Enduring Borders and Clear Skies

Critical Mineral Capability Enhancement and Economic Integration Program

THE MAGNIUM AUSTRALIA PROJECT

A proposal by

Magnium Australia Pty Ltd
ACN 641 065 867

Australian owned company

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Foreword

The foundry has four underlying attributes:

- The process is uniquely Australian, patented, and delivers a world leading manufacturing process.
- The foundry utilises and accentuates Australia’s natural minerals advantage.
- The foundry has stand-alone commercialisation fundamentals.
- The foundry will be the hub for advanced manufacturing in Australia.

We commit this proposal for Australia’s very own sustainable and scalable magnesium foundry to the Australian Government to adopt as part of our economic recovery and advancement of Australia’s global innovation standings. The novel coronavirus pandemic has exposed our heavy reliance on China and other source countries for many products, materials, and services.

The world’s biggest health and economic crisis has also pulled the curtain back on the need for Australia to increase our own sovereign capabilities, particularly in the production of minerals and metals of strategic and military importance.

A proud Australian SME, Magnium Australia Pty Ltd, stands ready to help create Australia’s next generation export market in these critical minerals and ensure the security of that market.

Most of the turning points in a nation’s history are the result of the emergence of a new leader or the loss of a leading figure. This is simply because they are more common events than fundamental shifts in the economy or an industrial revolution. Yet here we are. On the cusp of a technological revolution.

Commonly termed the ‘fourth industrial revolution’, it encompasses end-to-end digitisation and data integration of the value chain. At the very heart of the concept of this revolution is the idea that we can produce single outputs through highly flexible and intelligent manufacturing processes.

While the world’s superpowers are waging trade barbs on multiple fronts, Australia’s leaders should be applauded for prioritising and successfully mitigating the impact of this deadly global crisis on our nation’s health, our economy, and our people.

As Australia steps out from under this terrible pandemic, we know there has never been a better time to unlock our natural wealth and create new low emission, advanced technology-driven industries now available to us. We are strongly aligned to the Government’s recently announced technology investment roadmap.

As the Minister for Energy’s recently released white paper confirms, technology will drive a successful shift to secure, more affordable energy, and lower emissions.
Deploying the right technology when and where it is needed will allow Australian industry to capture new opportunities from rising global demand for lower emissions products. This proposal for a magnesium industry aligns with the Government’s key goal of ensuring Australia remains at the forefront of the global low emissions technological innovation.

This proposal seeks to create a blueprint for the practical assembly of the elements that we already possess, to produce a world leading magnesium industry.

Australia has the science, the mineral resources, the infrastructure, the people, and the leadership required to produce some of the world's most prodigious advancements.

This will set a precedent for the innovation that is possible by our great nation.

Magnesium lays across our land in abundance and yet the technology to activate it into a new value-add export industry has been largely ignored.

Globalisation has been confronted by irrevocable transformation, triggered by COVID-19. Australia’s ability to pivot, evolve, and grow through its natural resources, people, industry, and leaders must be acted upon. This blueprint underscores that it is in our national security interest to not only protect our critical minerals but to develop them into the strategic metals and products the world will want and need now.

We know this proposal can be enacted now. With it will come hundreds of high-value jobs and, most importantly, jobs for regional Australia along with the sovereign capability that we have forgone for too long.
Executive Summary

Critical minerals, or rare earths, are an essential component for advanced technology manufacturing in industries that include aerospace, defence, renewable energy, agricultural, and telecommunication technologies. These minerals are found in lithium ion batteries, which power everyday items such as smartphones and laptops.

Australia has developed and globally patented world leading technology in magnesium production which is far superior to current practices. Production Process is granted in Australia, Canada, China, Korea, Russia, and the US (US 9,090,954). The immediate opportunity is to commercially develop this technology and become the global leader and dominate this critical mineral space.

Magnesium is one of a handful of critical minerals found across regional Australia. Victoria has the throughput. While Queensland, Northern Territory, and South Australia have the supply of magnesium ore, the US has the demand, with its growing aerospace industry and ramping up of the renewable energy sector.

Whilst this offers up extraordinary untapped export opportunities, there is also the concern of our current over-reliance on China, which right now is the single largest supplier of magnesium. Whilst single supplier risk was always evident, through price rises and trade negotiations, it was not until the emergence of the novel coronavirus that the negative impacts of this import strategy were brought to the fore.

Conversely, access to this new advanced, low emission technology in which to properly mine magnesium also now allows us to build sovereign capability in mining and exporting our own critical minerals.

With known economic demonstrated resources of 312,232,24 million tonnes, Australia has the potential to meet 50% of the world's annual magnesium requirements25 for the next 250 years.

This represents a lifetime market opportunity on today's prices in excess of $253 billion - $297 billion; ultimately creating an annual potential export economy of over $1 billion per annum in the pure metal alone.

Magnesium is used in high-end products, and key established markets include, refractories, flame retardants, building products, and magnesium alloys. This includes motor vehicles, computers, by companies such as BMW, and in emerging industries, including aerospace. The core element in magnesium production is magnesium ore or magnesite.

Today Australia imports circa 10,000 tonne of magnesium per annum.2 This increases our annual trade deficit by 40M, and prices are rising.

For a tenth of our current import cost (estimated at $410M) Australia could build a world-class low emission facility to produce 30,000 tonnes of magnesium per annum.
This output will far exceed our domestic requirement of 10,000 tonnes. Australia could earn more than $80 million a year – in terms of net revenue – if we exported the remaining 20,000 tonnes. If prices for magnesium were to increase – as widely expected – so too would our revenue from this new export opportunity.

Magnium Australia has rights to the globally patented technology developed by Australia’s National Science Agency, the CSIRO, to produce magnesium metal in Australia at a more competitive rate than current global production, and importantly with significantly less environmental impact than any other magnesium facility or process worldwide. Beyond this proposal, it is our vision to licence this technology to other countries including the US.

This proposal outlines how Australia will benefit economically for generations to come from the globally significant Magnium Australia Project.

Local sustainable production of competitively priced magnesium aligns with Australia’s Critical Mineral Strategy by capturing overseas demand and diversifying supply origins. The Australian metals export market is falling against the minerals export market and Magnium Australia is endeavouring to assist in reversing this alarming trend.

Australia is making strong moves to strengthen its critical mineral capabilities and has recently signed agreements with the US and has opened the Critical Minerals Facilitation Office in Canberra. The US, UK, EU, and Japan all identify magnesium as a critical mineral and are looking to secure supply.

The Australian Mining, Equipment, Technology and Services (METS) sector enables the growth of new mines and processing facilities in Australia without significant offsite infrastructure investment.

Prime locations for the magnesium facility are:

- Regional Queensland - within proximity to Rockhampton
- The Northern Territory - within proximity to Darwin
- South Australia - within proximity to Adelaide
- Victoria

These are sites either have throughput or are where significant demonstrated magnesium ore bodies (feedstock) exist.
Energy

Energy prices in Australia are high compared to the US, China and in fact by global comparison. Delivering competitive energy prices is a core focus of Government and the expansion of renewables and gas production long term infers a lower cost for energy for future Australians.

The supply of long-term low-cost energy will be the key determining factor of the location of the Foundry as energy is the critical ongoing opex costs.

Per tonne requirements below, multiplied by a total output of 30,000 tonnes per annum.

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<td>Natural Gas - Calciner</td>
<td>GJ</td>
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<td>Water</td>
<td>m³</td>
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The output of the foundry is 30,000 tonnes per annum (tpa) with the potential to scale up to 100,000 tpa. The above numbers at 30,000 tonnes translate into approximately 570 Gigawatt hours (GWh) \((GWh=1,000 \ MWh=1,000,000 \ kWh)\) of electricity and 120 Terajoules (TJ) \((1 \ TJ=1,000 \ GJ)\) of Gas for the 30,000 tpa plant and 2 TWh, and 400 TJ for the scale up to 100,000 tpa.

Focusing on the 30,000 tpa foundry, 570 GWh of electricity represents approximately 70 MW flat base load and would be one of the largest handful of loads on a single site in any of the National Electricity Market (NEM) regions.

Electricity represents 94.4% of the foundry’s energy usage and a slightly higher percentage of cost. Another way of expressing the relativity of electricity and gas is that at 8 c/kWh \($80/MWh)\) for electricity and $9/GJ for gas, the annual gas cost represents just under 2.5% of the expenditure on electricity.

Additionally, to deliver it in practical terms our monthly Electricity bill at .08cents per KWh is $3,810,000.00. Which is commercially acceptable.

Businesses will be encouraged to develop downstream processing in the region and invite participation from industries, such as defence, aerospace, automotive parts, electronics, and advanced manufacturing – nationally and globally – to produce high-end products. Magnesium has superior machinability, which practically equates to easier to process and less expensive tooling.

A completed stage 4 commercial facility would create 750 FTE positions with established ancillary services, upstream and downstream business. Today the 40M Australia is expending on Magnesium imports is paying in part wages to foreign labour overseas. We have an opportunity here to build local new skillsets and expend those funds on shore.
The magnesium facility is proposed below in 5 financial stages.

**Stage 1**  
Research and develop technology. Build small test pilot plant 2kg capacity (Clayton, Victoria). Test feedstock and verify technology. Document. Patent technology globally, including China, USA and EU. **COMPLETED**

**Stage 2**  
$3.24M – Undertake a scoping study to ensure best location and export access. Secure option for feedstock of magnesium. Expected timeframe is 32 weeks. **IN PROGRESS – FUNDING COMPLETE**

**Stage 3**  
$28M – pilot plant – capacity 750 tpa (tonnes per annum)

**Stage 4**  
$70M – demonstration plant - capacity 2,250 tpa

**Stage 5**  
$335M – commercial plant - capacity 30,000+ tpa

**Total: $434.24M**

Overall we seek government support for stages 3, 4 & 5.

In this proposal we seek Federal Government matched funding for Stage 3.

In March this year, Queensland Resources Council Chief Executive and former Federal Resources Minister, the Hon Ian Macfarlane, observed that some of the challenges going forward in developing Australia’s critical minerals sector is the infrastructure and energy costs.

> “Resolving issues around infrastructure, energy costs and getting a stable local workforce is going to take a strategic approach and good cooperation between private enterprise and government.”

We believe our **Magnium Australia Project** meets and surpasses those challenges.

This project represents the pinnacle of capabilities of the Australian nation and what we can bring to the rest of the world.

We can disrupt China’s monopolistic dominance of the global magnesium market. We can strengthen our economy through a new value add critical minerals export market. We can protect our national security interests.

We can provide regional jobs and demonstrate what a strong partnership between government and private enterprise can look like but, most importantly, we can be world leaders in the fourth (advanced technology) industrial revolution.

And it will be the Australian communities who will reap the long-term benefits of such a project.
Strategic Observations

Australia has some of the world’s largest resource deposits and yet even now, 80% remains unexplored for mining.

In 2017, the global export market for minerals and metals was a combined $7.59 trillion, and Australia’s share amounted to just $255b.  

Australia is one of the largest exporters of minerals globally. Our export of minerals (excluding metals) has more than doubled in the last 20 years to capture 6.4% of the world market. In Queensland over the last 3 years, there has been a 30% increase in jobs to more than 60,000, with a value increase from $7.8 billion to $11.7 billion.

By stark contrast, since the year 2000 our export of metals has steadily declined by over 50% to just 1.06% of the global market.

Our dependency on overseas interests should be considered.
We Must Rise Up

The novel coronavirus pandemic severed critical global supply lines with stunning ferocity and speed. The shocking and sudden effect of the health crisis has Australians deeply concerned about our reliance on our traditional trading partners for critical goods and services.

As Australia increasingly relied on the low-cost source factories China and India for our and ever-increasing supply of goods, investment in domestic manufacturing innovation has diminished. Mining and processing of critical minerals in Australia has long been considered a slow and expensive alternative; that has attracted little concern for change.

Whilst the pandemic and the need for Australia to urgently rebuild our own economy has shaken that myopic indifference, we now have the technology and the determination to be a global leader and develop our own local capabilities in critical and rare earth minerals. This is in our national economic and security interest.

It will allow us to forge important and trusted global alliances at a time when we need these more than ever.

Why We Need to Strengthen Our Sovereign Capability in Critical Mineral Supply

According to a report published by the Department of Industry in October 2019; critical minerals are metals and non-metals that have important economic functions, can’t be easily substituted, and which face some degree of supply risk.

Supply risks can stem from geological scarcity, geopolitical issues, trade policy or other factors. What constitutes as ‘critical’ differs between countries, depending on essential demand applications, productive capacity, and import dependence. China dominates all parts of the global magnesium supply chain from mining, through processing to refinement and, as such, sets the world price.

Process developments including low-carbon technologies, as well as the rise of digitalisation across several industries, have seen increased global consumption of critical minerals.

Australia had already begun ensuring the security of its critical element supply, even before the novel coronavirus spread, but more needs to be done.

On December 11, 2019, Australia and the US signed a historic agreement unifying a joint commitment to secure the supply of critical minerals. Australia has established the Critical Minerals Facilitation Office in Canberra on the January 18, 2020.
Magnesium is listed on the critical minerals list of the US, UK, EU, and Australia. Global supply is currently dominated by China with an 87% share, and supply is under threat due to the damaging environmental impacts of their extraction process.8

As a result of emissions policies coming into force, overseas supply chains are expected to close plants, restricting magnesium production and leading to price rises. The EU and UK are also 100% reliant on overseas interests for magnesium supply.9
By not doing more to participate in the metals manufacturing, Australia is missing out from the benefits of the $1.9 Trillion metals export market.28

This proposal represents the opportunity to utilise our science, resources and knowhow for the benefit of the country, whilst creating Australian jobs, reducing global harmful emissions and enhancing Australia’s reputation in the world for both industry leadership and green technologies in an area (mining) that has often been the target of less than positive scrutiny.

Why Now Is the Right Time

Magnesium is the 8th most abundant metal in the universe.29

Magnesium is 34% lighter than aluminium, 60% lighter than titanium, 70% lighter than steel and dissipates heat 100 times better than plastic. It is also stronger in most applications than those structural metals. Besides its basic functions as a component in aluminium alloys, titanium, and steel production, magnesium can also be cast into various mechanical parts and replace aluminium alloys for virtually anything needed to be lighter and stronger.

About a third of primary magnesium is used in the production of aluminium alloys containing an average of 0.8% magnesium, for which packaging (35%), transport (25%), and construction (21%) are the major applications. Magnesium castings account for another third of consumption, chiefly in the automotive industry but also in aerospace components, defence applications, and consumer goods. Iron & steel desulphurisation and titanium production dominate the final third, with some minor use in wrought products and niche applications.

In the past pure magnesium has seen restricted use in certain cases due to concerns over its flammability in finely divided form. Today, thanks to modern advances in alloys, even NASA is utilising more magnesium in spacecraft, removing previous restrictions around its use. Magnesium has 16 times the vibration damping of Aluminium, making it ideal for use in lightweight electronic and computer casings and components. Magnesium-Diboride is a recently discovered superconductor that is now the subject of multiple NASA funded research projects.30,31

The global magnesium metal market has been viewed as a high value, moderate growth type market, which is expected to continue.33 During the past decade, the world has witnessed increased demand magnesium metal. This is primarily due to its application in aluminium alloy which is expected to be a $229 billion industry by 2025.32

The use of magnesium metal and magnesium metal alloys in aircraft and aerospace applications is expected to witness a steady growth. Aircraft manufacturers across the globe are focussed on developing lighter and more fuel-efficient aircraft in order to adhere to stringent emission norms and regulations imposed by various regulatory bodies and associations.
Low Emission Advanced Manufacturing

Greenhouse gas emission restrictions are coming into force globally. The transport industry is responsible for almost a quarter of the world’s CO2 emissions. As a result, manufacturers are exploring the process of “Light weighting” or reducing vehicle weight by using magnesium alloys resulting in 40% weight saving over traditional materials.

According to the European Commission, a 100kg reduction in a standard passenger vehicle can result in a car lifetime saving of over 1500t of CO2 per vehicle based on 200,000Kms. Greater availability of magnesium can tip the economic scales to enable greater uptake. It’s a self-fulfilling cycle and one Australia can comfortably lead.

How We Arrived Here

Until 2000, industrial magnesium metal production was dominated by molten salt electrolysis of magnesium chloride. The process is highly capital and energy intensive and requires production on a significant scale to operate economically. Over the last 20 years, electrolysis has been almost entirely displaced by the Pidgeon process, a silicothermic reduction method. The attractiveness of the Pidgeon process lies in its low capital cost, simplicity of operation, and high purity metal product, but this simplicity comes at the cost of batch operation, high labour intensity, and significant environmental impact. In the long-term, neither process is ideal.

From 1995, China began to increase domestic production to fuel their growing economy and opted to employ the ‘Pidgeon process’. The Pidgeon process requires limited capital investment, has a permitted economic operation at smaller scale than electrolysis,
produces high purity magnesium, and the dolomite feed is easier to process and handle than magnesium chloride.

Disadvantages include low process intensity (20kg/retort/day), high energy requirements, expensive ferrosilicon reductant, dangerous operation, high labour intensity, and significant environmental pollution, including CO2 emissions. In 1995 China was uniquely positioned to capitalise on this technology with rapid industrialisation, cheap labour, and close to zero environmental and safety standards.

From 2000, China has overtaken the US in output and in the process forced several electrolytic operations worldwide to close due to dumping. By 2008, production in Norway and Canada had ceased, and US output was less than half its 1994 level.

Today China’s accounts for over 87% of the world’s magnesium production creating a virtual monopoly.

As a result of China’s market dominance, prices have risen. Increasing environmental commitments mean the Chinese magnesium industry is now not without risk. The current Pigeon process produces significant amounts of pollutants and factories are becoming subject to environmental controls providing further potential supply restrictions. Some factories have recently even faced bankruptcy.

The US is attempting to protect its local job economy by placing tariffs on Chinese imported magnesium. This is hindering magnesium’s usage in the automotive industry due to the economic benefits.

The US / China trade war is real and capricious.

**The Proposal**

Key strategies are urgently needed to help Australia recover and foster in a resilient future for Australia that secures:

1. The ability to produce and refine critical minerals locally and sustainably.
2. The development and commercialisation of high tech, advanced manufacturing processes for the Australian materials sector.
3. New value chains that strategically position Australia as the global leader in quality sourcing and advancing technology for advanced research and manufacturing.

We believe that on the back of this crippling economic and health-crisis, our global trading partners will support our entry into the supply of on the world’s most in demand, critical minerals.

This blueprint will set the global benchmark for low emissions in mineral processing and will lay the foundations for securing long-term critical mineral supplies in Australia.
We commit this proposal to the Australian Government to work with us to design and establish the **Magnium Australia Project**.

Since 2003, CSIRO has been developing a new technology to produce magnesium metal. The process involves the carbothermal reduction of magnesium oxide followed by supersonic quenching of the gas products to produce a high purity magnesium powder. The science has been validated and is now ready for stage 1 plant operation. Compared to existing processes, the new plant can produce magnesium metal with less energy and lower labour requirements than either the electrolytic or Pidgeon processes, whilst exhibiting a significantly lower capital intensity than electrolysis and a much lower environmental impact. Furthermore, the plant does not produce chlorine as a by-product, unlike electrolysis, and operates continuously, unlike the Pidgeon process.

**Phase One: Completed**

Phase 1 has commenced with investment by its architects and the **Magnium Australia Project** is now ready for further development in commercialisation. The provisional plant design and initial costings has been performed. Feedstock verified. Patents lodged globally. Circa 10M spend. Additional high-level detail is available, upon execution of an NDA.

**Phase Two: $3.24M - In Progress Funded**

Phase two is a detailed blueprint on how the magnesium manufacturing plant would be leveraged regionally and prepare a feasibility study into the construction of an advanced technology facility in one of the locations – identified by Geoscience has having an ample appropriate supply of magnesium, or access to same: Regional Queensland within proximity to Rockhampton, the Northern Territory within proximity to Darwin or South Australia within proximity to Adelaide, to manufacture magnesium metal. Victoria is an option given its magnesium ore through put.

The investment is privately funded and has been committed. The outcomes can be delivered within 32 weeks.

**Phase Three: Cost $28M**

This funding is needed to secure and construct a functional pilot plant in a location identified in phase one, capable of producing 75tpa of magnesium and enhance optimal outcomes for the primary plant build.

The Federal Government invest an initial $14M. Match funding of $14M (to total $28M) in funds would be obtained from State Governments, Industry, Private Investors and Superannuation Funds.
We know there is competitive tension between these key states to host an advanced manufacturing hub. We believe that taxpayers will be the ultimate beneficiaries of this ‘bidding war’ for the Magnium Australia Project.

**Phase Four: Cost $70M**

Federal government would commit a further $35M covering 50% of the construction cost of a demonstration plant, which produces 2,250 tpa. This commitment would be matched by State Governments and private investment.

**Phase Five: Final Completion Cost $335M**

- Construction of a world-class commercial magnesium plant
- This is estimated to cost $335M with an ROI of 4 years.
- Funding would be matching private. We would need Government support to ensure private investment.

This plant would be capable of producing a minimum 30,000 tpa of magnesium and is scalable and replicable. This would be equivalent to producing 3% of the world's magnesium at a minimum, resulting in turnovers in excess of $100M and providing up to 60% less environmental impact.

Based on the research and model provided, this plant could lead the way to constructing plants to process other critical minerals. This would modernise Australia's mineral processing capabilities and become the cornerstone in an emerging export sector competing effectively against dominant global players.

Completion of this plant would also provide the capability to import raw magnesium ore for processing.

**The Size of the Prize**

Never has it been so important for the Australian, State and Territories governments and industry to promote collaboration and consultation in enhancing and securing a sovereign capability that will allow us to be a global leader of critical minerals. The patented technology is Australian developed and owned. The technology combined with Australia's competitive minerals advantage is a strong elixir for global domination in this sector.

The Advanced Manufacturing, Mining and Energy sectors represent a global market of over an estimated $5.3Tr by 2027. 10, 11
Globally, magnesium exports in 2017 were valued at $3.1B with Australia’s export value at less than $500,000. The magnesium alloys market is expected to reach $10.27B by 2027.

Australia’s opportunity to close the value-added processing gap and take advantage of this is a once in an industrial revolution event. The goal is 1/3 of global production of magnesium which is 3B annually.

The downstream economic value is expected to exceed 1B per annum. To be clear we believe the economic value will be significantly more. This is a moon-shot investment. Though the initial investment and outcome is able to be measured in purely financial terms the investment will open the Australian economy to advanced manufacturing on fronts not yet known. Further it will open the investment community to aggressively pursue value add to our mineral exports.

With Australia’s rich mineral reserves and advanced manufacturing capability we can provide cheaper critical minerals to the rest of the world cheaper and with the lowest environmental impact by a large degree.

The availability of critical minerals in Australia will enhance industries such as 3D Printing, Aerospace, Defence and Technology, creating a force multiplier for our economy.

These industries all have export growth potential and the ability to provide a complete integrated supply chain to deliver significant value into our export products.

Environmental impacts of traditional refining and manufacturing are under extreme scrutiny and Australia’s ability to provide sustainable methods will set us apart as the provider of choice on moral grounds alone.

Where did Australia Import Magnesium from in 2017?

China 87.56%

Courtesy of the Harvard’s Atlas of Economic Complexity

In Confidence
The World’s Governments Share Our Concerns

The EU have realised that not only are they wholly reliant on other countries for critical minerals, they do not even have the upstream steps in the value chain for further processing and refinement.\textsuperscript{15}

They have labelled access to critical materials as a national security question. \textsuperscript{16}

The US Department of Interior have released a list of 35 materials deemed critical to national security and the economy.\textsuperscript{17}

The UK acknowledges it has no identified list of critical materials and no redundancy in supply once they are identified. \textsuperscript{18}

The supply of rare earth metals was restricted during 2002-2008, tripling prices and forcing Japan to start stockpiling. \textsuperscript{19}

We must act now to establish Australia as a viable contender in this space instead of a mineral farm which is not scalable long term. This is an opportunity to drive long term accelerated growth to integral parts of our economy and be the key player in a global market.
**Why Magnesium Production in Australia**

The Australian Government plays a critical role in the development of infrastructure to support globally competitive industries and provide access to growing international markets. The Government’s support for infrastructure development has the capacity to stimulate and enhance economic productivity, reduce our capital costs, build competitive advantages, and deliver a multiplier effect throughout the economy, generating lasting economic and social benefits.

Australia has an abundance of critical minerals resources across the country. Critical mineral mines are often supported by existing infrastructure. The widespread distribution of critical minerals also suggests possible flexibility in the development of future infrastructure and supply chains for several.

The Australian, Federal, State and Territory governments continue to invest in upgrades to existing infrastructure. Road upgrades can reduce commercial costs for operators in Australia’s critical minerals sector by improving roads’ flood immunity to reduce road closures during wet seasons, supporting more productive heavy vehicle access and usage, and improving access to key infrastructure, such as ports, and electricity generation for resources developments.

Australia has a stable investment environment, good infrastructure for road, rail and seaborne trade, and no significant domestic security issues that could threaten supplies. Human capital is high, with key strengths in project management, skilled trades, engineering and other professionals. Australia is ranked second in the world by the Fraser Institute (2018) for the most attractive jurisdiction for mining investment, based on its policies and mineral potential.

High construction, environmental and safety standards apply to mining projects across Australia’s thousands of mines, protecting the industry’s social licence to operate.

Australia’s strengths are also reflected in its huge mining equipment, technology and services (METS) sector. The METS sector was responsible for $92B in gross value-added in 2017-18 and employs an estimated half a million Australians.

Australian capital cities have creative METS hubs supporting the mining industry, with 201 METS companies’ head offices being in Sydney, 186 in Perth and 149 in Brisbane.

Building this magnesium project in Australia plays to our national strengths and capabilities. It is akin to standing on the shoulders of a giant.
Growth in Regional Australia

Australia’s existing METS infrastructure allows the construction of the Magnium Australia facility without significant planning or investment in offsite infrastructure. As a result, economic benefit can be delivered immediately to the region where the plant is created.

Jobs will be created from the initial land surveying to construction, operation and ancillary services. Opportunity will also be created for small business to emerge as suppliers to the defence, automotive, construction, electronic and aerospace industries locally, nationally and abroad.

Magnium will have a local employment strategy focussed on diversity and inclusion. As part of that strategy, Magnium commits to provide opportunities for employment, training, procurement and support for Indigenous people and enterprises. We acknowledge Aboriginal and Torres Strait Islander People as the Traditional Custodians of the land on which we may deliver our services. We pay our respects to elders and leaders past, present and emerging.

The magnesite deposits required for a completely developed plant of this scale have been identified in regional Australia. This plant can be developed near any of these deposits. Mining operations in these areas are also expected to receive a boost for production outputs as demand increases.

As the local downstream processing industry develops, the import of raw magnesite for processing is a plausible outcome. The creation of a new export industry can reinvigorate growth in regional Australia. The overall value to regional Australia is yet to be quantified but is significant and sustainable.

Detailed research and modelling have revealed there are three suitable locations, with relevant ports with capabilities, for a magnesium plant in Australia, and these are not detailed in any order, all external to the actual cities, but for ease of reference proximate to:

- Rockhampton
- Darwin
- Adelaide
- Victoria
All three locations have significant economically proven resources and/or access to METs infrastructure.

Once the Magnium Australia commercial plant has achieved the economic scalability milestones for one State, it could be replicated across other States. This technology has the potential to scale up to 300,000 tonnes of production per annum across three sites. This would be almost 30% of the world’s magnesium metal supply creating thousands of jobs directly and via upstream and downstream industry enablement and growth.

**Why Our Technology Makes Magnesium Manufacturing a Cost-effective Reality**

CSIRO have developed the advanced technology that can now lead to a commercially viable plant that can produce magnesium with 80% less energy and up to 60% less CO2 emissions than the Pidgeon process used by other global producers, in particular China. It is also 50% less capital intensive and requires 70% less energy than the Electrolytic process whilst still producing significantly less CO2.

Schematic cross-section of a Pidgeon process retort

The Pidgeon overall process is extremely simple and produces a magnesium product with a purity higher than the electrolytic route at >99.97%. Unfortunately, the batch nature
of the operation results in low productivity (20kg/retort/day), high labour intensity, and high energy intensity through cyclic heating and cooling. Ferrosilicon production is also expensive and equates to ≈50% of the operating cost and since this and the coal-fired external heating consumes significant quantities of carbon the overall global warming impact through CO2 emissions is enormous. Finally, substantial quantities of slag are produced (6-8ton/tonne of Mg) and must be dealt with.

CSIRO has identified a global opportunity for magnesium production and reliance on an outdated obsolete process. In 2003 the CSIRO began to develop an efficient production process which significantly reduced environmental pollutants. The developed technology uses carbothermal reduction and a supersonic nozzle to efficiently produce high quality magnesium. It involves heating magnesia with carbon to extreme temperatures to produce magnesium vapour and carbon monoxide. The vapour and carbon monoxide are passed through a supersonic nozzle – similar to a rocket engine – at four times the speed of sound to cool the gases in milliseconds, condensing and solidifying the magnesium vapour to magnesium metal.
What Is Supersonic Quenching

It is rocket science

1. Pressure differential causes gaseous reaction products to flow into converging-diverging (‘de Laval’) nozzle
   Pinlet > Poutlet
2. When $\Delta P$ large enough, ‘choked flow’ occurs in throat; gas reaches speed of sound (sonic velocity)
3. When choked, gas expands to supersonic speed in outlet
4. Expansion causes a rapid drop in both pressure and temperature
5. ‘Freezes’ Mg in non-equilibrium state, limiting reversion

Flowchart:

Magnum Australia has terms to license this technology exclusively. The payback to CSIRO over the term of the licence is $760M. Hence the investment by the Government will see a significant return to Government bodies far exceeding normal return rates.

For technology specifics upon execution of NDA we can arrange connection between our team, CSIRO, and relevant parties.

This science is proven at a bench scale and protected globally. It has been developed over the last 17 years.

A detailed techno-economic analysis has recently been performed for a 30,000+ tpa plant built in Australia. This capacity represents about 3% of global production. As the production scale increases the capital costs reduce accordingly.

A plant could potentially be built in the USA under licence. This would remove the need for US imposed tariffs, which are currently sitting around 175% for imported magnesium.

Ultimately the long-term goal is to move into a position of global dominance with licenced production plants in various countries and the ability to impact global supply.36
By supporting the growth of advanced manufacturing and in Australia, we reduce our dependence on foreign supplies of critical metals and reduce the risk of global shortages for our other major trading partners.

Developed and implemented as intended this new plant, will create thousands of new jobs and elevate Australia's position as an innovative leader in sustainable mining and value-added processing.

**Conclusion**

The threat of a supply shortage in critical minerals for Australian, and indeed the world, has been a recent focus. The recent global health pandemic created by the novel coronavirus has thrust upon Australia’s economy a startling example of the worst-case scenario possible in an ecosystem dominated by monopolistic supply.

Australia has been plunged into an economic downturn of record magnitude and that has ramifications for generations to come. The ongoing trade turmoil and the very possible threat of another global health pandemic has brought requirement to safeguard supply dependencies impacting our people and economy to the immediate fore.

We must recover and recover beyond where we have come from.

This magnesium project will establish significant downstream processing opportunities in industries such as defence, aerospace and 3D printing and place greater demand on mining exploration and production for magnesium and other metals for alloy manufacturing such as aluminium. Successfully implemented, hundreds of jobs (directly and indirectly) will be created powering our economic recovery.

Australia is uniquely placed to protect our critical mineral supplies whilst creating a prosperous nation that leads the world in advanced and sustainable mineral production.

We are amid a once in an industrial revolution opportunity to pivot and lead sustainable mineral processing. Creating Australia’s “perfect storm” to innovate and drive long term accelerated growth.

Australia has the resources, the infrastructure and the people to make this project a reality. The return on investment to CSIRO is significant.

It is time to use our nation’s gifts to take the lead globally.

We seek overall support but financially matched funding from the Federal Government on Stage 3 of the magnesium foundry.
About Magnium Australia Pty Ltd

Magnium Australia is being established to explore and create projects for Critical minerals in Australia.

Clayton Cross

Clayton Cross is an experienced mining executive with a background in corporate and mining law. Securing his first tenement in the late 80's whilst studying as a student. He is the principal of corporate advisory and administration Cross Consult Corporate and has extensive experience in the areas of equity capital markets, corporate finance, structuring, asset acquisition, corporate governance and external stakeholder relations. Mr Cross holds both a Bachelor of Economics and Bachelor of Laws.

Shilow Shaffier

Originally from the coal mining town of Moranbah in Queensland, Mr Shaffier specialises in technology and commercialisation and has over 20 years' experience in the technology, services and finance sector. Mr Shaffier has worked for some of the world's largest technology companies such as HP, Fujitsu and DELL EMC. Most recently he has held CEO positions with technology companies requiring transformation and restructure for acquisition. Mr Shaffier is currently the Director of Commercialisation and Asset Management for Raven Corporate Management.

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About Magnesite

Magnesite or magnesium carbonate (MgCO3) is the primary source of magnesia (MgO). There are three main types of magnesia: caustic calcined magnesia (CCM), deadburned magnesia (DBM) and electrofused magnesia (EFM). CCM is used as a chemical in several markets including agriculture (fertiliser and feedstock), mineral processing, pulp and paper manufacture and water treatment. DBM and EFM are used mainly in the refractory industry as a kiln liner and so are essential for the production of steel, cement and glass.

Magnesia and magnesium brines are also used to make magnesium metal (Mg). Magnesium (atomic number 12) is the lightest metal and is commonly alloyed with aluminium to create a light, high- strength and corrosion-resistant alloy which is widely used in the aerospace and automotive industries. Magnesium is also being increasingly
used in the electronics industry, in both primary and rechargeable batteries and in superconductors.

The strong forecast growth in demand for magnesium and magnesite, together with increasing concentration of supply, has seen the all significant countries or Unions include both magnesium and magnesite in their list of Critical Materials.

References

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