AusIMM LEADERSHIP FOR RESOURCES PROFESSIONALS

bulletin

October 2019

VIEWPOINT
TIPS FOR ASPIRING LEADERS

LITHIUM
SECURING FUTURE SUPPLY

DRILL AND BLAST
NEW TECHNOLOGY AND INNOVATION

CREATING CONNECTIONS

A conversation with Florence Drummond from Indigenous Women in Mining and Resources Australia

bulletin

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October 2019

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See page 80 for AusIMM contact details.

AusIMM

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FRONT COVER PHOTO Rob Blackburn
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President's editorial

A healthy sector requires strong leadership

2019 has been a healthy year for the global resources sector and for our local industry, buoyed by higher iron ore and gold prices, leading to increased mining employment opportunities. In Western Australia in particular, employment is at levels not seen since before the GFC. This market strength has also been reflected at AusIMM conferences, with considerable growth in delegate numbers.

We must, however, continue to provide strong leadership and not become complacent. A global sector can be impacted by many factors out of our direct control, including geopolitical shocks and volatile markets. As resources professionals we are familiar with boom and bust cycles, and recognise the challenges they bring for our industry and ourselves as individuals. We all want to see pragmatic, sustainable growth, and to maximise the current opportunities, whilst curtailing future stress when times may not be as favourable.

Alongside the current narrative of a healthy sector we are seeing a fundamental shift in the way resources professionals work with a wider range of skills and resilience required. In this climate of growth and change, AusIMM will continue to take a leading role in creating a sustainable industry, ensuring our professionals are qualified, skilled, ethical and current. To do this, we also need to invest in our own organisation and develop closer relationships with key stakeholders such as government, universities and industry, to build long-lasting connections.

Our efforts now will ensure that we take the best advantage of the current opportunities while building strong foundations for our future.

Janine Herzig FAusIMM(CP)
President, AusIMM

CEO's editorial

Investing in our future

The global mining sector is clearly in good health and the reputation of the professionals we represent – who are key to shaping the future of our industry – continues to grow.

AusIMM is working hard to ensure our organisation is well-positioned for an even stronger future to best represent the work of our members locally and on the world stage.

For example, our Bulletin cover story highlights our work with Florence Drummond to recognise the strong contribution of Indigenous people to the resources workforce.

Another example is our deep commitment to leading the conversation on the workforce of the future and the skills pipeline. This was highlighted through our inaugural Resources Education Collaboration Summit in early October.

This Summit brought together key decision-makers from across industry, government and education to explore how they can work with one another in new ways to deliver long-term improvements.

We believe that these key stakeholders need to be better aligned in both their thinking and approach. While this is a complex issue with no quick fixes, the Summit has led to a clear call to action for greater collaboration, with a series of meaningful actions emerging for these key groups to work on together. This is a good start.

This Summit is just one of the many ways AusIMM is looking to collaborate, connect and influence thinking across the entire resources sector.

We are committed to ensuring the professionals we represent are positioned as key to building a stronger and more sustainable industry, which is essential for our national prosperity and helps create a better future for the communities our members work in.

Stephen Durkin FAusIMM
CEO, AusIMM

Fiona Morgan, Managing Director and CEO, Mintrex Pty Ltd, at World Gold 2019.

AusIMM conference season in full swing

AusIMM has hosted four conferences in the August-September period, showcasing technical excellence and highlighting the current strength of the sector.

Mine Ventilation 2019 was hosted in Perth from 26-28 August, and featured experts from around the world sharing and discussing the technology and cutting-edge research that is shaping the future of ventilation.

MetPlant had a record attendance of 400+ delegates and featured a range of high-quality presentations and Q&A sessions, while World Gold also drew more than 400 delegates and experts to cover all aspects of gold mining.

The professional development continued on 17-18 September with Sydney hosting AusIMM's Mining Leadership Summit. This two-day conference focused on empowering leaders to engage and effectively lead diverse teams while optimising productivity, adding value and attracting future talent.

AusIMM's 2019 conference season concludes in October and November with New Leaders (1-2 October), Future Mining (19-20 November) and Mining Geology (25-26 November) rounding out the year. More information is available at **ausimm.com/conferences**.
For more photos from AusIMM conferences visit **flickr.com/ausimm**.


Mine Vent 2019.

AusIMM celebrates inspirational women in mining

AusIMM is delighted to have partnered with Women in Mining (WIM) UK for the WIM100 Alumni Networking Lunch on 8 August.

Hosted at the Mitsui Iron Ore Development office in Perth, the event featured women who have been honoured in the *100 Global Inspirational Women in Mining* publications, and celebrated the diverse and inclusive mining workforce.

'It was fabulous to have so many inspiring WIM100 alumni together from the 2013, 2015 and 2018 WIM100 editions, both to celebrate and to galvanise future generations to go above and beyond,' said Melinda Moore, WIM UK's Head of Global Outreach.

AusIMM endorses international strategy

As part of our commitment to take the story of the Australian resources sector to the global stage and promote the world-class work of our professionals, the AusIMM Board has recently endorsed an international strategy, which encompasses three pillars of work:

1. To provide professional development on Australian codes, standards and best practice
2. To support and engage AusIMM's international membership
3. To build stronger connections with key international stakeholders, including government, kindred bodies and industry.

To guide the development and ongoing implementation of these three pillars, AusIMM appointed an International Advisory Forum (IAF) earlier this year. The role of the IAF is to ensure that the AusIMM Board and Management Team have appropriate counsel in all matters relating to our international presence, connections and opportunities.

AusIMM looks forward to creating stronger partnerships around the world with members, stakeholders, government and industry.

IAF members at the AusIMM office in Melbourne. L-R: David Olsson, China Practice Lead Consultant, King and Wood Mallesons; Tony Manini, Executive Director, EMR Capital; Alexandra Garton, Coordinator, Marketing - Strategic Projects, AusIMM; Stephen Durkin, CEO, AusIMM; Phoebe Tan, Senior Manager, Strategy and International, AusIMM; Colin Moorhead, Executive Director, Merdeka Copper Gold and AusIMM Immediate Past President; Michelle Ash, Chair, Global Mining Guidelines Group; and Rex Berthelsen, Group Manager Resource Geology, MMG.

New AusIMM member directory launched

On 16 September 2019, AusIMM launched our new online member directory, replacing the old PDF format.

The updated directory allows you to filter based on location, branch, discipline, and post-nominal, as well as the ability to search by first and last name.

Non-members can only see the list view – which displays a member's name, post-nominal, and profile picture. A signed in AusIMM member is granted more information through the grid view. This view displays a member's name, post-nominal, profile picture, branch, state and country.

For more information on the new member directory, including video tutorials on updating your privacy settings and uploading a profile picture, visit **ausimm.com/news/dt-update-the-modernised-member-directory.**

AusIMM CEO Stephen Durkin and IWIMRA co-founder Florence Drummond.

AusIMM pledges commitment to Indigenous women with MOU signing

AusIMM has signed a Memorandum of Understanding (MOU) with Indigenous Women in Mining and Resources Australia (IWIMRA), an organisation representing Aboriginal and Torres Strait Islander women employed in the resources industry.

With an audience in Perth of 150 mining professionals as part of the AusIMM Thought Leadership Series, the MOU was officially signed in late July as both organisations spoke publicly of their commitment to working together to support the needs and grow the voice of Indigenous women in the sector.

At the official signing, AusIMM CEO Stephen Durkin and Florence Drummond, co-founder of IWIMRA, spoke of the importance of the MOU and the impact their collaboration will have.

'AusIMM and IWIMRA recognise the strong participation and contribution of Indigenous people to the resources workforce,' said Mr Durkin.

'By working together, we can ensure that AusIMM is supporting all resources professionals, providing ongoing opportunities for professional development.'

AusIMM last year established its Council for Diversity and Inclusion, comprising many prominent industry representatives from a diverse range of backgrounds, who have promoted, supported and advised on AusIMM's commitment to the needs of the Indigenous workforce.

AusIMM is currently developing, in consultation with the Council and Indigenous representatives, an Aboriginal and Torres Strait Islander Engagement Plan for implementation.

Read more about IWIMRA co-founder Florence Drummond in this month's cover story on page 14.

AusIMM awarded for world-first online course

(L-R) Melissa Holdsworth, Brigid Meney, Phoebe Tan and Stephen Durkin.

AusIMM has placed in the top 10 (number six) in the AFR Boss Most Innovative Companies Awards in the Government, Education and Not-for-Profit category.

AusIMM was recognised for our work on our Online Professional Certificate in JORC Code Reporting, a world-first online training course to upskill global mining professionals on the Australasian mining standard (the JORC Code).

The content was developed by multiple industry leaders and curated from AusIMM's diverse professional communities. The course is delivered via Cahoot Learning, an internationally renowned provider.

The AFR Boss Most Innovative Companies list recognises the most innovative organisations in Australia and New Zealand, as judged by the expert panel assembled by the Australian Financial Review and Inventium.

AusIMM's Stephen Durkin (Chief Executive), Phoebe Tan (Senior Manager, Strategy & International), Melissa Holdsworth (General Manager, Stakeholder Engagement and Partnerships), and Brigid Meney (Senior Adviser, Policy and Media) were invited to the official Awards Night in Sydney on 8 August to accept the award (pictured).

Visit **ausimm.com/courses** for more information on AusIMM's Online Professional Certificate in JORC Code Reporting and to enrol for the next intake.

News

IMARC 2018.

Resource and energy exports tipped to hit new records as IMARC 2019 approaches

Australia's chief economist reported in June that the nation's resource and energy exports are set to hit a new record of $285 billion in 2019-20, before falling back in 2020-21. The increase in earnings has been driven by a spike in iron ore prices and a surging gold sector.

In WA alone, there are projects either under construction or committed to with a value of around $113 billion. Replacement iron ore mines, a planned LNG expansion and a buoyant gold sector are driving an increase in employment.

The June quarterly report said thermal coal was facing a tough climate, with prices deteriorating, and predicted that gold would replace thermal coal as Australia's fourth largest export in 2019-20. It also warned about uncertainties caused by US-China trade tensions.

Against such a backdrop, there has never been a better time to hear from some of the world's foremost mining leaders as they discuss global and Australian opportunities and challenges. More than 300 mining and resource experts will be in Melbourne this October for the International Mining and Resources Conference (IMARC), Australia's largest mining event.

Microsoft, BHP, Rio Tinto, Mitsui, Anglo American and South32 are just some of the companies that will discuss issues and trends including the opportunities that are attracting investors across the globe; leadership and trust in the digital age; critical considerations for doing business in 2020; what is affecting the global mining industry; avoiding digital disappointment; and getting the mix right in the mines of the future.

FMG will discuss cyber threats and protecting data; the Minerals Council of Australia will deliver an outlook on battery metals; the skills shortage and skills of the future will be examined; and opportunities in Latin America and Africa will be explored.

IMARC 2019 will cover the entire mining supply chain, from exploration to investment, production and optimisation, and new technologies and global opportunities. This year includes new focus areas on energy, the environment, workforce engagement as well as mine and plant optimisation.

Around 7000 mining and resource professionals will attend and participate in over 130 hours of content with five concurrent conferences and four workshops and masterclasses.

With Victoria as a global leader in the delivery of product and service solutions for the Australian and overseas resources sectors, Melbourne is the ideal location for this global event that attracts attendance from over 100 nations. The Mining Equipment, Technology and Services (METS) industry is one of Australia's largest export sectors, with Victoria taking a strong share of the sector's exports with revenue at about $17 billion.

Attendees will hear how Australia is leading the way in intelligent mining and improved production, with a case study on Australian-based Resolute Mining's Syama mine in Mali – the world's first fully automated mine. The latest mining discoveries, equipment, innovations and cutting-edge technologies will also be on display across the 1.2 ha expo floor with over 260 exhibiting companies.

To continue to achieve such high export numbers, miners can't do this alone. It is a collaborative approach and with participation from more than 400 mining companies and 35 international mining ministers, IMARC provides a unique opportunity for the thousands who will attend over three days, from October 29 to 31, to capitalise on the growth within the sector.

About IMARC

The International Mining and Resources Conference (IMARC) is where global mining leaders connect with technology, finance and the future. Now in its sixth year, it is Australia's largest mining event bringing together over 7000 decision makers, mining leaders, policy makers, investors, commodity buyers, technical experts, innovators and educators from over 100 countries to Melbourne for four days of learning, deal-making and unparalleled networking.
Visit **imarcmelbourne.com.**

Celebrating AusIMM member milestones 2019

Every year, AusIMM celebrates our members who have reached important membership milestones. In 2019, 1029 members reached milestones of 10, 20, 30, 40, 50, 60, 70 or 80 years of membership. Congratulations to all members listed here who have reached their 40, 50, 60, 70 and 80-year membership milestones during 2019. Our members are the strength of AusIMM and we value their service and commitment in supporting the Institute.

See the full list of milestones at **www.ausimmbulletin.com/milestones2019.**

80 YEARS

Mr William Gilfillan FAusIMM	Adelaide Branch

70 YEARS

Mr Bruce Ashton FAusIMM	Adelaide Branch
Mr Clifford Restarick MAusIMM	Melbourne Branch
Mr Oswin Wilson FAusIMM	Central Qld Branch

60 YEARS

Mr Zenon Alexander FAusIMM	Sydney Branch
Mr Thomas Aspinall FAusIMM	Southern Queensland Branch
Mr John Cramsie FAusIMM	Sydney Branch
Mr Kenneth Foots FAusIMM	Southern Queensland Branch
Dr Roderick Grant FAusIMM	Melbourne Branch
Mr Anthony Hope FAusIMM CP(Ret)	Tasmania Branch
Mr Brian Hurley MAusIMM	Perth Branch
Mr Ronald King FAusIMM	New Zealand Branch
Mr Keith Little MAusIMM	Southern Queensland Branch
Dr James MacKenzie MAusIMM	Perth Branch
Mr Phillip MacNamara MAusIMM	Sydney Branch
Mr Robert McNeil FAusIMM	Southern Queensland Branch
Mr Derek Miller FAusIMM(CP)	Southwest WA Branch
Mr Jeffrey Olliver FAusIMM	Adelaide Branch
Mr Robert Pyper FAusIMM	Southern Queensland Branch
Mr Terence Roberts FAusIMM	Melbourne Branch
Mr Douglas Traves FAusIMM	Southern Queensland Branch
Mr Keith Yates FAusIMM	Adelaide Branch

50 YEARS

Dr Robert Allan MAusIMM	Melbourne Branch
Mr Christopher Bailey MAusIMM	Southern Queensland Branch
Mr Michael Bennell FAusIMM	Brazil
Mr John Blackburn FAusIMM	Perth Branch
Mr Raymond Cantrell FAusIMM	Hunter Region Branch
Mr John Casey FAusIMM	Sydney Branch
Dr Christopher Clarkson FAusIMM(CP)	Southern Queensland Branch
Mr Neil Clifford MAusIMM	Melbourne Branch
Mr Duncan Coles FAusIMM	Southern Queensland Branch
Mr Robert Cotton FAusIMM	Sydney Branch
Mr Leslie Davis FAusIMM(CP)	Southern Queensland Branch
Mr Trevor Ellis FAusIMM(CP)	United States of America
Mr Keith Elvish MAusIMM	Perth Branch
Mr Kevin Foo MAusIMM	United Kingdom
Dr Vytenis Garnys MAusIMM	Melbourne Branch
Mr Richard Gazzard MAusIMM	Southern Queensland Branch
Mr John Geoghegan MAusIMM	Lachlan Branch
Dr Suzanne Golding MAusIMM	Southern Queensland Branch
Mr Roger Gregg FAusIMM	New Zealand Branch
Mr Norman Hanson MAusIMM	Melbourne Branch
Mr Rodney Harden FAusIMM	Melbourne Branch
Dr Hugh Herbert MAusIMM	Southern Queensland Branch
Mr Graham Howe MAusIMM	Broken Hill Branch
Mr Thomas Hunter FAusIMM(CP)	Southern Queensland Branch
Mr Allan Jackson FAusIMM	Perth Branch
Mr Anthony Jannink FAusIMM	Melbourne Branch
Mr David Jenkins MAusIMM	Melbourne Branch
Hon John Jones AM AAusIMM	Perth Branch
Mr Gregory Kater FAusIMM	Southern Queensland Branch
Mr Phillip Kelso MAusIMM	Sydney Branch
Mr Peter Lester MAusIMM	Perth Branch
Mr Kevin Luxford FAusIMM(CP)	Southern Queensland Branch
Mr Ian MacCulloch FAusIMM(CP)	Central Victoria Branch
Mr Peter Masters MAusIMM	Southern Queensland Branch
Mr Peter Matthews MAusIMM	Sydney Branch
Mr Peter McCarthy HonFAusIMM(CP)	Central Victoria Branch
Mr Alexander McLaurin FAusIMM	United Kingdom
Mr Jack Mullins FAusIMM	Canada
Mr Peter Munro FAusIMM	Southern Queensland Branch
Mr Patrick O'Dwyer FAusIMM	Southern Queensland Branch
Mr Joshua Pitt MAusIMM	Perth Branch
Mr Graham Pope MAusIMM	Southern Queensland Branch
Mr Russell Purvis FAusIMM	Perth Branch
Mr Keith Quast MAusIMM	Adelaide Branch
Dr William Rankin FAusIMM(CP)	Melbourne Branch
Dr John Read FAusIMM(CP)	Southern Queensland Branch
Dr John Reid FAusIMM	Southern Queensland Branch
Mr Tony Robbins MAusIMM	Thailand
Mr William Runge FAusIMM	Southern Queensland Branch
Mr Terence Schorn FAusIMM	Canada
Mr Edward Skey FAusIMM	Central Victoria Branch
Prof Leon Thomas FAusIMM	Lachlan Branch
Dr Grant Thorne FAusIMM	Southern Queensland Branch
Mr Douglas Tompsitt MAusIMM	Lachlan Branch
Mr John Trudinger FAusIMM	Melbourne Branch
Mr David Tucker MAusIMM	Perth Branch
Mr Ewen Tyler AM FAusIMM	Melbourne Branch
Mr Phillip Uttley FAusIMM	Southern Queensland Branch
Dr Ronald Woods OAM FAusIMM	Melbourne Branch
Dr Robert Yeates FAusIMM(CP)	Sydney Branch
Mr Christopher Young MAusIMM	Lachlan Branch

40 YEARS

Mr Brian Baldock FAusIMM	Melbourne Branch
Mr Ian Bane MAusIMM	Sydney Branch
Mr Peter Benjamin MAusIMM	Perth Branch
Mr Gary Benson MAusIMM	Southern Queensland Branch
Mr Gary Brabham FAusIMM	Perth Branch
Mr Augustine Bravo FAusIMM	Melbourne Branch
Mr Ian Buchhorn MAusIMM	Perth Branch
Mr Glenn Burlinson MAusIMM	Southern Queensland Branch
Mr Gregor Carr MAusIMM(CP)	Southern Queensland Branch
Mr Charles Chapman MAusIMM	Canada
Mr Robert Corkery FAusIMM(CP)	Sydney Branch
Mr Robert Cranstoun MAusIMM	Southern Queensland Branch
Mr Peter D'Auvergne MAusIMM	Central Victoria Branch
Mr Dean David FAusIMM(CP)	Perth Branch
Mr Gary Davison FAusIMM(CP)	Melbourne Branch
Mr Rodney Doyle MAusIMM	Illawarra Branch
Mrs Annette Elliott MAusIMM	Perth Branch
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Mr William Howell FAusIMM	Vietnam
Mr Gregory Jones MAusIMM	Southern Queensland Branch
Mr Ian Kelso MAusIMM(CP)	Southern Queensland Branch
Mr John Kopcheff FAusIMM	Perth Branch
Mr Michael Kriewaldt FAusIMM	Lachlan Branch
Mr Antony Laing MAusIMM	Hunter Region Branch
Mr Robert Larke MAusIMM	Perth Branch
Dr David Lauder MAusIMM	Southern Queensland Branch
Dr Nicholas Lindsay MAusIMM	Perth Branch
Mr Murray Lines MAusIMM	Sydney Branch
Mr Robert Love FAusIMM	Perth Branch
Mr Kenneth Luke MAusIMM	New Zealand Branch
Mr Ian McAleese MAusIMM	Sydney Branch
Dr Bruce McConachie MAusIMM	Southern Queensland Branch
Mr Hamish McLeod MAusIMM	Southern Queensland Branch
Mr David Miller MAusIMM	Perth Branch
Mr Richard Morland MAusIMM	Canada
Mr Stephen Munro FAusIMM(CP)	Southern Queensland Branch
Mr Graeme Newman MAusIMM	Melbourne Branch
Mr Johnson Oyelodi MAusIMM	Southern Queensland Branch
Mr Joseph Pease FAusIMM	Southern Queensland Branch
Mr James Phelan MAusIMM	Central Victoria Branch
Mr David Poulter MAusIMM	United States of America
Mr Adrian Pratt FAusIMM(CP)	Melbourne Branch
Mr Christopher Prowse MAusIMM(CP)	Melbourne Branch
Mr John Ralph AC FAusIMM	Melbourne Branch
Mr Philip Reese MAusIMM	New Zealand Branch
Mr David Rich MAusIMM	Perth Branch
Mr David Rose FAusIMM(CP)	Perth Branch
Mr John Seaward FAusIMM	Southern Queensland Branch
Mr Anthony Smith MAusIMM	Southern Queensland Branch
Mr Murray Stevens MAusIMM	New Zealand Branch
Mr Alan Taylor FAusIMM(CP)	Melbourne Branch
Mr Ian Williams AO FAusIMM	Perth Branch
Mr Peter Wright MAusIMM	North Queensland Branch
Mr John Wyche MAusIMM(CP)	Sydney Branch
Mr Gavin Yeates FAusIMM(CP)	Melbourne Branch
Mr Allan Younger MAusIMM	Perth Branch
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Upcoming 2019 and 2020 Conferences and Events

More to be announced

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futuremining.ausimm.com

Perth | 25–26 November
mininggeology.ausimm.com

Adelaide, Brisbane, Melbourne, Perth, Sydney | 2–6 March 2020
iwd.ausimm.com

Perth | 25–27 March 2020
undergroundoperators.ausimm.com

Brisbane | 28–30 July 2020
tailings.ausimm.com

Brisbane | 26–28 August 2020
lifeofmine.ausimm.com

Brisbane | 9–11 September 2020
milloperators.ausimm.com

Profile

‘IWIMRA is focused on people and their stories. It has allowed members to connect locally and internationally.’

A voice to be heard

Florence Drummond is determined to build connections and create conversations that showcase Indigenous involvement in the mining sector

Liz Swanton

Articulate and ambitious, Florence Drummond is passionate about what she is doing and where she is going, but she already knows what she is most proud of.

‘Creating this platform to give visibility and voice to Indigenous people. Full stop,’ she says, and there is no missing the certainty in her voice.

‘This platform’ is Indigenous Women in Mining and Resources Australia (IWIMRA), a network Florence co-founded with her sister Jessica to showcase Aboriginal and Torres Strait Islander women in the sector, with the focus on learning through the art of storytelling and to encourage others to consider careers in resources.

It was a case of necessity being the mother of invention. Frustrated by the lack of opportunity and unity for Indigenous women, Florence and her sister looked for a familiar national network and when they couldn’t find one, they created IWIMRA.

‘We wanted to facilitate stronger connections between Indigenous women working in a sector that is traditionally male and non-Indigenous,’ Florence says.

‘It started through conversations with other people, about the lack of quality progression. I thought: surely there’s something out there that can support professional development.

‘I’m mindful of not always categorising Indigenous and non-Indigenous people. But we need to start in a space where we feel culturally safe. I found there was not a lot out there specifically available for Indigenous people in the industry.

‘We built IWIMRA through our personal networks and by asking who’s out there, what are they doing, and trying to learn more about their stories. Most of us in the sector live on other people’s country, in other people’s communities, so we also wanted to know from other women how they fulfil their cultural and spiritual obligations to their families and their own communities when they are so far away from home.’

Growing a community online

Social media helped build the connections and so began a network from which great things will come. Florence has been encouraged by the industry’s support of IWIMRA, because she believes the resulting conversations will be highly productive and in line with the future of mining.

‘Facebook has made a huge difference in terms of launching IWIMRA. It’s such a great vehicle in that it is safe and approachable. Our conversations about Indigenous people in mining have always been very difficult conversations to have, but unpacking this through storytelling has allowed people to understand better.’

Florence says IWIMRA is focused on people and their stories. It has allowed members to connect locally and internationally with other Indigenous women working in the industry. The result is conversations about similarities and challenges and how to work together to improve outcomes.

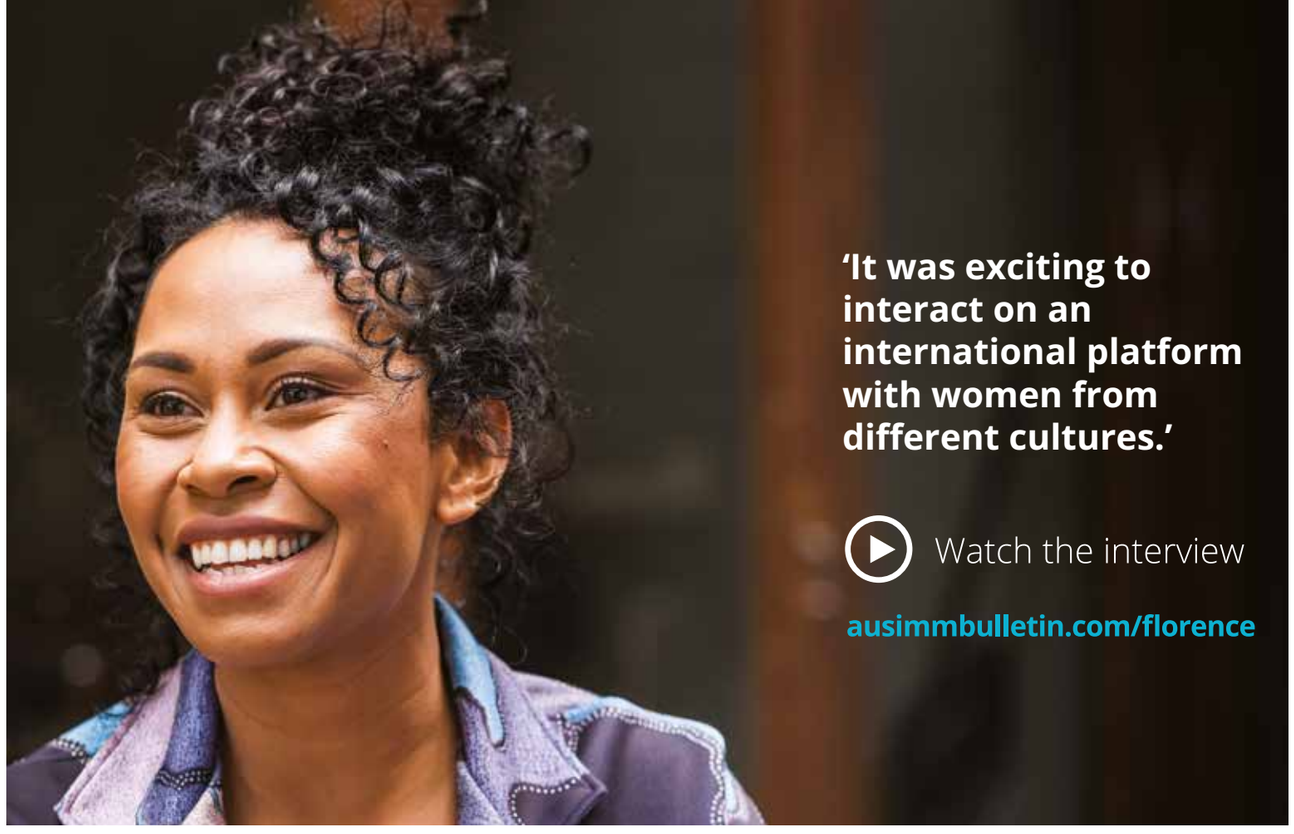
‘One of the most rewarding things is, when we do share these stories, how much traction we get; it’s like a public applause. I absolutely love that! We’re showcasing women who feel invisible, or feel the work they do isn’t appreciated. Telling their stories reflects a deeper commitment to greater opportunities for themselves and their families. And the comments on our posts amplify the love and make our community stronger.’

Working with AusIMM

As part of its progress, IWIMRA recently signed a Memorandum of Understanding with AusIMM with the aim of working together.

The agreement unites the two organisations in their understanding of the contribution Indigenous people make to the industry and their commitment to supporting ongoing opportunities for professional development. Florence believes the partnership has the potential to provide greater benefits to assist upskilling the current workforce.

Profile



‘We don’t have a lot of Indigenous geologists, metallurgists and people in highly technical fields. By working with AusIMM, we’re committed to better showcasing people in those professions, so that others can be inspired to reach out and learn more.

‘How do we progress to something better if we don’t see it every day? That’s my goal with this relationship. And vice versa; IWIMRA is committed to helping understand Indigenous engagement with the industry. Like any relationship, it is about intent and communication.

‘I am confident this will help to further reconcile relationships on a professional level, and help share stories of positive outcomes for Aboriginal and Torres Strait Islander people and the mining industry, as well as helping to understand significant national conversations, in particular, the Uluru Statement from the Heart.’

Building a career and early influences

Florence’s own career in the mining industry started six years ago, when she joined Rio Tinto’s northern operations as a machine operator mining bauxite, basing herself in Weipa on the Cape York Peninsula.

Florence is excited about building her career in an industry she never considered when she was first looking for what the future had in store.

A proud Dauareb/Wuthathi woman, she was born and raised on Thursday Island in the Torres Strait, the oldest of eight children. Even in childhood she stood out from the crowd, her family living in a house her grandfather built just after WWII. She says it is significant in her community to own a house when so many are still in public housing, and speaking about it brings forth her first expression of gratitude.

Her second relates to the value her parents placed on education. After going to primary school on Thursday Island, Florence had five years as a boarder at the Kooralbyn International School in Brisbane. She says her schooling there has had one of the most important impacts in her life.

‘It gave me an understanding of what is out there in the world, and who is out there – the different countries, languages, cultures. It was an amazing way to spend my high school years.’

She laughs at the fact she never asked her parents why they chose that school, although she mischievously suggests perhaps because it was the furthest place from home! Thinking back, she believes the experience shaped her mind to think bigger and broader about her life, to remain curious, knowing there were no real limits on what she wanted to be.

‘It really did change how I thought about different races of people. As we grow through those impressionable years, we form our ideas on society and the world – we’re shaped by those thoughts and the environment we are in.

‘Around me everyone had different languages – but we were all friends. We slept in rooms next to each other, went to dinner together, spent the weekend together. So from growing up on an island of a few thousand people, and then going to a school that took two flights and a two-hour bus ride to get to, it was a very different experience.’

When Florence left school she worked in the events and hospitality industry while she tried her hand at tourism and law at university.

Although she left before graduating, these study areas were part of an inner desire to help others and she has some regret for not valuing the potential of that education at the time and really following through. She admits she was easily distracted and lost focus, but she built a life and enjoyed it – until years later, living and working in Melbourne and a long way from her community, she realised she needed to be closer to home.

‘I also wanted to earn a decent living, to have a quality lifestyle and there were very few opportunities for that in my community. When I was home for Christmas on holidays and saw my Grandmother’s ailing health, I knew it was time to come home. I saw there were jobs on offer at Weipa – I never even knew there was a mine site at Weipa.’

Florence flew back to Melbourne and convinced her partner to pack up their apartment and make the move north – although apparently he thought it was just for a holiday.

‘We had a caravan and a 4WD, so we pretty much drove all the way up to Weipa with no job, no anything, just the determination to make it happen. And it did happen – after two months of being here, pretending to be tourists and living in the caravan park, we both got jobs with Rio Tinto.’

Joining the world stage

Florence’s international schooling came full circle earlier this year. As part of her journey with IWIMRA, Florence was the only Torres Strait Islander delegate from Australia at the United Nations 63rd Commission on the Status of Women in New York. She is extremely grateful to the National Rural Women’s Coalition and the National Aboriginal and Torres Strait Islander Women’s Alliance for creating this opportunity.

‘Ever since I was a child I wanted to work for the UN. I had this heroic idea I could work for the UN, make great decisions and change the world. With this real-life experience I wanted to understand what relationship the UN has with government and industry, and what role they play in a global context.

‘It was exciting to interact on an international platform and have conversations with women from different cultures, and in so many ways we all shared the same stories.

‘There is a lot of culture that is similar. Dating back to colonisation, we have so much of the same history and it’s interesting to see how far each country, or each culture, has grown and improved since then. It was excellent to have conversations on that level, and to talk about what more we can do.’

Testing the limits

For Florence, the move to Weipa and joining the industry was the catalyst for much that has happened since. Florence admits she often pushes herself outside her own comfort zone, and understands the importance of taking ownership and leading by example. She feels her greatest responsibility is to encourage her nieces and nephews to be courageous and to never give up.

She feels as if she is ‘holding a space’ for other Indigenous women so they have the confidence to step up – and she is adamant that it must happen, for the benefit of Aboriginal and Torres Strait Islander people and the entire mining industry.

‘I think it’s important to acknowledge and understand the significant relationship, cultural and spiritual, that Indigenous people have to the land. This understanding could assist with much more informed, respectful and sustainable relationships.

‘What I have learnt so far is that many mining companies have great plans in place that are aligned with the Sustainable Development Goals 2030 and Indigenous Procurement Policy, we just need to communicate this better. Highlighting our commitments and achievements of what we are developing together will help to build a sustainable future.’

Florence is determined to be part of that movement and that message, but there is a part of her looking even further and higher. She has plans to study in the fields of finance and international diplomacy to greater develop her understanding and participation globally.

‘When I was younger, I never understood how Australia, being a first world country with third world conditions in some communities, is a bit of a see-saw...I wanted to go and work for the UN and work on things globally, but in my backyard things aren’t...’ she pauses, ‘...things aren’t great.

‘How do you try and balance the humanitarian focus that you have and what you would love to do, with trying to make actual improvements at home in your own community, in your own country?’

At the helm of something greater, Florence is poised for a future she is still discovering.

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Current challenges and opportunities for the minerals industry

This article is based on a distinguished lecture delivered at an AusIMM Melbourne Branch lunch in June 2019

Peter McCarthy HonFAusIMM(CP), Principal, AMC Consultants Pty Ltd

The greatest challenge our industry faces today is the growing public antipathy to mining projects, exacerbated by events such as tailings dam failures and facilitated by social media.

This challenge can be overcome by changing the way we operate through technical innovation and through better two-way communication with our community. We can accelerate the process of innovation through the free communication of ideas between mining companies, researchers, consultants, contractors and manufacturers.

We also need to revisit the concept of value, and to question the drive for large developments to achieve economies of scale.

A review of the history of innovation in mining gives insights into how changes occur and what the business case for innovation should look like. To understand the opportunities, we must explore the concept of the 'adjacent possible': the new and emerging technologies that have not yet been adopted by the minerals industry.

Our biggest challenge

People are never going to love the mining industry. There will always be vocal and committed groups who oppose everything we do. Logic cannot sway them, even as they buy cars, mobile phones and the many products of our society that depend on mining. If you are pro-environment, so they reason, you must be anti-mining. Increasingly, this message is taught in schools and reinforced through social media. It is even a theme in popular science journals and influences the selection of ethical investments.

Image: salajean/Shutterstock.com.

'We need to change the way we go about developing projects and selecting technologies.'

Our sector will not be able to persuade our opponents that they are wrong. Instead, we need to change the way we go about developing projects and selecting technologies, and how we engage with the communities around mining operations. New mines will be approved and gain support only if we listen to the community and respond.

These days it can take decades to get a large project off the ground, and many will not be accepted by communities, however attractive the economics might be. Even small communities in remote, lightly populated areas now have the power, aided by social media, to stop development. And if a mining company works with a government to gain approvals without the support of the local community, it can expect ongoing opposition, demonstrations, active non-government organisation (NGO) attention and damaging social media campaigns that can lead to losing the project. In developing countries, the new owner may well be the government, using its army to suppress opposition.

An important consequence of our poor image is that young people, particularly professionals, don't want to join our industry. In turn, a shortage of experienced people is one of the causes of poor business performance and adverse community impacts.

Many of the operational problems the sector faces have emerging technological solutions. Highly selective mining, using rock cutting machines and belt sorting, will reduce the amount of rock going to processing and tailings storage. New dry processing techniques will reduce the size of wet tailings dams (though they may bring new dust control challenges). New processes will be found to turn some rejected material into useful products such as bricks, pavers and tiles. Selective underground mining will greatly reduce the surface impact of mines and their associated waste dumps. Mining orebodies slowly, over several decades instead of as rapidly as possible, will establish community support and reduce initial capital costs. Yes, we can maximise net present value (NPV) by going in big, but that is the approach that has alienated society. Smaller mines need fewer workers and less accommodation, making on-site living more feasible. They use less power and have less impact on the environment.

The need to manage project risk was well understood in the past. A small mine was built, often with second-hand plant, and then cash flow from the operation, or equity funding from the now-reassured investors, was used for a series of expansions and optimisations. If there was a problem with the initial ore reserve or cost estimates, the exposure of shareholders to this problem was minimised and managed.

Project risk includes loss of social licence. A slow start and gradual build up allows the community to adjust, while allowing the mining company to understand and mitigate impacts, and take advantage of employment and training opportunities. With a measured approach, environmental impacts develop slowly and can be mitigated before they become serious.

In recent years, many project investment decisions have been made on the assumption that unlimited project finance is available. Due to global economic circumstances this is no longer the case, and a more traditional approach to project optimisation is needed. After considering risk, a modest-sized, staged development may provide better shareholder returns than the largest project that an orebody can theoretically support. Staged development may require multiple parallel processing circuits and smaller, more selective mining machines operating at higher cut-off grades.

Tailings dams

Our biggest unsolved issue is the use of tailings dams. History keeps reminding us that tailings dams can cause massive environmental damage and they can fail. Even the biggest and best mining companies cannot manage them safely all the time. From Bougainville and Ok Tedi in the 1980s to Vale's two failures in 2015 and one in January 2019, tailings management is not just a public relations issue for our industry. Tailings dams are a real threat to communities and the environment. While dams continue to operate, our opponents are justified in their opposition.

Bigger mines mean bigger tailings dams, and the risk has increased by a factor of 20 every third of a century.

According to Bowker and Chambers (2015), half of all the 'Very Serious Failures' in the last 70 years (to 2010) occurred in the last 20 years. Bowker and Chambers predicted more than 20 failures from 2010-2019, with a total unfunded public cost of $6 billion. They were right, and by 2019 we have exceeded that estimate. These losses are uninsurable.

Bowker and Chambers say that the cause of tailings dam failures is not only a technical problem, but rather that the combination of falling grades and higher throughputs have created large, fast-growing tailings dams at mines with slim operating margins, where safety factors may be pushed below an acceptable limit.

How can innovative technology help us?

Biologist Stuart Kauffman introduced the idea of the 'adjacent possible' in relation to prebiotic chemical combinations, which are all the possible combinations that could arise from a primordial soup. Author Steven Johnson took this further in his 2010 book *Where good ideas come from*, saying the adjacent possible is 'a kind of shadow future hovering on the edge of the present state of things, a map of all the ways in which the present can reinvent itself.' The electric battery revolution and digital transformation of industry (ie Industry 4.0) are two parallel streams that are coming together. High-capacity batteries and smart communication will rapidly change the way we operate. It's like bringing together gliders and internal combustion engines in 1903 to create powered flight.

Past innovation in mining

In his thesis on the development of mining technology in Australia, Ralph Birrell (2005) classified innovations as micro-innovations (successive small changes) or as macro-innovations (radical new concepts without clear precedents). Sometimes, several important micro-innovations combine into what amounts to a single new concept. I would like to consider the origins of a few mining technologies and how they related to the adjacent possible.

- **1712:** Thomas Newcomen, an ironmonger who knew what was possible with new iron technology, developed the first practical steam engine for mine pumping.
- **1808:** John Taylor, a mining engineer, developed the Cornish rolls crusher after seeing an apple cider crusher.
- **1831:** William Bickford, a Cornish merchant, invented safety fuse from an idea he got by visiting a rope maker.
- **1844:** C Brunton, an American, created the first pneumatic rockdrill, an idea based on him seeing a steam engine.
- **1904:** Daniel Jacklin, at Bingham Canyon in Utah, applied railway technology, including locomotives and steam shovels, to revolutionise open pit mining.
- **1905**: Henry Sulman perfected froth flotation based on a body of new research, including observations by a brewer of bubbles rising in beer. There were many other patents, but Sulman won the IMM gold medal.
- **1956:** Robert Acre developed ANFO following analysis of the accidental 1947 Texas City ammonium nitrate explosion.
- **1957:** Joy Manufacturing Company produced the diesel powered, rubber tyred Transloader, the first underground load-haul-dump vehicle, based on knowledge of open pit loaders.
- **1962:** James S Robbins company developed the raise borer from machines they were already building for civil tunnelling.
- **1966:** Ket Carter operated our first mechanised decline mine at Cleveland Tin in Tasmania, using newly available underground diesel loaders and existing surface trucks.
- **1971:** Boliden mine operated the first autonomous diesel trucks underground, using mainframe computer technology that had just become available.

I'm going to stop there, which was only a couple of years after I joined the industry. There have been innovations since then of course. But to me, none have had the impact of those listed above. Importantly, in each case the innovation came from observation or application of an existing technology in the adjacent possible.

Image: F8 studio/Shutterstock.com.

What is today's adjacent possible?

In January 2019, Rio Tinto announced that they would be establishing a think tank to be named the Pioneer Hub in Brisbane and will consider partnering with technology companies like Microsoft and Apple (Gray, 2019). I am sure the Pioneer Hub will be exploring the adjacent possible.

When looking at broader innovations around the world, we have recently learned that:

Current challenges and opportunities for mining

'Sometimes, several important micro-innovations combine into what amounts to a single new concept.'

- The use of hydrogen as a fuel for mobile equipment is becoming practical.
- A Birmingham, UK team is part of a consortium of academics and businesses developing quantum gravity sensors or gravimeters that will be twice as sensitive and 10 times as fast as current equipment. According to the team, quantum technology could 'transform the world in ways we can barely imagine' (Bowler, 2019).
- Bill Gates is leading a coalition of billionaires to create a 'Google Maps for the Earth's crust', specifically for mineral exploration (Farchy, 2019).
- Autonomous drones are raising productivity at mine sites and reducing costs. These unmanned aerial vehicles' ability to gain access to constricted areas and inspect equipment that cannot be easily reached by human inspectors also eliminates safety risks while enabling more ground to be covered in less time.
- The military has drones with explosive payloads that can fly for two hours in a swarm, avoiding each other as they overwhelm a target. The low-cost Kalashnikov drone can fly for 30 minutes at a speed of 130 km/h and carries 2.7 kilograms of explosives. It can be guided to explode on a target 65 kilometres away (Sly, 2019).
- Photon assay technology provides a chemistry-free, non-destructive assay in minutes. It provides accurate and fully automated analysis of mineral grades in ore samples with high throughput rates and has the potential to replace conventional fire-assays.
- NextOre, a company spun out of CSIRO, applies sophisticated sensing technology for mining. NextOre's products apply magnetic resonance technology to deliver second-by-second information about material on high-speed conveyors that can be used for real-time decision making, primarily ore sorting.

One thing that is not in the adjacent possible at present is asteroid mining. We will not see asteroid mining in the lifetime of anyone alive today. The two largest companies established to do it, Deep Space Industries and Planetary Resources, have both failed since Donald Trump cancelled the Obama asteroid program (Crane, 2019). An economic analysis by French research institute CentraleSupélec shows that mining asteroids for platinum, for example, will almost never be worthwhile as the supply on earth would undercut the price (Hein, Matheson and Fries, 2018).

But imagine drones carrying ore, flying out of a portal high on a mountainside, across some jungle and a wide river, to a plant or railhead! It would look like a European wasp nest. We have drones today that could do that job, and the costs are not outrageous. We would need continuous mining machines producing finely broken ore and loading it into containers for the drones to carry. Is that the adjacent possible?

Objections to innovation

At the Austmine 2019 conference, one of the vendors told me that his product will not sell because it is substantially more expensive than the existing technology. It will save lots of capital and operating expense elsewhere in the mine, but decisions are made on upfront cost.

One of the speakers was quite comfortable in telling us that, although he thinks a particular technology is the way of the future, he will not try it until it has been proven at someone else's mine.

It is easy to dismiss my suggestion about drones because the costs are not defined, and the technology is not yet developed. The easy path is to ignore such fanciful ideas. I attended an excellent presentation by Gavin Yeates for the AusIMM Melbourne Branch earlier in 2019. Gavin pointed out that the only way to overcome inertia is to create a business case for innovation. How do we do that?

In mining we already have a process for making a business case: the feasibility study process. We proceed through a series of stages, from conceptual, to prefeasibility and then feasibility, each becoming more detailed and costing more than the previous stage. In that way, we limit our exposure and can reject the innovation if it is proving to be commercially impractical. However, I have made early-stage proposals for such studies of possible innovative technologies to mining companies and to collaborative research groups without a nibble of interest. Why is that?

Adoption

While the mining innovations I listed earlier seem valuable to us in retrospect, some took many years to be adopted by the mining industry. Safety fuse, an obvious winner, was unpopular for decades because of cost, and people continued to pour gunpowder into goose quills. Autonomous underground trucks are yet to catch on. Some of the reasons given for slow adoption have been:

- it will be more expensive than the status quo
- it is difficult to retrofit in an existing mine
- the workforce will need re-training
- there is a lack of supporting infrastructure and spares.

Gavin Yeates has previously pointed out that many of our mining processes are the same as they were 50 or 100 years ago. He concluded that we only get one chance ▶

‘The only way to overcome inertia is to create a business case for innovation.’

per orebody to choose the technology that will be used. It is too difficult to make changes, other than minor changes, once the mine is operating.

I once did a study that showed it took, on average, seven years for a new mining technology to be trialled in an Australian mine. It took a further 13 years from the first trials until widespread adoption or, in other words, general acceptance. If it takes 20 years for a new idea to achieve acceptance, then who will support the development of such ideas?

Commercial interests

With a few exceptions, mining companies are not interested in true research and development, though they like to package some activities under that label if there is a tax advantage to doing so. For reasons of internal approval and finance they need to de-risk the development studies for any new mineral deposit. If forced to innovate to make an operation work they will do so, but all parties involved – the owners, consultants, financiers and technical auditors – want to use proven technology and leave the risks in the areas of geology and product markets.

Equipment manufacturers, traditionally based in Scandinavia and the USA and more recently in China, have no incentive to change current paradigms. They will build faster, bigger machines, improve operating availability and continue to compete in the way that Kodak, Agfa and Fuji competed before the advent of digital photography. There are exceptions: my friends at Gekko Systems in Ballarat are true innovators and have won many awards for their products. They remind me of those 19th and 20th century innovators I mentioned earlier.

Universities and collaborative research organisations, including those that are notionally government owned and funded, are heavily dependent on industry funding. In my experience, the industry has little appetite for long-term innovative research.

Consultants – and here I hold up my hand – have ideas that could lead to innovation, but are too bound up in the daily grind of timesheets and monthly invoices to pursue those ideas. The scope of their activities is dictated by their clients – the financiers and mining companies.

Mining contractors are innovators. They are always looking for the edge over their competitors and are willing to gamble on good ideas. However, they need payback within a year or two, and the history of innovation tells us that a short payback is unlikely.

Feasibility studies for new technologies are expensive, but to be convincing I think they need to be conducted with the same detail and rigour that we apply to established technologies. Performance and cost data must be built up from first principles. Who will fund the work needed to make the business case for the research to be done?

I believe that the change will come from wealthy investors and innovators. In other words, from the likes of Bill Gates, Elon Musk, Mark Zuckerberg and Jeff Bezos. In 2016, Musk established the Boring Company, whose website (**boringcompany.com/products**) says:

Estimated project pricing can typically be provided within one week. Stay tuned for the Tunnel Price Calculator coming to this site in 2019, where the user can enter product line, location, geology type, and length, and the calculator will return a project price range maximum and minimum.

Mining innovation needs passionate advocates who can influence investment decisions. That means having experienced mining engineers, geologists and metallurgists in senior management and board positions where these decisions are taken. Even with the best will in the world, a lawyer or banker may struggle to recognise a complicated technological opportunity.

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On-the-job training

I mentioned earlier that we have trouble attracting young people to the sector. Technological innovation will create opportunities for young people, but university education usually lags well behind the workplace. For some jobs, a background in computer games may be more valuable.

Unfortunately, in my experience many academics in the minerals area have lacked practical experience and struggled to relate to their students. The disparity in salaries with industry draws talented people away from the universities. Staffing and funding levels go up and

down and rarely synchronise with the cyclic demand for graduates. The content of courses lags the changes happening in our high-tech industry.

I had the great fortune to be trained in a big underground mine through a cadetship and graduate scheme operated by Conzinc RioTinto of Australia. The scheme ended many years ago, but the people who passed through it went on to lead several of Australia's largest mining companies. I am sure that I learned more on the job, every day, than I learned at night school in the university college. I had worked on several of the leading technologies of the day before I had graduated. Good geologists and engineers combine practical skills and experience with a solid academic background, but I believe well-structured training is more important.

Industry cadetships can provide an opportunity to develop professionals quickly and soundly. In four years, universities can provide only a basic grounding in general engineering, chemistry, geology, economics, management, the environment and all the new applications in information systems, control systems, robotics and so on. The field has grown beyond a generalised undergraduate syllabus. Employers, be they mining companies, contractors or consultants, should accept the cost of providing undergraduate cadetships and structured graduate training as part of the cost of doing business, to a much greater level than they do at present. This includes better support for professional development programs offered by AusIMM and other societies. The adjacent possible is too close, and is moving too quickly, for traditional career paths to remain viable.

'Industry cadetships can provide an opportunity to develop professionals quickly and soundly.'

Conclusion

The greatest challenge for our industry is to change the way we operate, so that we meet community expectations. We have opportunities to make changes through technological innovation and through more effective training of our professional people. We need to fund research programs that run for longer than one or two years, and to properly evaluate opportunities using the staged feasibility study process.

Future mines will be highly selective, moving smaller tonnages, and increasingly they will be underground. They will apply technologies that exist today and are hovering at the edge of the adjacent possible.

Expenditure on innovation around the adjacent possible is like expenditure on exploration. It ensures the business will continue beyond the life of existing activities. That is what true sustainability is all about.

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Russia

Key facts

- **Population:** 143 891 021
- **Land area:** 17 098 242 km^2
- **Natural resources:** Oil, timber, copper, diamonds, nickel, gold and many more
- **GDP:** US$1.658 trillion (2018)

A full reference list is included with the online version of this article at **www.ausimmbulletin.com**.

Spanning 11 time zones and two continents, Russia has an impressive endowment of natural resources and is a major player in the global sector

Ryan Leaver, Marketing and Editorial Assistant, AusIMM

Following the disbandment of the Union of Soviet Socialist Republics (USSR or Soviet Union) in 1991, Russia as we now know it came to fruition. Previously one of 15 bodies comprising the USSR, the disintegration of the Soviet Union saw Russia become an independent state.

Russia is one of few countries that are located across multiple continents, Europe and Asia. Its capital city Moscow is situated in Europe, and most of the country's population is concentrated in the European area of the country.

The largest country in the world, Russia has sixteen bordering nations and around 100 languages among more than 120 different ethnic groups.

Image: f11photo/Shutterstock.com.

One unique aspect of Russia is that its large population is on the decline. Having peaked in 1990 at 148 million, it now sits at approximately 144 million and according to the United State Census Bureau, could drop to 111 million as soon as 2050 – representing a decrease of more than 20 per cent.

But Russia's declining population has not yet had an impact on its large resources industry. Due to its sheer size, Russia is unsurprisingly the richest nation when it comes to wealth of natural resources.

Mining in Russia

Russia has the largest mining industry in the world, with the total estimated value of its natural resources being around US$75 trillion, more than the US (US$45 trillion) and China (US$23 trillion) combined.

Russia is a leading producer in dozens of resources including platinum, gold, iron ore, diamonds and palladium. The majority of Russia's natural resources are found in Siberia and the Russian Far East. The country also holds the second largest coal deposits in the world, behind only the United States.

Despite some recent economic headwinds and variable mineral and metal prices, the resources sector continues to play a key role in Russia, contributing greatly to the nation's GDP. Mining is one of the country's most sizable industries and provides a great amount of exportable goods.

Russia provides around 20 per cent of the world's cobalt and nickel, while also producing around seven per cent of both iron ore and coal. Of these minerals, coal production in Russia is on a steady incline, while iron ore and nickel are remaining relatively steady.

Alongside the steady production of the above listed major minerals and metals, Russia is the world's third largest gold producer, sitting behind only Australia and China. But the Russian gold industry expects to double its output by 2030, which would see them become the second largest producer of gold in the world.

Along with the future of gold mining in Russia looking bright, their current domination of the nickel market is set to provide great benefits, with a worldwide increase in lithium-ion batteries currently increasing at a great rate.

Trade and finances

With Russia's mining industry in such a stable state and with growth looking likely in the near future, it also provides a lot of opportunities for mining equipment companies from across the globe as Russia imports around US$3 billion worth of mining equipment each year.

In 2017, Russia imported US$221 billion worth of goods, which ranked it as the 19th largest importer in the world. This data saw Russia's most common imports being packaged medicaments (3.7 per cent of imports), closely followed by cars (3.5 per cent) and vehicle parts (3.4 per cent).

Despite being the 19th largest importer in the world, 2017 saw Russia ranked 14th for exports, resulting in a positive trade balance of US$120 billion. Russia's most commonly exported goods are crude petroleum (28 per cent of total exports) and refined petroleum (17 per cent).

Russia's exports are sent all over the world, with the most common destination being China (US$39.1 billion worth of exports), followed by the Netherlands (US$27.2 billion), Germany (US$19.9 billion), Belarus (US$18.5 billion) and the United States (US$15.4 billion).

Conclusion

With the imminent turn of the decade and an exciting short-term future in the mining industry, Russia is set to continue to be a powerhouse in resources, not only within its own borders, but all around the world.

Tips for a future leader

As the world changes, leaders also need to adapt to ensure that they're effective in a drastically different landscape. By being emotionally intelligent, comfortable with change, and someone who develops those around them, future leaders will drive performance in their teams.

Dr Ali Burston
Managing Director – Metisphere

The current work climate is changing at a rapid pace. Over the past five years, we have seen an increase in automation and technological implementation, which is altering the way we work in dramatic ways. Research shows that people are spending more time than ever looking at screens and communicating through technology.

What does this mean for workers? Some argue the changes we are seeing have impacted how effectively we communicate, by reducing our empathy and making it harder to read emotions in others (Twenge and Campbell, 2018). Increased automation and more complex systems have also resulted in a surge of demand for highly specialised IT experts, who have skills that not all of us possess.

So it's worth asking: what can future leaders do in this drastically different landscape? I believe it is important to emphasise a new and diverse skillset, made up of the following elements.

1. Emotional intelligence

As screen time and new ways of communicating are increasing, our ability to perceive and understand emotions is decreasing. This means that leaders with high emotional intelligence are worth their weight in gold. In simple terms, as workers climb the corporate ladder, their role generally is more about managing others (and themselves) than it is about their specified technical skills.

We also know that perceiving and understanding emotions, two of the core elements of emotional intelligence, are both directly related to a leader's capability to lead (Forbes, 2018). Future leaders must be able to use their emotional intelligence to manage highly technical experts to achieve best outcomes.

2. Being comfortable with change

Change is unavoidable. And it's not always easy to manage. As good leaders, it's imperative to learn how to become comfortable with change and facilitate it within your team (Forbes, 2017). Resistance to change occurs at all levels, and leaders are required to reduce perceived fear of the unknown and enable others to move through change more smoothly. Why? Well, the future is uncertain, and if we cannot facilitate innovation or creativity in our team members during complex systems change (such as introducing artificial intelligence or automation), then the team and entire organisation may find it difficult to adapt to new ways of working.

3. Provide challenges to your team, encourage innovation and provide a sense of purpose

Leaders need to do more than facilitate and manage change; they need to encourage innovation as well. A leader that can promote innovative and creative thinking nurtures a culture that is flexible and offers rapid problem-solving and solution-finding during times of change (Forbes, 2017). Moreover, a leader must logically frame issues to team members in such a way that creates investment in the work and avoids thinking from team members such as 'I do not understand why we are doing this' or 'we've always done it this way – why change?'. Understanding yourself first and then communicating the change provides an opportunity for team members to connect and believe in their purpose (Lewis, 2019).

By assigning tasks that challenge and encourage team members, they are able to explore their comfort zones more frequently, developing a sense of adaptability and resilience (two incredibly powerful traits to have in an ever-changing environment!) (Bass and Avolio, 1994; Dumdum, Lowe and Avolio, 2013). The additional benefit of upskilling your workforce increases the total capability of your team. Providing team members with the autonomy and independence to explore tasks with guidance and mentoring provides further challenge and engagement.

Image: alphaspirit/Shutterstock.com.

That's not to say that leaders should assign new tasks every week; the caveat for this is that if you don't plan and implement these challenges strategically, team members can become overloaded, thereby achieving the opposite effect (Belmonte and Murray, 1993). Rather than feeling empowered, team members may feel overwhelmed, helpless and incompetent (Day, Crown and Ivany, 2017). Instead of experiencing achievement during uncertainty and independent work, they may feel isolated and abandoned.

In summary, leaders should allow their team members to be innovative and creative by:

- questioning assumptions
- reframing problems
- approaching old situations in new ways.

Leaders understand the importance of including team members in the process of addressing problems and finding solutions. Team members are our greatest asset in generating new ideas and solving problems creatively. Which is why it is integral that individual member's mistakes or divergent ideas should not be publicly criticised. Team members should be encouraged to try new approaches and feel safe in sharing their ideas to improve the team.

Conclusion

Future leaders need to be emotionally intelligent, comfortable with change, and be able to develop those around them for new and disruptive solutions. As the world changes, our leaders should too; we should all endeavour to be future leaders!

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Forecasts of a lithium 'glut' are far from the truth

There has been much talk around an apparent 'oversupply' of lithium. Here, veteran Australian lithium expert Adrian Griffin puts this talk into context.

Adrian Griffin
Managing Director, Lithium Australia NL

Many equity market and lithium industry analysts have seized on recent statistics for lithium supply and demand as indicative of long-term market trends. They see the rapid increase in hard-rock production, combined with a slower than anticipated uptake of electric vehicles (EVs), as a sure sign that the sky is about to fall in on the lithium price.

This position has led to forecasts of a glut in supply that will send the value of lithium, and the chemicals produced from it, tumbling fast.

Closer examination, however, reveals this to be far from the truth.

If global demand for lithium-ion batteries grows beyond the pundits' wildest expectations, which it seems it may, then conventional sources of lithium supply simply will not cope with demand.

How then might 'infinite' lithium supply be achieved? Unconventional sources will have to fill the gap. But how, and when, such sources will be exploited are the fundamental questions. The answers to those questions are not yet clear, as the sector remains captive to misinformation, misinterpretation and misunderstanding.

Culpable are corporates and governments – large and small – jockeying for a larger slice of what is anticipated to be a very large pie, the next global industry.

For example, while experts debate the rate of uptake of lithium-powered vehicles, China fiddles with its EV subsidies.

Already, converters of spodumene – a common mineral rich in lithium – struggle to cope with adding capacity or planning future expansions. Yet we are told there is an oversupply of spodumene concentrates.

These are short-term aberrations, but as legislative changes pre-empt the banning of internal combustion engines around the world, it is apparent that any perceived oversupply of lithium may actually be short-lived.

Taking a longer-term view, some 3.5 million tonnes of lithium carbonate equivalent (a common measure of value employed in the lithium industry) will be required annually just to power the EVs needed to meet the legislative requirements in place from 2030 or thereabouts.

Factor in growing demand of lithium for energy storage and electronic goods and it becomes harder and harder to realistically envisage current and planned lithium operations meeting that demand.

So, where will the 'new' lithium come from? Current mining expansion will not meet lithium demand longer term. As mines mature, production will dwindle.

New mines targeting lower grades can fill demand gaps, but alternative sources of lithium may prove more attractive as genuine supply shortages put pressure on conventional production.

As Earth's 'throwaway society' matures and (hopefully) develops a culture of custodianship for the planet, recycling will replace new materials as the preferred source of supply.

When the market matures to the point of product saturation, with continual expansion no longer required, demand for – and the recycling of – lithium will synchronise.

If that does occur, newly mined material will only be necessary to top up that regained through recycling.

Unfortunately, such a scenario seems a long way off, and if global population continues to increase by around 1.07 per cent a year (82 million people) it may never be realised.

In the meantime, an exponentially increasing demand for lithium will have the industry scratching its collective head about new sources of supply.

'How then might "infinite" lithium supply be achieved? Unconventional sources will have to fill the gap.'

So, what might some of those sources be? Options include the following.

- Seawater
- Geothermal and oilfield brines
- Spent lithium-ion batteries
- Lithium clays
- Spodumene tailings
- Lithium micas found in pegmatites and greisen.

Seawater contains lithium in very low concentrations (~0.17 parts per million). Due to the large volumes of water that would be required, evaporation ponds will not work commercially. Also, seawater contains many other dissolved minerals, so traditional separation technologies would involve not only huge energy consumption but also fouling of the filtration media or regenerants.

If the recovery issues for seawater can be resolved, its commercial advantages will centre on location and its ubiquity. In fact, exploiting seawater as a source of lithium could resolve much in the way of political uncertainty and security risks and in so doing enhance sustainability.

Geothermal and oilfield brines have been much studied, but their low lithium concentrations present processing challenges and, with oilfield brines, the

VSPC's Brisbane facility. VSPC is a wholly-owned subsidiary of Lithium Australia NL.

expense of pumping from great depths. Japan and New Zealand have achieved geothermal brine success but key efforts in the US have not. In the UK, hot springs in old mine workings have been found to contain lithium and this potential source is being investigated.

Spent lithium-ion batteries – worldwide, enthusiastic adoption of lithium-ion batteries in huge quantities is causing great environmental concern, since once depleted most end up in landfill. Presently, only nine per cent are recycled. In Australia, the figure is less than three per cent. Right now, smelting is the main means of recovering the metals these batteries contain, but the lithium is usually lost in flux or off-gas. Research into lithium recovery through condensation of the off-gas from such smelting is currently underway, as is the development of more efficient recovery processes that will make recycling of lithium-ion batteries a potentially significant new source of lithium (as well as other energy metals).

Lithium clays, while low-grade compared to conventional hard-rock lithium deposits, are garnering attention. Mexican deposits have been metallurgically assessed and future production from the region is anticipated. Other lithium clay deposits – including in Nevada – contain both lithium and boron, but recovery from such deposits remains very energy-intensive.

Spodumene tailings – given the ways in which spodumene mineral separation circuits perform, and how commercial concentrates are produced, most pegmatite orebodies offer a relatively low lithium yield in terms of tonnes of ore mined. Conventional conversion processes are energy-intensive and feed rates dependent on relatively coarse particle size, so much of the fine spodumene is discharged to tailings. Emerging processing technologies, however, can improve recovery rates for both coarse and finer particles, thereby limiting waste and utilising material previously considered unsuitable for conventional lithium processing. This represents a great industry opportunity.

Lithium micas are the world's most abundant lithium minerals. Lepidolite in particular is commonly associated with tin, tantalum and tungsten mineralisation. When those elements are mined, vast quantities of lithium micas are currently discharged as waste. Given that extraction and some processing costs are already covered, lithium mica waste streams become an obvious target for lithium production, but further processing innovation is required.

'Enthusiastic adoption of lithium-ion batteries in huge quantities is causing great environmental concern.'

A proactive approach to maintaining social licence

This article is a summary of a presentation delivered at the AusIMM Social Licence to Operate Forum in Melbourne, May 2019

Terence Jeyaretnam
Partner, Climate Change and Sustainability, EY

The current social licence paradigm

Social licence used to apply only to the mining and oil and gas sectors, but now plays a pivotal role across a large number of industries: banking, health and aged care, live animal exports, agriculture, tobacco, sugar, palm oil, gambling, technology and social media, pharmaceutical, infrastructure and transport.

There are two key reasons for this expansion.

Rapid and pervasive 21st century industrial growth has put severe pressure on our ecosystems and consequently, our communities. This has led to social licence becoming ever more important to an increasing number of industries.

Second is the growth in connectedness of our society through the internet and social media. This has led to stakeholder-first approaches being even more important, as rapid and widespread communication can quickly define common sentiment and perception.

Within these mega trends, a new proactive approach is needed to maintain social licence. There are six key factors to this approach.

1. A focus on materiality

Approaches to gauging the materiality of social licence issues have evolved considerably over the past two decades. These approaches have become similar to those used by the financial professionals in defining financial materiality. It is important to regularly refresh the process so that new and emerging issues are identified and proactively managed. The Global Reporting Initiative provides a framework to consider material issues for an asset or organisation (Global Reporting Initiative, 2015).

2. Stakeholder primacy

Stakeholder primacy was key during the birth of the industrial age, and is now considered just as important. That is, to know who your key stakeholders are, their levels of influence and impact, their views regarding your operations, and to know them as they change. The set of standards released by AccountAbility (2018) around stakeholder engagement, assurance and assurance principles provide a useful framework to understand stakeholder materiality, responsiveness, inclusivity and impact.

3. Voluntary disclosure

Involuntary disclosure (when someone else makes the disclosure on your behalf) is reputationally much more damaging (eg an exposé) than voluntary disclosure. There are significant drivers for voluntary and transparent disclosure of your impact, including from investors, the stock exchange and civil organisations. Early and voluntary disclosure is a critical tool in building and retaining trust with your key stakeholders.

4. Best practice performance and targets

It is important that organisations have best practice performance and targets to ensure that social licence is maintained. This is well-known, but what is different today is the availability of information to your key stakeholders about what best practice is. If you are below expectations, it is likely that you will be held to account by stakeholders.

5. Collective impact

Collective impact refers to a group of important actors from different sectors committing to a common agenda to solve a specific social problem. A program involving only one actor (eg a mining company) may be appropriate for addressing non-complex problems. However, collective impact is an approach to solving complex social problems. Taking a collective impact approach requires moving away from the traditional, more isolated ways that organisations attempt to solve problems. In a mature social licence context, it is important that social and community investment by the mining sector is collective in its approach in order to help solve the endemic local issues faced by our communities.

6. Executive capability

Social licence issues may mostly be identified at the operational level, but it is critical that the entire organisation is able to understand and respond to these issues as one. Consequently, executive and board level capability in environmental, social and governance issues is central to the ability of the entity to respond and manage issues in a timely and effective manner.

Conclusion

Social licence comes from maintaining and growing legitimacy, credibility and trust. The resources industry needs to reaffirm trust with its key stakeholders. This trust narrative must come from within and must engage all types of stakeholders, from investors to activists. The narrative put forward by the sector must show vulnerability, courage and leadership. It must have a point of view on critical emerging issues and must not be afraid to single out and be vocal against the relatively small number of operators and proponents that may tarnish the rest of the industry's reputation.

The views expressed in this article are the views of the author, not Ernst & Young. This article provides general information, does not constitute advice and should not be relied on as such. Professional advice should be sought prior to any action being taken in reliance on any of the information. Liability limited by a scheme approved under Professional Standards Legislation.

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Mining sector update

How the industry is faring in 2019

Richard Fortune
MAusIMM, Director,
Alto Partners

Overall sentiment for the mining sector is strong. Yet, as many of you know, the industry is currently experiencing 'the best of times, and the worst of times.' Many producers are debt free and enjoying record prices, while many explorers and developers are languishing as they wait for equity market sentiment to swing their way.

Despite shaky global markets, coal and iron ore have powered ahead, with gold the standout performer. Battery metals are experiencing a sharp correction, while base metals are subdued by global growth concerns. Some specialty metals, industrial minerals and fertilisers are garnering niche interest.

One of the big issues facing the industry is a shortage of suitably qualified and experienced mining professionals. Discussing this with a range of companies, large and small, some trends have emerged.

Age compression

It's no secret the age of mining leadership is dropping, particularly in the majors. For example, it's not uncommon for 30-somethings with commercial backgrounds and limited operational experience to be promoted to General Manager (GM), taking responsibility for substantial operations.

The GM role is a good example, because it is often the crossover point into executive leadership, where the leader transitions from managing areas they know well to recruiting and relying upon competent managers in areas outside their domain experience. The quality of the GM's downline is crucial to their success.

One of the pressing challenges facing this new generation of GMs is that these downline roles are getting harder to fill. The pool of suitably experienced operational and technical managers atrophied in the downturn, and there is a mere trickle of graduates in the university pipeline.

Yet ageism persists, with young leaders wanting to recruit even younger managers. This is further limiting the pool of desired candidates, which is amplifying the experience shortage and leading to wage inflation in middle management (data and trends outlined in Alto Partner's recent Executive Remuneration Report).

Image: Mike Charlesworth/Shutterstock.com

Experience on the bench

There is a growing pool of underutilised executives in their 50s and 60s; some there by choice, but many through restructures and the simple reality that there are less spots at the top of the organisation. Many of these candidates are consulting but looking for opportunities.

Underutilised, they wonder why the industry is screaming out for help, yet they are met with 'sorry, you are overqualified'. It's true that some will never work effectively under a younger leader, but there are many more who have retired their ego and would be excellent advisors or mentors.

Fresh thinking in a safe set of hands

A new generation of leaders are championing innovation, technological advantage and positive cultural change. Yet their success relies upon domain experience they may not have had time to accumulate.

I use the term 'experience shortage' rather than 'skills shortage'. Experience is not something that can be microwaved and served up on demand. Skills can be developed quite quickly, but experience is forged in the furnace of operational pressures, challenging relationships, ambiguous data and difficult decisions. Experience keeps people safe, avoids costly errors and imparts success to the next generation.

It's worth considering how the new leader should best access this experience, and how organisations can retain this experience in-house. Perhaps we need to think laterally with advisory boards, new roles and organisation structures that enable 'fresh thinking in a safe set of hands'.

AltoPartners provide executive search and leadership advice to boards through 54 offices across 34 countries. Richard Fortune is a Director of AltoPartners Australia, and he is a leader of the firm's Natural Resources Practice.

How the JORC Code affects mining finance

This article is an excerpt from 'Reporting and converting resources to reserves – how confident are we?' by Mark Noppe, found in AusIMM Monograph 30: *Mineral Resource and Ore Reserve Estimation – a Guide to Good Practice*

Mark Noppe FAusIMM(CP), Managing Director and Corporate Consultant, SRK Consulting (Australasia)

As the mining sector continues on an upward trajectory, miners and explorers have an important imperative to assure investors and stakeholders that their Mineral Resource and Ore Reserve estimates can be trusted.

Since we cannot totally escape the risk and uncertainty related to minerals projects, more transparent, consistent and balanced views of technical confidence will better inform both internal and external stakeholders, particularly investors, about the expected risk in the project.

The JORC Code sets out the minimum standards, recommendations and guidelines for Public Reporting in Australasia of Exploration Results, Mineral Resources and Ore Reserves. The JORC Code is fundamental to the way capital markets work in respect to reporting mineral projects. These reports should provide investors with a level of confidence that appropriate consideration has been taken when assessing the viability of a project.

'Consistent and balanced views of technical confidence will better inform both internal and external stakeholders.'

Image: katjen/Shutterstock.com.

Here are three ways that a Public Report written in accordance with the JORC Code helps manage risk for both investors and mining companies, based on the Code's three governing principles 'Transparency, Materiality and Competence':

- Transparency means that the reader of the Public Report is provided with sufficient information and the presentation is clear and unambiguous. A reader should be able to understand the report and not be misled by the information or by omission of material information.
- Materiality requires that a Public Report contains all the relevant information that investors and their professional advisers would reasonably require, and reasonably expect to find in the report, for the purpose of making a reasoned and balanced judgement on the project.
- Competence requires that the Public Report be based on work that is the responsibility of suitably qualified and experienced persons who are subject to an enforceable professional code of ethics (the Competent Person).

Given that only about two per cent of financial investment globally finds its way into the mineral and mining sector, the industry needs to preserve and improve its risk perception in the eyes of investors. Competent Persons should strive to better present the technical risk and uncertainty associated with minerals projects in the context of project maturity to provide more consistent, and balanced views of confidence, risk and opportunities for both internal and external stakeholders relying on this reported information.

AusIMM Online Professional Certificate in JORC Code Reporting

Mark Noppe is a facilitator in the AusIMM Online Professional Certificate in JORC Code Reporting, an interactive eight-week course delivered online for mining professionals responsible for public reporting, particularly aspiring and current Competent Persons. For more information on the course, and other AusIMM courses available on JORC Code Reporting, visit **www.ausimm.com/courses**.

A version of this article originally appeared at MiningNews.net.

All quiet on the western front – a WMC retrospective

What lessons for the future can be learned by looking back at the remarkable story of an iconic Australian mining company?

Charles Reis

Building a culture that fosters creative problem-solving is a hallmark of success in start-up businesses. In the early stages a can-do attitude is vital, together with a healthy dose of optimism and self-belief. Shortage of capital drives leanness. Multi-tasking, shared responsibility and taking risks can, if things go well, eventually lead to innovation and extraordinary company earnings.

In recent decades, this approach has been seen frequently in the technology sector. But there was a time when the same hunger was apparent in mining. Companies with little capital attracted imaginative people who could think differently about a problem; then managed to turn a few measured risks into unimaginable wealth when new deposits were discovered, or when a different technical solution substantially altered mining or processing methods. These were outcomes that rewarded shareholders and sometimes catapulted companies to the next tier of the industry.

One of the best examples of this success was Western Mining Corporation (WMC). Like many other companies of the era, WMC started life as a small-time gold explorer and miner in the 1930s. The company honed its exploration and mining skills in outback Western Australia, and then transformed itself into one of the world's major producers through a consistent pipeline of exploration successes; firstly, bauxite and then in quick succession iron ore, nickel and copper-uranium. To discover one major minerals province in a company's history is remarkable – to discover several is extraordinary. As recalled by author, historian and former WMC executive Gilbert Ralph, WMC also used imaginative methods in its exploration of oil in Australia and the USA; and in the case of phosphate, introduced a new processing technology to produce a range of high-quality fertilisers. It was sustainable success – the aspiration of every company regardless of industry.

But how is it that one company could enjoy a long period of extraordinary growth, while others during the same period struggled and then simply disappeared?

Firstly, WMC managed to prolong the attitude of its small-company roots; it recognised, out of operational necessity, that success was dependent on local initiative. In its early days, communication to remote areas was poor, so decisions needed to be made locally. This required a high level of trust in localised management. The company succeeded in attracting people who could work autonomously in a tough geographic environment and get things done, which in turn bred a can-do attitude. In the words of former CEO Hugh Morgan, if something could be fixed with fencing wire, then it often was. Head office in the very early days was run by a small team of just six people, who were also hands-on. And so, the genetics of the company were formed.

WMC staff, 1958.

Furthermore, the early absence of any meaningful operational support from head office, coupled with the tyranny of distance, meant that operations had to rely on the resources at hand, pushing more responsibility down the organisation to the lowest levels. As observed recently by consulting firm VCI in its latest *State of Play* report, innovation originates from those closest to the issue. This was a defining practice of WMC.

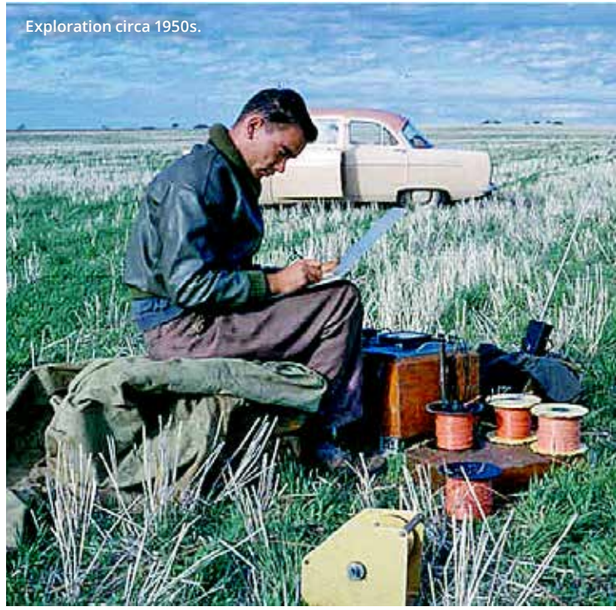
Secondly, the company progressively recognised that the fixed market price for gold (as it was then) limited its prospects. To grow, WMC needed to diversify and this meant doing things and going into commodities where it had little or no previous experience. The company chose an exploration-led strategy, and its early successes shaped everything that followed.

Roy Woodall, WMC's renowned head of exploration, believed that successful exploration outcomes were a combination of thinking differently and investing in the ongoing development and education of geologists to ensure they had the most current industry knowledge. He emphasised that exploration was a science, just as mining was a science and not simply extraction. In the recently published WMC history *Mandarins and Mavericks*, Roy summed up the prevailing attitude of the time: seeing what other people see; but thinking what no one else has thought before.

The third defining characteristic of WMC was its willingness to take risks. The journey to success was littered with small failures and challenges that were quickly forgotten, but the successes, when they occurred, came to define the company. Few, if any, were fired for a failure, provided the intent was right. It was part of the ethos of WMC to 'have a go'.

Finally, the culture of WMC was different. People today remember colleagues in a familial way. Culture is nebulous to define, but former long-term employees will most often cite a sense of being valued, and a feeling that they belonged. Hierarchy was mostly invisible except on organisational charts; and successive leaders from the Chairman down maintained a constant presence at site, understanding first-hand the intimate details of business performance and the invariable production bottlenecks. The company's prevailing attitude was that all problems could be solved. And in the words of the late Sir Arvi Parbo: persistence wins.

Photos courtesy Gilbert Ralph and WMC Group Historical Collection.



Exploration circa 1950s.

However, in the 1980s, the business of mining began to change, and external pressures challenged WMC's traditional model of local operational accountability. Increased government bureaucracy created demands of all mining companies, and the industry had to quickly adapt by bringing in experts to match these demands, creating its own centralised bureaucracy to deal with a burgeoning regulatory regime that covered everything from environment and health to listing rules and reporting requirements. In the 1990s, technology exacerbated the change, as all companies including WMC sought to reduce administrative duplication. This became a tipping point for WMC, catalysing changes in leadership and operating paradigms across the business.

'To discover one major minerals province in a company's history is remarkable – to discover several is extraordinary.'

WMC analysts visit, Agnew 1999. Back row: John MacDonald, Andrew Little, Graham Cartwright, Craig Temby, Cory Nolan, Joy Ross. Front Row: Peter Chilton, Peter Blight, Keith Docking, Charles Reis, Brian Warner, Peter Mangano.

While the 'can-do' culture remained, WMC, like all listed companies, now had to factor risk on multiple levels into many of its decisions. As boards came under increasing pressure from shareholders, and decisions were subject to greater media scrutiny, management needed to exercise greater caution. Business processes that may have previously empowered discretionary rights in managers quickly become standardised and in many cases systematised. However, as the balance tipped rapidly from autonomy to conformance for other miners, WMC tried hardest to preserve its traditional roots that fostered individual innovation.

Even in the last years leading up to the takeover by BHP, WMC remained the most progressive of Australian miners in its attitude to safety, the environment, gender equality, technology and people. Under the leadership of Hugh Morgan and then Andrew Michelmore, WMC produced more than 25 CEOs who went on to lead other companies.

While many former employees may lament the passing of WMC, its legacy lives on through the enduring connections that former employees made between each other. It was a business school, a mining school and an extended family – all rolled into one. It fostered curiosity, invested in innovation, and genuinely tried to empower its people.

It will be a very special company that can replicate WMC's achievements and create the same sense of belonging that continues to endure amongst its many thousands of former employees.

Charles Reis is a former WMC executive and an independent advisor to the resources industry.

Photo courtesy Charles Reis.

Educating the next generation of geoscientists

Following on from its successful NExUS graduate program, the University of Adelaide is looking to expand its offering to Honours students studying mineral geosciences

Dr Graham Heinson and Dr Richard Lilly, University of Adelaide; and Patrick Lane, NExUS 2018 participant

Since 2016, the University of Adelaide has had a national presence in the delivery of graduate level coursework in mineral exploration through its National Exploration Undercover School, or NExUS. The three-week NExUS summer school program is well regarded by industry, providing high-level training in mineral exploration and geoscience for 30 of the best graduating Honours students from around the country. A new Honours in Mineral Geoscience course, starting in 2021, will build on this reputation, providing a year-long training program that will lead to greater employment outcomes for students looking to work in the minerals industry.

New Honours course format

The first half of the year of the new Honours degree consists of coursework split into three themes:

- Mineral Exploration Science: understand the challenges and opportunities in the global minerals industry (five-week module)
- Mineral Exploration Skills: develop technical skills, from geological context to the emergence of new technologies and data analytics (ten-week module)
- Mineral Exploration Professional Practice: understand workplace skills, from leadership and communication to native title, stakeholder engagement and environmental best practice (five-week module).

In the second half of the year, students will put these skills into practice with a collaborative project with one of the State and Territory Geological Surveys in South Australia, New South Wales and the Northern Territory.

The new Honours program will use blended delivery/teaching methodologies (such as flipping) that include online learning modules to enhance face-to-face involvement and a student-centred approach. Students in the program will experience varied modes of assessment including assignments, examinations, practical work, reflections, competency-based assessment and field trip reports.

For more details contact Professor Graham Heinson University of Adelaide via **Graham.Heinson@adelaide.edu.au.**

NExUS – a three-week course providing world-class training in mineral exploration

The new Honours program builds on the reputation, experience and teaching methods developed in the University of Adelaide's NExUS program. The most recently completed program, the third annual National Exploration Undercover School (NExUS) took place over three weeks in November-December 2018, and was attended by 32 eager and excited geoscience students and early career mining and exploration professionals.

NExUS is funded by the Minerals Council of Australia (MCA) Minerals Tertiary Education Council (MTEC). Delivered by key figures in industry, government and academia, NExUS participants are exposed to leading exploration concepts and technology to face the challenges of effective exploration through post-mineralisation cover. The course consists of workshops, interactive lectures and hands-on activities both in the field and in the classroom, with evening networking events with senior representatives from industry and professional organisations.

'As we are forced to explore not only deeper, but under extensive cover, specialist skills are required to meet the challenges that arise.'

The 2018 NExUS cohort represented every Australian state and territory and were selected from eleven different universities, together with early career geoscientists from five different exploration and mining companies, Geoscience Australia and the NSW geological survey. Participants (including geology and geology/engineering undergraduates, Honours and Masters students, and recent graduates), are encouraged to not only to think critically about the challenges facing mineral explorers today, but also the technology and practices required to overcome these challenges. As we are forced to explore not only deeper, but under extensive cover, specialist skills are required to meet the challenges that arise. NExUS aims to bridge this knowledge and training gap with this intensive introductory course, focusing on the four core themes of the broader, nationwide UNCOVER Australia initiative, which aims to help lift the success rate of finding Tier 1 and Tier 2 deposits to the rate enjoyed 30 years ago in the exposed domain. The four themes are:

Characterising the cover – new knowledge to confidently explore beneath the cover

Investigating Australia's lithospheric architecture – a whole-of-lithosphere architectural framework for mineral systems exploration

Resolving the 4D geodynamic and metallogenic evolution of Australia – understanding ore deposit origins for better prediction

Characterising and detecting the distal footprints of ore deposits – towards a toolkit for minerals exploration.

NExUS 2018 recap

The 2018 participants (nicknamed 'NExFam') assembled in the state-of-the-art South Australian Drill Core Reference Library in Tonsley, SA – their base for the first week. Diving into the core themes, the class was given introductory presentations from Rohan Cobcroft (Geological Survey of South Australia) and Phil McFadden (UNCOVER) on the challenges facing the exploration and mining sector. This was followed by Stephan Thiel and Kate Robertson (GSSA) with an in-depth explanation of the 4D architecture of the Gawler Craton, focusing on the newly acquired AusLamp data. This was rounded off by showcasing the potential of Magnetotellurics (MT) for deep crustal imaging in the facilities 3D visualisation suite. Anthony Reid (GSSA) gave an enthusiastic presentation of the history of the GSSA and the lessons we can draw from the past to help us in the future. All this in the first day, setting the pattern for the rest of NExUS: a knowledge packed, three-week journey.

Week one continued to expand on the UNCOVER themes with a one-day regolith workshop under the expert guidance of Carmen Krapf and Malcolm Sheard (GSSA), with components of biogeochemistry and hydrology from Anna Petts (GSSA) and Adrian Costar (DEW), followed by a one-day geochemical dispersion workshop by Ravi Anand and Walid Salama from CSIRO. Discussions and practical exercises on sampling mediums, regolith interfaces and appropriate geochemical techniques put the students' newfound knowledge to the test.

Logging exercises on core from the Coompana drilling campaign, led by Rian Dutch and Adrian Fabris (GSSA) were followed by a tour of the Hylogger, incorporating a hyperspectral data workshop taught by Alan Mauger (GSSA). Week one ended with a stand-out structural geology workshop by Jun Cowan and

Brett Davis (Orefind) utilising their new software where students learnt to identify and plot structures using assay data, as well as the 'dos and don'ts' of collecting structural measurements from drill core.

Week two took the cohort to Strathalbyn in the Adelaide Hills, where lessons learnt in week one were put into practice in the field at Hillgrove Resources' Wheal Ellen prospect. A wide range of activities took place over three days of intensive field work. Some teams focused on detailed mapping of the prospect under the tutelage of Michael Belperio (Newmont), while others conducted geophysical surveys with Mike Hatch, Derrick Hasterok, Ben Kay (University of Adelaide) and representatives from ZZ Resistivity, Zonge Geophysics and Geoscience Australia. Detailed and honest discussions were had while acquiring data from induced polarity, magnetics, resistivity, MT and gravity surveys as well as geochemical soil sampling.

Evening discussions on each day's activities and pXRF analysis of the soils proved fruitful in practicing data processing and analysis. NExFam also visited the historic Brukunga pyrite mine to learn about rehabilitation from John Mignone (GSSA) and the Boart Longyear drilling research facility, learning how new technology is transforming the drilling industry.

Returning to Adelaide for the end of the week, the cohort attended the South Australian Exploration and Mining Conference (SAEMC), giving many of the students their first experience attending a conference, and a great chance to test their newly developed networking skills with enthusiasm. Inspired by the evening networking talks, an impromptu session was also held by representatives of the AusIMM Women in Mining Network (WIMnet) and Women in Earth and Environmental Science Australasia (WOMEESA) on inclusion and diversity in the mining industry. The day was topped off by an inspiring session with senior geoscientists from BHP discussing their career paths and passing on some personal advice for graduates.

Week three was based at Walleroo on the historic Copper Coast of the beautiful Yorke Peninsula, where Richard Lilly taught several workshops on ore textures and breccia systems combined with daily field trips to historical copper mine sites. Highlights of the week were paragenetic logging exercises conducted on highly altered drill core from Rex Minerals IOCG-Skarn Hillside deposit, *in situ* regolith studies courtesy of Colin Conner, as well as numerous opportunities for specimen fossicking (including beautiful atacamite!).

Week three tied together the knowledge and skills developed during the first two weeks with fun field work and enthusiastic discussions among participants. To conclude the course, Gavin Springbett (G&S Resources) presented a workshop on the JORC code, resource estimation and a 3D orebody modelling session in Maptek Vulcan software. The final morning also included a 'real world' talk and highlighted the importance of Aboriginal and Torres Strait Islander cultural heritage, safety systems, effective communication and teamwork.

'An essential component of NExUS is networking, giving participants the confidence, means and contacts to return home and continue learning.'

An essential component of NExUS is networking, giving participants the confidence, means and contacts to return home and continue learning from those they met during the course. Most nights throughout the course finished with an informal talk by industry professionals on a diverse range of subjects from general advice for graduate geologists to different perspectives on exploration methodologies. Leading industry professionals such as Kathy Ehrig, Jamie King and Jesse Clarke (BHP); Janine Harzig (AusIMM President); Joel Blake and Alex Richards (Rio Tinto); Glen Little and Anna Olgivie (Minatour Exploration); Kevin Stephens and Christine Thomson (FMG); and Josh Leigh (AIG) all shared their experiences, advice and some great stories. Importantly, these informal evening sessions gave participants insights into the different aspects of working for both large and small companies, as well as the opportunity to ask a myriad of questions on all aspects of careers and exploration. The cohort also fostered strong ties between themselves with friendships made and experiences swapped.

The importance of this course to the participants and the minerals industry cannot be underestimated. A strong social media group continues daily to discuss and share knowledge and experiences as they move into new roles in the industry, enthusiastically passing on lessons learnt to their peers. Cumulatively the NExFam has just reached a century; with 102 alumni since inception. A mid-year reunion took place in Perth in early September 2019 and reunited many of the 102 participants of the 2016, 2017 and 2018 groups.

The next program will be delivered in November-December 2019 and had a record number of high-quality applications.

Delving deeper into deep earth imaging

CSIRO's Deep Earth Imaging Future Science Platform continues to lead the way in conducting vital research into the imaging, conceptualisation and prediction of resources

Tim Munday, Lead, Deep Earth Imaging Future Science Platform, CSIRO

Image: Johan Swanepoel/Shutterstock.com.

Since its inception in 2017, CSIRO's Deep Earth Imaging Future Science Platform (DEI FSP) has conducted fundamental research in the imaging, conceptualisation and prediction of water, energy and mineral resources. In one of the largest recent recruitment campaigns in the earth sciences in Australia, a transdisciplinary team of 20 early career researchers, four mid-career researchers and a Platform Director was created with the aim of contributing to the national mission of securing the future supply of resources from the subsurface. DEI FSP is now well established on a path that will provide Australia and its mining industry with the next generation of algorithms and tools to support the sector in exploring at greater depths across the continent and offshore.

Our techniques and their applications

DEI FSP's imaging techniques, employing passive and active methods, can be used to identify/characterise a wide range of subsurface features. This includes the major crustal scale structures underpinning mineral systems, the architecture of sedimentary basins hosting hydrocarbons and mineral deposits, and near surface characteristics such as the water table.

On the continental scale, our team has focused on value-adding to precompetitive datasets. Geoscience Australia's extensive active seismic acquisition campaign over the past decades has resulted in multiple crustal seismic transects across the continent. However, the broad application of seismic velocity model building, or more generally construction of geological models, has not kept pace with the release of these high-quality datasets due to the labour-intensive process of analysing them. By combining machine learning techniques and geophysical inversion, DEI is developing automated workflows to construct geological models from seismic data.

Recordings of the seismic wavefield contain a wealth of information about the earth. Traditionally, only a small subset of this information is extracted and used to constrain the subsurface. DEI has developed new methods that allow prediction of the full wavefield response of an earth model, which is key to improving the quality/resolution of subsurface images. We have combined forward modelling techniques with a Bayesian approach, and by using high-performance computing infrastructure we have been able to produce images of the complex geology beneath places such as the Lord Howe Rise deep sea plateau off eastern Australia.

'DEI is developing automated workflows to construct geological models from seismic data.'

The increased interest in passive seismic data sets (both acquired and applied) across the minerals and oil and gas sectors has also been a focus for DEI FSP researchers. To extract the maximum amount of subsurface information from these unique data, particularly those acquired at continental scale by universities and government agencies, early career researchers within DEI have been developing workflows to extract additional pieces of information from the wavefield that will help the creation of the next generation of seismic velocity models. Ultimately, these techniques are applicable across scales, ranging from mapping the boundaries of cratons all the way to defining the geometry and extent of the regolith at the mine-scale. In the future, we will seek to progress methods that will combine the information from both passive and active seismic data sets, with the goal of improving the spatial resolution of our models.

Making the most of magnetotelluric data

Another important source of information about the subsurface is magnetotelluric data. Measuring the ratio of the electric and magnetic field variations provides an indirect measure of the electrical resistivity distribution in the subsurface. Understanding the robustness of images inferred from these measurements depends on understanding how the noise in our recordings of the electrical and magnetic field affects processing and analysis of the data. DEI has therefore developed novel processing techniques for magnetotelluric data that permit the quantification of the noise in the data, thereby helping users to more comprehensively assess the robustness of models of the subsurface electrical resistivity. Understanding the robustness of models is particularly important for our fusion of different sources of information – for example, point estimates of cover thickness obtained using multiple geophysical techniques. Our cover thickness estimate assimilator provides a cover thickness map and associated uncertainties while accounting for the uncertainties of the individual point estimates of cover thickness and breaks in spatial correlation resulting from faults.

Direct and indirect observations are only one source

of information when it comes to deriving subsurface models. Current exploration approaches commonly seek to image the subsurface. DEI is developing workflows centred around the numerical simulation of processes related to the formation of sedimentary basins, aquifers and alteration zones associated with a mineral system. Most geophysical inverse problems are non-unique; ie, if one model can be found that fits the available data, then it is likely that there is a wide range of alternative models with some different characteristics that can fit these data equally well. Some of these models may fit the data well but might not be plausible from a geological perspective. Therefore, they may have little relevance in a resource exploration context.

Our ability to simulate the formation of structures that host resources or orebodies allows us to determine which models are geologically plausible. This then becomes a valuable source of prior information when it comes to inferring models of the subsurface from geoscience data sets, particularly geophysical data. An ability to generate plausible models and geophysical observations for these models also allows us to generate training datasets for machine learning algorithms. Once the training of these algorithms is complete, they provide a rapid screening tool to identify prospective domains of the subsurface prior to employing or developing more accurate and comprehensive inference methods.

The challenge of hidden variables

A common theme around DEI's development of methods for the inference of subsurface models involves addressing the challenge posed by hidden or latent variables. Two examples of this are:

- where for well log data, we need to identify lithological units prior to inferring rock physics models for each lithology
- where in the calibration of a reactive transport model for a mineral system, we must first identify alteration zones based on our geochemical field observations.

Traditional approaches to these types of inference problems are sequential, with the first step being a qualitative interpretation of the data seeking to label or classify the data, and the subsequent step being an inference of a subsurface model from the classified data. This labelling, or classification of the data, is often a time-consuming step that is subject to qualitative interpretation. By using methods that combine unsupervised learning with model inference, we can treat this as a joint problem and derive objective models of the subsurface that do not rely on a potentially subjective, and sometimes erroneous, interpretation of the data.

Multiple applications of the workflows and algorithms

While Deep Earth Imaging aims to develop methods

Image: Edward Haylan/Shutterstock.

that answer specific questions for a specific resource problem, rather than focusing on more generic approaches, the workflows and algorithms under development do have multiple applications. For example, extracting information about available groundwater resources through the interpretation of geodata (eg airborne electromagnetics, magnetics, digital elevation models, Interferometric Synthetic Aperture Radar (InSAR)) can involve a determination of regolith thickness, palaeovalley location and fault networks.

On a fundamental level these methods are applicable to other questions an explorer may have – for example, information about palaeovalley structures is also central to understanding the formation of channel iron ore deposits. Due to its transdisciplinary nature, the DEI FSP can readily exploit such synergies.

Supporting the next generation of earth scientists

As much as the Future Science Platform is about developing and applying its science, it is also about supporting opportunities for the next generation of earth scientists to transition into positions in industry, academia and government. The early career researchers who joined DEI have taken advantage of training in a wide variety of subjects including project management and mathematical inverse theory. Combined with this has been the opportunity for DEI to engage with world-leading scientists from Australian and international universities, research institutes and government bodies. Nine PhD projects have been supported by the Platform at selected Australian universities on topics of relevance to deep earth imaging. This further contributes to the development of a nationally relevant geoscience capability.

This emergence of a collaborative geoscience innovation hub at DEI FSP was the result of CSIRO recognising the challenges facing Australia in securing its resource base. Over the next three years, the DEI FSP will continue its effort to address these challenges under the three pillars we refer to as Imaging, Conceptualisation and Prediction.

Imaging

An ever-increasing volume of geodata drives the development of novel techniques that can produce snapshots of resource systems. Future breakthroughs will be based on advances in sensor networks and computational techniques to extract the maximum amount of information from our observations.

'The Future Science Platform is supporting opportunities for the next generation of earth scientists.'

Conceptualisation

Our understanding of mineral, energy and groundwater systems only increases when we combine images of the subsurface with geological knowledge. Confidence in predictions will increase if they are underpinned by formal interpretations of images and transparent conceptualisations of geological processes.

Prediction

Accurate predictions are the key to de-risking exploration in geological complex settings and managing water and hydrocarbon resources. Improving prediction will require advancing inference capabilities so we can turn images and conceptualisations into insight and understanding.

Underpinning this focus will be an increased effort in developing the next generation of inference techniques that combine advances in data processing, machine learning, model parametrisation, data collection, forward modelling, inversion and predictive applications. We will become more outward focused and the technologies we are developing will transition from a proof of concept stage to delivery for industry and government.

Linked to this increased external engagement, the DEI will convene its inaugural interdisciplinary subsurface conference (Sub20) around the themes of imaging, conceptualisation and prediction of water, energy and mineral resources, to be held in Perth in February 2020. Over two days, we will focus on the science required, developed and deployed by academia, industry and government to prospect today for the resources that will underpin our low energy future.

The conference will include a combination of keynotes, panel discussions, presentations and networking opportunities. Emphasis will be placed on the next generation of techniques to acquire knowledge about the subsurface; by for example combining machine learning, forward modelling, inverse theory and predictive applications. We look forward to your participation.

The application of unmanned aerial vehicle technology to detect blast movement

This is an edited excerpt from a paper that was originally presented at AusIMM's Iron Ore 2019 Conference

J Loeb, Global Consulting Manager; Brane Pesic, Senior Systems Engineer; and Kausik Dasgupta, R&D Manager, BMT

At most hard-rock mine sites around the world, blasting is a critical process by which rock mass is broken into smaller pieces to assist mining of orebodies. During blasting, ore moves from its *in situ* position. The BMT designed blast movement measurement system is the only efficient way of discerning the final orebody location after a blast. The measurement system works by installing Blast Movement Monitors (BMMs) in a bench before a blast. During the blast, BMMs move with the ore and their final resting locations allow BMT's bespoke software to accurately measure movement in 3D space and generate dig polygons for the mine site.

The process described above requires users to walk on the post-blast muck pile and locate BMMs using a hand-held detector. This can be dangerous due to presence of subsurface gas, voids, unstable grounds, blast tie-in debris and more. Some of BMT's existing customers located in the arctic circle have to locate the sensors in treacherous icy conditions. There are also mine sites in Australia and around the globe that would like to use BMMs for blast movement monitoring but cannot do so due to their internal safety controls restricting access to post-blast muck piles.

To solve these issues, BMT embarked on an 18-month quest to find a solution to allow mining companies to experience the benefits of accurately measuring blast movement without having to walk on a post-blast muck pile. After vetting many different potential solutions, it was decided that BMT would develop a detection system based on Unmanned Aerial Vehicle (UAV) technology.

As part of developing the UAV-mounted BMM Detector, prototype testing has been conducted in mines in Australia and Europe. This article summarises the results from the most recent testing conducted at an iron ore mine in Western Australia.

The Blast Movement Monitoring system

The Blast Movement Monitoring system was developed and patented by the University of Queensland and commercialised under licence by Blast Movement Technologies. The system consists of transmitters, BMMs, which are placed within the blast area prior to blasting. The transmitters are then located after the blast with a purpose-designed detector and the acquired data is processed using BMTs bespoke software package to calculate movement of orebodies as a result of the blast. The complete standard system is comprised of:

- the Activator: a remote control that switches each transmitter on and programs it as required
- BMMs installed in dedicated drill holes within the blast that are then surveyed
- a purpose-built Survey-Enabled Detector (SED), also known as the GP5350, is used to locate each BMM after the blast and determine its depth
- BMM Explorer software calculates the 3D movement vector of each BMM. The data is stored in a database for future reference.

UAV-mounted BMM Detector components

Hardware – commercial 'off the shelf'

The BMT UAV-mounted BMM Detector is designed for ease of assembly, replaceability and maintainability in mind. The following commercial 'off the shelf' items were selected for the BMM Detector:

- DJI M600 Pro Flight Platform with A3 Pro Flight Controller
- DJI DRTK GNSS system for precision navigation
- Trimble BD990 GNSS receiver with Trimble AV59 Antenna
- Pacific Crest radio module with whip antenna
- iPad-based ground station for flight planning and monitoring.

Hardware – BMT designed

The following BMT designed hardware was mounted on the DJI M600 Pro using the DJI Ronin MX Gimbal:

- Remote Processing Module (RPM) based on the existing GP5350 SED design
- Light weight coil antenna based on the existing GP5350 design.

Software – BMT designed

BMT has developed the following software packages to assist in BMM and blast movement calculation:

- software for ground station to enable mission planning and flight monitoring
- software to post-process acquired data to ascertain BMM locations
- BMT's existing desktop software package BMM Explorer to calculate blast movement.

UAV-mounted BMM Detector operation

When using the UAV-mounted BMM Detector, BMM installation is done using BMT's existing SED. The install points are then transferred to the iPad and used as waypoints for the post-blast detector flight. In the prototype, the search for BMMs is conducted following a predetermined grid pattern with install points of each BMM assigned as the centre point of each grid. The grid dimensions can be manually set by the user before the flight, which are a function of the expected movement.

The system is fitted with three separate GPS systems, two of which are used for navigation. The detector uses the onboard DJI DRTK as the primary system for navigation and the standard GPS as a redundant active standby system. The third GPS system onboard is a Trimble GNSS receiver which is used to record BMM locations with centimetre-level accuracy. The detector system is also fitted with forward and downward facing lasers. These lasers are configured to pause the flight if either of them detects an object either in front of or under the UAV. If an object is detected, the UAV will pause and hover at the point of detection allowing the user to decide whether to continue or cancel the mission.

Before take-off, once all individual components of the UAV-mounted detector system are powered, the system does an automated pre-flight check. If all checks pass, the operator can send a command through the iPad to the UAV to start the mission. The UAV then automatically takes off and flies to the BMM install location and searches along the pre-planned grid for each BMM location. Once all grids are completed, the UAV automatically returns home (ie to the take-off location) and lands without any user intervention. An option is also designed into the system for the UAV to automatically return home if the batteries powering the UAV reach a charge level of 25 per cent. The point at which a mission is suspended is recorded in the onboard flight controller. The UAV can resume the mission once the batteries have been replaced.

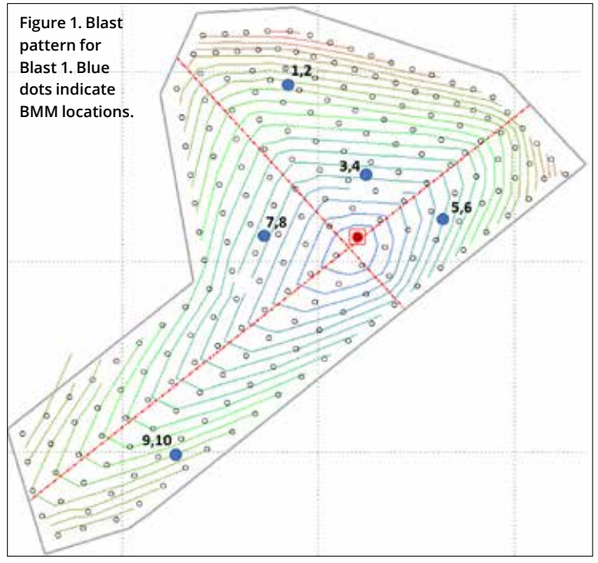


Figure 1. Blast pattern for Blast 1. Blue dots indicate BMM locations.

Prototype testing at iron ore mine site

As part of developing the UAV-mounted solution, the prototype system was tested at an iron ore mine at Western Australia. Two blasts were monitored using a conventional SED and the new UAV-mounted BMM Detector. Following is a summary of results from each blast.

Blast 1

Ten BMMs were installed in five separate monitoring holes in Blast 1, and all ten BMMs were detected post-blast using the SED. Figure 1 shows a plan view of the blast, including the initiation point, timing contours, and centrelines. The numeric labels on the plan correspond with the corresponding BMM number. The blast was initiated in a centre-lift configuration. To the southwest, the blast was confined by blasted muck. The remainder of the blast perimeter was confined by unblasted rock.

Two BMMs were installed in each hole. As the bench height was 10 m, the target installation depths were 3 m and 6 m below the collar of the hole. The powder factor used for the blast was 0.29 kg/t.

Blast movement calculations (based on SED and UAV data)

An SED and the new UAV-mounted detector were used to survey the muck pile for BMMs. Due to operational constrains, the UAV-mounted detector attempted to find eight BMMs only. It successfully detected six of them.

Blast 2

Twelve BMMs were installed in seven separate monitoring holes in Blast 2, and all 12 BMMs were detected post-blast. Figure 2 shows a plan view of the blast, including the initiation point, timing contours, and centreline. The numeric labels on the plan correspond with the BMM number. The blast was initiated in a v-configuration from the western edge of the perimeter toward a choked face. The remainder of the blast perimeter was confined by unblasted rock. The powder factor for Blast 2 was 0.27 kg/t.

Blast movement calculations (based on SED and UAV data)

A SED and the new UAV-mounted detector were used to survey the muck pile for BMMs. Due to operational constrains, the UAV-mounted detector attempted to find five BMMs only. It successfully detected all five of them.

Potential value generated by accounting for blast movement with flight enabled detector

For the purposes of this analysis:

- ore loss is defined as ore sent to a waste dump
- dilution is defined as waste, processed or stockpiled as ore
- misclassification is defined as material with ore classification being treated as ore with a different classification. It is assumed that each delineated polygon has a different downstream destination.

It is important to note that the comparison is made between mining ore blocks in their pre-blast position (ie no blast movement translation and no field adjustments) versus the translated blocks by movement vectors.

The results of the analysis is shown in Figure 3.

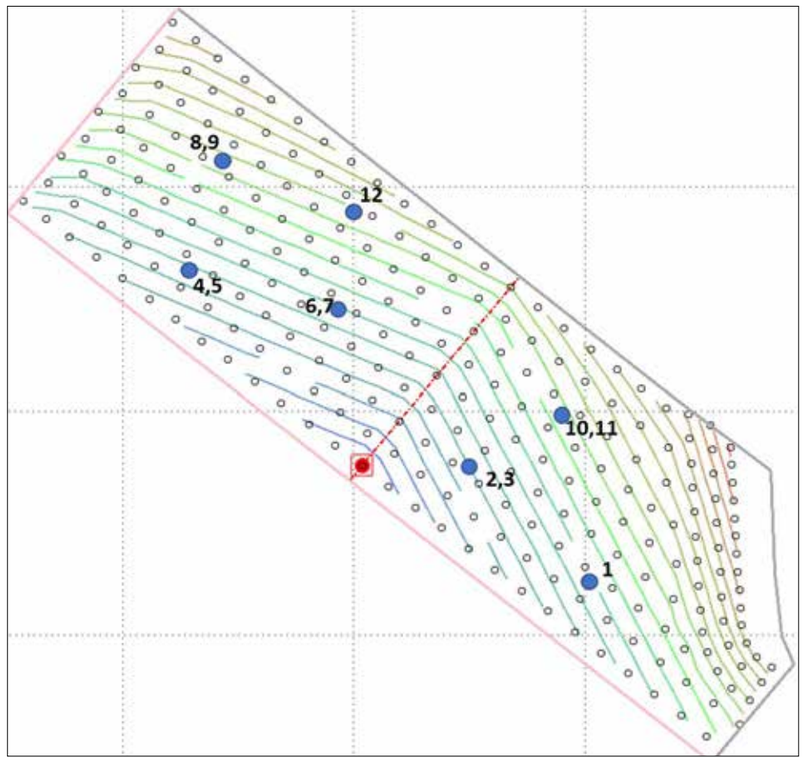


Figure 2. Blast pattern for Blast 2. Blue dots indicate BMM locations.

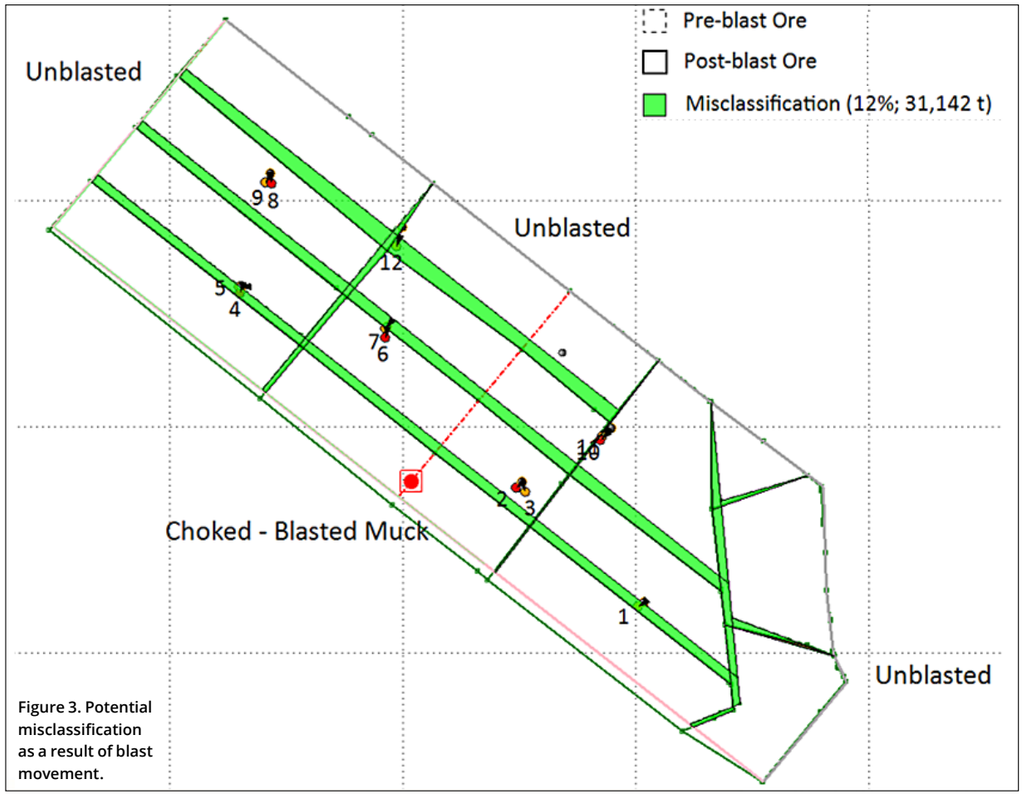


Figure 3. Potential misclassification as a result of blast movement.

If the ore was mined in situ, rather than the post-blast locations translated using measured vectors, then there would have been approximately 31 142 tonnes of material sent to the wrong downstream destination (12 per cent misclassification).

Conclusion

The current trend on mine sites across the globe is to increase safety and productivity via use of automation. BMTs 'off-the-muck-pile', UAV-mounted BMM detection solution is in line with that trend. There are several key benefits to this approach. On one hand, the UAV-mounted detector system improves safety on treacherous muck piles, while on the other hand it addresses staffing issues at mine sites. An automated detection system also reduces error in measurements by eliminating any human error during BMM detection using BMT's existing hand-held detector.

The automated detection system will allow mine sites the opportunity to collect BMM data during the stand-off period. This will have significant improvements to reconciliation, reducing misclassification and reducing ore loss and dilution. Therefore, it can be summarised that BMT's UAV-mounted detector system will allow quicker, faster and easier measurement of BMM data and thereby increase safety and productivity at mine sites where this system is implemented.

Five problems electronic blasting experts can solve

In a highly competitive and increasingly scrutinised operating environment, mining companies need immediate performance enhancements based on proven principles and reliable technology. Electronic blasting, when deployed by skilled professionals, can deliver measurable benefits.

Martin Vasilescu, Country Manager Explosives, Davey Bickford Enaex

In a new landscape where efficiency is the gold standard, mining leaders across the world are looking to decrease inputs, increase outputs, and raise the level of safety. Questions are also swirling around social licence and the environment. Taken together, these challenges can seem overwhelming – but there's no need to go it alone.

As with any great task, the key is to break things down into manageable steps. Electronic blasting experts occupy a unique position in their ability to do this. Why? Because the application of electronic blasting doesn't rely on experimental or theoretical measures. Electronic blasting uses proven technology and expertise to unlock reliable pathways to greater efficiency. We've known for a long time that every shot has an effect on downstream performance, but only in recent history have we seen how profound those downstream effects can be.

So how can blasting experts help demystify the path to a leaner and more productive operation? Here are five specific problems that can be solved when current technology is skilfully applied.

1. Long and cumbersome blasting processes

Safety and strategic concerns, in addition to outdated methodology, can make the blasting process painfully expensive and slow. The inability to fire multiple or larger shots at the same time makes setup more arduous and requires a greater number of blast days. Furthermore, limitations on the size of blasts will result in a loss of precision and less control over the operational effects.

In co-operation with electronic blasting experts, operators can optimise their blasting, with the results being better wall formation, reduced downtime and faster advancement of pits and tunnels.

2. Vibration that disturbs nearby existing operations or communities

For mining companies, success in the 21st century comes with a new set of rules and expectations. The effects of a given mine on nearby communities, and on the environment, have reached critical importance. Reducing ground vibration is a definite and practical way to lighten those critical footprints.

Image: kemdim/Shutterstock.com.

Electronic blast experts can reduce and predict ground vibration by selecting a timing regime tailored to the geological conditions. Combined with controlled firing of large and multiple blasts sequentially, fewer blast events translates to better relationships with surrounding communities.

3. Less than optimal safety

Key innovations over time have reduced the dangers inherent to blasting, but the hardware and configurations at many mining sites remain less than optimal – and since one blasting accident or mishap is one too many, elevating safety standards and outcomes during the blasting process is a universal priority.

There are many notable safety features in some of the world's most advanced electronic blasting systems include secure encoded communication protocols for superior firing control and data transmission. Safety is taken to higher levels through the expert application of hardware, integrated modems and next-level detonators.

4. Poor fragmentation and a lack of material uniformity

The blasting process has a critical impact upon hauling, crusher-circuit throughput, and other key aspects of downstream operations. When fragmentation is poorly controlled and material is not uniform, productivity suffers. Next generation electronic blast systems bring a level of control over material uniformity that could only be imagined in the past. Real performance gains are unlocked at multiple points in the production chain.

5. Lack of control over muck piles and dilution

The excavation of muck piles is another performance issue in mining operations which, if not overlooked, has perhaps been too readily accepted for what it is. With electronic control, the shape and looseness of the muck pile can be tailored to the excavation equipment and/or mining method, leading to efficiencies.

Dilution is another old problem that is taken as a given. The costs are multifarious – the unwanted material has to be moved, crushed, processed and then sent to the dump or tailings. Meanwhile, the grade of ore can be affected by high dilution levels.

We know that the blasting process has a large impact on dilution. Electronic blasting can be used to reduce levels of dilution, preserve higher grades of ore, and reduce operational costs associated with processing dilution.

'When fragmentation is poorly controlled and material is not uniform, productivity suffers.'

Proven principles and reliable technology

At a moment when new technologies are breaking onto the scene every day, so much remains in the realm of the theoretical, the unproven and the experimental. There is no doubt that automation will play a bigger role in years to come and that new technologies will unlock new productivity gains.

Meanwhile, the global mining community stands in need of immediate performance enhancements based on proven principles and reliable technology. The best electronic blasting hardware, as applied by dedicated experts, can deliver gains that are both practical and sustainable over the long haul.

Image: Courtesy Anglo American.

The importance of the flow of data across the mining value chain

Digital innovation is critical for mining companies looking to gain a competitive advantage. How might this innovation be deployed in drilling and blasting?

Mark Roberts, Product Manager Mine Operations, Maptek

In today's market, digital transformation in mining companies has become a business necessity and is key to maintaining a competitive edge. By 2021, companies investing in digital innovation as a single integrated business process will outperform competitors by 20 per cent on profitability. Yet, a recent poll found that 37 per cent of mining and metals executives have little or no knowledge of the digital landscape (EY, 2018).

A myriad of benefits arise when mining companies embrace digitalisation – it can improve safety, help teams anticipate and deal with failures, optimise scheduling and material flow, and track and maintain mining performance in real time. For drill and blast, fully integrating digitalisation can increase drilling accuracy, enhance online data management, save costs for explosives and create a faster and easier improvement process.

Still, digitalisation becomes meaningless if you do not have solutions for information sharing; software integration and the seamless flow of data is essential.

Integrating software

Commonly, mines will use many independent software packages and systems from different suppliers. Each piece will have its own interface, data and format, and operating staff will have to inspect a range of disconnected screens to connect different parts of the process. Disconnected products create the need for manual input and often the data does not represent a true set of events. This approach is clunky, time-consuming and reduces efficiency and profitability.

'A myriad of benefits arise when mining companies embrace digitalisation.'

While stand-alone software apps used in isolation can be reasonably powerful tools, many mining software suppliers are moving to better integrate their own apps and support interfaces with third-party systems. For example, Maptek recently collaborated with Sasol (a South African energy and chemicals company) to integrate BlastLogic with the IBIS bulk explosive truck control system. The BlastLogic tablet, which dynamically updates drill and blast plans in the field, can communicate directly with IBIS to control explosives loading. In an environment where even a slip of the finger can waste time, money and be potentially dangerous, this integration removes the need for manual data entry, saves time, preserves data integrity and increases safety.

In terms of the data that can be exploited from drill navigation systems, Maptek has collaborated with leading equipment providers. Epiroc is one example where this has resulted in an automated, integrated solution to streamline data transfer from an Epiroc drill through to Maptek BlastLogic and Eureka applications.

Some vendors position their integrated systems as an idealised solution, but when it comes to trial or implementation, these are found to have significant gaps. On paper, various tech provider offerings appear the same, but if the solution is not built holistically from the beginning, flaws can have a significant impact on long-term mine performance.

Getting isolated apps to integrate with third-party systems after they have been developed is difficult. It generally requires a large effort to work reliably when running data under the pressure of production requirements; any deficiency in how well the various components are integrated leads to additional risk.

Any meaningful solution requires significant resources dedicated to addressing workflow and functional requirements as they change over time. This is the difference with sustainable software systems from specialist mining technology providers.

The expectation for integrated systems has increased significantly. Better tools are needed to deal with the scale of today's mines. Functional departments are also keen to increase coordination to support better decision making, thereby optimising each element of the mining cycle as part of a total business system. This requires an understanding of all systems, processes and interfaces and how they fit together.

The starting point is sharing accurate information quickly from a variety of data sources. This is no easy task considering the sheer scale of data flow involved and the high production velocity targeted. And without integration, unnecessary burden is placed on the end user to transform and import/export data to enable tasks across other functions.

It's important to embrace software that can flawlessly integrate with other products to ensure that the information you're collecting to make decisions truly reflects what is happening at your sites. A true software provider will improve operations through their understanding of your value chain.

Case studies: the benefits of an integrated blasting platform

Most recently, an open pit gold mine has improved their day-to-day operations and provided greater business intelligence through Maptek's Blastlogic platform, which has the capability to manage the company's drill and blast process from design to performance measurement. The integrated tracking of vibration, fragmentation, performance, cost and inventory of each blast allows continuous improvement and informs future planning.

Implementation of the platform led to direct benefits including increased drill accuracy, efficient back analysis, enhanced online data management, cost savings for explosives and a faster and easier improvement process. Results of each blast are fed back automatically, leading to less time spent deciding what needs to change in designs.

Further, digital benchmarking allowed the effect of changes to be measured. For example, with all drill data integrated with blasting results, improvements in accurate charge placement are easily identified, delivering better fragmentation. Blasting can be performed with smarter and safer sequences.

Access to digital drill and blast data also allows easier communication between departments. For this operation, the integration of data has provided:

- detailed control of drill and blast KPIs
- the ability to audit contractors and the blasting process
- synchronisation of drill and blast tasks into a single platform
- data and process transparency
- correlation of data in 3D for simple analysis and summary dashboards to track technical, economic and operational opportunities.

Another company embracing digitalisation is Anglo American. BlastLogic enabled improved design compliance monitoring and downstream productivity optimisation across their open pit operations. Their technical team launched an

‘The alignment process gave engineers additional time for other tasks and reduced data management errors.’

improvement project in 2017 to provide a foundation for developing sound drill and blast designs that could be effectively executed and easily reconciled.

The new approach enabled compliance to design metrics and provided confidence in sustainably achieving desired blast outputs. The technical system included advanced drilling design, blast design and reconciliation and benchmark reporting capability. The solution has enabled efficiency gains through standardisation and alignment of various processes. For example, one operation required normalising four different coordinate systems used by three different drill navigation systems and general mine planning software.

Although systems had previously been in place to manage disparate data, the alignment process gave engineers additional time for other tasks and reduced data management errors. Integration with existing applications has reduced the need for information to pass through different systems and further decreased transformation or re-formatting requirements. Due to the wide geographic distribution of operations, the technical system is hosted in centralised data centres on each continent and the validated data is consolidated through a global reporting platform. This has led to improved integration between different business unit technical teams, allowing benchmarking and aligning operations on key compliance to design metrics. Importantly, it has resulted in a reduction of inconsistencies and discrepancies in metrics reported between operations, as the calculations and data are derived from a single, standardised source of truth.

Common access to centrally stored and managed data allowed different functional teams to meaningfully collaborate, start delivering sustainable operational value and identify additional improvement opportunities. In particular, the coordination shone a light on the importance of tracking and analysis of drill and blast metrics in a consistent manner across the global business. Inefficiencies are now clearly identified at critical stages of the process, and site personnel are empowered to devise strategies for improvement.

Improving industry practice

When generating a charge design for each hole, site practice has been based on rule-of-thumb and ‘gut-feel’ and then carrying out a number of checks, including for confinement. Recently, a coal operation looked for a new approach. The scaled depth of burial (SDOB) calculation in charge design provides an indication of confinement of an explosive charge based on variables including explosive quantity, explosive location and hole diameter. Rather than calculating the SDOB values as a manual ‘check’ for charge confinement, an algorithm was designed whereby desired SDOB values are input to determine the correct explosive position to achieve the user-specified confinement. The process is accurate and able to be repeated at the click of a button. The benefits included removing variability around blast confinement and coal seam protection. Now the drill and blast engineer simply specifies the desired confinement values, and the newly adopted platform calculates the charge plan that will achieve the required result.

While the need for software integration and a seamless data flow is essential, a forward-thinking approach to digital transformation remains critical to gaining a competitive advantage. According to IDC, by 2024, 25 per cent of companies will have digital twins integrating geospatial, geological and mine operation insights to integrate planning, execution and maintenance. Through a recent collaboration with Maptek and PETRA, mining companies will, for the first time, be able to use all their historical performance and resource data for mine value chain optimisation.

For mining companies to embrace digitalisation and software integration, aligning with credible mining technology partners is critical. These partners ultimately understand how operational functions intersect, and can build integrated, agile, cutting-edge solutions accordingly.

Mark Roberts has an extensive background specialising in strategy, technology and innovation that he brings to improving mine performance by enhancing the processes around drill and blast activities.

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Modern tin mining and processing at Melaleuca, Port Davey, Tasmania

A unique story of a small-scale mining operation in the remote reaches of South West Tasmania

Marie Willson

Rallinga Mine processing plant.

Image: Marie Willson

The first recorded discovery of alluvial tin (cassiterite) in South West Tasmania was near Point Eric, Cox Bight in 1891. In 1935, cassiterite was discovered on the Melaleuca plain (near Port Davey) and the deposits were exploited by a succession of small-scale operations. In 1941, the lease was purchased by Charles King who worked the deposit alone until 1945 when he was joined by his son Deny King.

In the summer of 1973, Peter and Barbara Willson and their young family sailed into Port Davey for a holiday and returned to Hobart having purchased part of the King lease and other leases in the area.

Peter Willson was a mining engineer and cray fisherman who came to Tasmania's South West after working in the coal mines of England and Norway and the copper mines of Zambia. As a qualified mining engineer, Peter and his wife Barbara used modern alluvial mining, processing and smelting techniques to produce tin from the peat soils of Melaleuca.

Life at Melaleuca

Peter started mining at Melaleuca in 1974 with just a pan, pick, shovel and wheelbarrow. He continued to fish in the crayfish season and Barbara, a qualified teacher, taught full-time in primary schools in Hobart. As Melaleuca was accessible only by boat, bushwalk or light aircraft, Peter transported goods and materials for the construction of the house and outbuildings into Port Davey on his cray boat *Flicken*. By the end of 1974, Peter had built the house and outbuildings and pegged out and planned the mine workings in Melaleuca.

It became clear that the *Flicken* was not suited to the mining operation; a vessel capable of carrying heavy loads and bulky materials safely was required. In collaboration with Bernard Wilson, a fisherman and boat builder in Triabunna on Tasmania's east coast, Peter designed the new boat. Peter and Barbara helped Bernard to build the boat and the *Rallinga* was launched in 1979.

The mining operation was gradually expanded with purchases of heavy machinery: a backhoe, excavator and dump trucks. These were transported to Port Davey via barge, the *Rallinga* or a fishing boat of sufficient size and then driven several kilometres overland and across creeks to the mining operation. To increase production, Peter designed and built a processing plant and later a tin smelter.

Peter and Barbara provisioned dry goods, meat, eggs and fuel for six months at a time during half-yearly trips on the *Rallinga* to Hobart. Barbara's garden was the primary source of fresh food. Fish and firewood were obtained during monthly trips out to Port Davey. Power for the house was provided by windmill and solar panels. A six-cylinder Lister diesel generator and alternator provided power for the mine. Smaller diesel generators provided power for Peter's workshop and the smelter.

Mining

At Melaleuca, alluvial tin (cassiterite) is found in the gravel sands that lie between bedrock and the overlying peat topsoil. Strip mining proved to be the most economic and practical method of winning the cassiterite-bearing coarse gravel sands.

A small excavator, two small front-dumpers and two portable pumps were used in the mining operation. To reach the gravel sands, the peat topsoil of a strip 5-7 m wide and up to 100 m long was carefully removed and placed to the side of the strip. The reach of the excavator and the depth of the peat topsoil limited the strip width. Topography and the distribution of cassiterite limited the strip length. The gravel sands were removed down to bedrock, transported to the processing plant via dump truck and processed. Once the strip was complete, tailings and washed coarse gravel were returned to the strip. Over time, the excess water drained away through the surrounding peat and gravel sands and the tailings consolidated. The topsoil was then replaced and monitored to ensure successful revegetation. The remaining washed coarse gravel was used to maintain the mine operation's roads and the nearby airstrip.

'Strip mining proved to be the most economic and practical method of winning the cassiterite-bearing coarse gravel sands.'

Processing

The processing plant used a gravity circuit to separate the cassiterite from the gravel sands and was designed and built entirely by Peter.

The gravel sands were tipped from the dump trucks through grizzly bars into a small rotary crusher. The rotary crusher broke down the gravel sands to football sized lumps (or smaller) and these were carried via conveyor belt to the trommel. As it rotated, water was introduced into the trommel, thereby 'washing' or separating out the coarse gravel leaving the fine gravel sands, cassiterite and water (the slurry).


Rabbling the charge.

The washed coarse gravel was transported via conveyor belt to the waste bin. The slurry then passed through a series of jigs that separate the fine gravel sands from the cassiterite. The fine gravel sands and water were pumped back into the strips as tailings. The cassiterite and water then passed over a ripple board to glean any gold and into a tank where the cassiterite settled out. Water from the tank was cycled back into the trommel. The settling tank was periodically emptied and the cassiterite concentrate shovelled into drums.

Initially the operation produced drums of cassiterite concentrate for sale to smelters in Sydney (Associated Tin Smelters) and Brisbane (Northern Smelters). Foreseeing the eventual closure of the tin smelters and because he was always looking for the next challenge, Peter began to work on smelting and refining the cassiterite concentrate on lease.


Strip mining and loading process.

Smelting

In 1992, Peter designed and built his first smelter, a blast furnace. The process of smelting cassiterite in a blast furnace requires extreme temperatures and a consistent quality of feed. Even so, it is notoriously difficult to control the smelter product. Due to the extreme heat, the blast furnace could only be operated in sleeting weather. This limitation combined with disappointing recoveries led Peter to abandon the blast furnace.

Peter started construction of the reverberatory furnace in 1997. Owing to its considerably more complex design, construction took the better part of a year.
The smelting process inside the reverberatory furnace required cassiterite concentrate, diesel oil for fuel, coke for reductant and shell grit for flux. In combination with significant heat, these facilitated a chemical reaction that reduces cassiterite to tin. The shell grit, coke and diesel oil were transported into Melaleuca by boat during half-yearly provisioning trips to Hobart.

The smelting process began with warming up the furnace with a wood fire for 12 hours. At the end of this period, the charge was weighed out, tipped into the top of the furnace and distributed inside the furnace using a rabbling iron. The intake and exhaust fans were then turned on and the burner ignited. The furnace exhaust flue was designed in such a way that fumes from the smelter settled in the horizontal section of the flue releasing only hot air from the stack. More charges were tipped into the top of the furnace and distributed inside until it was at capacity and the correct temperature (1300°C) was reached. This was measured using cones that visibly deform at specific temperatures. The chemical ▶

Top Image: Erika Shankley, Bottom: Willson Family


Tapping the furnace to release the molten tin.

reaction took several hours to complete and reduced the charge to a molten pool of tin inside the furnace. At this point, the furnace was tapped through a small hole in the base. The molten tin ran out into 30 kg inverted pyramid moulds that sat on miniature rail tracks. Once solidified, these 30 kg pyramids were the smelter product.

Refining

The smelter product still contained some impurities. To improve the quality of the product, two separate refining processes were undertaken. Both refining processes were dependent on the low melting point of tin (230°C). The impurities (dross, slag and inclusions) generally have a higher melting point than tin, thus, heating the initial smelter product to approximately 230°C separated the tin from the impurities.

The primary refining processes took place while the furnace was still hot. A large inclined iron plate was placed on top of the furnace and heated during the smelting process. The 30 kg pyramids of smelter product were placed one at a time on the plate. As the pyramids slowly melted, the tin trickled down the plate into another mould leaving the impurities on the plate. The recovered tin cooled in the moulds before secondary refining.

Peter constructed a 'kettle' in which the secondary refining process took place. The kettle consisted of a deep steel tub with an inclined plate to one side and an outlet at the base. This sat on top of a wood-fuelled firebox and the whole apparatus rested on a wheeled base.

To start the secondary refining process, the firebox was lit and several 30 kg pyramids of recovered tin were placed in the kettle. Once the tin was molten inside the Kettle, a pipe was submerged, and compressed air was gently bubbled through the molten tin. Impurities were entrapped by the bubbles as they rose to the surface. The impurity-rich froth was then scraped off and placed on the inclined plate. Any remaining tin trickled back down into the Kettle leaving the impurities on the plate.

Once the secondary refining process was complete, the final 10 kg moulds were filled by refined molten tin from the kettle. The refined 10 kg bars were sold to foundries. The product was so pure that it was used as a direct input into the foundry processes. After the closure of the Sydney and Brisbane smelters, Peter and Barbara's smelter was the only remaining tin smelter in Australia. Consequently, Peter reduced mine production to ensure that the entire cassiterite concentrate could be smelted for sale.

Environment

The mine workings encompass a large part of the Melaleuca plain but only a small percentage is still visible from the ground or air due to diligent rehabilitation. Peter was careful during topsoil removal and replacement to ensure speedy revegetation. Historical workings on the Melaleuca plain were re-seeded with native seeds harvested from the area using traditional methods. Very little waste was produced from the household and mining operation; anything unable to biodegrade was stored and transported back to Hobart for disposal.

Peter and Barbara also played an important part in the preservation of the endangered Orange-Bellied Parrot by monitoring numbers, siting nesting boxes within the lease and providing accommodation and resources to researchers and scientists.

Legacy

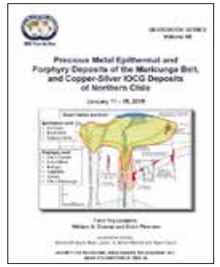
Isolation, weather and the environment presented many challenges to living and working in Melaleuca. Surmounting these challenges to maintain a comfortable household and profitable mining operation required planning, resourcefulness and ingenuity.

In 2011, Peter and Barbara agreed to relinquish the majority of their mining leases to the Tasmanian Wilderness World Heritage Area. The mine plant and workshops, smelter, house and outbuildings that remain in Melaleuca today are a testament to a remarkable couple who built a life on the quiet edge of the world.


Stockpiling the smelted tin.

Images: Erika Shankley

Society of Economic Geologists: Guidebook Series Volume 60



Precious Metal Epithermal and Porphyry Deposits of the Maricunga Belt, and Copper-Silver IOCG Deposits of Northern Chile

Edited by Borden Putnam, Rael Lipson, K Brock Riedell and Ryan Taylor

Review by Tony Wiggins and Andres Chifflet

The publication of short-form SEGF student field trip notes (undertaken in January 2019, led by William X Chavez and Erich Petersen) covering specific geological domains with mines and prospects is a welcome and innovative product for industry professionals and researchers. The format is guided by a primary purpose, being an easy-to-use point of reference for site and core-shed visits, with plans, sections, commentary on mines and other relevant information, including a comprehensive reference list.

For industry practioners, the publication includes an up-to-date summary of published papers on mines and prospects, augmented by technical materials released by the operators covering mine-specific details. This information from private operators is typically not available outside the industry professionals of the area or the companies, and is an important resource.

As the Maricunga Belt is a historic field with a lot of technical and research work undertaken in the 1980s, the summary is particularly useful, reducing time that would be otherwise required to find relevant information across different publications. This guidebook covers the epithermal and porphyry deposits of the Maricunga Belt, and selected silver-copper mines in the north of Chile. The Maricunga Belt, and affiliated domains, have attracted recent attention, most notably from positive exploration results and development work undertaken by major gold mining companies. Goldfields Salares Norte prospect, located to the north of the belt, is included in the field notes, which are current and only eclipsed by information released by the company recently as part of a feasibility study.

Kinross (historic operator of the La Coipa and Maricunga mines) has recently announced it will restart work at La Coipa and Marte-Lobo (both featured), and the Norte Abierto project (composed of the Caspiche and Casale deposits, each featuring prominently in the recent merger of Newmont and Goldcorp). Although these properties are shown on the itinerary as Copiapo-based core shed visits, the technical information is handed by the authors in a satisfying and well-compiled manner.

A summary of the Candelaria-Punta del Cobre District, located in the Copiapo Valley, south of the city of that name, was of particular interest. As with other visitors to this area, I was intrigued with the geology of the extensive copper workings here and their relationship to the large-scale Candelaria operation. The publication draws on local and published information to draw a clearer picture on the exploration potential of this historic Cu-rich district.

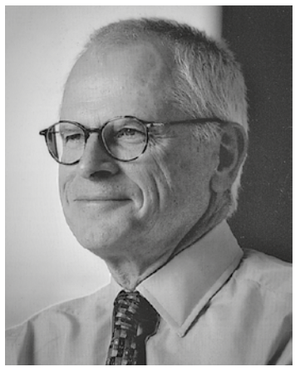
A range of smaller deposits are described, including Manto-type Cu-Ag mines near Taltal, epithermal precious metal deposits located on the southern end of the Yamana Belt, with each summary drawing on previously unpublished mine planning and operating data.

In summary, this publication is recommended for those geologists seeking a handy reference to important regions of mineralisation in Chile. The publication can be purchased in PDF from the Society of Economic Geologists (SEG) at **www.segweb.org**.

Don Morley

1940-2019

Jeff Gresham MAusIMM and David Griffiths



Donald Marshall Morley was born in Brisbane on 11 February 1940. Don's mother, Evelyn (nee Marshall) died in 1948 and his father – to enable him to continue his own career and the travel that it involved – enrolled Don as a boarder at Brisbane Boys College. Don successfully completed his secondary education in 1957. It was no surprise Don decided on a career in mining as his father, Ian Morley ISO, had a long and distinguished career in the industry including being one of Queensland's longest serving State Mining Engineers.

In early 1958, Don took up a position with the Sulphide Corporation at Cockle Creek in NSW and during employment with that company, as a trainee metallurgist and shift supervisor, completed a Bachelor of Science (Honours) in metallurgy at the University of NSW in Newcastle in 1964.

In June 1966, Don moved to Canada and later that year married Jane Sutton in the Christ Church Cathedral in Montreal. He continued working in the metallurgical field in both Canada and the US. In 1968, he was accepted into the prestigious University of Chicago Graduate School of Business and graduated with an MBA in 1968.

In August 1970, Don joined Western Mining Corporation (WMC) as a Corporate Analyst. Given his skill set and strong work ethic, Don rose quickly in the organisation, becoming Manager Corporate Planning in 1972 and Financial Controller in 1974. In 1980, he was appointed General Manager Finance and Treasurer and in March 1983, he joined the WMC Board as Director of Finance and Administration.

During his time as a WMC Director Don worked closely with the company's Managing Directors; initially Sir Arvi Parbo AC Kt and, from 1986, Hugh Morgan AC. Both had great confidence in Don's ability to carefully manage the company's finances, and he was intimately involved in many of the major corporate decisions on the strategic direction and growth of the company. When Don announced his intention to retire from the company in June 2001, Hugh Morgan said 'Don is the complete minerals executive. He combines a sound knowledge of minerals science with strong business ability, and is an outstanding contributor and colleague. We will miss his wisdom, dry humour and his leadership.'

Don's planned retirement had to be put on hold when Alcoa of America made an informal takeover bid for WMC. In an endeavour to ensure WMC shareholders achieved maximum value from their investment, the WMC Board decided to demerge itself into two companies – one to contain the interest of Alcoa of Australia and the other to hold the remaining assets. This was successfully achieved in October 2002.

Don then retired from WMC, but took on the role of Chairman of the newly listed company, Alumina Limited, in November 2002. He retained this position and other non-executive board positions until 2012 when he retired to spend more time with his wife Jane and family. It also gave him time to enjoy his sailing and other interests and spend more time with Jane at their homes in Albert Park, Melbourne and at Byron Bay.

As his father did, Don took on a much broader role within the mining industry outside his responsibilities with WMC. Over a membership of 59 years with AusIMM, he made a significant contribution to the minerals industry. He initially became involved at a Branch level but soon played a role in the organisation of AusIMM events. He was Treasurer of the Organising Committee of the 13th Congress of the Council of Mining and Metallurgical Industries held in Singapore in 1986. He was AusIMM Honorary Treasurer from 1987 to 1996 – a difficult time for the Institute – and served on the AusIMM Council (predecessor of the AusIMM Board) from 1992-1996.

In 1997, Don received the Beryl Jacka award 'in recognition of his long association and major contribution to the affairs of the AusIMM and his significant and sustained services to the minerals and petroleum industries.' In 2000, Don was elected President of AusIMM at a pivotal time in the reorganisation and restructuring of the Institute. During his Presidency, Don travelled extensively to visit as many Branches as possible and stressed the need for AusIMM to provide scholarships, bursaries, course recognition, conferences and publications. In 2009, Don was made an Honorary Fellow.

In addition to his various roles with AusIMM, Don served on other industry bodies including Chair of the World Gold Council, 1997-99, and as Treasurer of the International Council of Mining and Metallurgical Institutions (CMMI).

In 2011, a suggestion was made that there should be a history of WMC written and published. Don took on the task to chair a small committee that was charged with the responsibility of finding an author to write the book and to see the project through to completion. More than 80 former WMC employees contributed to the costs involved in the writing, production and publication of *Mandarins and Mavericks: Remembering Western Mining 1933-2005*, which was published in 2017.

'We will miss his wisdom, dry humour and leadership.'

Seeing this project through to a successful conclusion was no mean feat, and Don utilised all the characteristics he had displayed during his working career: an intelligent and enlightened approach to the task, a determination to see it successfully completed, and the ability to retain his dry sense of humour even at the most difficult of times. Sadly, towards the end of this project, Don's health deteriorated but he continued to be involved to ensure the project was successfully completed.

He passed away peacefully at home on July 18 and is survived by his wife, Jane, sons Samuel and Hugh, grandchildren, Luther and Marcel and sister, Colyn Storer.

Don Morley made a significant contribution to the growth and development of WMC, AusIMM and the broader Australian mining industry. He will be sadly missed by family, friends and colleagues.

Michael Oley

1944-2019

Liz Oley

After graduating in Chemical Engineering from the University of Queensland, Michael Oley joined the CRA (now Rio Tinto) Group at its operations in Broken Hill, NSW. He was based there eight years, although he spent extended periods at Weipa, North Queensland and Palabora, South Africa.

In May 1975, Michael joined the corporate consulting group of Roan Consolidated Mines (RCM) at their head office in Lusaka, Zambia. RCM operated a number of copper mines, smelters and refineries, as well as cobalt and precious metals processing facilities on the Copperbelt of Zambia.

On return to Australia, Michael rejoined the Rio Tinto Group at its Australian corporate headquarters in Melbourne where he spent the next 10 years working on corporate strategy, particularly in the area of technology. His work involved extensive travel to Europe, the USA and Japan. During this time he also completed postgraduate studies in mineral economics.

In late 1988, Michael joined a small team within Rio Tinto who were examining the feasibility of developing a large open pit gold deposit at a remote location in the Indonesian province of East Kalimantan on the island of Borneo. For the next three years, he remained based in Melbourne although he spent over half his time outside Australia. The feasibility study was positive and in early 1992 he moved to East Kalimantan as Director of Operations.

For five years, he lived in the coastal town of Balikpapan, from where he commuted by helicopter to the mine site on a weekly basis. In early 1997, Michael took up a consulting position in Jakarta at Rio Tinto's country headquarters where he was involved with environmental issues associated with the group's Indonesian mining operations. As an ex-colleague from Grasberg pointed out, Michael worked with others to get the expansion environmental approvals for the increase in concentrator capacity from 115 kt per day to 250 kt per day.

It was a time of great change in Indonesia with the downfall of Soeharto, the first free elections in almost fifty years and the granting of independence to East Timor. In mid-2000, Michael took early retirement from Rio Tinto. At his farewell he said 'My involvement with Kelian will remain one of the highlights of my working life. Despite what some of the more radical members of the green community might have us think, major mines are not developed that often and to take part in the final exploration stages through feasibility studies, final design, construction, commissioning and operations is an experience that doesn't come very often. I was lucky enough to have that experience at Kelian.'

Michael returned to Melbourne with his wife Liz and became a full-time student at the University of Melbourne. After completing a number of undergraduate subjects in Art History and Philosophy, as well as learning Ancient Greek, he did a fourth year in philosophy, gaining first class honours. He was part way through a PhD in Philosophy when his supervisor took another job. His research area was the aesthetic theories of the 18th century German poet, dramatist and philosopher Friedrich Schiller, and he was examining the relevance of his ideas to the role of beauty and art in modernity.

Michael Oley died unexpectedly in his sleep on 16 February 2019.

Dr Anthony Richard 'Tony' Norman

1959-2019

Russell Penney FAusIMM, Doug Brewster, Phil Uttley and Guowei Xu

Tony Norman, a well-known and respected international exploration consultant and expert structural geologist, died suddenly and unexpectedly at his Melbourne home in May. Born and raised in Sydney, Tony embodied a strong family ethos and displayed much energy, practicality and intellect in everything he pursued. Like many of his peers, Tony developed his love of being in the outdoors as a Boy Scout: fishing, bushwalking and mountaineering were lifelong passions.

This upbringing led to a career in geology and by 1981 Tony had earned a BSc (Hons) and MSc from the University of Sydney. Tony joined the university bushwalking club and walked throughout the Blue Mountains, and in later years scaled many peaks with friends: the remote mountains of Patagonia, the Cameron Hills of Fiordland, New Zealand, the Ruwenzori Mountains of East Africa and the wilds of South West Tasmania.

After university, Tony first worked at the NSW Department of Mineral Resources and then completed a PhD in 1991 at Macquarie University by undertaking a doctoral thesis on the structural geology of the Aruntas, Northern Territory.

After returning from post-doctoral work in Canada in 1994, Tony worked with the Etheridge, Henley and Williams consulting group, based in Canberra, on international assignments, gaining experience in mineral exploration and an assignment at Porgera Mine. In 1998, Tony joined Pasminco Exploration as a Principal Geologist for Project Generation in South America. He gained the nickname 'Stormin' working in Peru and Mexico searching for carbonate hosted and high-sulphidation base metal deposits.

From 2001 to 2005 he worked with Placer Dome in Australia and China, mainly on geological modelling of gold resources. He then joined Sino Gold Mining in 2005, working on the geology of the Jinfeng mine in Guizhou Province, southwest China, where he helped to mentor and train the Chinese geology team. He subsequently headed a Sino Gold–Gold Fields generative alliance exploring for intrusive-related gold-copper deposits throughout China, and the technical services unit at Sino Gold, until its takeover by Eldorado Gold Corp in 2009. Subsequently, Tony became a world-roving consultant, adding many destinations and projects to his experience.

Tony was a redoubtable field geologist and mineral explorer; no amount of discomfort would restrain him from getting his hands on the rocks. His focus was always on the detailed geology and technical aspects of finding orebodies. Wherever Tony went to work he demonstrated a quiet energy, determination and commitment to the task at hand. Tony passed on a high degree of professionalism through his mentoring and patient training of many geologists that he worked with overseas; Tony developed many friendships which he continued to maintain. He remains highly respected by all his colleagues.

In addition to his mastery of geology and exploration, Tony was a polymath who enjoyed wide interests. He was a very keen and lifelong fisherman, having learnt the art as a boy on Sydney Harbour and the annual family holidays to Port Stevens.

Tony enjoyed a great generosity of spirit with family and friends. He hosted his beloved mother Gwen, nephews and nieces on several grand international trips in recent years. He was a very gracious and generous host to friends with many of us given spare keys to his smartly restored inner city cottage, and many enjoyed salubrious stays.

To those of us who knew Tony well his sudden and completely unexpected death has been a great shock. At his funeral ceremony he was surrounded by long-time family and friends with many different trades and interests he had embraced during his multifaceted, but also very geological, life.

Ave Tony.

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The Australasian Institute of Mining and Metallurgy was founded in 1893, and incorporated by Royal Charter in 1955. To find out more about AusIMM visit **ausimm.com**

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