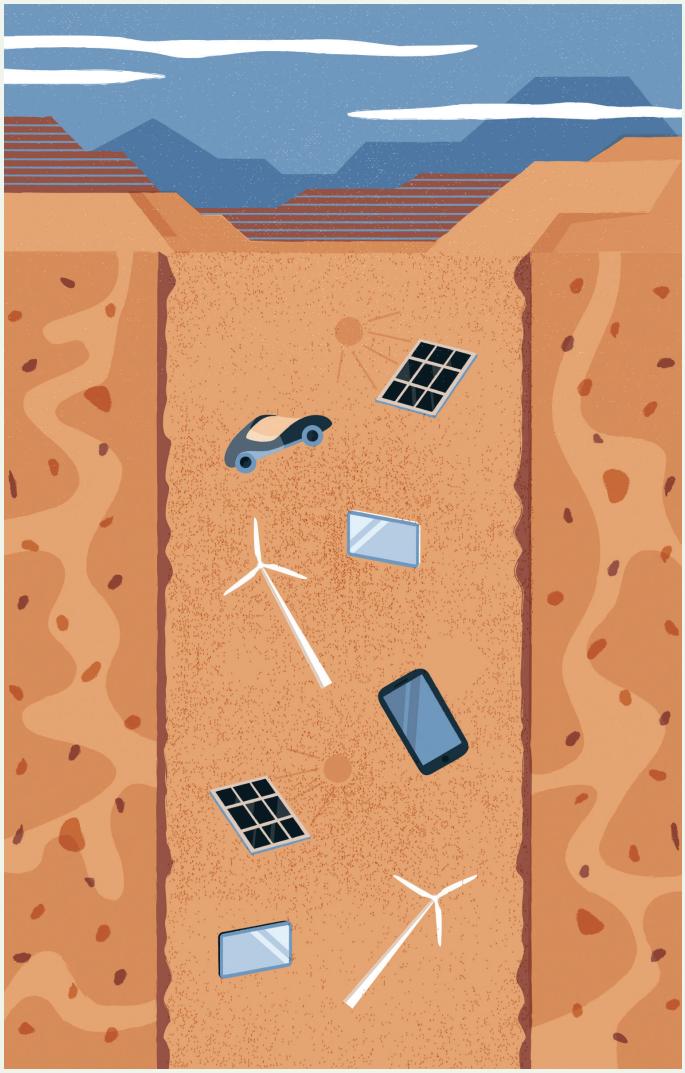


RESOURCES

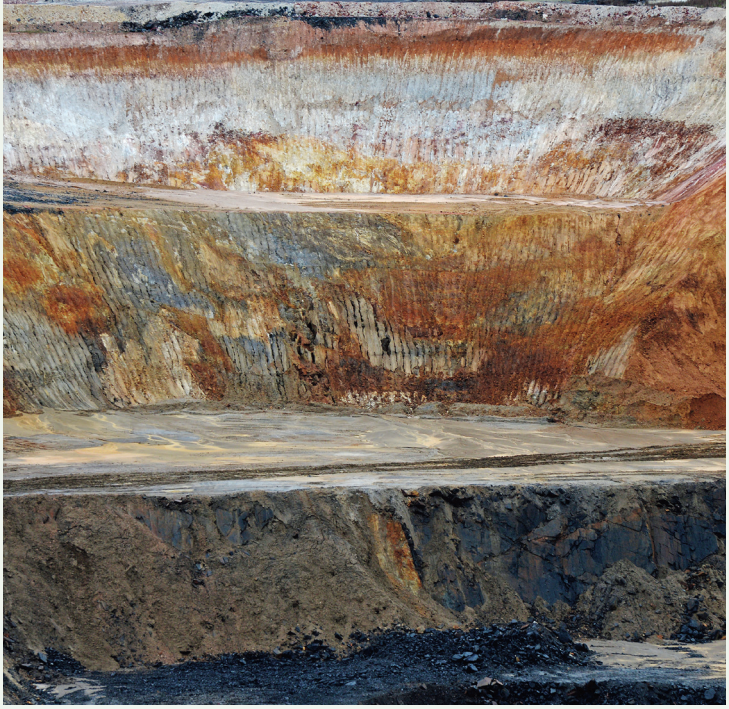
Mining's new rock stars

In what might be its most sustainable move yet, the resources industry is exploring old ground for new critical minerals that will not only drive Australia's next mining and tech booms but also the transition to a decarbonised energy future. By **Jane Nicholls**. Illustrations by Bea Crespo.

Coal, iron ore, bauxite, gold, copper, zinc and lead have been at the heart of this country's mining industry since the first earth was moved. But as the staples of modern life shift, so does our demand for resources. With smartphones, flat screens, solar panels and wind turbines now firmly in the picture, a new set of minerals is in demand and, with rich deposits, Australia is once again in the spotlight.

The most critical of them? Rare-earth elements, cobalt, lithium, vanadium, nickel and manganese, according to Geoscience Australia. The rise of the electric car, for instance, will drive even greater need for these minerals, along with copper. A 2017 UBS analysis predicted that in a 100 per cent electric-vehicle world, the incremental commodity demand would call for 2898 per cent more lithium, 1928 per cent more cobalt, 655 per cent more rare earths, 105 per cent more nickel and 22 per cent more copper. And to keep up with the creation of solar panels and wind turbines, a 2018 Dutch government study revealed that global production of several rare-earth metals – including neodymium, which can be sourced in Australia – must increase twelvefold by 2050. It all adds up to a boom, by any definition.

While some of these minerals have been mined for many decades, others were previously ignored in prospecting or were dug out but consigned to tailings stockpiles or slag heaps as waste because the technology that required them was yet to be invented. Now, with the scientific community realising the potential of the new tech-metal mining boom, that's all changing.



A new age of exploration

"We weren't traditionally looking for some of these minerals," explains Sandra Occhipinti, CSIRO research director, minerals discovery, citing lithium and cobalt as two of the disregarded resources. "We didn't need them so they weren't worth anything – and we only mine for things we need." Occhipinti is leading some 82 research scientists working in minerals discovery across Australia – including geologists, geophysicists and geochemists – "to become almost 'geomagicians' who predict what we're going to find below the surface". Defining deposits of the new hot-property minerals requires careful data collection, high-tech data analysis and modelling, complex geophysical work and going back over old ground, even waste stockpiles. "We've been really good at finding nickel but we haven't looked for cobalt in the same place – there are opportunities in old ground for cobalt and lithium," says Occhipinti.

As the new technology that relies on these minerals advances, so do the analytical techniques to find them. "With lithium, either we just didn't analyse for it or the analyses were no good. So we're reanalysing old samples to work out regions that are prospective for lithium then narrowing our focus." This applies to all the minerals now deemed worth looking for. "We start at a really large scale and find an area that looks like it's prospective for a particular mineral and then we can narrow our search space down by [using] different sampling techniques, different types of analyses, maybe by drilling into the rock itself rather than just looking at the regolith [loose rock and soil] on top." The task is vast, she says. "We're looking at regions the size of several European countries that we haven't explored."

Better ways to "crack a walnut"

As Occhipinti's group works to find those resources, another CSIRO team is developing more efficient and environmentally sustainable methods of processing them. "We're always surprised to discover some of the legacy processes that are unnecessary – really horrible processes, including some older, misguided concepts around the metallurgy," says Chris Vernon, CSIRO research director, minerals processing. "We know walnuts can be smashed by 16-pound sledgehammers but sometimes all it takes is a much smaller hammer or a kitchen spoon." The CSIRO research is aimed at "better environmental outcomes and solving the bigger mineral-processing challenges," he adds, and "areas we know are going to confer value for the nation long-term".

More than ever, Australian companies are looking to value-add by processing the minerals onshore rather than exporting the raw materials and miners engage Vernon's team on a commercial basis to help. "We're usually called in when something becomes difficult," he says. As well as working on the science to process the minerals of

↘ Rare-earth elements

"Rare earths are not so rare but they're not particularly easy to process and are generally tied up in forms that nature doesn't want to give up," says CSIRO research director Chris Vernon.

(REE)

What are they used for? Modern electronics, including the strong, lightweight magnets in electric vehicles and wind turbines.

Where are they found? Alkane Resources, best known as a goldminer, has state and federal approvals to mine and process rare earths in NSW's Central West. The Australian company estimates its $1.3 billion Dubbo Project will go into production two years after final investment is secured. "It's a chance to reclaim some of the game," says Alkane managing director Nic Earner.

What's the potential? Assuming the demand for rare-earth elements continues, the mine could have a life of 75-plus years and the potential to create jobs across generations. Alkane estimates up to 250 ongoing jobs and an economic boost to the region of $60 million per annum. "In terms of the metals of the future, rare earths have the potential to create significant value and contribute to the growth of new industries," says Robert Gee, general manager of the Minerals unit at ANSTO, Australia's Nuclear Science and Technology Organisation.

new interest, the CSIRO is collaborating "with a number of Australian companies on developing less energy-intensive and more environmentally friendly processes".

One of the challenges of processing minerals, explains Vernon, is that "you're not just dealing with the material you're interested in. You're also dealing with maybe 50 other things that you have no interest in at all… and these tech metals are generally [found] in nature at low concentrations."

Vanadium, which makes steel lighter and stronger and is increasingly used in battery technology (see right), is a prime example. "A good vanadium ore has somewhere between half and one per cent vanadium in it and the rest is iron, silica, titanium, clays and all sorts of other stuff," he says. "The trick is designing a good process that's not based around the chemistry or behaviour of the target metal but eliminating all the other 'passenger' materials you don't want."

Dealing with these low-concentration deposits is a big change from the commodities that have traditionally dominated the Australian Securities Exchange. "With iron ore, you dig and ship something that's about 60 per cent iron – really very pure," explains Vernon. "You get some traces of phosphorus, silica and aluminium but it's good enough to put into a blast furnace, reduce it, melt the steel out of it, with all the other materials ending up in the slag."

Miners are getting savvy about other now-valuable minerals in the ore. "Our most forward-looking customers are asking what they can do with the by-products. It's a terrible shame to dig something up, crush it and then not use it." One

Research scientists have become more accurate in predicting which minerals might exist in certain areas

Vanadium

Interest is growing around this lesser-known critical mineral, particularly in emerging battery technology.

What is it used for? Vanadium redox flow batteries (VRFB) suit stationary rather than mobile energy storage. "Lithium is a good battery in the car and a vanadium battery would store the energy used to recharge that lithium battery," says Samantha McGahan, stakeholder engagement manager at Australian Vanadium Limited (AVL). It's also used to make smart windows, pacemakers and stronger, lighter metal alloys.

Where is it found? The main vanadium project for AVL involves mining just south of Meekatharra in Western Australia. Covering about 260 square kilometres, this deposit is one of the highest-grade projects under development anywhere, according to the company. "There is demand for two mines our size to fill the supply deficit," says McGahan.

What's the potential? AVL is working with the Australian Government's Future Battery Industries Cooperative Research Centre (FBI CRC) at WA's Curtin University. "Battery metals are a critical resource for Australia and if managed properly, much more value can be retained in Australia than with previous mining ventures," says McGahan. "The goal is to add value to the minerals here rather than direct-shipping ore and then buying the [core] material back." With steel manufacture accounting for 92 per cent of vanadium consumption, the Chinese government's new high-strength standard "is creating big demand", she says.

Tailings from previously mined regions could contain minerals now considered valuable

company, says Vernon, was processing vanadium but realised "it could also get titanium and a high-grade iron oxide, which are frankly too valuable to throw away".

A sustainable approach

"We're looking at getting more out of our deposits and one way to do that is by mining tailings and waste," says Occhipinti. Improved extraction and processing techniques also mean "we might look at something that was mined in the 1960s and '70s and be able to extract more metals."

According to Vernon, the world needs to keep these minerals out of landfill after they've been extracted, processed and deployed for their first use. "All of these wonderful things we take for granted – computers, mobile phones, electric cars and other tech knick-knacks – contain these metals… and we need a plan to recycle them."

Here's a sobering thought for anyone who has a drawer full of old phones: Vernon says mining a tonne of earth for gold yields, on average, two to five grams of gold, while a tonne of discarded mobile phones would yield at least 100 grams of gold. "It doesn't threaten the primary industry of mining," he says, "but it assures us that the future is rosy for the materials that are going to start running out." ●

(Co+Ni)

Cobalt and nickel

"Cobalt and nickel are fellow passengers in Australia," says the CSIRO's Chris Vernon. "Their chemistries are very similar so they often occur together in geology."

What are they used for? These metallic elements are key components of rechargeable batteries and are essential for electric vehicles.

Where are they found? In WA, Galileo Mining's Norseman and Fraser Range projects are focused on cobalt and nickel. There are also discussions about the potential of re-mining tailings from old operations where significant cobalt remained after the nickel was extracted. "It's another example of how we're working to improve process chemistry to capture all of the value [from mining] instead of just the main value," says Vernon.

What's the potential? "Australia has the potential to become a much bigger cobalt producer," he says. "Now that we're more focused on battery materials, the resources industry is realising that if you can separate cobalt and sell it on its own, it's quite a valuable product."