



Australian Government

Chief Scientist

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Thank you Virginia for that kind introduction.

I'm very pleased to be here in Melbourne and be able to reconnect with this community.

Thank you, Robin, for inviting me.

I'd like to acknowledge your contribution as a former Chief Scientist, and your important advocacy for Australian innovation especially in the mining and mineral processing industries. I know you as a huge supporter of quality research that is translated to impact for the benefit of our country.

Ralph Homes, what can I say but you're a legend in minerals processing.

I want to start by acknowledging the traditional custodians of the land on which we meet. I am speaking on the traditional lands of the Wurundjeri people.

I acknowledge the elders who are caring for those lands. I pay my respects to the old ones who have come before and the young ones who will follow.

There is a remarkable longevity associated with the Aboriginal connection to this land, perhaps 60,000 years of connection. It's an extraordinary period of continuous occupation.

There is also a longevity about our continent, which has some of the oldest rocks on earth, close to the age of Earth itself. This ancient age, the age and stability of the Australian landform, is also why we're here today. It's what has created such a rich source of metals and minerals. A red and scrubby surface, and such wealth underneath.

Australia is literally a gold mine. It's also figuratively a goldmine for many of the minerals now considered critical across much of the world. Which puts us in the spotlight now as the world gears up for a low-emissions future.

I have some history with the mining sector. Before I became Australia's Chief Scientist, when I was at the CSIRO, I led a team that developed LandTEM. This is a system that detects and maps deep ore bodies. LandTEM sits on the surface, and uses quantum tunnelling effects to detect the magnetic fields induced in underground deposits - using a superconducting quantum interference device, or SQUID, for short. You'll be relieved to know that's as far as I'll go in explaining the science!

I had young children at the time so I didn't go out into the field as much as I would have liked to. But the machine went far and wide – to Murray Bridge in South Australia, Cannington near Mount Isa, Triton in western NSW, to Western Australia. Even to the Arctic Circle in Canada. LandTEM travelled for me. Since then, it's been used by miners to locate and delineate nickel, silver and gold worth some billions of dollars. We were pretty pleased with that success. But what's coming next in sensing and mapping capability will leave that technology in its wake.

As leaders and researchers in the minerals processing industry, you will no doubt be alert to the buzz about the promise of quantum sensing. Quantum technologies will revolutionise the ability to see and map underground and underwater. Quantum control will vastly improve the ability of sensors to detect target signals. We anticipate an improved sensitivity of 500 times what we can achieve today. That

represents significant promise to the mining industry. But quantum technologies are not strictly what I'm here to speak about today.

Today, I want to focus on the role of critical minerals in helping Australia reach its zero-emissions target. I want to share my vision for the industry, and for how to make the most of the opportunity that is in front of us. And it is an enormous opportunity indeed.

We've come to talk about mining in Australia as an industry with an end-by date. But as you and I both know, the reality is that mining is set for a boom – a new kind of boom to help Australia – and the world – achieve the net-zero target. As the World Bank puts it, “A low-carbon future will be very mineral intensive”. It certainly will.

The CSIRO describes this as a “seismic pivot”. Most of the critical minerals needed for the energy transition have significant deposits in Australia. Rare earths for magnets. Titanium and palladium in the hydrogen sector. High-grade silicon for use in solar cells, an industry predicted to be 10 times its current size in a decade's time. Magnesium and tantalum for medical applications. High-grade nickel supply needs to increase by 24 times just for electric vehicles. Graphite, cobalt, lithium, manganese and vanadium for batteries. The World Economic Forum expects a 14-fold growth in global demand for batteries by 2030. Lithium supply will have to increase six times to meet that demand. Forgive me for so many numbers. But the figures are staggering.

For those involved in extracting and processing critical minerals, you're in a sweet spot. Demand is significant. Investment, including government investment, is significant. And public support is high.

So, how to capitalise on this moment? What does the pathway to success look like?

I have four answers to that question. The first relates to the issue of public support for this mission. The second is about the real nature of the opportunity in front of us. Third, I want to talk about the disruptive power of the emerging technologies and the need for flexibility and imagination in our response. And finally, the importance of partnerships across research, government and industry.

First, the sweet spot.

When I suggest that public support is high, I'm speaking anecdotally. I don't actually have any evidence to hand about the level of enthusiasm for extracting and processing critical minerals. What I'm really referring to is the widespread support for low emissions sources of energy, and the global commitments to net-zero targets. And in reality, I'm not at all sure the public has a detailed understanding of what this means for extracting and processing the minerals needed by the emerging technologies.

So to be clear: To the extent that the critical minerals agenda has public support, it rests on the climate and environmental outcomes, and the outcomes for local communities.

This is why we are at a critical moment in time. It is a seismic pivot in minerals and technologies. But it is also a pivot point – a moment of balance, where we can choose the pathway to success through embedding these technologies in our climate ambitions, and cement our nation into the emerging clean energy supply chains. Or not.

The demand is not simply for all the minerals on the periodic table. The demand is for minerals that are extracted and processed with low energy intensity – and which support a reduction in greenhouse gas emissions rather than adding to the problem.

This is the expectation from our international partners, the manufacturers of electric vehicles and batteries. It is also the expectation from consumers, from the cars they drive, to the solar panels on their roofs. It is especially the expectation of young Australians as they look to their futures.

If the extraction process is environmentally destructive or creates a new pile of waste in the form of spent batteries, it will not meet the expectations, whether locally or internationally.

As you know better than me, many of the current technologies for extracting and processing minerals are energy intensive, and environmentally damaging. From producing hydrogen, to creating high-grade silicon for solar cells, these are applications that have the potential to increase our use of fossil fuels and carbon emissions. Extracting just 1 gram of platinum requires moving and processing 1 tonne of ore.

Another example is the use of hydrofluoric acid for purifying graphite for batteries. Almost all of the world's battery graphite is made this way. But hydrofluoric acid is highly toxic, and has significantly negative impacts on the environment. The CSIRO has developed a new method and is now working with an industry partner to test and commercialise it. This is the kind of mindshift needed across a range of mineral processing technologies.

Then there is the waste. Waste is a challenge that cannot be shunted off to a later date. Just consider batteries. Lithium-ion battery waste in Australia is projected to grow from just over 3000 tonnes in 2016 to near 200,000 tonnes by 2036.

These issues of low-impact extraction and processing, and recycling, are not only about global emissions targets. They're about the expectations of local communities and the needs of local environments. Nor are they optional or second-order considerations. They are part and parcel of what we're signing up to. They are critical to ensure ongoing community support and acceptance. They will inform robust blockchain technologies to support that underpinning of public trust, and help secure the future and the markets for Australian production. Our environmental, social and governmental offering is second to none internationally. And if we get it right, this will be a significant advantage for Australia.

So that is my first answer today to the question of how to maximise the opportunity: Get the environmental and community responses right.

My second message is the urgency of lifting our capability well beyond dig and ship.

The real nature of the opportunity in front of us is not to be the world's quarry for minerals. And I know you agree with me on this. The international race is for the processing market - because that's where the value is - mid-stream processing, using the critical minerals for the creation of metals, chemicals and alloys.

Just take the example of lithium ion batteries. It has been calculated that Australia receives less than 1 per cent of the value of the minerals that go into lithium ion batteries. When you consider that we export about 7 billion dollars worth of those

minerals - nickel, cobalt, lithium and manganese - you get a sense of the scale of the lost opportunity. Seven billion dollars of minerals exported for others to add the value.

I heard Minister Bowen say recently that we installed 60 million solar panels on our roofs over the past decade. But just 1 per cent were assembled in Australia, and even then from components manufactured overseas. As he said, “we can do a lot better than that”.

Chris Vernon at the CSIRO talks about “lengthening and strengthening” the supply chain, and it’s a great way to express it. We have an opportunity to lift the complexity of our economy, broaden jobs and capabilities, and improve the security and diversity of our supply chains.

Consider that the Biden Administration has mandated that 40 per cent of materials for manufactured goods, including battery components, must be sourced from the US or from trade-agreement partner countries. This will grow to 80 per cent in a few years. It presents a massive opportunity for Australia. It also makes it more attractive not to export ores and raw concentrates for upgrading overseas.

So processing - not an extra, but integral to the opportunity.

To my third message, and this is a message I deliver to sectors across the Australian economy: The importance of preparing for disruption. Understanding that the phase we are in, of seismic change, is not temporary; it is our reality for the next decade and the one after.

Use of digital technologies has expanded much faster during the pandemic for obvious reasons. But this is just the tip of the iceberg. Automation and robotics, artificial intelligence, quantum technologies including sensing, will all accelerate over the coming decade and they will be a substantial part of your work.

We know that much – and we can predict ways in which these technologies are likely to impact your business. But we don’t know the whole story.

The digital disruption on the horizon is not simply about advances in current technologies. It’s about fundamentally new technologies and some of the applications will no doubt take us by surprise. I did a little dance of agreement when I read Professor Batterham on this subject. He wrote that “predicting winners in the technology race is neither effective nor intelligent”. As he said:

“Technology development is inherently unpredictable. It has changed in the past and will change in the future. As such, to better our clean power position, we should embrace a wide range of possible solutions.”

This is a wise message.

It is very true that Australia has world-leading innovations in the mining industry and has been responsive to new technologies. But it is also true that very few of us have been sufficiently attuned to scanning ahead for opportunities and for risks.

Let’s face it, the climate challenge has not arrived suddenly or without warning. With sufficient foresighting, mitigation would have been underway years ago. For that matter, the pandemic and its challenges associated with supply chains and sovereign capability did not arrive without fore-knowledge and warning. It just wasn’t

taken seriously enough. These are lessons we all need to take forward as we anticipate – and imagine – what might be on the horizon over the coming decades.

We are in a most uncertain strategic environment. Technology disruption is constant. Our understanding of critical minerals is not fixed, but under review as capabilities, needs and technologies change.

This creates a necessity for continual innovation. Hedging against the known risks and the unknown risks means embedding innovation and readiness to adapt. Cementing our industries in systems to ensure sustainability – systems that support regional communities, build the social fabric, and support the environment.

Perhaps we could refer to it as the Sicilian school of architecture. Built for the long term.

My fourth and final message today is about partnerships.

There is a strong focus at national level and a number of initiatives underway. The three Australian Government science agencies – CSIRO, ANSTO and Geoscience Australia – are globally recognised for their scientific and technical expertise, and are already collaborating to tackle a range of technical bottlenecks.

The Industry Department is working to unlock the economic opportunities. It's working to speed up the development of the processing technologies that we need to move downstream. The department is working with Australian firms, state with state and territory governments, and with international partners.

My office is leading a report to understand Australia's technology readiness and gaps for processing. The aim is to identify relevant mid-stream processing technologies – both available now and emerging. This report recognises the need to act quickly and effectively to ensure Australia's place in the supply chain. I hope we'll have it completed by the beginning of next year, if not sooner. As you'll be aware, the states are also investing.

So there is a confluence of activities and ambition. I want to ensure we coordinate this work – so we're all pulling in the same direction and making the most of our resources and efforts.

I often describe Australia as a Goldilocks country - big enough, smart enough and resource-rich enough to be a global player, but not so big that the complexities overwhelm the ability to coordinate and collaborate. We're just the right size to be able to come together to solve problems for maximum effect. Like the perfect-sized conference. Too big and great ideas can get lost in the deluge of thousands of papers and delegates spread across the city. Too small and you're better off heading to the pub and calling it networking!

For those of you working in critical minerals industries, the message of collaboration and partnerships is a really important one. Science is here to help, in the development of techniques for safe extraction to minimise the environmental impact and more efficient processing, and problem-solving to develop applications in low-emissions energy technologies. Science and research are your friend.

But science cannot do these things alone. The pathway to success requires a shared commitment, design and engineering, investment, skills development, and collaboration.

Let me reinforce the point by circling back to the LandTEM, my foray into the mining sector. When we developed the science – the quantum tunnelling technology – we knew its potential. We knew it represented a step-change in the ability to detect and map structures that had previously been hidden. But the question was, what to map? What was the real-world application for this piece of discovery?

We went to industry to ask. We identified sectors which might be interested – medicine, mining and communications – and we asked them, who wants to invest? Which of you wants to partner with us to explore how this piece of technology might be useful to your sector? The miners – BHP – said, yes please. It was a wise decision. And as I said, the benefits were significant.

But LandTEM would not have been built – or at least not built by us for the benefit of Australia – without the system working together: Government investment through the CSIRO in the science, and the recognition by BHP that it was worth their attention, and their investment. It's no good waiting until the device is on the shelf, whether that is LandTEM, or the quantum mapping technologies on the horizon. Because the device might never be on the shelf unless the investment is there for the hard work of solving the problems of technology, science and design on that path to a final product. And if you do wait till it's on the shelf, you're already behind your competitor – the one who was there during the development.

There is so much value to be had from critical minerals, not simply in turning a profit, but improving our lives, our security and the health of our planet. This is a collaborative endeavour, an ecosystem – our own version of the soil that feeds the tree which that the truffle.

Scientists and researchers examine the nature of the world – and test and experiment with ways to apply that knowledge. Industry makes use of that science to create jobs and prosperity, and to help make the world a better place. It is the job of government to get the settings right, the parameters in which you will work, the regulatory and partnership settings and the incentives, so we can make the most of the discoveries and the investment.

Let me conclude by saying Australia's mining technology and knowhow is recognised around the world. It really is a success story for our nation. It is a critical part of the fabric of so many aspects of our society. Down to the cars we drive, the roof over our heads, the technology we use every day, our national security.

This will not change. Mining will continue to impact the lives of all Australians. Even if you live off the grid, you're still going to need solar panels and semiconductors.

What will change is the nature of what we're extracting from the ground, the tools we use, and what comes after extraction – processing to value-add, and partnering internationally to advance our nation's capabilities and further our strategic interests.

To make the most of this opportunity, fundamentally, we must be clear about where our advantage lies.

Certainly, we have a natural advantage. But as I have said to you today, where Australia has an edge, it lies in extracting and processing critical minerals in a way that does not negatively impact the environment, but is carried out within the tenets of the circular economy.

Our edge lies in building transparent and trustworthy supply chains.

Our edge lies in recognising the role of Indigenous Australians, as custodians and inhabitants of the land, but also as a source of knowledge about land management.

Our edge lies in extracting and processing critical minerals in a way that supports and builds regional communities.

So when you buy critical minerals from Australia you know they are associated with positive social impacts, you know their carbon footprint, you have confidence in their environmental credentials, and you know that you are engaging with an end-to-end system that incorporates recycling and manages its own waste.

That is the vision that we have to offer. My hope is that we can work together to realise it.