



**Australian Government**  
**Chief Scientist**

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**AUSTRALIAN RARE EARTH CONFERENCE**

***Getting down to Earth***

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I'm very pleased to be here. This is just the kind of boundary spanning event that I like to see, and I congratulate all of those involved in bringing this event together.

As you know, the work ahead is complex in technology and ambitious in scale, and there is time pressure. Which means we need research and industry to come together, be clear-eyed about the problems that need solving, and find ways to leverage the significant public investment and interest in this task – the task of unlocking the full potential of rare earths, and critical minerals more broadly. We need a really active, proactive, effort from all parts of the system.

Which is precisely what I understand you to do be doing today and tomorrow in this really comprehensive gathering. So congratulations, it's great to see.

During my career – as Australia's Chief Scientist and before that in my research and project-lead roles at CSIRO – I've often worked on problems that, like this one, are very broad, and multifaceted. I've come to picture these kinds of challenges as a puzzle that needs systematic piecing together.

When you start a puzzle – most likely during that lull after Christmas and the Boxing Day picnic – you dump all the bits on the floor. You turn them over one at a time. Then you find all the pieces with a straight edge. If you're especially organised, you might group the other pieces according to colour or pattern. This is slow work, and it's not always easy to perceive progress.

Then you piece together the outside frame, and begin to fill it in. And then, finally – and I'm sure there's an equation for the exact point where this happens – things suddenly start to speed up. The gaps in the puzzle get smaller and smaller until right at the end your brain works faster than your hands to put it together. There's so much activity, you very nearly find yourself at two separate conferences on rare earths on one day!

OK, I exaggerate. We've combined the conferences. And we're not at the end game yet in rare earths. We're at the stage of assembling the framing for this industry – and ensuring we have the right elements together for the other parts of the puzzle.

But the thing that is uniquely challenging for us at this moment is that we're not working in a linear fashion from discovery to experiment, to start-up to commercialisation, to scale. We're doing all of those steps at once, working from all directions towards the goal. That truncates the timeline, and it means we're working right at the intersection of research and business.

Today, I want to talk a bit about my own experience of working at that intersection. And I want to offer a few of my thoughts about the way this puzzle should be put together.

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As many of you will know, I'm a physicist. My research was in semiconductors and then in superconductors, and at the CSIRO one of the biggest projects I was involved in was leading the development of LandTEM, a mineral exploration sensor system.

LandTEM is a superconducting device that uses quantum effects to find the magnetic signatures of ore bodies, induced by the transient electromagnetic mineral exploration method. It works remotely, while sitting on the surface at site, and it's been used to map out deposits of nickel, silver and other conductors in multiple mine sites.

So, a great success!

Well, yes. But far from an overnight success. That machine took 12 years of my life, and that was 12 years after we had developed up the technology.

We did the first field trials with BHP in 1991 and what followed was a decade of stop-start trials. We offered it for commercialisation at four consecutive mineral exploration events, over and over again. We trialled it as an airborne, underground and surface device.

After BHP pulled out in 1998, we worked with a company called Falconbridge, and finally made a deal with Outer-Rim Developments. The arrangement with Falconbridge was yet another proof-of-concept field trial. It was under that arrangement that we were able to establish the LandTEM's ability to detect massive nickel-sulphide ore bodies at a depth of 200 to 300 metres. That was at the Arctic in 2000. Boy, it was cold!

But despite all this work with mining firms over many years, the final commercial deal was with a small company, Outer Rim Developments. We commercialised LandTEM through a technology transfer agreement with Outer Rim, by having their subcontractor's CEO working with us at CSIRO for six months.

This meant that the details of the SQUID electronics, construction of the LANDTEM hardware and understanding of the operation was transferred out of CSIRO to an exploration contractor – which used what they'd learned to build their own LandTEM systems for prospecting in Canada. They sold several systems in Canada, and in Australia they did contactor mineral exploration for many different mining companies. They still do but under a different business name.

I only know what's going on with LandTEM now if I look for ASX announcements. It's sort of like looking at Instagram or Facebook to see what your children are up to.

So that's the potted history. What were the lessons learned?

Well, I learned that getting a commercial partner on board through that development phase is a slog.

The SQUID technology actually had potential across a number of sectors, so when we originally took it to market, we pitched it to defence as well as to mining. The mining industry was receptive, so we got them to first base, unlike defence.

But we had to work really hard over a decade to keep the attention of the industry, convince them it would enable more sensitive, deeper detection and cheaper and

faster exploration, and eventually find a commercialisation partner -- which as it turns out was not one of the big miners. No one was prepared to take the risk. So this is the background against which I comment now, when I call on industry to engage with the research, right at that edge of new technologies. And take a much greater responsibility for research and development.

We hear a lot about Australia's low R&D spend compared to others in the OECD. But when you break down the figures, the real underspend is not in government; it's in business. If business stepped up to the plate, the government side of the equation could be properly focused on fundamental research. That would put us in a much better position to solve those significant technology problems that remain.

There's another benefit – and it's a cultural one. We're quite remarkably siloed in the way we go about the commercialisation process in Australia. The different parts of the commercialisation process don't always talk to each other well enough, or work as a complete ecosystem – even to the point where people are not aware of the science on the one hand, or potential applications on the other.

If you have a culture where industry is reaching in to the research sector and investing in the science, that process of discovery and problem solving becomes more integrated with real-world requirements. And I suspect also that the culture of innovation and experimentation becomes much more embedded into your business.

This is important, because the reality is that we don't have all the tools in the toolkit to reach net zero, and technology deployment is a long process.

One of the pieces of work I'm involved in at the moment through the National Science and Technology Council recognises this challenge. You might look back with whiplash at how fast the smart phone went from non-existent to must-have. But the development of the smart phone was actually a 30-year process, starting in 1970. The car took almost 70 years to get from invention to widespread commercialisation.

We have to be realistic about these timeframes. Technology deployment for a zero-emissions economy will take 20 years. Working backwards, that means proof of concept by 2030. And that means that the new technologies are likely to be in the laboratory now.

We're planning a National Science and Technology Council report that recognises the realities of long deployment. It will identify the promising areas of fundamental research in relation to net-zero technologies where Australia has a potential advantage, including the efficient processing of raw materials.

It will look at options that are cooking in the labs now, and ask whether we're on track and identify gaps – recognising that only a small proportion of the research will be commercialised and scalable.

I anticipate this will provide additional clarity for all of us in government, research and business to ensure we're focusing our efforts in the right place.

So that's my first observation: The importance of investing in the research, listening to the science – and whether in research, government or business – engaging in real collaboration. So that we can truncate the long timeline from discovery to application, commercialisation and scaling up, and bring all those pieces of the puzzle together.

We were certainly persistent with our mining technology at the CSIRO, pitching our device to companies over those years. But that wouldn't be enough in the environment we're in now. We can't afford to be dillydallying around for 12 years to get someone's interest.

The second lesson I take from my experience with the LandTEM system was that we didn't think carefully enough about the business model. Admittedly, it was more than 20 years ago and research commercialisation was at a different stage than it is today.

But we licensed the tech, whereas in retrospect, it would have been better to have created a spin-off company to build and maintain the devices, and rent them out. Better from the perspective of creating a sustainable business model. Better from a maintenance perspective. And better from a technology perspective because it would have allowed us to continually improve and update the technology with new science.

So I've developed a school-of-hard-knocks appreciation of the importance of the right business model. And as I work with government to unlock the potential of critical minerals now, the business model is top of mind.

There's no question that Australia is in the room and in a good position in this sector. I travelled to Japan and South Korea at the end of September – where it was made very clear to me that Australia is front of mind as a valuable supplier of critical minerals including rare earths.

There's also no question about the level of demand. The scale is truly mind-blowing. As you'll be aware, demand for rare earth elements is expected to grow by up to seven times by 2040.

It's a demand boom driven by the renewable energy switch – permanent magnets in electric vehicles and offshore turbines. It's astonishing to think that a typical electric car requires six times the mineral inputs of a conventional car. I understand that the US market for electric vehicles alone could consume 10 per cent of the global supply of rare earth elements for magnets by 2025. But as the International Energy Agency identifies, there's "a looming mismatch" between global climate ambition and availability of critical minerals. So supply is an issue – which means a renewed effort devoted to finding new deposits.

But this is about more than taking advantage of booming demand. It's about supplying the right product. Applying the right business model.

Kodak is often held up as an example of a company that failed to recognise and respond fast enough to the disruptive forces that were at play in its industry. But in fact, Kodak did respond to disruption in the world of print photography. It developed digital

cameras, and for a brief moment there, we were all buying them. The company even invested in an online photo sharing business.

The Kodak lesson is not about failure to respond to changing circumstances. What's actually required is to grasp the full picture, to see and embrace the new landscape for what it is. Digital photo sharing wasn't simply an opportunity to expand Kodak's print business. It was the new business.

The rare earth opportunity is not simply a new mining opportunity. It is a new business that requires a fundamentally new business model. It's mining, but not as we know it.

I've been giving some thought to what we can do at the national level to assist this process of developing the right business model for mining. But for the moment, I want to stress three important elements.

One, it's not dig and ship. It's all about midstream processing. If Australia is going to reap the benefits of this boom, increase skilled employment and lift complexity in the economy, we need to move up the value chain. That's the business you need to be in.

Two, Australia's ambition to enter into supply chains across a range of emerging technologies does not stand apart from the geopolitical landscape. The focus is on being part of the supply chains with our partner countries.

And three, we need to be clear-eyed about the nature of the international market.

This mining opportunity is quite simply inseparable from the global climate ambition. And that means it's inseparable from the environmental footprint of mining and processing operations, and the requirements of the circular economy.

In all of my international engagements, the expectation is absolutely clear that the minerals we export will be extracted and processed with excellent environmental credentials. There is simply no getting away from this.

The requirements of the circular economy must be built in to everything that is done in this space, right from the beginning. That means low-emissions extraction, care for the environment at source, a low call on resources such as water, and end-of-life recycling and management of waste. Soup to nuts, as they might say in the US.

Current recycling rates for critical minerals are negligible – and when we do recycle, we're using technologies that are heavy on energy and the environment. Just consider the fact that Australia produced more than half the world's lithium in 2019, but recycled almost none of it.

Recycled content is the expectation of the market – you'll be aware of the EU Battery Directive to stipulate minimum recycled content in batteries by 2030. But it's also an opportunity for Australia. There's a market and an opportunity for new, viable recycling technologies.

There's also a pressing need for extraction and processing techniques that have a low environmental footprint and emissions profile. I find it extraordinary to think that it takes 1,600 litres of water to obtain the 19 kilograms of copper used in a family car.

I'm sure these issues will be part of your discussions and I look forward to hearing more about the solutions you're working on.

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I spoke earlier about the National Science and Technology Council work on promising research for low-emissions technologies. The NSTC has another piece of work in the pipeline in relation to critical minerals.

This report is considering mid-stream processing, which, as I said earlier, is where we need to be. This report acknowledges considers the economic challenges and the significant costs associated with processing.

It also acknowledges the resource-intensity of minerals processing, and the significant energy and water requirements, along with the environmental impacts. In this context, it identifies a range of novel techniques for processing, in various stages of research and development, such as phytomining from plants.

This will inform the work program of the new National Critical Minerals R&D Centre, and feed into the National Battery Strategy and the National Reconstruction Fund.

So, there's a lot of work underway at government level, through the NSTC, which the Prime Minister chairs, and through the Critical Minerals Facilitation Office. All of this is designed to accelerate this industry, and to accelerate it in the right direction.

But as I often say, none of us can do it alone. It's about science, but it's also about expertise in business, in design, ethics, governance – the whole shebang.

I referred to this at the start of my talk as a puzzle, and it's a not an easy puzzle. The degree of difficulty is high enough that by the time we get the framing pieces in place, everyone needs a swim and a gin. Or a glass of Brian's pinot noir.

But at the same time, I don't think it's anywhere near the most difficult problem we face. We're a mining nation and we're resource rich. We have a shared ambition across Australia, but also with our international partners. We have excellent science. We have investment and we know the scope of the challenge. We clearly have a resources sector that's listening and engaged. It's impressive to think that virtually the entire rare earths industry is represented today, if I understand correctly. So we have the fundamentals in place and we're in the same room.

What I want to see now is that we get the business model right – recognising that this jigsaw puzzle is framed by the clean-energy transition and the environmental imperative.

And I urge you to be brave! Success will not come to those who wait, watch and copy. Success will come to those who actively and assertively engage with this new landscape.

For those of you in the business of rare earths extraction and processing, continue to reach in to the research community as you are doing today. And invest in research and development – because that's where the gold lies.

Thank you.

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