :
0
10km
5461000N
337100E
5462500N
337300E
5 cm
AMG REFERENCE POINTS ADDED
STANLEY
SMITHTON
Port Latta
WYNYARD
SOMERSET
BURNIE
PENGUIN
ULVERSTONE
TURNERS BEACH
West Point
River Cruise
Milkshake Hills
Lake Chisholm
Dip Falls
Hellyer Gorge
Temma
Ballour
Mt. Bertha 703
St. Valentines Peak 1106
Leven Canyon
Gunn's Plains Caves
Black Bluff 1339
Sandy Cape
Mt. Norfolk 759
Iron Ore Mines
SAVAGE RIVER
Waratah
Mt. Cleveland 855
Luina
Mt. Pearse 1002
Guildford
King Solomon Cave
Marakoopa Cave
Cradle Mountain Lodge
Mountain Scenery
CRADLE MT
Conical Rocks Point
Tullah
ROSEBERY
WALLS

EL25/89.

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997024

Enquiries: J G Oakes
Phone: 33 8362
Your Ref:
Our File: JGO46.93:JH

Mr N M Thomas
Chairman
Mineral Holdings Australia Pty Ltd
2nd Floor
135 Collins Street
MELBOURNE VIC 3000

- 9 SEP 1993

Dear Sir

Reference is made to your report titled "Proposal for a feasibility study into the production of magnesium metal from ores in Northern Tasmania" - TCR93-3476R.

The appendix refers to 20 hammer drill holes and 8 surface samples on EL 25/89. Please supply by 7 October:

- a map of the drill holes with AMG co-ordinates giving the exact location of the holes and the depth of each.
- a map of the surface samples with AMG co-ordinates giving the exact location of each.
- date, depth, and material recovered from the holes.
- date and material recovered from surface samples.
- details of analyses of the material.

Yours faithfully

GO
J G Oakes
EXECUTIVE OFFICER
c.c. Mr D Burgess Rosny Park

R/S to G. Oakes
8 Oct. 1993

23294

997025

Vic Threader & Associates Pty. Ltd.
A.C.N. 009 576 596

CONSULTING GEOLOGIST

43 Kingston Heights
Kingston Beach Tas. 7050
Telephone: (002) 29 5277

2 3 SEP 1993
ROSNY

Mr J.G. Oakes,
Executive Officer,
Tasmania Development and Resources,
P.O. Box 56,
ROSNY PARK,
Tasmania 7018.

22nd September, 1993.

Dear Gil,

E.L.25/89 Smithton (Mineral Holdings Aust. P/L)

The information requested in your letter of 9th September 1993, addressed to Mineral Holdings Australia Pty Ltd, is contained in ARs 1989-90 and 90-91. In summary:

10 percussion holes were drilled in 1990 and

8 surface samples taken in 1991.

Another 8 percussion holes were drilled, 6 of which were located on outcrops corresponding to the surface samples.

Please let me know if any further information is required for your records regarding this exploration.

Yours sincerely,

Vic Threader

MINES		
FILE REF. EL25/89		
2 3 SEP 1993		
DOC. REF. 13692		
	FOR ACTION	FOR INFO.
JGO	✓	

c.c.M.H.A.

E.L.43/70 Dip Range (Mineral Holdings Aust. P/L)

(Exploration by Longworth & McKenzie 1981)

Borehole AMG Co-ordinates

No.	mE	mE
DD1	373 400	5 463 350
2	150	62 350
3	360	750
4	350	960
HD1	372 450	5 462 560
2	460	550
3	470	550
4	480	540
5	590	550
6	550	555
7	560	550
8	540	560
9	530	570
10	520	575
11	480	590
12	740	775
13	730	785
14	750	765
15	373 040	5 463 065
16	050	060
17	373 060	045
18	060	035
19	410	345
20	410	350
21	450	340
22	400	360
23	430	340
24	380	325
25	370	350
26	230	135
27	220	145

21st September 1993

Vic Threader