

ISSUE 14 MARCH 2018

# resourceful



BRINGING CSIRO RESEARCH TO THE MINERALS INDUSTRY

**INNOVATE  
IMPROVE  
GROW**

Australian innovation is solving today's challenges, while underpinning strategic programs to unlock future value in the mineral resources industry.

# Why collaborate with CSIRO?

Because together we can do great things

10

## ways we can work together



**Harness tech  
and innovation**



**Achieve a deeper  
market presence**



**Access  
world-leading R&D**



**Hire world-leading  
facilities and tech**

**IP**

**Create IP and  
licence tech**



**Embed an  
R&D expert**



**Enter new markets**



**Access grants  
and funding**



**Prepare for  
the future**



**Connect through  
our networks**

**Talk to us about how we can help you take on the world**

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## LEADER'S COMMENT

# SOLUTIONS FOR CHALLENGES OF ALL SIZES

As Australia's most trusted publically-funded research agency, CSIRO brings together multi-disciplinary experts to deliver R&D solutions in a range of different ways to benefit the mineral resources industry. **JONATHAN LAW** writes



Jonathan Law

CSIRO strives to be Australia's catalyst for innovation. "Catalyst" is a powerful analogy for CSIRO as it implies a facilitating role within a broader landscape.

CSIRO's focus is not on science for its own sake, but for the impact it has on Australia and the globe. With collaboration as the cornerstone of success, we facilitate programs, partnerships and networks that lead to innovation to benefit the economy, environment and community.

This mission includes supporting a productive mineral resources industry as one of Australia's key areas of competitive advantage: your business, your impact in the world and your prosperity.

This edition of *resourceful* showcases our role as Australia's innovation catalyst for the mineral resources industry, by focussing on the range of different ways organisations can work with us – from solving today's problems to strategic R&D programs to unlock future value.

One great example, is our work on a commodity flow database developed with several international partners for the United Nations Environment. The database is providing unique insights into global trends that drive markets and innovation, helping businesses and governments prepare for the future.

Back at home, the Australian continent is a minerals treasure chest with the contents largely hidden under barren sedimentary cover. To uncover this wealth, we've partnered with state and territory geological surveys to take advantage of new knowledge and tools to create opportunities for industry and attract investment into Australian exploration.

Also critical to innovation and growth in Australia's exploration sector are funding mechanisms for small and medium-sized companies. CSIRO expertise is widely deployed in minerals exploration programs through government-funded embedded researcher programs, ensuring that cutting edge science is right behind the drill bit.

As we work with a wide range of organisations, there is no 'one-size-fits-all' approach: we deliver tailored solutions for challenges of all sizes.

Sometimes innovation is there to be picked off the shelf, and can be accessed through our scientific consulting services. For example, our world-leading expertise in electrical connections for electrowinning is providing energy and greenhouse gas savings for metal producers around the world.

In contrast, bigger challenges such as unlocking complex and low-grade resources need a long-term commitment in order to make a fundamental change. Our development of a new process technology for phosphate ores is one example of developing Australian technology IP around a key industry challenge to deliver to global markets.

Fostering national science capacity and expertise is also a long-term game – one which CSIRO is committed to. On behalf of the BHP Billiton Foundation we are delivering a program to grow science, technology, engineering and mathematics (STEM) education and engagement with Indigenous Australians.

These examples show how we partner with a wide range of organisations – from multi-nationals to SMEs, government, research institutes, industry associations and universities.

Together, we can help your organisation succeed in new and better ways. We can help you increase competitiveness, reduce risk and expand markets, while driving the change Australia and the world needs. ●

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# FIRING UP PHOSPHATE PRODUCTION

A new smelting process for phosphate ores could open up the world's lower grade reserves, while solving the industry's waste problem. The solution has been licensed to an Australian company with plans to take it to the global market.

**TONY HESELEV** reports

Phosphorus in the form of phosphate, is an irreplaceable component in fertiliser with an estimated global market worth US\$51.6 billion. Demand for phosphate fertiliser is predicted to increase as a growing world population puts pressure on the food supply chain.

However, global phosphate producers are grappling with increasing production costs as the world's better quality reserves are depleted.

The industry is also looking for solutions to phosphogypsum – the problematic waste byproduct created by the predominant phosphate process used today known as “wet acid”. About three tonnes of phosphogypsum waste is created for every tonne of phosphate produced using wet acid, resulting in about three billion tonnes being stockpiled annually.

A new CSIRO-developed process solution aims to solve these problems by making low grade reserves economical to mine and reducing problematic waste.

It has been licensed to Australian company Pyrophos who are leading the technology commercialisation to meet the needs of phosphate producers.

“We’ve identified an opportunity in the phosphate market and licensed the IP to Pyrophos, which is taking the solution to market,” CSIRO research group leader, Keith Barnard, says.

The new smelting-based process offers producers significant cost and environmental advantages over the predominant wet acid process.

In contrast to wet acid, the new process involves applying heat to phosphate ores, resulting in a safe gravel byproduct. The gravel byproduct could be valuable for construction as a road base aggregate or used in Portland cement production. As phosphates tend to occur in sandy areas, it is common for these regions to be short of gravel-type construction materials.

Another key benefit of the Pyrophos process is that it has a much smaller plant footprint than the wet acid process, incorporating two processes in one unit, while replacing the more expensive sulphur with coke.

This means that producers could save about two-thirds on capital costs than with current sulphur or wet acid plants, while benefiting from substantially lower operating costs. This meets the needs of an industry in which there have been no major technical breakthroughs in 20 years and that produces a commodity product with large volumes and tight margins.

The IP underpinning the Pyrophos licence agreement is partly new and partly conventional. It is built on top submerged lance (TSL) technology, which was originally developed by CSIRO and is applied commercially in copper, tin and zinc smelting.





The new aspect applies CSIRO's advanced simulation techniques and bespoke facilities to extend the TSL technology into the operating conditions required for phosphate processing.

CSIRO's Steven Wright, an expert on high temperature mineral processing, spent two years building on the ideas of TSL and related technologies to discover the most effective and efficient ways of processing phosphate via smelting.

Mr Wright and his CSIRO colleagues have also undertaken thermodynamic modelling, bench scale experimental tests and techno-economic assessments of the technology. Tests indicate that the proposed process could be technically and economically viable.

"CSIRO has developed the core IP and will be the R&D centre supporting our design engineers for our work with individual producers," Pyrophos managing director, Mark Muzzin, says.

## **CSIRO creates IP for the mineral resources industry. Contact CSIRO with an idea to see how they can help to develop it.**

"We bring industry knowledge to the partnership – from the economics, to the processes and people. It's now up to us to evolve the IP and convert it into commercially proven technology.

The technology's development has also involved commercial guidance and industrial design input from technical advisers at WorleyParsons who have extensive experience and relationships in the phosphate industry.

Pyrophos now has plans to market the pyrometallurgical technology in up to 30 countries. The largest phosphate producers are in China, Morocco and Western Sahara, the US, Russia and Jordan. Australia also has phosphate resources where the process may provide an economic advantage.

Aspects such as the technology's safety, environmental performance, operational stability, constructability, maintainability and economic performance will also continue to be improved. Pyrophos will progress this work in collaboration with a broad range of phosphate producers.

CSIRO will continue to provide R&D expertise through testing services involving a number of stages of increasing complexity. These services include mathematical evaluation, desktop analysis, scoping, pre-feasibility studies and use of CSIRO's high temperature pilot plant in Clayton, Victoria. ●

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# WORLD-CHANGING IDEAS

A new innovation fund is investing in start-up and spin-off companies born out of the public research sector that have potentially life-changing, high-yielding ideas. There are already four in the bank.

**DAVID SIMPSON** reports

You've heard of them. The transistor, steam engine, antibiotics, even CSIRO's own WiFi – these are ideas that have changed civilisation.

According to Bill Bartee, director of Main Sequence Ventures and manager of the CSIRO Innovation Fund, there are going to be more. Their founders may be out there now, just waiting to be discovered and nurtured to success.

"We're looking for the next Microsoft, Oracle or Apple – people with concepts that have the potential to become products or processes that will significantly change the way we live. We think there's a good chance that we'll find one or more in the Australian public research sector," Mr Bartee says.

Discovering the next big idea is not an easy task. For every project in which they invest, the team at Main Sequence Ventures look at and assess approximately one hundred. Then, following the rule of thumb of venture capital investments, they hope that one or two out of ten companies will be successful, while three or four will have some degree of success and the remainder will fail. Crunch those numbers and you'll discover that to get those one or two successful projects requires examining one to two thousand investment candidates.

What's the secret to identifying a potentially successful project? According to Mr Bartee, the most important factor is the people involved in it.

"A great team can fix a broken technology, a great technology can't fix a broken team. So, people are a vital part of how we assess potential. They are probably an order of magnitude more important than the technology itself when we are considering a start-up investment."

Initial investments of the CSIRO Innovation Fund can range from hundreds of thousands to millions of dollars. The investment model also reserves capital to add to the first investment as the project demonstrates success or achieves pre-determined milestones.

"Some of the reserve capital will never get spent, because the companies don't make it. We then apply that unused reserved capital to other companies that are being successful, and we bet heavily on the winners," Mr Bartee says.

"We might end up with five to 10 per cent of the fund in one company, but it will have earned that investment by demonstrating continued success."

The Fund is unique in that it comprises \$70 million in federal government funding through the Australian Government's National Innovation and Science Agenda, \$30 million revenue from CSIRO's WLAN programme and soon to be raised private funding. The total target value of the fund is \$200 million.

Two of the four investments of the Fund to date include Morse Micro and Q Ctrl.

Morse Micro, founded by experienced semiconductor engineers, are building a next generation WiFi chip, called WiFi HaLow. The aim is to expand the signal footprint of a WiFi chip from 50 to 100 metres, to more than a kilometre, while using far less power. With the ability of a coin-sized battery to power a HaLow chip for two to three years, the 'internet of things' will become a much more useful place.

Q Ctrl, started by a quantum physicist from the University of Sydney, aims to develop a solution to control errors generated by quantum computing. There are currently a range of approaches to building a qubit, which is the basic computing unit of quantum computing. However, they all share the problem of generating large amounts of errors. Q-Ctrl's objective is to become one of the world's preeminent error control companies.

When asked where he thought the Fund might find investment opportunities in the mining sector, Mr Bartee pointed to unmanned aerial vehicle (UAV or drone) management and interpretation software, artificial intelligence and machine learning as areas in which projects had already demonstrated potential to deliver results on a global scale. ●





## GET A KICK START

CSIRO Kick-Start is another new initiative for innovative Australian start-ups and small companies, providing funding support and access to CSIRO's research expertise and capabilities to help grow and develop their business.

The program offers eligible businesses access to dollar-matched funding of \$10,000-\$50,000 to undertake the following research activities with CSIRO:

- research into a new idea with commercial potential
- development of a novel or improved product or process
- test a novel product or material developed by the company.

CSIRO's experienced SME Connect team works alongside SMEs to identify the relevant research capabilities best suited to their needs, and facilitates researcher introductions and project scoping.

They also assist with the application process and maintain an end-to-end engagement with the SME and researchers to ensure favourable outcomes for all parties.

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### **AUSTRALIAN GOVERNMENT R&D PROGRAMS AND INDUSTRY GRANTS ARE AVAILABLE TO HELP COMPANIES GET THE MOST OUT OF THEIR R&D EXPENDITURE.**

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CSIRO Kick-Start projects must be under 12 months in duration and businesses are required to make a cash contribution that matches the funding voucher.

Gold exploration company, Calidus Resources, is already taking advantage of the initiative. CSIRO is assisting Calidus by undertaking research and reporting on conceptual models for gold mineralisation, ore-shoot controls and relative chronology of tectonic events to help target drilling and expedite resource definition.

"With the assistance of CSIRO, we are getting a much clearer picture of ore-shoot control and methods that will allow us to rapidly and inexpensively explore the majority of our landholding," Calidus managing director, Dave Reeves, says.

"Work on the ground is progressing rapidly. We are able to drill with greater accuracy, thereby reducing discovery cost per ounce, as well as generate numerous high-ranking targets that will be investigated during the coming year."

**[www.csiro.au/SMEConnect](http://www.csiro.au/SMEConnect)**

# DISRUPTIVE CHALLENGES



Keeping pace with rapid technological change and disruption is an emerging challenge that the mineral resources industry and research sector need to pay attention to, says industry leader and chair of CSIRO's Mineral Resources Advisory Council, Paul Dowd.

Interview by **ADAM COURTENAY**

## **What are the greatest challenges the mineral resources industry is facing today?**

Many of the great challenges relate to lower grade orebodies, more complex metallurgy, exploration under cover and community acceptance. They remain the big challenges and are well known.

But, there is one challenge that is only just emerging. We used to be able to consolidate technology and that's not possible now. Change is happening so quickly and the period of consolidation of technology is no longer linear, but exponential. New technology creates redundancy in some previous developments and therein lies one of the great challenges. Things are becoming redundant so quickly. Before we know it, there's a better system out there.

Understanding the probability of ranges of disruptive technologies and research outcomes, by using auditable processes, could significantly manage the risk of wasted research and other investment resulting from premature technology redundancy.

## **From your perspective, what needs to happen to solve these challenges?**

There are two things we need to think about. Firstly, nanotechnology. A fighter jet may cost \$200 million because it has so many safety measures in the system to protect the pilot. Take the pilot out of the aircraft and use a drone, and then there's no more need for costly protective systems. We need to think the same way in mining – rather than larger pieces of equipment with large development to get them in and out, we research from a nanotechnology perspective. We must go from big is beautiful to small is beautiful.





**Let's not lose sight of the fact that CSIRO discovered WiFi. Everything we've seen in disruptive technology would not exist if WiFi had not been discovered by CSIRO.**

The other thing is energy viability. As the trucks, loaders and dozers get bigger, they all use the same sort of energy – liquid hydrocarbons. We need to look at electric energy which is 95 per cent efficient compared to diesel combustion, which is at best 40 per cent efficient.

Then there's energy storage. It's still in its infancy and it's clumsy, but we now have to be looking at storage in the mining industry – not the least because we're operating in very isolated areas. Now, if there were some way to have adequate storage then we could seriously consider renewables and a whole range of associated technologies.

Additionally, with the emergence of new demand for particular minerals and elements, there is likely to be a “re-balancing” of other minerals within a possible completely new era of energy.

**What do you see as the main role of CSIRO, the nation's science agency, in working with the industry and solving these challenges?**

The main role of CSIRO is to continue with the culture it has been so good at adopting – working in tandem with industry. CSIRO has virtually reinvented itself and adopted a far more commercial-facing culture. It's training people to understand the commercial reality of getting ideas from concept, through to research into verification and then onto market.

It has also developed a new operating paradigm “fast to fail”. Failure can be one of CSIRO's most important tools. Proving quickly that something doesn't

work opens the door to those ideas that will. This concept is far more appropriate in this era of rapid technology disruption. In research terms, CSIRO is ahead of the game in this area. It has to help the mineral resources industry to get to a “fail fast” mentality.

**What value is CSIRO creating for the mineral resources industry in Australia and globally?**

Let's not lose sight of the fact that CSIRO discovered WiFi. Everything we've seen in disruptive technology would not exist if WiFi had not been discovered by CSIRO.

CSIRO still needs to have the backroom boffin – the person who looks over the horizon and sees the next WiFi-like breakthrough. That said, CSIRO still has to keep focused on the disruptive technology era and learn to manage it better.

What we need is a recognised process or processes deployed before we start spending on research. If we understand the probability of a certain number of ranging outcomes, we are not just betting the farm on any one thing.

CSIRO can be scientific in selecting which directions it heads in and, in doing that, it'll come up with something nobody expected.

**How do you see the organisation supporting industry growth in Australia?**

It's all about CSIRO being at the centre of the minerals value chain, which goes from exploration through to the marketing of various products.

In the past 10 to 15 years, we have treated each of the processes separately, albeit, with some minor integration. We need to go beyond that now, by putting together real data with different probes, measuring devices and instantaneous measuring that is then sent to big data computers. We'll then start to see relations that we can't currently identify along the value chain. That may alone be one of the big breakthroughs.

In data management terms, the chain will be fully integrated. But, there may be adverse consequences. Once you have all the data coming in and analysed instantly, it probably makes you more prone to cyber attacks than ever before. It could hold a company to ransom. This is a real problem we have to face up to.

**How essential is collaboration to industry innovation?**

Collaboration is a good thing. We still find that companies at the big end of town think they have a competitive advantage in technological developments and don't want to share that.

But, we can collaborate in the pre-competitive space, such as for cybercrime solutions. For example, the industry needs patches to stop cybercrime. If miners do this individually, there will be huge opportunities for cyber criminals to get in and knock each one of us off in turn. If we're together on this, there's a better chance to be secure against cybercrime. ●

**Paul Dowd is non-executive director of Energy Resources of Australia, PNX Metals, as well as a board member of the Resources and Engineering Skills Alliance. He is also the Chair of CSIRO's Mineral Resources Advisory Council.**

# TOWARDS SUSTAINABLE GROWTH

A valuable knowledge base is helping the policy and business community understand how global material flows and impacts on economies. It aims to help balance economic growth with better environmental outcomes and show how countries are tracking against sustainability targets. **ADAM COURTENAY** reports

There have been plenty of measures of global economic growth over the years and numerous estimates of how burning hydrocarbons is progressively contributing to climate change.

What's not so commonly understood, or as widely publicised, is the relationship between the extraction, trade and consumption of materials and the importance for both the environment and the economy.

It seems like a very simple question. When you take natural resources out of the Earth, what are the exact benefits and damages being done? If we know exactly how much the world is consuming – whether it be metal ores, fossil fuels, crops and timber, construction materials, or water and energy – what is the end equation?

From this knowledge, businesses and governments can contribute to make the entire chain of material throughput more efficient to balance economic growth and environmental impact.

The need to decouple economic growth and human wellbeing from ever-increasing consumption of natural resources has become one of the world's most important policy discussions in recent years, and CSIRO is at the heart of trying to put intelligence to this question.

CSIRO's expertise in the flow of global material and its impact on economies has come in the form of a database. This large database can track the inflows and outflows of materials and resources from 1970 until the present day and model the real impact of these activities for every country in the world. CSIRO and its international partners curate it on global material extraction and resource productivity for United Nations (UN) Environment.

No other scientific organisation has this information at its fingertips and CSIRO team leader, Heinz Schandl, has been instrumental in ensuring the database is the foundation stone of the UN's Environment Programme's policy on intelligent resource extraction.

Dr Schandl says that if we can find the right equilibrium of use and extraction, we can then know more about the means to reduce carbon emissions and keep global warming below two degrees Celsius. We can also know more about how to yield higher economic growth and more targeted employment with less detrimental impact.

"The data we provide is different to traditional environmental data," Dr Schandl says.

"Here we are looking at the resource-use consequences of the global economy, which we call pressure indicators. The advantage of the pressure indicators over just knowing the impact is that they are closely related to economic processes.


"We can identify which industries can make the greatest contribution to resource efficiency and get the greatest economic gain."

Dr Schandl explains CSIRO's role in leading an international consortium that prepares the dataset and provides numbers to the UN International Resource Panel (IRP), whose job is to report on the use of materials and energy and the production of wastes and emissions in the global economy.

It can then see the connections between economic growth and human wellbeing from the global resource patterns.

There are many datasets from which the global material flow database is assembled. Bodies, such as the UN's Food and Agricultural Organisation, report on crop and timber harvest, while the International Energy Agency offers numbers on the extraction of coal, oil and gas.





"We take their raw data and use it according to internationally agreed standards to create the material flow resource productivity database," Dr Schandl says.

The global material flow database has been the key dataset used by the IRP, which issued an important report in 2016 at the UN High-Level Political Forum revealing the status, trends, structure and dynamics of resource use, including extraction, trade and consumption of biomass, fossil fuels, metal ores and non-metallic minerals.

The report found that global material use has tripled over the past four decades, with annual global extraction of materials growing from 22 billion tonnes in 1970 to 70 billion tonnes in 2010. Global material use has accelerated since the year 2000 during a period of sluggish global economic growth resulting in a declining global material use efficiency and contributing to fast increasing environmental impacts.

Interestingly, Dr Schandl says that the CSIRO data reveals that the mining and metals industry has been expanding even in periods of economic slowdown that we are supposedly experiencing now.

"The data is telling us that the boom is not over at all."

Since 1970, only the 2008-09 period showed any real decrease in demand, but in all other years the metal industry has been growing and should continue to grow into the future.

"We may be seeing a mismatch between supply and demand, a short-term effect which people might call a downturn. But, this has nothing to do with whether the world economy needs more metals in the future, which it clearly does," Dr Schandl says.

*Continued over page.*

**CSIRO can help organisations capitalise on future opportunities or prepare for potential threats.**



The report also introduced a new material footprint indicator that shows the amount of materials that are required for final consumption in a country. It's shedding light on the true impact of economic growth.

With the historic adoption of the 2030 Agenda for Sustainable Development in September 2015 in New York, the international community has now committed itself to 17 Sustainable Development Goals (SDGs) to harmonise economic growth, human wellbeing and environmental integrity.

Indicators from the global material flow database are used to monitor the progress countries are making in regard to improving the resource efficiency of production and consumption (SDG target 8.4) and sustainable natural resource use (SDG target 12.2).

Dr Schandl explains that there is still work to be done to improve the database's applications and to expand its use into new areas. The data is being used for policy-making by the Japanese Sound Material Cycle Society law, the Chinese Circular Economy law and the European Union's Sustainable Use of Natural Resources directive.

"In the future, we need to drill this down to make it more relevant to various business sectors and possibly even to individual corporations," Dr Schandl says.

This is done by identifying national hotspots in terms of sectors or products where investment could be focused to create the largest benefits.

This analysis helps to identify economically attractive resource efficiency with large co-benefits for greenhouse gas abatement, pollution reduction and waste minimisation.

"We will be able to show every industrial sector exactly what its resource performance is. We will be able to focus on specific products,

processes and industries and ask how their environmental performance – including materials, energy use, waste and emissions – can be improved," Dr Schandl says.

Stefanos Fotiou, the director of the Environment and Development division of the Economic and Social Commission for the Asia-Pacific (ESCAP) region used CSIRO's research for many years to provide technical support to ESCAP members. He believes that the use of the database will multiply in time.

"The more we use the CSIRO database, the more we find value," Dr Fotiou says.

"It will be useful to understand the interlinkages between the economy and the environment, as well as the predictive value this data could have when we try to analyse trends and the impacts of some processes."

Dr Fotiou says the end-game is to know the "breaking points" for a particular industry.

"Ultimately, we need to find answers to questions such as how much coal we use and what will happen if we use more or less. And, do the same for other resources, such as oil, minerals, energy and agricultural products."

He also emphasises that this is not just about the negatives of growth.

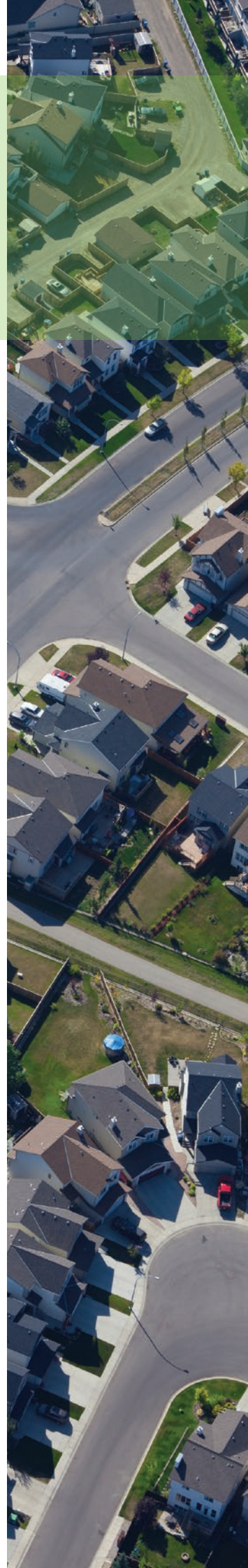
"We see our role as the intermediary. We offer simulation tools to show what will happen to your energy mix or what will happen if you increase your energy efficiency by a certain percentage.

"It's not just about how to save the planet – it's about how to save resources and money." ●

**You can access the global material flows database at: [www.resourcepanel.org/global-material-flows-database](http://www.resourcepanel.org/global-material-flows-database)**

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EMBED A RESEARCHER IN YOUR BUSINESS

# ADDING DEPTH TO MAPPING

**A detailed 3D map revealing rock type has been achieved for eight-times deeper below the surface than was previously possible, enabling Marindi Metals to better target its drilling program.**

**TIM THWAITES** reports

By combining geological data from several different sources in an innovative way, CSIRO researchers have been able to provide a junior exploration company with a detailed 3D map of the rock types up to 800 metres underground. Previous approaches could only “see” about 100 metres below the surface.

Marindi Metals inherited a tenement in the McArthur Basin in the Northern Territory from a merger with Brumby Resources. The collaboration with CSIRO has now provided the company with data on the block, which looks like yielding a better targeted drilling program for a fraction of the time and resources it would normally cost.

“We provided some geophysical data and CSIRO provided us with the expertise to interpret it in new ways,” Marindi managing director, Joe Treacy says.

“The net result was that it changed our thinking on that particular block. It’s been a great help to us. It showed us the target horizon was not as deep as people thought, which makes it more prospective.

“In the past, we would have had to drill to find that out – that’s expensive and a real problem for a small company.”

At the same time, the six-month project has allowed researchers from CSIRO to explore and test new models and ways of combining airborne electromagnetic data with ground-based gravity data and geochemistry from drillcores.

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**THE COLLABORATION CAME TOGETHER UNDER THE AUSTRALIAN GOVERNMENT’S INNOVATION CONNECTIONS PROGRAM. INNOVATION CONNECTIONS PROVIDES GRANTS OF UP TO \$50,000 TO SMALL-TO-MEDIUM ENTERPRISES (SMES), ENABLING THE PLACEMENT OF A RESEARCHER IN THEIR BUSINESS TO WORK COLLABORATIVELY ON A PROJECT “TO DEVELOP AND IMPLEMENT A NEW IDEA WITH COMMERCIAL POTENTIAL”.**

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Projects funded through Innovation Connections last for up to a year and companies are generally required to match the government money on a dollar-for-dollar basis. In this case, CSIRO also contributed funds to drive the project because of its strategic alignment.

The story actually began in another place at another time. CSIRO project leader, Sam Spinks, a geochemist, had earlier been working in the Capricorn region of Western Australia on the southern edges of the Pilbara, where Marindi also have interests.

Dr Spinks worked on how to use geochemical indicators to point to the location of potentially exploitable mineral deposits. His work in the Capricorn provided Marindi with useful information as to where deposits of zinc and even gold might lie in their area.

Dr Spinks had also worked in the McArthur Basin. Given his previous links with Marindi and how they valued engaging with research and development, it occurred to him that their intention to explore in that area was the perfect opportunity to look at employing a combination of different types of survey data on a local scale.

Marindi already had airborne electromagnetic data across their block, and Dr Spinks was able to get hold of cores previously drilled in the area and lodged with the Northern Territory Geological Survey (NTGS) in Darwin. The collaborative team then commissioned a commercial survey company to take ground-based gravity readings across the block.

Dr Spinks’ geochemical interpretation gave CSIRO geophysicists a better understanding of the likely mineral make-up of the area. It allowed them to calibrate and better interpret the picture derived from the electromagnetic and gravity data, producing a much more refined 3D model of the rocks beneath.

“The geophysical datasets are absolutely complimentary, and using both in combination with geochemistry improves our understanding of the subsurface geology in 3D,” Dr Spinks says.

The project has not only provided useful and practical information to the two collaboration partners, but has also given the NTGS important feedback on what data it can gather to expand the local useability of its information, and where it should be taking a closer look. ●

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ACHIEVE A DEEPER PRESENCE

# BUDDING SCIENTISTS

An important education program aims to increase Indigenous Australian participation and diversity in science, technology, engineering and mathematics studies and professions. **LOUIS WHITE** reports

Aboriginal and Torres Strait Islander peoples have been using science for thousands of years – from looking to the stars to navigate and using native plants for medicine to drawing on physics to make effective weapons and tools.

Despite a deep connection between culture and science, there are few Aboriginal and Torres Strait Islander students and professionals in science, technology, engineering and mathematics (STEM).

Set up to address this gap, is the \$28 million Indigenous STEM Education Project funded by BHP Billiton Foundation and designed and delivered by CSIRO.

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**CSIRO CAN WORK WITH ORGANISATIONS TO DESIGN AND DELIVER TAILORED R&D OR SOCIAL PROGRAMS ACROSS STEM EDUCATION, THE ENVIRONMENT AND COMMUNITY.**

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The project works with teachers to increase their competencies and confidence in teaching Indigenous content inquiry (the combination of indigenous cultural practises using the lens of scientific enquiry) in schools. The project also works with Aboriginal and Torres Strait Islander students to both

inspire and support them in their STEM studies. It is comprised of six program elements that cater to the diversity of students across remote, regional and metropolitan schools as they progress through primary, secondary and tertiary education and on into employment.

“Since October 2015, we have had 13,000 Aboriginal and Torres Strait Islander students and up to 700 teachers across more than 155 schools engage with the program,” CSIRO project director, Therese Postma, says.

“We are measuring students’ participation and achievement in STEM subjects as well as their attitudes and aspirations towards science and science-related careers.

“We are also measuring and evaluating improvements in teacher capacity to teach science and mathematics to Aboriginal and Torres Strait Islander students. This will be the major indicator of the project’s success.”

The six program elements together target primary and middle school students in remote Aboriginal communities; mainstream students in upper primary and junior secondary schools across Australia; a select cohort of Year 10, 11 and 12 students from across Australia who have demonstrated aptitude in science and mathematics; and tertiary students who otherwise might not have access to a university STEM education.



“The project and the Foundation are helping to address sustainability challenges confronting our current and future generations,” BHP Billiton Foundation’s Rebecca Samulski, says.

“We need critical thinkers who have an innovative approach to solving ongoing problems facing the world right now.

“We will evaluate the program this year to see what is working and what is not and hopefully we will see positive results in the not-too-distant future.”

Responsible for the project’s delivery, CSIRO has established relationships with schools in Queensland, New South Wales, South Australia, Northern Territory and Western Australia.

CSIRO has also developed new Indigenous context inquiry resources that will help teachers engage students more effectively in STEM studies. These are hands-on activities that demonstrate the links between science and different aspects of traditional knowledge, such as making fires, use of resins and more.





“We deliver three summer schools every year that aim to support and inspire 105 talented Year 10 Aboriginal and Torres Strait Islander students to study STEM related subjects in Years 11 and 12,” Ms Postma says.

“We also provide teacher professional development and coaching in the classrooms so that teachers are confident using the resources and can support other teachers in the school to use them. It helps to deliver outcomes that are sustainable when the project ends.”

The six elements of the project include: Science Pathways for Indigenous Communities, PRIME futures, Inquiry for Indigenous Science Students, Aboriginal Summer School for Excellence in Technology and Science (ASSETS), Bachelor of Science (Extended) and the Indigenous STEM awards.

“The Science Pathways for Indigenous Communities targets primary and middle school students in remote Indigenous communities and uses on-country projects as the context for learning science linked to Indigenous ecological knowledge,” Ms Postma says.

“The program engages western desert community schools, in consultation with traditional owners and other elders, to develop integrated two-way science teaching and learning programs.”

The Inquiry for Indigenous Science Students program helps develop lesson plans linked to the Australian Curriculum involving science investigations with an Indigenous context and focuses heavily on professional development of teachers. The PRIME Futures program, delivered by the YuMi Deadly Centre at the Queensland University of Technology, offers professional development to teachers so they can better engage with Aboriginal and Torres Strait Islander students and teach mathematics in an Indigenous context.

“We are currently more than half-way through the original project. One of the major components is developing a sustainability plan as CSIRO and BHP Billiton Foundation are committed to increased Aboriginal and Torres Strait Islander participation and representation across STEM fields,” Ms Postma says.

“Several of our programs have already established a peer-to-peer training model where teachers can pass knowledge, resources and skills onto their colleagues. We are also developing an online learning management system for teachers and other educators to be able to access the project resources beyond the life of the project.”

“Aboriginal and Torres Strait Islander culture and identity is fundamentally important in student achievement. A strong cultural and academic focus is guiding the development, implementation and evaluation of this program.”

Studies have shown that diversity in education, organisations, workplaces and teams lead to higher returns, innovative ideas and have much high participation and engagement from students and employees. ●

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# THE POWER OF GOOD CONNECTIONS

**Power-intensive industries at home and abroad are working with CSIRO on improving electrical connections to cut their energy use, operating costs and carbon emissions. TONY HESELEV reports**

Smelters and other metal production plants use vast amounts of power, so energy efficiency is crucial especially as electricity prices continue to soar and countries around the world work towards cutting their carbon emissions.

Some metal-making electrolysis processes such as smelters and electrowinning or electrorefining operations are electricity-intensive and involve high-current electrical connections.

Harsh process conditions in these plants degrade the electrical connections, which results in them becoming more variable and less efficient.

Traditionally, industries operating these plants focused on energy savings in electrochemical processes rather than those associated with electrical connections.

A world-leading team from CSIRO is helping industry clients in Australasia, Europe and Africa identify how and where energy is being consumed inefficiently.

CSIRO studies had shown that improving electrical connections could generate more than 30 millivolt savings for each electrolytic cell, requiring little if any capital expenditure.

For a typical modern aluminium smelting operation producing 1.6 million tonnes a year, these energy savings would be enough to power 27,000 average Australian households, or deliver total annual savings of more than \$5 million.

CSIRO's David Molenaar, principal research engineer and leader of the energy efficiency team, says about 10 per cent of electrical energy is consumed in the electrical connections.

"In electricity-intensive plants, it's critical to identify points of electrical energy inefficiency because this affects a plant's stability, consumes excess power and impacts production," Mr Molenaar says.

The CSIRO team has demonstrated that significant energy savings can be made by improving the efficiency of electrical connections delivering power to the electrolysis processes.

"Reducing power losses is also the most cost-effective way of decreasing industrial carbon emissions associated with electricity use, especially in countries that rely on coal-fired electricity plants, such as Australia, South Africa, China and the United States," Mr Molenaar says.

CSIRO's team has extensive knowledge and experience of the thermal, mechanical and electrical phenomena present in high-amperage electrical connections. Using this knowledge, controlled testing and computational modelling, the team improves the design and maintenance of the connections.

For example, a client whose plant was experiencing electrical inefficiencies and energy wastage required CSIRO to redesign the plant's electrical connections.

The team was able to verify energy savings of more than eight megawatts (mW) using in-plant measurements, offline testing and computer modelling.

The energy efficiency team uses a high amperage testing facility at CSIRO's Clayton site in Melbourne to conduct full-scale testing of new designs and industrial materials, and customises testing to meet each client's needs.

"Together, our testing facility and modelling can analyse full-scale industrial components offline under normal operating temperatures, atmosphere and current densities without interrupting the client's production," Mr Molenaar says.

"This allows us to generate highly accurate data and insights into the way electricity flows through the components and across electrical contacts."

Mr Molenaar says adopting a "whole-of-plant" approach in which maintenance was optimised to minimise voltage loss would also reduce costs.

"It's possible to optimise the service life of electrical connections and the electrode fleet to achieve the minimum total cost to the business, with low capital expenditure," he says.

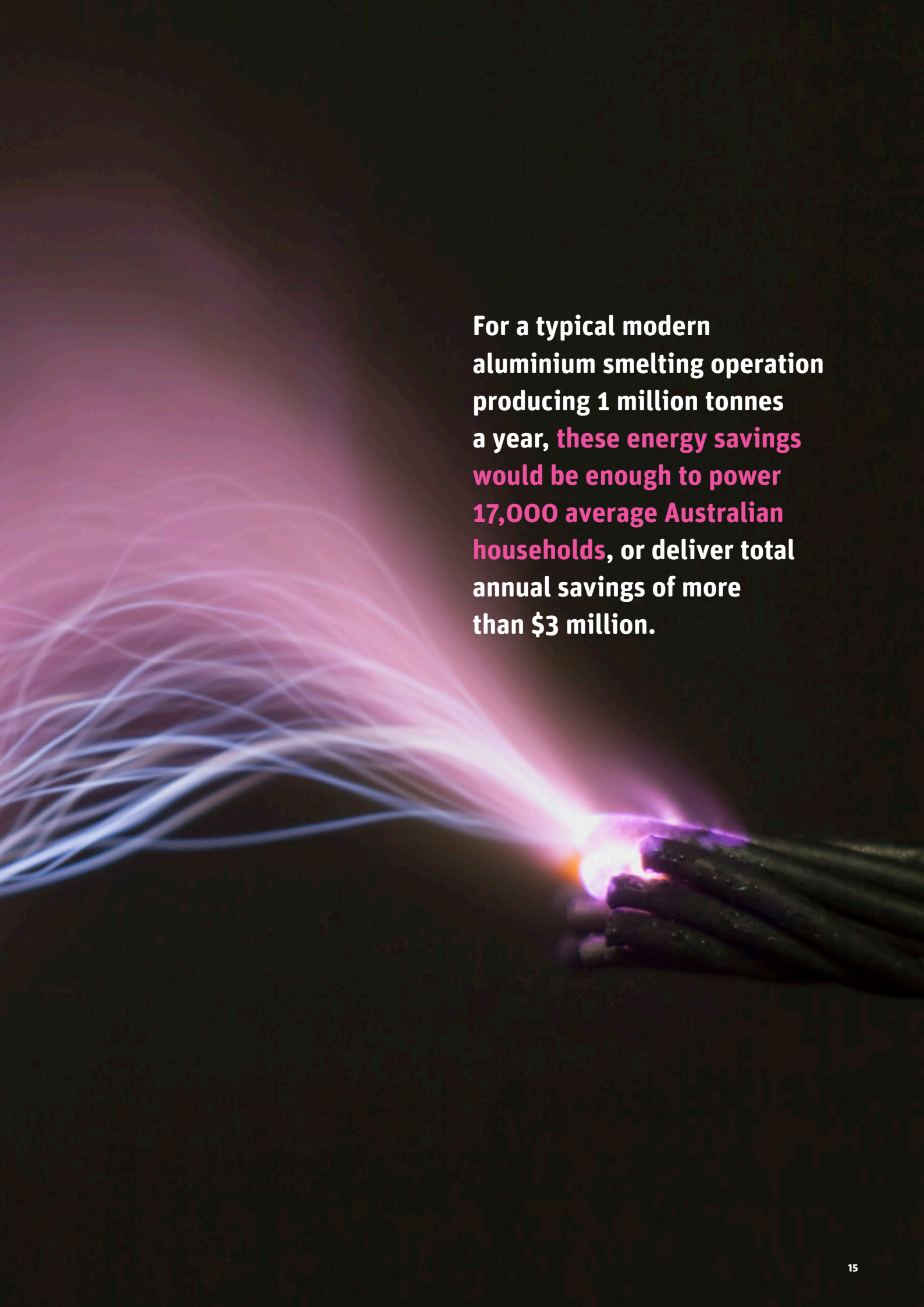
The CSIRO team has worked mainly with aluminium smelters, and copper, zinc and nickel electrowinning or electrorefining operations since it was established in 2009.

As relationships strengthen through ongoing work, clients are increasingly seeking the CSIRO team to be involved in their technical planning and research.

In this way, our clients become our partners. ●

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A hand is holding a glowing plasma torch. The torch has a bright purple and blue flame that is shaped like a fan. The background is dark, and the light from the torch is the primary source of illumination.

**For a typical modern aluminium smelting operation producing 1 million tonnes a year, these energy savings would be enough to power 17,000 average Australian households, or deliver total annual savings of more than \$3 million.**



# SMARTER, FASTER SURVEYS



The region home to the well-known, yet mysterious Coompana magnetic anomaly was the testing ground for a recently-completed “smart sampling” trial that saw an area twice the size of Melbourne surveyed in just one week.

**TIM TREADGOLD** reports

The famous “blue hole” – also known as the Coompana magnetic anomaly – on the South Australian section of the Nullarbor Plain, gets its name from the colour generated by scans of what is an area of deep and unusually low magnetism. It has fascinated geologists since first noticed more than 40 years ago.

A recent “smart sampling” trial undertaken over the blue hole was not specifically designed to test it, though the surface geochemical and vegetation sampling might help throw more light on the geological mystery.

The primary aim was to trial a system of rapid, in-field sampling and analysis using helicopter transported scientific facilities to characterise the chemistry of a large area. The work may lead to more detailed exploration planning.

Any additional knowledge of the blue hole would be a bonus and perhaps help fine-tune theories about its genesis, which include being formed when the Earth’s magnetic field was reversed, following a meteor impact, or because a northern hemisphere remnant shifted south by tectonic movement.

The team comprised of researchers from the Geological Survey of South Australia (GSSA) and CSIRO, with assistance from two traditional land owners and a helicopter crew. The field trip was designed to outline the chemical characteristics of a 4000 square kilometre (km) area, an expanse roughly twice the size of Melbourne and its suburbs – in a week.

Traditional soil sampling can take months using ground-based crews, as individual samples weighing two to four kilograms are collected and returned to a central laboratory for analysis. This trial replaced traditional techniques with advanced portable tools, such as x-ray fluorescence (XRF) and spectral analysis.

Samples of vegetation, mainly bladder salt bush and pearly blue bush, were also collected and tested for the presence of minerals.

In several senses it was a project “on the fly” as they travelled via helicopter to 310 sites that they subjected to surface geochemical sampling and analysis.





**What we showed is that we could conduct a regional sampling operation, generate good geochemical and mineralogical results, and then refine our sampling while on site by returning on the last day to an area of particular interest.**

Ryan Noble, CSIRO

As well as the broadacre survey based on 4km centres, the focus was narrowed down to take a close look at a specific area with samples of 36 centres in a hexagon shape with 1km centres.

The smaller area was chosen partly because of interesting results, but also to test how it could be done by mineral explorers working in an unknown area with the advantage of having in-field tools. This would enable a specific area to be analysed quickly and in greater detail without having to organise a return field trip, which is what mineral explorers currently have to do.

“We learnt a bit about the area that we didn’t know before. We learnt how to survey much more quickly and that could represent a big cost saving when applied by a mineral exploration company,” Dr Noble says.

“We have more to learn. One improvement that might become clearer after we go back over the modelling is to see whether we could have got away with only collecting 80 samples instead of the 300, which is very much what smart sampling is about.

“The Coompana field trip was a test case to demonstrate that an exploration project can cover an area much more efficiently with new technology over traditional methods that can involve generating thousands of samples and take months, not days.”

Refinements are planned to the smart sampling method, such as how much material is needed in each sample, to replace the two-to-four kilograms collected in a traditional survey with as little as 200 grams, a major weight and cost saving when a helicopter is used.

“Now that we’ve characterised the area, we have to take the next step which is looking for an anomaly which could become an exploration target. We hope to do that with the GSSA in an area with known mineral deposits and expand from there,” Dr Noble says.

“As we build the knowledge base by testing an area with known mineralisation we can apply our model to that data, and use that to find other mineralised areas.” ●

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Ryan Noble, a principal research scientist with CSIRO and member of the team, says the trial was remarkably successful.

“The starting point was to take sufficient soil and rock samples to characterise the area, which meant digging a small hole between 20 and 30 centimetres deep at each sample point, as well as collecting vegetation,” Dr Noble says.

“Samples were prepared in the field, which was one of the more unique features of the project, because it involved crushing and milling and then pressing each sample into a form suitable for portable XRF and spectral analysis.”

XRF provided a good indication of chemistry, spectral analysis provided a proxy for the mineralogy.

The entire process was rapid with an analysis achieved every four minutes thanks to the creation of an efficient production line, an essential aspect of a project visiting so many sites in an area measuring 80km by 50km.

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**ALONGSIDE ITS PARTNERS, CSIRO IS SHOWING HOW NEW TECHNOLOGY AND RESEARCH SOLUTIONS CAN BE TAILORED TO GIVE ORGANISATION'S THE CUTTING EDGE NECESSARY TO GROW AND COMPETE IN AN EVER MORE COMPETITIVE ENVIRONMENT.**

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“What we showed is that we could conduct a regional sampling operation, generate good geochemical and mineralogical results, and then refine our sampling while on site by returning on the last day to an area of particular interest,” Dr Noble says.

The first lesson learned from taking the latest in science to the outback, rather than simply retrieving samples of the outback for later scientific analysis, was that it can be done, and a lot quicker than was expected.

The second was that the silica content in the soil samples appeared to match up with the blue hole magnetic anomaly, but was probably related to a limestone unit closer to the surface.

### QUEST TO EXPLAIN THE PILBARA'S UNUSUAL 'WATERMELON-SEED' GOLD NUGGETS

An old-school gold rush kicked off in the Pilbara goldfields last year, following the discovery of hundreds of gold nuggets uniquely shaped like watermelon seeds.

Sole prospectors and exploration companies alike flocked to the area in search for these nuggets hosted as conglomerates, on or near to the Earth's surface.

One company, Artemis Resources, recovered 547g of nuggets from prospecting the area in just four days. While the nuggets are valuable in their own right (their bounty was roughly worth \$25,000) the hype since has focused on what they might mean for bigger gold discoveries in the area.

Could these nuggets be a fruitful sign of a profitable gold deposit hiding below the surface? Is there potential for a whole series of new discoveries of similar mineral rocks across the region?

Speculation has drawn similarities to the host rocks around Witwatersrand (aka Wits) gold deposit in South Africa, arguably the largest gold deposit in the world.

Right now, we don't have any scientific evidence to back this claim. What we do know is that these nuggets are different from most of the known gold reserves in Western Australia, such as around Kalgoorlie.

Until we look into the geology of the rocks and how they formed – in other words, the origin of the mineralisation – more questions than answers will remain.

That's why, we're working with Artemis Resources to get to the bottom of how these unusual gold nuggets formed and why they exist.

**For the full story, visit:**  
[blog.csiro.au](http://blog.csiro.au)

### WORLD-FIRST GENETIC ANALYSIS REVEALS AUSSIE WHITE SHARK NUMBERS

Of all apex predators, the white shark *Carcharodon carcharias* (commonly known as the great white) is perhaps the most fascinating. The potential danger from (very rare) human interaction has embedded the species in our national consciousness.

Debate as to the size and status of the white shark populations across the globe is both vigorous and often contested, and it is fair to say we have never had an accurate picture. Now, for the first time we estimate that the total number of adult sharks across the Australasian region is around 2,210. We're lacking data on juvenile sharks in one region so it's difficult to say what the total Australasian population is, but it's likely to be in excess of 8,000-10,000 animals.

CSIRO researchers working with Australian and New Zealand scientists in the National Environmental Science Program have used world-first genetic analysis to investigate white shark populations.

The results of this project, published on Thursday in the journal *Scientific Reports*, are the first estimates of white shark adult population size, trend and survival rates for the Australasian region.

**For the full story, visit:**  
[theconversation.com](http://theconversation.com)

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