MTM CRITICAL METALS

MTM Critical Metals Limited
Suite 2, 38 Colin Street
West Perth WA 6005

ASX: MTM

Phone +61 8 6391 0112
info@mtmmetals.com.au
ABN 27 645 885 463

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Significant Multi-Metal Recovery from Electronic Waste Including Palladium & Tin

HIGHLIGHTS:

- **Successful Very High Recovery of Tin and Palladium** from electronic waste (e-waste) using FJH, expanding the list of recoverable metals to gold (Au), silver (Ag), copper (Cu), Tin (Sn), and Palladium (Pd)[1].
- **Broader Commercial Potential:** With the addition of tin and palladium, the FJH process demonstrates enhanced versatility and commercial viability as a sustainable e-waste recycling solution.
- **Sustainable & Environmentally Friendly:** No toxic chemicals or non-selective incineration; simple process minimises environmental impact.
- **Strategic Industry Engagement:** discussions underway with e-waste suppliers to support further testing and strategic partnerships, aiming to advance towards full-scale commercialisation.
- **A rich source of metals without mining risks:** E-waste can contain up to 1,300 g/t silver, 300 g/t gold, 4% tin & 500 g/t palladium [2], offering an "above-ground" resource with no exploration risk or mining costs.
- **Massive Market Opportunity:** Over 60 million metric tonnes of e-waste generated annually, containing precious and base metals valued at over US$70 billion in potential recoverable content[2].
- **Recycling e-waste could meet a significant portion of global metal demand**, supplying up to 10% of Cu, & 57% of Pd, while reducing reliance on mining and mitigating supply chain risks from unstable regions.
- **Challenges with Current Methods:** Metal recovery from e-waste using pyrometallurgy releases toxic dioxins and furans, while hydrometallurgy uses hazardous acids that generate significant toxic waste tailings[3].

MTM Critical Metals Limited (ASX: MTM) ("MTM" or "the Company") is pleased to announce additional successful results extracting metals from e-waste using Flash Joule Heating (FJH). Building on the previously reported high recovery of gold, silver and copper[1], the Company has now successfully recovered tin (Sn) & palladium (Pd), confirming the versatility of FJH in efficiently extracting multiple metals from e-waste.

This was achieved **without the use of toxic acids**, recovering approximately **86% of the tin** and **82% of palladium** content from printed circuit boards (PCBs), a common component of electronic waste (e-waste). These advancements greatly enhance the commercial potential of FJH as an environmentally friendly solution for recycling metals from discarded electronics. The recovered metals are among the most valuable components in e-waste, substantially increasing the economic potential of recycling it through FJH technology.

MTM Chief Executive Officer, Michael Walshe, said: *"We are thrilled by the progress made in demonstrating the versatility of Flash Joule Heating for e-waste recycling. The successful recovery of tin and palladium, alongside gold, silver, and copper, highlights the significant potential of FJH as an efficient recycling solution for printed circuit boards. With e-waste representing a vast untapped 'urban mine,' our technology offers a sustainable approach without the environmental burden of traditional mining or hazardous processing. We are excited to advance discussions with industry partners as we continue our journey towards commercialisation".*

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[1] ASX:MTM announcement dated 12/09/2024 *'High Gold Recovery from E-Waste using FJH Technology'*, ASX:MTM announcement dated 25/09/2024 *'High Silver & Copper Recovery from e-Waste'.*
[2] Manikandan, Inbakandan & Nachiyar 2023
[3] Mishra et.al 2021.

Why This Breakthrough Matters: E-waste is one of the fastest-growing components of solid waste with over 60Mt produced annually of which only about 20% is recycled. This vast repository contains precious and critical metals like gold, copper, and palladium, valued at over US$70 billion in potential recoverable content[4].

E-waste contains a variety of valuable metals. For example, printed circuit boards (PCBs) can contain up to **300 g/t of gold, 1300 g/t of silver, 4% tin & 500 g/t palladium;** concentrations far higher than in natural ores. However, recovering these metals through traditional methods is energy-intensive, environmentally damaging, and expensive[5]. The majority of global metal recovery from e-Waste is done in smelters/incinerators across China, India, Nigeria, & SE Asia, often using unregulated methods[6].

Challenges with Current Methods: Metal recovery from PCBs primarily uses pyrometallurgy and hydrometallurgy. Pyrometallurgy involves high-temperature smelting, which releases toxic dioxins and furans, especially when burning e-waste containing flame retardants, while hydrometallurgy relies on harmful acids that generate substantial toxic waste. Both processes have high energy consumption, produce harmful emissions, and often struggle with low recovery rates for certain metals, particularly silver[3].

Table 1: Comparison of FJH versus traditional / established e-waste metal recovery methods

Method	Recovery Rates[3,2,6]	Issues	FJH Comparison
Pyrometallurgy	Gold: 70-90% Silver: 70-90% Copper: 80-95% Tin & Palladium: 40-75%	Energy-intensive, releases toxic dioxins and furans, high capital costs, metal losses in slag	FJH is simpler and cleaner, avoids dioxins. Likely significant CAPEX & OPEX savings
Hydrometallurgy	Gold: up to 90% Silver: 60-85% Copper: 80-95% Tin & Palladium: 40-75%	Expensive, uses harmful acids (sulfuric, nitric, cyanide), generates toxic waste, requires complex wastewater treatment	FJH avoids toxic chemicals and complex treatments, offering a more environmentally friendly option
FJH Process	Gold: **70%** Silver: **~67%** Copper: **48%** Tin & Palladium: **>80%**	Early-stage test with unoptimized results show potential for a cleaner and simpler process	FJH requires only a chlorine flash and water wash, significantly reducing environmental impact and potentially energy consumption

The **FJH technology** offers a sustainable and efficient solution – by applying direct electrical energy under a chlorine gas atmosphere, FJH can vaporize metals from e-waste and recover them in a 2-step procedure without using toxic acids or non-selective incineration. The FJH process works by 'flash' heating e-waste in a chlorine gas atmosphere, vaporizing the target metals like gold for efficient separation and collection via metal chlorides.

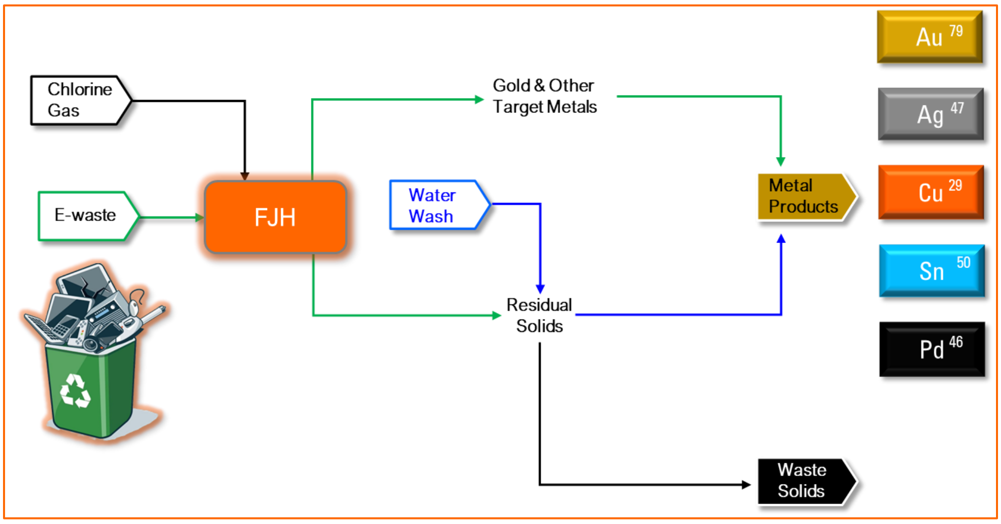

Figure 1: Schematical overview of FJH recovery of metals from e-waste

[4] Patel 2024
[5] Manikandan et.al 2023; Muthusamy, Muthusamy, & Chinnadurai, 2021.
[6] Li, et.al 2022

Summary of Method & Results

OVERVIEW: Initial FJH tests demonstrated significant tin (Sn) and palladium (Pd) metal chloride recovery from printed circuit board (PCB) e-waste from a simple FJH and water washing process.

- The purpose of the testing was to verify the extraction of the target metals from e-waste using MTM's prototype following up on previous works undertaken by Rice University[7].
- **Single Flash Test**: The initial, unoptimized flash test was conducted using samples of shredded 'low gold grade' (Au sub 100 ppm) e-waste. The metals were flashed in a chlorinated atmosphere to facilitate the formation of metal chlorides and the vapourised products were collected via condensation.
- **Water Washing**: After flashing, water washes were conducted to remove metal chlorides from the residual solids. TotalQuant Inductively Coupled Plasma Mass Spectrometry (ICP-MS)[8] was used to quantify the metals in both the solid residues and the water wash solutions.
- **Results**: **High Sn & Pd Recovery from E-Waste using no acid.** 86% yield for Sn & 82% for Pd at this unoptimized, proof-of-concept stage with plans to enhance the recovery efficiency in subsequent tests.

Table 2: Summary of Initial FJH recovery of Sn & Pd from e-waste as metal chlorides ($SnCl_4$ & $PdCl_2$)

METAL	Tin (Sn)	Palladium (Pd)
E-waste feedstock elemental metal content (g/t)	15,008 (15% w/w)	17.0
Product elemental metal content (g/t) (in metal chloride form)	12,956 (13% w/w)	13.9
Recovery (%)	**86%**	**82%**

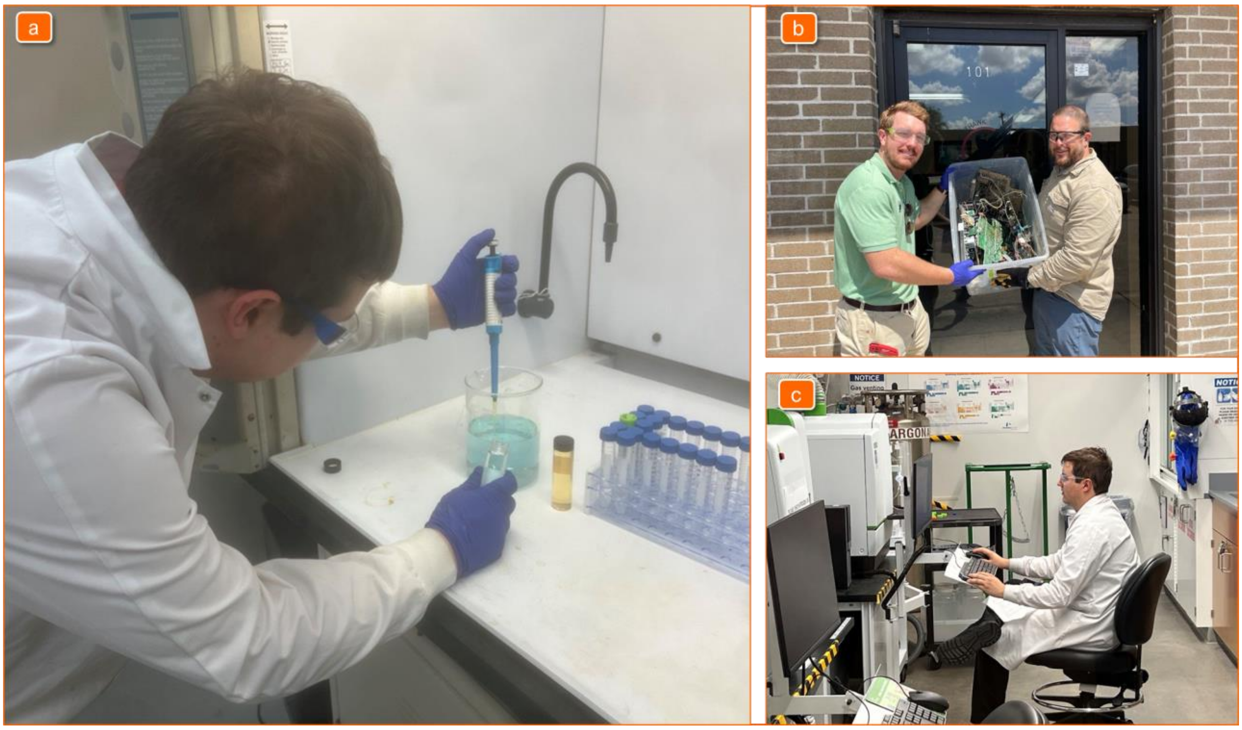

Figure 2: (a) Laboratory preparation of results characterisation via ICP-MS, (b) KnightHawk team holding E-Waste scrap feedstock, (c) KnightHawk team performing ICP-MS analysis at Rice University Shared services program

[7] Deng et.al 2021

[8] TotalQuant refers to a mode in ICP-MS where all measurable elements are detected and quantified in a single run without prior specific selection of elements. This is particularly useful for complex samples where a comprehensive elemental profile is required. It is considered qualitative (or semi-quantitative) (±25% accuracy) because, in the TotalQuant mode, it provides a broad overview of the elements present in a sample without the rigorous calibration that would be needed for fully quantitative results & does not account for possible elemental interferences between various metals.

Market Opportunity

In 2022, it was estimated that **62Mt of e-waste was generated globally**, with only 20% being formally collected and recycled, and this forecast to grow to over **75Mt by 2030**[9]. The economic value of the metals in this waste is estimated at > USD70 Billion, including USD15 Billion from gold and USD19 Billion from copper[7]. However, most of this value is lost due to incineration, landfilling, or substandard treatment[10].

Figure 3: Breakdown of metals contained in the 62Mt of e-waste generated in 2022. Source: Forti et.al 2024; Patel, 2024.

E-waste is particularly rich in precious metals, often surpassing traditional ore bodies in metal content and is a growing waste source in most countries. For example, **printed circuit boards (PCBs)** can contain up to **400g of gold**, **6000g of silver & 30,000g Tin per ton**, while **TV boards** have **280g of silver**, **20g of gold**, and **10g of palladium** per ton. **Computers** also contain significant amounts, with up to **600g/t of gold** and **2000g/t of silver**[11].

E-Waste Recycling: A Promising Solution to Meet a Substantial Portion of Global Metal Demand

A significant portion of the world's metal production demand could be met by recycling e-waste, rather than relying on the more environmentally damaging primary metal mining of mineral ores. For example, in 2022, e-waste contained approximately 2.1Mt of copper, which accounted for 10% of the total copper production in 2023. Similarly, an estimated 57% of global palladium production and 14% of tin production could be supplied from e-waste recycling[13]. Leveraging the metals present in e-waste offers a sustainable and economical alternative, reducing the need for energy-intensive mining. Many of these metals, such as Pd, are currently sourced primarily from countries with complex geopolitical relations, like Russia, which creates supply chain vulnerabilities.

Table 3: World metal production (2023) & Global E-Waste Production in 2022–Contained Metal content[12]

Metal	Global Production in 2023 (t, metric)	Metal Content in E-Waste (2022) (t, metric)	E-Waste contained metal content as % of Global Production	Major Producing Countries
Copper (Cu)	22,000,000	2,100,000	10%	Chile, Peru, DRC
Gold (Au)	3,500	270	8%	China, Australia, Russia
Tin (Sn)	306,000	44000	14%	Indonesia, China, Myanmar
Palladium (Pd)	210	120	57%	Russia, South Africa
Silver (Ag)	25,505	1200	5%	Mexico, Peru

[9] Global E-waste Monitor 2024
[10] Forti 2024
[11] Yazici& Deveci 2013
[12] IEA 2024; IPMI 2023; ITA 2024; ICSG 2024; USGS 2024

High Per Capita E-Waste Generation in Australia, USA & Japan ⇛ Key Recycling Opportunities

Australia, the USA, and Japan are among the highest contributors to per capita e-waste generation globally. Each produces substantial amounts of e-waste due to their high levels of consumption and rapid technology turnover. In 2022, Australia generated approximately 21 kg of e-waste per person, while the USA and Japan followed closely with per capita rates of 19.4 kg and 16.9 kg respectively[13]. This presents both a significant environmental challenge and an opportunity for efficient recycling solutions like FJH.

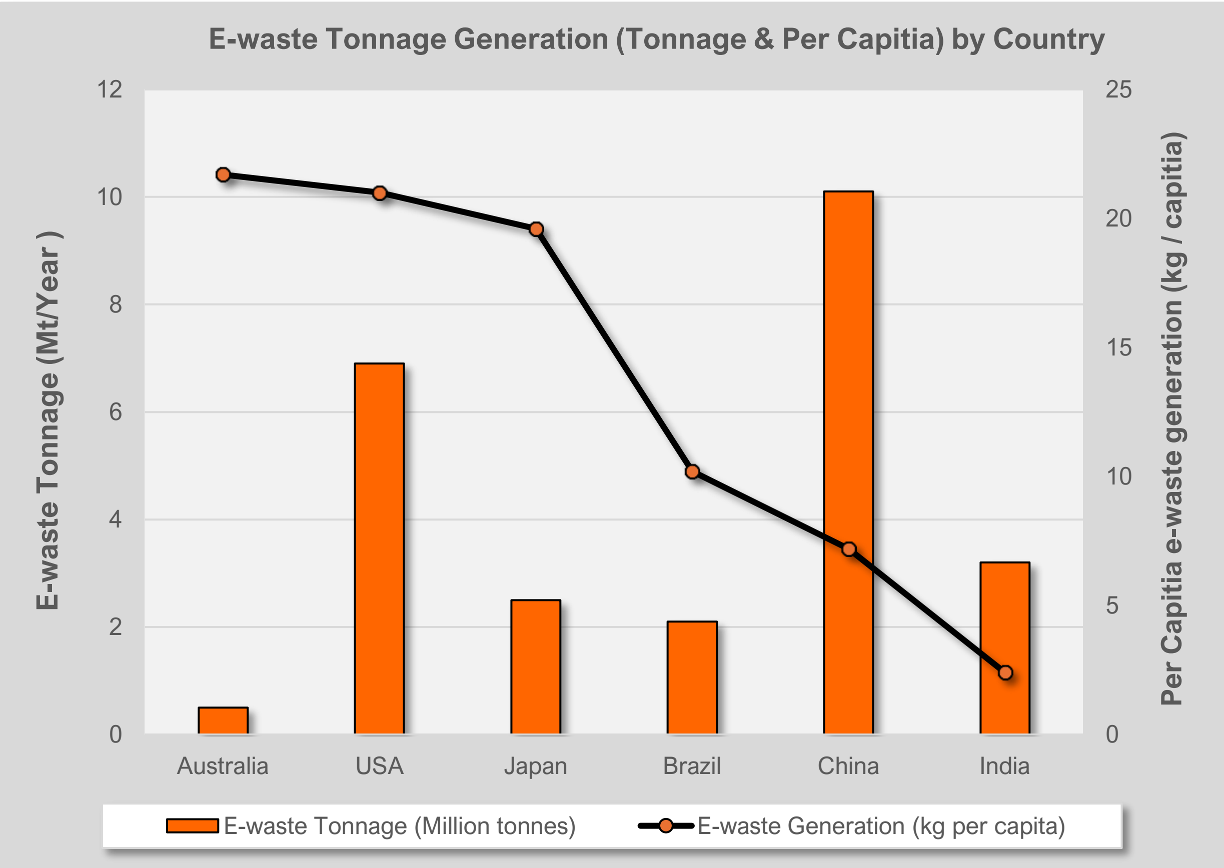

Figure 4: E-Waste generation by tonnage & per capita various countries in 2023 (Source: Mairizal et.al 2023)

Importance of Tin and Palladium in Modern Industries

Tin is an essential industrial metal widely used in electronics, particularly for soldering due to its low melting point and excellent conductivity. The majority of tin consumption occurs in the electronics sector, highlighting its strategic importance[14].

Palladium, on the other hand, is a precious metal with high demand in the automotive industry for catalytic converters, as well as in electronics for its role in multilayer ceramic capacitors[15]. The successful recovery of these metals not only adds value to MTM's recycling capability but also contributes to the circular economy by helping reduce reliance on primary mining of these critical resources.

[13] Mairizal et.al 2023
[14] ITRI 2024
[15] J.P. Morgan 2024

The E-Waste Problem for the Electronics Industry

A small percentage of electronics collected for recycling are typically sent to a limited number of smelting facilities located in Asia, Canada, and Europe. These facilities, which are capital intensive and have high operating costs, extract valuable metals by either melting the e-waste at extremely high temperatures or using strong acids for chemical leaching. Any leftover plastic is often incinerated to fuel the smelters. While these processes recover metals effectively, they generate significant carbon emissions and harmful toxic by-products.

Moreover, a large portion of e-waste is offshored to poorer nations, such as Ghana in Africa (*Fig. 5*), where mountains of discarded electronics accumulate in landfills. These informal recycling sites, such as Agbogbloshie, are notorious for improper disposal methods that allow e-waste to rot and leach toxic substances, such as lead, mercury, and cadmium, into the environment. This leads to severe health risks for local communities and widespread ecological damage.

Countries like Australia and the USA, with some of the highest per capita e-waste generation (*Fig. 4*), have a unique opportunity to address this issue by adopting more sustainable, efficient technologies like FJH. By processing e-waste domestically, they can reduce the harmful environmental impact of offshoring and turn the growing e-waste problem into an economic opportunity while safeguarding both human health and the planet.

Figure 5: Example of enormous e-waste dump in Agbogbloshie Ghana, Africa. Resident uses fire to burn off plastic, in order to salvage copper wire Source: Hakkens 2016.

By capturing the economic value of precious metals in e-waste and offering a more sustainable recycling method, MTM is positioned to capitalize on this significant market opportunity while addressing a pressing global environmental issue.

Next Steps:

- **Prototype Testing:** Continue optimisation of the FJH prototype reactor to scale up the recovery process.
- **Commercial-Scale Facility:** Finalise the design and operational plans for the 1-ton per day facility.
- **Strategic Partnerships:** MTM is actively engaging in commercial discussions with potential e-waste suppliers to support ongoing test work and explore strategic partnerships to scale up the technology for commercial applications. The Company sees these partnerships as key to achieving widespread adoption of FJH technology and maximising its positive impact on e-waste management.

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This announcement has been authorised for release by the Board of Directors.

For further information, please contact:

Michael Walshe
Chief Executive Officer
MTM Critical Metals Ltd
+61 (0)8 6391 0112
info@mtmcriticalmetals.com.au

Media Contact
David Tasker
Chapter One Advisors
+61 (0)433 112 936
dtasker@chapteroneadvisors.com.au

PREVIOUS DISCLOSURE

The information in this announcement is based on the following MTM Critical Metals Limited ASX announcements, which are all available from the MTM Critical Metals Limited website www.mtmcriticalmetals.com.au and the ASX website www.asx.com.au.

Previous **e-waste-related announcements** highlighted

Date	Description
03/04/2024	Flash Joule Heating Prototype Complete, Testing Commenced
06/05/2024	Flash Joule Heating Prototype Test Increases REE Recovery
31/05/2024	Global Licence Agreement Secured for Flash Joule Heating Technology with Rice University
24/06/2024	Positive Advances with Metal Recovery Test Work
09/07/2024	Positive Lithium Extraction Results from Flash Joule Heating
13/08/2024	Addition of Chlorination enhancement to FJH Licence
21/08/2024	Flash Joule Heating converts Spodumene to Lithium Chloride
27/08/2024	Gallium Recovered from Semiconductor Waste Using FJH Tech
06/09/2024	MTM Advances FJH Commercialisation with 1 TPD Demo Plant
12/09/2024	High Gold Recovery from E-Waste using FJH Technology
18/09/2024	Further Advances in Lithium Refining with Flash Joule Heat
25/09/2024	High Silver & Copper Recovery from e-Waste using FJH

The Company confirms that it is not aware of any new information or data that materially affects the information included in the original ASX announcements and that all material assumptions and technical parameters underpinning the relevant ASX announcements continue to apply and have not materially changed. The Company confirms that the form and context in which the Competent Person's findings are represented have not been materially modified from the original ASX announcements.

ABOUT MTM CRITICAL METALS LIMITED

MTM Critical Metals Limited is a dynamic company with a dual focus on mineral exploration and metal recovery technology development. We hold exploration assets prospective for niobium (Nb), rare earth elements (REE), and gold, strategically located in Western Australia and Québec. Additionally, we possess exclusive licensing rights to the innovative Flash Joule Heating technology, a cutting-edge metal recovery and mineral processing method developed by esteemed researchers at Rice University, USA.

Flash Joule Heating (FJH) is an advanced electrothermal process that enhances metal recovery and mineral processing compared to traditional methods. By rapidly heating materials in a controlled atmosphere, FJH efficiently extracts metals like lithium from spodumene, gallium from scrap, and gold from e-waste, among others. This technology has the potential to revolutionise metal recovery by reducing energy consumption, reagent use, and waste, offering a more economical and environmentally friendly alternative.

MTM's West Arunta Nb-REE exploration assets are situated in one of Australia's premier exploration hotspots, where over $60 million has been invested by ASX-listed companies such as WA1 Resources, Encounter Resources, Rio Tinto (in JV with Tali Resources), and IGO Limited. MTM also holds tenements in other key mineral regions across Western Australia, including the Mukinbudin Nb-REE Project, East Laverton Gold & Base Metals Project, and Mt Monger Gold Project. In Québec, the Pomme Project is a highly promising carbonatite intrusion rich in REE and niobium, located near the world-class Montviel deposit.

ABOUT KNIGHTHAWK ENGINEERING

KnightHawk was founded in 1991 and specializes in identifying high technology solutions in a short timeframe. They have executed projects throughout the United States, Europe, and Asia. Their clients range from individual entrepreneurs to the large industrial organisations such as Shell, Exxon Mobil, Chevron and NASA. They have a depth of experience and expertise and are leaders in design, failure analysis and troubleshooting across a range of engineering disciplines. KnightHawk was selected for its expertise across a wide range of disciplines and their focus on ensuring outcomes in a timely manner.

Figure 6: Knighthawk Engineering, FJH Team, Houston Texas

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