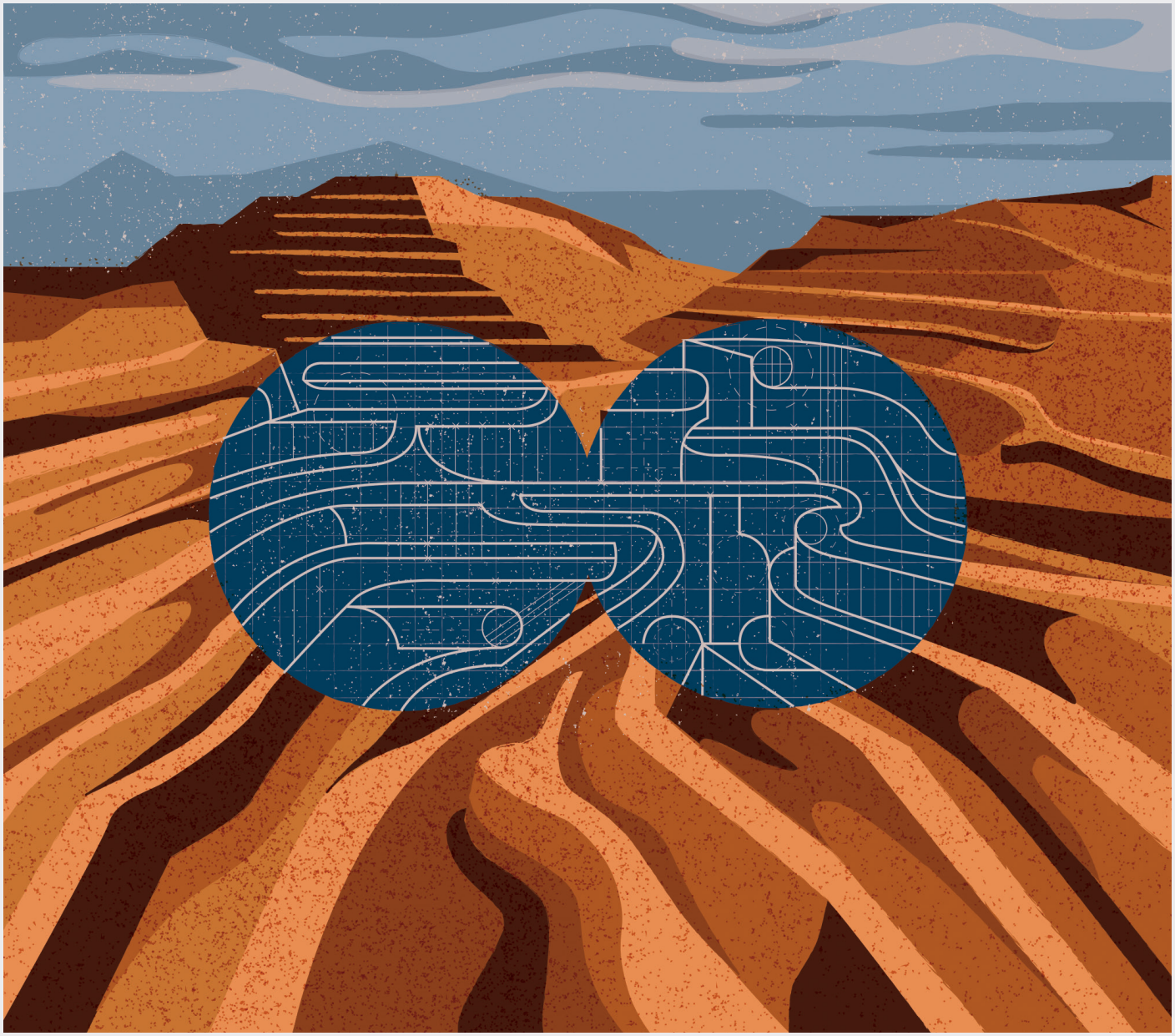

SPECIAL REPORT

Mining: the new frontier

Autonomous drones, intelligent software, scientific advances, new-age analytics and world-leading education – the future of the resources sector is here, writes **Jane Nicholls**. Illustrations by Bea Crespo.

Mining is arguably the original heavy industry yet it's also been an early adopter of digital operations: even in the early stages of the Internet of Things, the industry saw the potential for productivity and safety gains. Leading the way with autonomous trucks and trains, resources-rich Australia continues to develop transformational mining technologies, while building robust research and education networks. So, what's next? Plenty. We investigate five critical areas of innovation – each one essential to a sustainable and productive mining industry that will also ensure greater wellbeing for the people who keep it moving.

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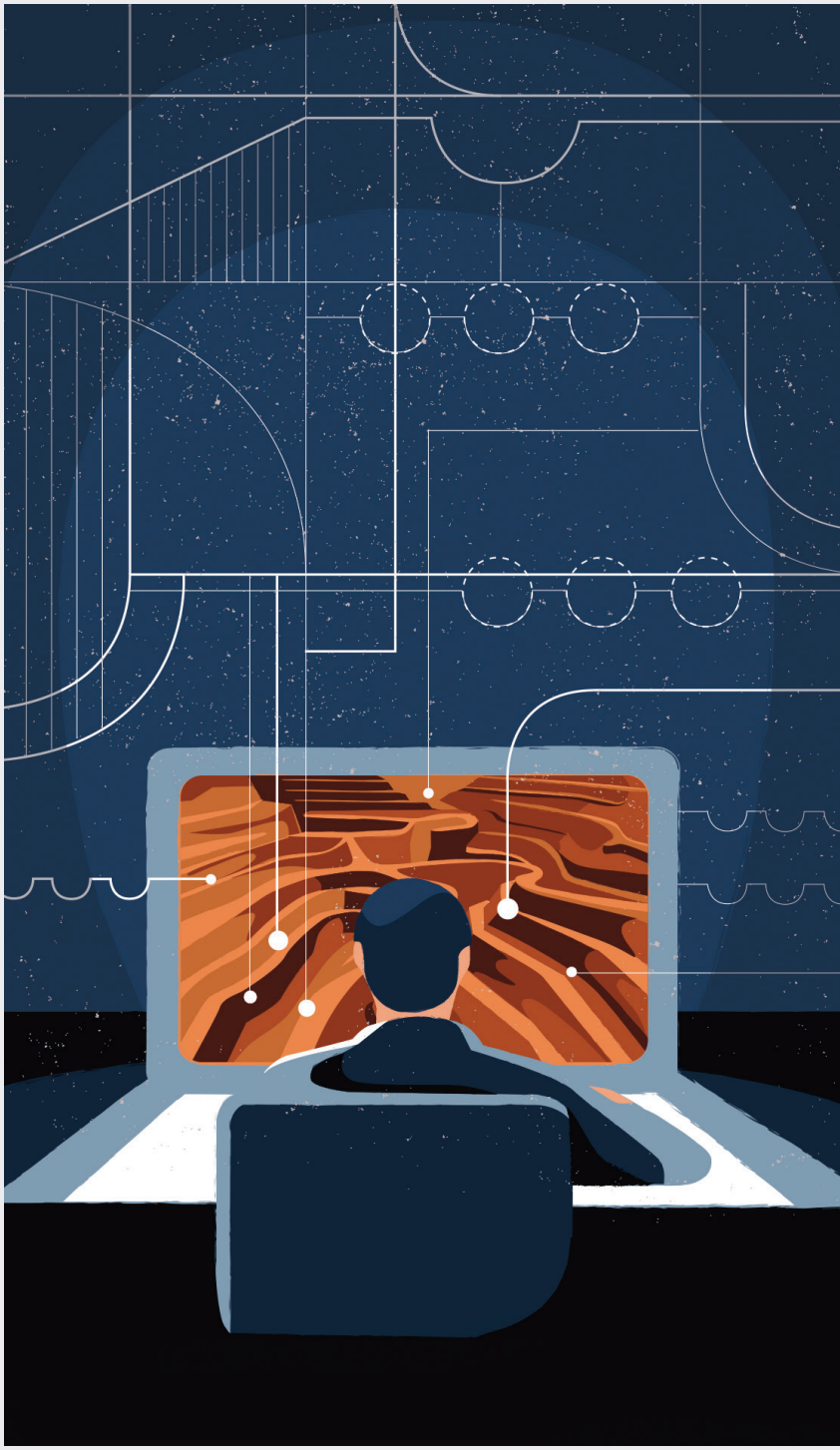


What's next in… software

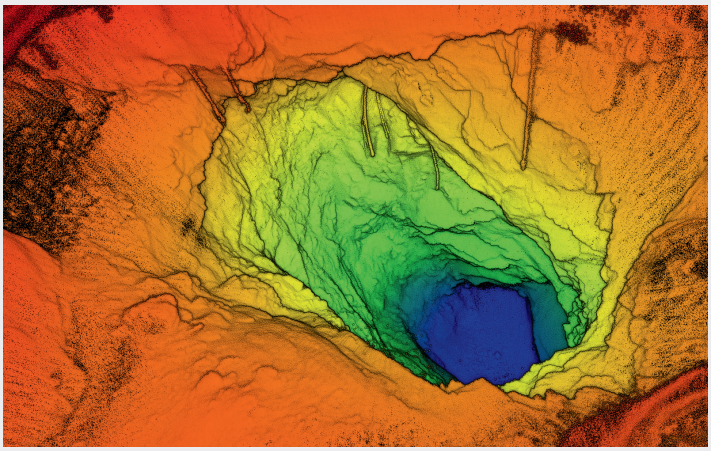
Around the time that computing was becoming integral to mining, Perth company Micromine got into the software side of things. Founded in 1986, the company now has 19 offices around the world and offers geological planning, design and mine management software in seven languages, including Mandarin and Russian. While most of its developers are still based in Perth, more than 70 per cent of Micromine's revenue is generated overseas. "We're one of the few Australian companies exporting technology rather than commodities," says chief technology officer Ivan Zelina.

Micromine's flagship product is a planning and design package for mines, built using computer-aided design (CAD) and 3D graphics. "But it's not just the graphics; you also have to do the maths," says Zelina. "A typical Micromine programmer is a double-degree maths and computer science graduate."

Today's software looks nothing like the original and is constantly evolving. "We do a big release every 16 months or so and six or seven releases in between." Micromine "does the life-of-mine planning and optimisation for 20 years out, all the way down to one week", says Zelina. The upside of working in IT in the dynamic mining industry "means I'm never bored", he adds.

Within the next 12 months, Micromine is expected to unveil new products using artificial intelligence (AI). "AI is not only for Silicon Valley," says Zelina. "We're the company that has to bring AI into mining; who else will, if not the mining-software houses? We can't expect someone in San Francisco to do it."

Zelina also reveals that Micromine is "well advanced" in a project that uses computer vision to collect data, built on top of Google's machine-learning framework, TensorFlow. He acknowledges that there have been "two or three AI winters" in the past in IT "but this time it's for real – we're getting concrete results". While Micromine is already trialling a prototype, Zelina wants to keep further details of the product under wraps until it's officially released in 2019 – or "hopefully earlier".



What's next in… robotics

Automation has already made mining safer and more predictable, with autonomous trains, trucks and drilling rigs being directed by city-based operations centres thousands of kilometres away. "One of the challenges for the future mine will be doing that more efficiently," says Fred Pauling, leader of the Robotics and Autonomous Systems Group, part of the CSIRO's data innovation network, Data61. Pauling envisages automated haulage underground – not by the massive trucks that rumble across mine sites today but by "multiple smaller vehicles hauling less ore but doing it more quickly so that the overall system is more robust".

While not specifically focused on resources, Data61's Sixth Wave Alliance, announced in May, is vital to the sector. Foundation partners include the federal government's Department of Industry, Innovation and Science; National Energy Resources Australia; and oil and gas giant Woodside. The mission is to advance robotics technologies. "Australia has highly relevant research capabilities in robotics," says Pauling. He points to the International Conference on Robotics and Automation, held in Brisbane in May, as a "big signal" of this – it was the first time the global event has been held in the Southern Hemisphere.

We're already a world leader in aerial autonomy, says Pauling, citing the Data61-developed Hovermap, a module that turns a drone into an autonomous craft capable of flying solo and navigating underground, mapping the terrain in 3D using lasers. Last September, Hovermap completed a world-first autonomous flight beyond the line of sight inside Jundee, a Northern Star Resources goldmine in Western Australia.

"A mine surveyor can sit the Hovermap on the ground, point it vaguely in the direction of the stope [the excavated interior where minerals are being extracted], press the button and it will fly into and around the stope, gathering all the data it needs to map it, then fly back and land exactly where it took off from – all in a matter of minutes," says Pauling.

The autonomous drone mission is an achievement for Data61 and the results are revolutionary. "We showed the data to mine geotechnicians and they were blown away by the detail," says Pauling. "It's providing much richer information in a safer and more timely way." Hovermap is expected to be launched this year by Emesent, fulfilling the Data61 mission to develop and commercialise Australian technology.

Hovermap (top) flies autonomously to map underground mine stopes, collecting data that's translated into images (below)

What's next in… higher education

Curtin University in WA offers world-class mineral and mining engineering education, according to the Quacquarelli Symonds global ranking system. It's bested only by the Colorado School of Mines in the United States.

As mining education adapts to keep pace with the industry's digital transformation, Curtin's WA School of Mines (WASM), which was established in 1902 and has campuses in Perth and Kalgoorlie, will begin introducing undergraduate courses in robotics, computer vision, automation and drone technology in 2019. The new courses will focus on the mining aspects of the technologies and underpin, rather than replace, the fundamentals.

"A very old industry is being transformed as mining becomes more digital, and that's very exciting and appealing to young people," says Professor Chris Aldrich, deputy head of WASM. "Digital skills are now part of the basic technical competency and we want our students to have a broad understanding of digital technologies, as well as the hard skills, so they can make a difference in the industry."

While leery of predicting the future, Aldrich doesn't rule out that "certain aspects of mining could be fully automated – the mine of the future is a digital ecosystem – and I don't think there are inherent limits to the future technologies". Aldrich says that Australia is at the "forefront of mining technology but we have to work hard to maintain that lead".

What's next in… science

At the Australian Resources Research Centre in Perth's Technology Park, scientists are working on the future of our minerals and energy industries. On the top floor sits the CSIRO's Future Science Platform (FSP) for Deep Earth Imaging. As well as training young scientists, the FSP is "creating tools for the exploration of minerals, energy and groundwater", says platform director Dr Mike McWilliams. "We're like a small startup. The CSIRO is like our venture capitalist and we're building the tools, techniques and methods that we hope the CSIRO and exploration industry will be using in five to 10 years from now, mostly in geophysics, mathematics, statistics and remote sensing."

Part of the FSP's aim, adds McWilliams, is making Australia an attractive place for the global exploration industry: "We can't do anything about tax policy or business conditions but we can make data and methods available that make Australia more productive."

Richard Chopping, an FSP team leader, says that "the easy-to-find deposits have been exploited or they're being extracted now. We need to go further underneath the surface and change the approach, from the direct detection of deposits to making predictions about where they might be."

Chopping likens this exploration science to searching for your car keys. "Not only are the keys not on top of the couch, they're buried deep under the cushions – but which cushion, which couch and which keys? We need a way to see [beneath the surface] and our work is around the tools and techniques that enable that."

Seismic exploration is one new frontier. Back in the old days, dynamite and, more recently, mechanical methods were used to reveal what lay beneath. "You put energy into the ground, soundwaves bounce off in the subsurface and you use receivers to capture the reflected or refracted energy and try to recover an image," explains McWilliams.

The FSP team is working on ways to receive and process sounds from the earth without using energy to create them – a method known as ambient-noise seismology. "The earth is a pretty noisy place and distant earthquakes, tides and other things produce acoustic energy that bounces off the subsurface," says McWilliams. "If you're clever about it with receivers and processing techniques, you can make images of the subsurface without putting energy into the ground – you just listen – and the cost is considerably less. You're using passive seismic information to make images of the subsurface."

Learning new skills at an event run by CORE Innovation Hub

What's next in… data analytics

The industry faces a double conundrum. First, there's a lack of data-science expertise among experienced geologists, metallurgists and engineers, many of whom have been sidelined in the technology march. On the flip side, there's a dearth of industry expertise among data-science graduates.

Enter Sophie Hancock, a geoscientist whose role is "skills catalyst" at CORE Innovation Hub. Founded in 2016 and headquartered in Perth, CORE is a collaboration between mining, oil and gas operators, suppliers, researchers and startups that nurtures innovation. It will launch in Brisbane this year and has plans to expand to the Americas.

Hancock's baby is CORE Skills, which will kick off its pilot education program in September, co-designed with industry partners such as gas operator ATCO Australia and miners Rio Tinto and Roy Hill. Executive leaders take part in a two-day program, while four professionals (including geoscientists) from each company attend sessions one day a week for three months to build their data-science capabilities. Explains Hancock: "The idea is to hit the two critical layers inside organisations: the people who crunch the numbers and use the data to make recommendations and the leaders who are responsible for the budget, who can be advocates for strategic opportunities."

Real data sets and immediate problem-solving are in play. "It's not dry statistics," says Hancock. "It's job-relevant, specific and context-rich. The shorter you make the distance between the learning environment and the day job, the easier it is for people to take the new skills into their organisations."

"Engineers like maths but if they're not comfortable with complex analytical tools, they're not likely to use them," says Michael Brooks, general manager of customer experience and business development at ATCO. "The CORE Skills program will help us to upskill them in that area. Given the high number of variables in energy today, we have to look at so many things beyond our own gas network and we have to use new tools rather than traditional statistical methods. Our staff are really excited about the program and its potential." ●