AusIMM LEADERSHIP FOR RESOURCES PROFESSIONALS

bulletin

December 2019

EXPLORATION
DATA-DRIVEN APPROACHES

VIEWPOINT
CHANGING THE FACE OF MINING

UNDERGROUND MINING
CREATING HEALTHIER ENVIRONMENTS

SETTING THE BENCHMARK

Owen Hegarty on developing world-class people, leadership and standards

bulletin

Contents

December 2019

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Regulars

Lead articles

Viewpoints

Articles

Special feature: Exploration

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President's editorial

AusIMM leading on a world stage

AusIMM members are some of the finest practitioners in the world, and can be found living and working all over the globe. By committing to our Code of Ethics each year when we renew, AusIMM members reinforce our promise to uphold the highest professional standards and our commitment to continuing professional development.

As a result of AusIMM's leadership on standards, it is fitting that companies, governments and communities all over the world look to us and our people for safe, sustainable and productive outcomes. We are committed to showcasing and sharing the tangible contributions and critical role that our people play to a much broader audience, so that our communities can better understand and appreciate the work we do and the value we create.

For AusIMM, the most effective way to share these stories is by continuing to build strong and mutually beneficial relationships with like-minded international organisations, through the delivery of conferences and other technical content to delegates from around the world, and by our leadership in industry through codes and standards such as JORC.

Our people are renowned for exporting resources, technologies, systems and solutions to every corner of the globe. This expertise, underpinned by trust and the highest professional practice, is something to be celebrated.

Janine Herzig FAusIMM(CP)
President, AusIMM

CEO's editorial

Delivering on our strategy

Throughout 2019, AusIMM has continued to deploy our strategy to be a stronger and more effective organisation.

We have delivered an impressive program of high-quality technical conferences with strong delegate support – in some cases up 50 per cent on previous numbers. Our industry is in good health and our conferences are hitting the mark in providing world-class forums for sharing knowledge.

We are positioning AusIMM as a better-connected organisation. The relationships we have forged in 2019 will help us deliver critical professional development initiatives to a broader audience, and help us prepare for an even better future for our sector.

We expanded on and delivered our online JORC courses, and are leveraging these to build a stronger international presence. This work showcases our role as custodian of the global standards that underpin confidence in our industry.

Behind the scenes, our digital transformation is ensuring that AusIMM is well-positioned for the future to deliver better service to members no matter where they are.

All this work is positioning AusIMM to have a stronger profile as the Trusted Voice of the resources sector. As an organisation backed by a Royal Charter, we are committed to AusIMM being the credible voice of reason with our views backed by data and science, not anecdotes and emotion.

As we continue to become a more relevant organisation, we are growing our profile to better represent the people in resources, who are building a more prosperous future for the communities that we are all a part of.

Stephen Durkin FAusIMM
CEO, AusIMM

AusIMM New Leaders Conference 2019

AusIMM's New Leaders Conference (Perth, 1-2 October) brought together 200 university students and young professionals from all over Australia. The long-running conference series helps develop student and graduate mindsets, and gives a unique opportunity for delegates to network with peers and mining employees.

A selection of students were also invited to visit Immersive Technologies' new 'Experience Centre' in Perth, which demonstrates the latest technology and best practice in the sector through simulation technology and other hands-on exhibits.

A/Prof Thierry Peynot speaking at New Leaders 2019.


Students from New Leaders were also invited to visit Immersive Technologies' new Experience Centre in Perth.

AusIMM President 2020

AusIMM President 2019 Janine Herzig FAusIMM(CP) has been nominated by the AusIMM Board to serve for a second term as President in 2020.

Janine, the AusIMM Board and Management Team are continuing to work closely together to keep building AusIMM's profile as the Trusted Voice for all resources professionals and as an inclusive, relevant and contemporary organisation.

Janine Herzig (left) with student members at the 2019 AusIMM Awards Dinner.

AusIMM signs agreements to strengthen ties with industry in Indonesia

AusIMM is pleased to announce that we have signed a Memorandum of Understanding (MOU) with Indonesia's Association of Exploration and Mining Development (EMD).

On 8 October in Jakarta, AusIMM and EMD agreed to work together to develop the exploration and mining community, exchange knowledge and information for both organisations' members, and to assist in implementing programs that will benefit members by increasing their professional knowledge.

AusIMM also took another step forward in our international strategy, signing an MOU with the Australia Indonesia Business Council (AIBC) at IMARC on October 29. The MOU commits our organisations to working more closely together to support mining professionals in both Australia and Indonesia.


Myke Jones, EMD Indonesia and AusIMM CEO Stephen Durkin.

Election of three Directors to AusIMM Board

AusIMM members have elected three Directors to the AusIMM Board for the period 2020-2022:


Chris Carr FAusIMM(CP)


Dave Clark FAusIMM(CP)


Sara Prendergast MAusIMM

The new Directors will commence their appointments on 1 January 2020. Dave Clark and Sara Prendergast are current Directors who have been re-elected, and therefore continue as members of the Board.

A field of six candidates nominated for the election. All candidates are thanked for their commitment to AusIMM and their willingness to make a further contribution by standing for election to the Board.

AusIMM acknowledges outgoing Board members Immediate Past President Colin Moorhead and Director Chris Davis, and thank them for their dedication and commitment to AusIMM. Colin has served as an AusIMM Director from 2014-2019, including AusIMM President in 2017-18; Chris has served as AusIMM Director from 2012-2015 and 2017-2019.

AusIMM formalises partnership with Yokogawa Australia and New Zealand at IMARC

AusIMM has formalised its new partnership with Yokogawa Australia and New Zealand at a special signing ceremony at IMARC 2019 on Tuesday 29 October.

The signing ceremony featured traditional Japanese elements, including sake tasting and the display of daruma dolls, a symbol of perseverance and good luck.

The signing formally marked the start of a partnership with AusIMM to draw on both organisations' expertise to explore the impact of digitalisation on the industry, and showcase technological developments and innovation to industry professionals.

Greg Hansen and Stephen Durkin at the partnership signing at IMARC 2019.

AusIMM announces partnership with Austbrokers Countrywide

AusIMM is pleased to announce a new partnership with insurance and risk management specialists Austbrokers Countrywide.

The partnership will deliver on a joint commitment to best practice, protection and safety for industry professionals.

Working closely with Austbrokers Countrywide, AusIMM will explore the latest thinking and best practice in professional indemnity insurance keeping members up-to-date through webinars, online articles and other professional development activities.

As the peak body for resource professionals, CEO Stephen Durkin said AusIMM is looking forward to formalising its pre-existing relationship with Austbrokers Countrywide and continuing to provide valuable information for professionals across the AusIMM network.

'Austbrokers Countrywide has been operating in Australia for more than 65 years and engages directly with our members across the whole country including international projects. We are looking forward to continuing to collaborate with Austbrokers Countrywide for the benefit of our AusIMM membership, particularly those working as consultants in the sector.'

Austbrokers Countrywide Director Greg Hansen said he welcomes the partnership and is looking forward to continuing to outline the importance of professional insurance and risk management with the help of AusIMM.

'It is important for professionals to have the correct insurance and to engage in good risk-management strategies when involved in mining consulting work. With experience in helping consultants in the resources sector, Austbrokers Countrywide can assist people to choose the insurance policy that is right for their circumstances.'

The partnership was signed at the AusIMM stand at The International Mining and Resources Conference (IMARC) on Tuesday October 29.

Victorian AusIMM Women on Boards Scholarship winners announced

AusIMM, together with the Victoria State Government Department of Jobs, Precincts and Regions, is delighted to announce the winners of a new scholarship program to increase the number of women on boards in the resources sector and beyond.

The scholarship program launched last month as a three-year pilot program, and recognises the expertise of technical women in the resources industry of Victoria and the need for more women and more diversity of women in our boardrooms.

Three outstanding and experienced women – Sarah Callil, Tara Halliday and Loretta Fallaw – were awarded the scholarship, which will see them go on to complete a series of AICD courses and be profiled through AusIMM events and publications.

Sarah Callil, Director of Growth and Innovation at Worley, started off with a Bachelor of Engineering at Melbourne University and has worked at Worley for 18 years, completing her Master of Business Administration in this time. In her application Ms Callil spoke persuasively about the benefit of the scholarship to help achieve goals for the industry.

Tara Halliday, a Principal Environmental and Social Consultant at Coffey, began her career in Environmental Engineering at RMIT and has been working in environmental and social consulting for over 20 years, having spent the last 12 at a senior management level in the resources industry. Ms Halliday impressed the judging panel with her strong commitment to community and experiences on not-for-profit boards over her career, a strong foundation for her pathway onto boards in the sector.

Loretta Fallaw, a development and approvals manager at Donald Mineral Sands, started out with a Bachelor of Engineering. Her application exemplified life-long learning and a commitment to professional development, having completed several courses and training seminars across her time in the industry. Ms Fallaw's experience in regulatory approval process, particularly at a Victorian level, set her apart as a candidate for the scholarship.

The recipients will take part in two courses through the Australian Institute of Company Directors, including the Company Directors course, and will receive facilitated introductions to recruitment organisations through the AusIMM for potential board positions, as well as profiling opportunities in the *AusIMM Bulletin* and across social media.

AusIMM at IMARC: celebrating our Global Community of Mining

IMARC 2019 drew more than 7000 resources professionals from around the world to Melbourne from 29-31 October, and as a proud Founding Partner of the conference (alongside the Victorian Government, Mines and Money and Austmine), AusIMM took a leading role in making the conference an outstanding three days of knowledge sharing and networking. AusIMM showcased our Global Community of Mining at IMARC 2019, with a packed three-day program of speakers, events and activities.

AusIMM's world map filled with delegate pictures.

Tuesday 29 October

AusIMM CEO Stephen Durkin opened the 'Global Market Trends' plenary session on the first morning of the conference. At the AusIMM stand on the exhibition floor, a number of presentations and networking events provided delegates with the opportunity to learn more about AusIMM's professional development offerings, as well as taking part in our 'Global Community of Mining' campaign, where photos of delegates were taken to fill our world map.

At Tuesday's morning tea, AusIMM's JORC subject matter experts shared key insights about our community-based online courses. At lunchtime, representatives from the membership team shared the benefits of membership and what's on offer for members in 2020.

During the afternoon break, AusIMM Manager of Accreditation Programs John Theodoulou presented on AusIMM's Chartered Professional (CP) Program and answered questions about becoming a CP.

The first day wrapped up with a well-attended networking event.

Wednesday 30 October

Wednesday morning featured Federal Resources and Northern Australia Minister The Hon Matt Canavan giving the opening ministerial welcome at the start of a plenary session on sustainable mining principles and social licence to operate.

At morning tea, AusIMM was joined by representatives from the Australia Indonesia Business Council to sign a Memorandum of Understanding.

At lunchtime, co-founder of IWIMRA Florence Drummond joined AusIMM at our stand to reaffirm the ties between the two organisations and network with delegates. Florence, whose story featured on the cover of the October *AusIMM Bulletin*, spoke passionately about building connections and creating conversations that showcase Aboriginal and Torres Strait Islander people in mining.

Thursday 31 October

Thursday saw the focus shift to the next generation of resources professionals, with AusIMM hosting mining recruitment experts Swann Global who offered resume reviews for students and recent graduates visiting our stand.

At lunchtime, Dr Ali Burston shared information about AusIMM's 2020 Mentoring Program, and spoke about the benefits for both mentees and mentors. For more information on the benefits of mentoring, see Dr Burston's article on page 36.

Over the three days, hundreds of people stopped by AusIMM's stand to take part in our Global Community of Mining campaign, filling our world map and sharing stories of where they had lived and worked. The campaign showcased how truly international the resources sector is, and highlighted once again that the strength of AusIMM is in our dedicated community of people.

Florence Drummond and Stephen Durkin.

Dallas Wilkinson and Dr Ali Burston.

AusIMM networking event on Tuesday 29 October.

AusIMM deeply concerned by nature of protests at IMARC 2019

As the peak body for professionals in the resource sector and an IMARC founding partner, AusIMM was deeply concerned by the nature of the protests targeting conference delegates.

Many trying to enter the conference were subject to poor and in some cases aggressive behaviour from some of the protestors.

The IMARC demonstrations appeared to be targeted by those with extreme views. The protests specifically and unfairly targeted the fossil fuel industry and ignored the fact that IMARC is a forum for the broader mining industry to collaborate on sustainability and to promote the development of mineral resources and technologies to address the global needs of society.

It is clear to most observers that the mining industry provides the raw materials that society needs. Almost everyone agrees mining is necessary, but must be done to the highest professional and ethical standards.

The AusIMM exists for exactly this reason, and provides assurance and builds trust through accreditation, professional codes and standards, and by providing continuing professional development and collaboration opportunities to share knowledge, so that policy debates and conversations are led by scientific fact and not emotion or ideology.

AusIMM Tarkwa Student Forum – Fourth Annual Conference

Recently the AusIMM Tarkwa Student Forum held their annual conference, sharing insights to members and students and providing an opportunity to network with industry professionals.

The conference's main theme was highlighting the importance of education and development in careers for the resource sector, as well as establishing a solid future for sustainable economic growth.

The conference was held over one day with a large panel of keynote speakers willing to share their insights and support for mining education. Students heard from professors and industry professionals about developing career skills and the necessity for education and development opportunities to create fulfilling careers.

Theophilus Mensah, former president of the AusIMM Tarkwa Student Forum and now mining engineer with Perseus Ghana Mining Limited, highlighted major myths every graduate engineer has about the mining industry, and spoke about the transition from graduate to resources professional.

With an emphasis on where students would like to take their careers in mining, this conference was the perfect opportunity to gain inspiration from industry professionals and potential mentors.

A solid support system is invaluable to any student wanting to develop their skills in mining, and being a student member of AusIMM grants opportunities for networking and a supportive community to help create a strong career in mining.

AusIMM Tarkwa Scholarships

The AusIMM Tarkwa Scholarships are a joint initiative to support those studying mining at the University of Mines and Technology in Tarkwa, Ghana.

Two scholarships, worth AUD$750 each, are awarded to help students with educational costs. Visit the AusIMM website for more information.

Core Skills 2019: Brisbane Exploration Data Centre

This year's running of the joint AIG/AusIMM 'Core Skills' five-day course occurred in late October at the Queensland Government's Exploration Data Centre (EDC) in Zillmere, Brisbane. It was the third event in the series to date, following on from the initial two-week event in 2015 and a one-week version in 2018.

This year saw 22 attendees at the course with participating geoscientists travelling from as far as Tasmania, Perth and Mongolia. The EDC is one of two major core storage facilities run by the Queensland State Government, and has been the venue for all courses to date given the extremely strong support and assistance we enjoy from EDC staff, who help to deliver the course by managing all the core retrieval and layout logistics.

The Core Skills course aims to develop introductory-level industry-focused skills for students, recent graduates and early career geoscientists in the areas of core logging, sampling, assaying, QAQC and data interpretation.

Read the full report at **www.ausimmbulletin.com**.

AusIMM announces six-year partnership with BHP

AusIMM has announced a six-year partnership with BHP that will deliver technical and leadership conferences for resources sector professionals.

The partnership will bring the industry leaders together on AusIMM's renowned conferences. BHP will provide technical expertise, support, and ongoing collaboration opportunities through the conference series.

AusIMM is a member-based, not-for-profit professional association, and a world-leading provider of industry conferences. AusIMM has a long history of providing high-quality events to thousands of people each year, and its extensive conference calendar advances professional development, increases technical knowledge and expands industry networks.

As a global resources leader, BHP is deeply committed to best practice across its world-wide operations. The company's investment in AusIMM highlights the shared commitment to professional knowledge sharing, and promoting and upholding industry codes and standards.

AusIMM CEO Stephen Durkin said the partnership would strengthen AusIMM's already renowned reputation as a leading knowledge provider for people working in resources.

'BHP's long-term investment will help AusIMM deliver critical professional development initiatives to a broader audience, and drives AusIMM forward in meeting our core aims of upholding the highest standards of practice within the industry.

'The broader audience will in turn help us develop our communities and foster strong relationships between all professionals and stakeholders in resources.'

Laura Tyler, BHP's Chief Geoscientist and Asset President – Olympic Dam, said the partnership reinforced BHP's commitment to technical leadership and innovation.

'BHP and AusIMM share a common goal of promoting and sharing world's best practice. This partnership will increase the visibility of technical professionals, foster more collaboration and idea-sharing on critical issues, and provide opportunities to upskill the global resources workforce.'

The partnership was signed at BHP's Adelaide offices on Wednesday 13 November, in front of leaders and representatives from both organisations.

AusIMM

Leading the way for people in resources

Thank you for being part of our global community of mining in 2019. We're proud to represent over 13,000 members in more than 100 countries.

Join us in 2020 and share our commitment to uphold standards, create communities and connect professionals.

ausimm.com/renew

AusIMM member benefits

Shaping careers

Access a year-round program of world class professional development opportunities including technical conferences, leadership events, online courses, webinars and publications.

Developing leaders

Receive global recognition with your AusIMM postnominal, uphold professional codes and standards, celebrate excellence at AusIMM awards and access mentoring programs.

Connecting professionals

Enjoy networking with professional peers and industry leaders at AusIMM conferences and events and via our Community of Interest groups.

Sharing knowledge

AusIMM members receive access to the AusIMM Bulletin, OneMine the global mining database, digital publications, video content and more.

AusIMM

Conference and Event Series

Plan your 2020

ausimm.com/conferences

AusIMM delivers world class technical conferences and leadership events to thousands of industry professionals each year. Our comprehensive 2020 program offers people working in the resources industry opportunities to advance professional development, increase technical knowledge and expand industry networks.

- AusIMM PD hours
- Knowledge exchange
- Discover latest trends
- Interact with industry experts
- Network with your peers

INTERNATIONAL WOMEN'S DAY 2020
Brisbane | 2 March
Sydney | 3 March
Melbourne | 4 March
Adelaide | 5 March
Perth | 6 March
Hobart | 10 March

UNDERGROUND OPERATORS CONFERENCE 2020
Perth | 25–27 March

MINING LEADERSHIP SUMMIT 2020
To be announced | May

MINESAFE INTERNATIONAL CONFERENCE 2020
Perth | 3–4 June

LITHIUM AND BATTERY METALS CONFERENCE 2020
Perth | 23–24 June

INTERNATIONAL URANIUM CONFERENCE 2020
Adelaide | 1–2 July

AUSTRALIAN MINING LEADERS FORUM 2020
London | 14–15 July

MINE WASTE AND TAILINGS CONFERENCE 2020
Brisbane | 28–30 July

LIFE OF MINE CONFERENCE 2020
Brisbane | 26–28 August

THOUGHT LEADERSHIP SERIES 2020
Melbourne | **Sydney** | **Brisbane**
Adelaide | **Perth** | Dates to be announced

MILL OPERATORS CONFERENCE 2020
Brisbane | 9–11 September

OPEN PIT OPERATORS CONFERENCE 2020
Perth | 21–22 September

NEW LEADERS CONFERENCE 2020
Brisbane | 28–29 September

OREBODY MODELLING AND STRATEGIC MINE PLANNING CONFERENCE 2020
Perth | 23–25 November

AUSROCK CONFERENCE 2020
Sydney | 1–3 December

Setting the path for success

One of Australia's most experienced mining identities believes this country can – and should – set standards for the industry worldwide, with AusIMM having a critical role to play

Liz Swanton

Owen Hegarty denies with a laugh that he is thinking about world domination, but he firmly believes Australia is on track to take a leading role as the mining industry moves forward into the 21st century.

'Aussie leadership is terrific. Whether it is leading groups, teams or companies, we're very good at it. We're rigorous and reliable, so it's a very good set of standards and conduct for others to follow.'

Currently the Executive Chairman of specialist mining private equity company, EMR Capital, Owen has had more than 40 years' experience in the global mining industry.

He is also a long-standing member and former director of AusIMM, and has been recognised for his achievements through several prestigious awards, including the Institute Medal (2005) and Honorary Fellowship (2019). He believes AusIMM is facing a great opportunity to grow its influence worldwide.

'The world needs AusIMM to be more expansive in its influence internationally, because we have world-class people, leadership and codes and standards. We need to use these world-wide – not as a competitive thing but as a seriously necessary thing for the mining, metals and minerals supply side.

'We are supply-side people, so we must ensure that metals and mining continue to meet demand, but in a professional, proficient, well-governed way.

'I see AusIMM playing a bigger role. Our standards are so good, we should be shaping and helping as much as we can, particularly with more demands from regulators and governments.'

Owen believes this type of leadership is particularly crucial at a time when the industry is facing complex challenges, especially in regards to social value and stakeholder engagement.

'The handbooks you need for doing the business these days are still being written,' Owen says. 'We're still pioneers, and I think it is situations like this which offer AusIMM a chance to take the lead because it is one of the credible institutions. And that's where I would love to see it more well known – as one of the best in the world in terms of standards and credibility.'

Owen's pedigree gives him carte blanche to make such an observation. His long career in the industry includes 24 years with Rio Tinto, starting as a junior and progressing through the ranks to head up the company's Asian and Australian copper and gold businesses.

He led Oxiana from the mid-1990s, taking the company from a junior explorer to a multi-billion dollar Asian and Australian explorer, developer and operator in base and precious metals. Owen then formed EMR Capital, a Melbourne and Hong Kong-based private equity firm that has eight mining projects and operations worldwide. ▶

'The world needs AusIMM to be more expansive in its influence internationally, because we have world-class people, leadership and codes and standards.'

Profile

He credits the people and culture at Rio Tinto for shaping his approach to the business and his subsequent success, having started with the company in the days when it was headed up by legendary chairman and chief executive, Sir Val Duncan.

‘What a wonderful company and wonderful people. I spent time in all commodities, all companies, all countries thanks to Rio, and I was extremely lucky to do so. There are too many great people, legends and mentors to mention but I have strived to follow in their footsteps because they encouraged that.’

Owen says the three things that stand out from his time there were the importance of rigour and discipline, a positive disposition, and being growth oriented.

Working in the business evaluation department in London with John Simkiss, one of many mentors he acknowledges with gratitude, Owen describes his role as a ‘spreadsheet jockey’. That meant he was responsible for researching and writing. He learnt, early on, the how-to of project evaluation.

‘It was all very rigorous, disciplined, growth oriented and entrepreneurial – certainly Val Duncan was – but also risk averse. It was a good balance of learning to grow the business, and business value, as well as ensuring downside protection. I was greatly impressed by all those wonderful people that I had the opportunity to work with and talk to over a long period of time.’

From those junior days – which include memories of running (literally) print-outs of ore prices from head office to IBM and back again to enable project decisions to be made – Owen made his way onwards and upwards through the company, working in a range of different roles.

He gained much along the way from some of the greats in the industry, a variety of mentors who taught him different ways of looking at the business and understanding it. Many had a great capacity to communicate and encourage, and as he gained the benefit of that, he also became determined to replicate it.

‘They were very good at ensuring that whatever you are doing, you pass on the lessons of the good, the bad and the ugly. So now when I get in the room, and we have people everywhere – everyone from the chairman to the spreadsheet jockeys, at least I can relate to them.

‘I can bang on a bit – not pontificating but just giving people clues as to how we should look at this, why we should do that, why we should think about this, what about the upsides, what about the downsides, what about the sensitivities. I try to do this so people know these are the sort of things that have to be taken into consideration when you’re making big decisions. It’s about encouraging and communicating.’

Given so many memories are about the people he has met along the way, it’s not surprising that Owen rates people as one of the most important ingredients in the growth and success of any company – but they have to be special people and looked after.

‘My mantra is that you want people who are skilled. That’s number one. They must have the background, the experience, the training, in whatever discipline it is, whether they are the financial evaluator or your general manager of operations.

‘Number two is commitment. That’s all about motivation, persistence, resilience, the striving to succeed, the ability to focus and prioritise, to take things all the way through. It’s one thing to have the skills, but you need the commitment to see it through.’

‘Nothing can take the place of persistence. I think American president Calvin Coolidge said something along those lines, but the simpler one is the Japanese definition of persistence,’ he chuckles. ‘That is: if you get knocked down six times, you have to get up seven times.’

The third important ingredient for success, perhaps obviously, is having the right asset: the right commodity in the right country with the right strategy. Then there is what comes next, as the company grows.

‘Always work on the development of your people. Nurture them. You spend time and energy on a project, so you have to spend time and energy on your people, bring them up in terms of training and development, whether it is in the rainforests of Laos or at company headquarters.

‘Aside from what I learned at Rio Tinto, I’ve always worked with the ideas of Stephen Covey, who wrote *The Seven Habits of Successful People*, which is very people-oriented. Another good one is Jim Collins’ *Good To Great*, although it’s a bit more corporate.

‘I still refer an article or a book to the people I work with. I know they don’t have time to read it all, but if they get one or two things from it that helps build their career, that’s important.’

Owen’s approach to life and work, and the importance of people, started long before his time at Rio, although those years underlined the early lessons. Born and bred in country Victoria, Owen credits his parents for their efforts and a work ethic that was handed down to the four boys they loved so much.

‘They were devoted to our education and upbringing and we are eternally grateful for that. You’re never grateful for it at the time, but you are grateful for the rest of your life that they spent such a big chunk of their lives working for us.’

Early years were spent in places like Yackandandah in north-east Victoria, and Morwell in the Latrobe Valley, due to his parents’ various business interests. Later his mother turned to teaching English and maths in the South Gippsland area and he was one of her students. It’s a time he remembers fondly.

‘It was school, sport, Saturday night pictures, Sunday school, repeat – because that’s what life was like back then. And my best memories of that time, aside from my family, was exactly that pattern repeated. Sunday school was a bit of a chore until we stopped doing that, but we kept doing everything else and I loved it.’

When school was done, he headed for Melbourne’s Monash University and earned an honours degree in economics. When asked about his study choice, Owen says he was looking for something that would give him a feel for how the world works and economics seemed to give that broad coverage.

‘I think it actually teaches you to be a jack-of-all-trades and master of none. You can end up quite multi-disciplined, and work across different types of economies, political regimes and industries.

‘From that perspective, it was a good grounding for a general management and worldly type of career in a mining company like Rio. Of course my brothers would say I had to do economics because I couldn’t do anything else,’ he laughs.

It probably comes as no surprise to learn that what Owen is most proud of in his career is the same gift his mentors gave him: helping others succeed. He’s a strong believer in teamwork and taking people on the journey – if the ‘game’ is played properly, you improve your own game at the same time as you help others to improve theirs.

‘I am happy I’ve been able to help people grow in their jobs, in their lives, in their professional aspirations. It’s about giving people clues, I suppose, and helping them by demonstration, particularly when it comes to education and development, and career shaping and planning.

‘It’s been said that experience is what enables you to recognise a mistake when you make it for the second time. I don’t know where this came from, but it’s one of those definitions that you learn from – or you should!

‘One of the most important lessons for me in my career has been that whatever you do, when you recognise it as a mistake, don’t do it again. And, if possible, make sure other people don’t do it too.

‘So to see people prosper and blossom,’ he says, ‘is something I am proud of, when I have helped and it has worked for them. It’s really good when you know you haven’t given someone a bum steer!’

AusIMM Professional Employment and Remuneration Survey 2019

AusIMM's annual summary report on professional employment in the resources sector suggests a sustained upturn in employment and continued sector confidence

Professor Rebecca Mitchell and Dr Raymond Trau, Health & Wellbeing at Work Research Unit (HoWRU), Macquarie Business School, Macquarie University; and Brigid Meney, Senior Adviser – Policy and Media, AusIMM

AusIMM is the peak body and trusted voice for all professionals in the resources sector and represents more than 13 000 members working in Australia and internationally.

To inform its policies and strategic agenda, AusIMM conducts an annual Professional Employment and Remuneration Survey (PERS). This survey provides a unique and detailed insight into professional employment in the sector, as well as priorities and perspectives of AusIMM members. Over the next 12 months, AusIMM will strengthen initiatives and advocate for policies that respond to these priorities.

In October 2019, AusIMM invited all members to complete the survey. Responses from a generally representative sample of 2038 professionals provide a clear picture of a sector that is enjoying strong employment and a positive outlook for future growth. While there remains work to be done, a summary of the data depicts a sector that is committed to strengthening its inclusivity and the professional development of its workforce.

This is a summary report of the full survey results. A more detailed analysis of the survey will be made available to members via **ausimm.com**.

Employment

Figure 1 depicts sustained improvement in unemployment overall, which suggests that the sector continues to enjoy almost full employment. The marked decrease from over 14 per cent unemployment in 2016 appears to have stabilised. Of note, while men reported significantly greater unemployment during the earlier downturn, gender differences have now reversed. While this slightly raised proportion of women unemployed may raise some concerns, data-related limitations suggest caution in interpretation.

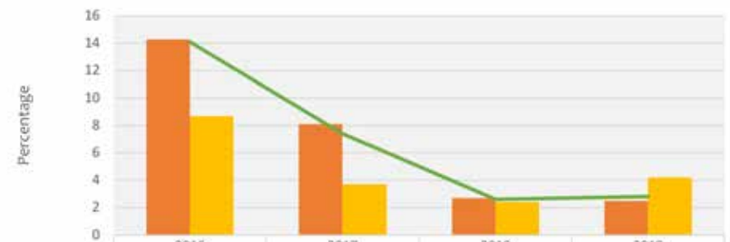
When compared to the Australian unemployment rate, the resources sector has shown some volatility (Figure 2). In 2015, Australia-based members had nearly triple the national unemployment rate. This has reduced over the past four years and remains well below the national average. This is of particular note at a time when overall unemployment in Australia is relatively low. Redundancies experienced in the sector also remained low, raising slightly from five per cent in 2018 to 7.7 per cent in 2019.

Unemployment by professional discipline (Figure 3) suggests that the pattern of sustained low unemployment is consistent across the sector. While geotechnical engineering and environmental science professionals have enjoyed consistently low unemployment rates, other disciplines, particularly geoscience, faced significant unemployment in 2016 and 2017. Since 2018, each discipline has retained a low unemployment rate.

The trend of sustained unemployment was relatively consistent across all Australian regions (Figure 4). For NSW, ACT and Queensland, unemployment is less than two per cent in 2019 with similarly low levels in 2018. Unemployment remains highest in Tasmania and Victoria, as well as South Australia and the Northern Territory.

In alignment with these low unemployment figures, confidence in the resources sector remains high. In 2015, more than 50 per cent of respondents predicted a decrease in career opportunities, and only 17 per cent perceived that sector growth was likely. However, from 2016, we saw a steep rise in confidence reflected in a predicted increase in perceived opportunities and corresponding decline in respondents predicting decreased opportunities (Figure 5). Optimism in the

Figure 1. Unemployment – total, women and men.



	2016	2017	2018	2019
Men	14.3	8.1	2.7	2.5
Women	8.7	3.7	2.4	4.2
Total	14.1	7.4	2.6	2.8

Figure 2. Unemployment – Australia-based AusIMM members.

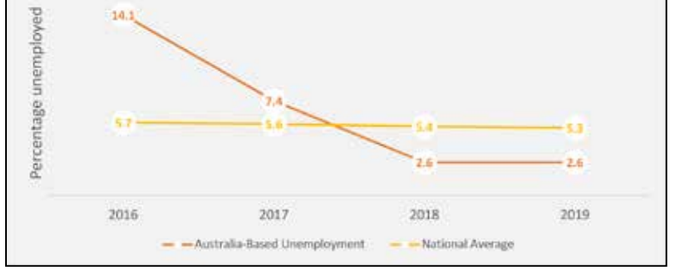


Figure 3. Unemployment by professional discipline.

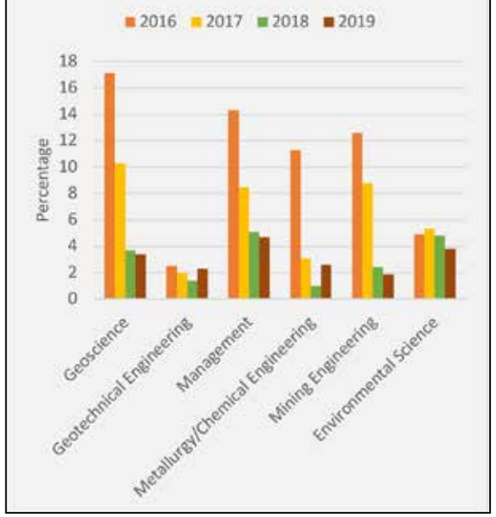
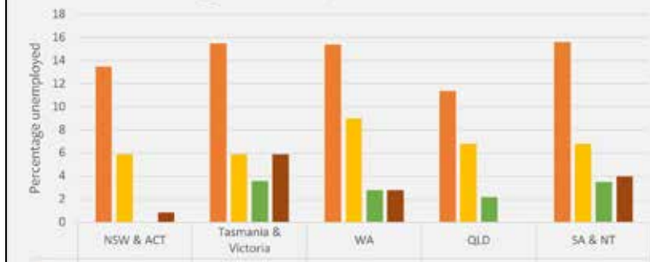
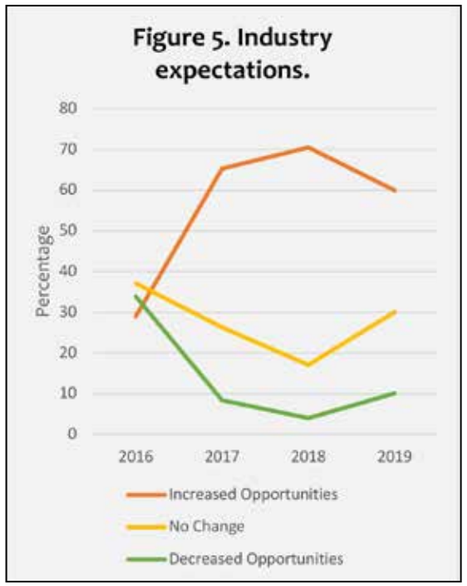


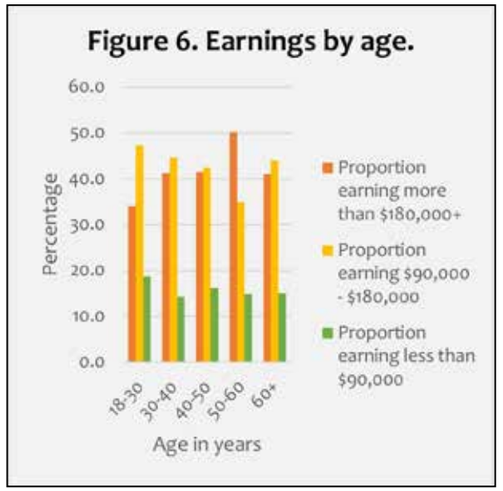
Figure 4. Unemployment by state.

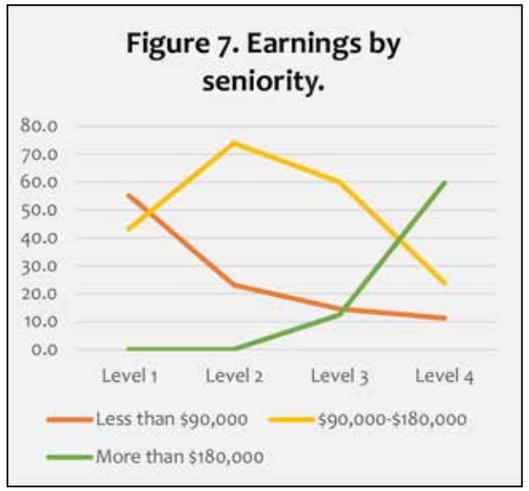


	NSW & ACT	Tasmania & Victoria	WA	QLD	SA & NT
2016	13.5	15.5	15.4	11.4	15.6
2017	5.9	5.9	9	6.8	6.8
2018	0	3.6	2.8	2.2	3.5
2019	0.9	5.9	2.8	0.0	4.0

Figure 5. Industry expectations.







sector continues, though more respondents predict that there will be a continuation of the current situation and slightly fewer predict further growth. This may reflect a realisation across the sector that skill shortages are limiting growth potential.

Twenty-nine percent of respondents rated skill shortage as the key barrier to continued growth in the industry. This reflected the most significant barrier to expansion, surpassing government regulations and 'red tape' (21 per cent) as well as barriers associated with capital approval (20 per cent). Interestingly, neither environmental concerns (11 per cent) nor community approval (7.5 per cent) were perceived as extensively limiting sector development.

Remuneration

While skill shortages may hamper industry expansion, they have likely also contributed to significant wage growth over the past 12 months. Almost 50 per cent of respondents reported a salary increase (46.6 per cent) with nearly 70 per cent of respondents (68.9 per cent) earning in excess of $130 000 per year. This supports recent ABS (2018) figures indicating that mining sector employees are the highest paid in Australia.

Salaries are relatively consistent across all ages (Figure 6). A peak in earnings is evident for those aged between 50-60 years and a slightly lower proportion of younger employees (18-30 years) earn more than $180 000. Across all age brackets, fewer than 20 per cent of professionals earn less than $90 000.

Differences in earnings across age brackets is likely to reflect seniority, at least in part. The 2019 PERS categorised work into four levels:

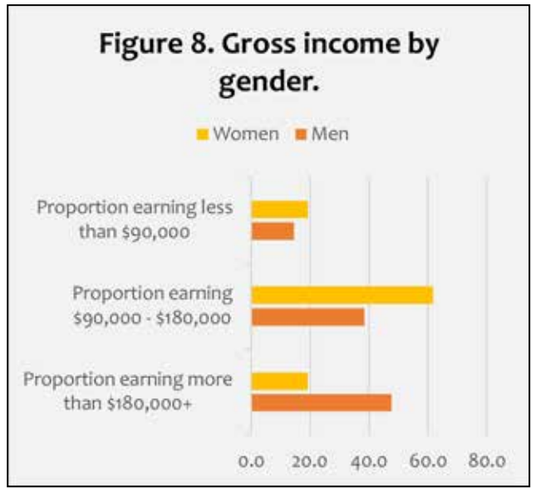
- Graduate professional performing tasks of limited scope and complexity. Approximately 3.3 per cent of respondents fall into this category.
- Intermediate professional performing duties requiring the application of mature professional knowledge under supervision. Level 2 appointments account for 8.7 per cent of industry professionals.
- Senior professional required to perform work involving considerable independence. More than one-third of AusIMM respondents appraise their level of responsibility at Level 3 (35.4 per cent).
- Lead professional usually responsible at a management level, accounting for half of AusIMM professionals (50 per cent).

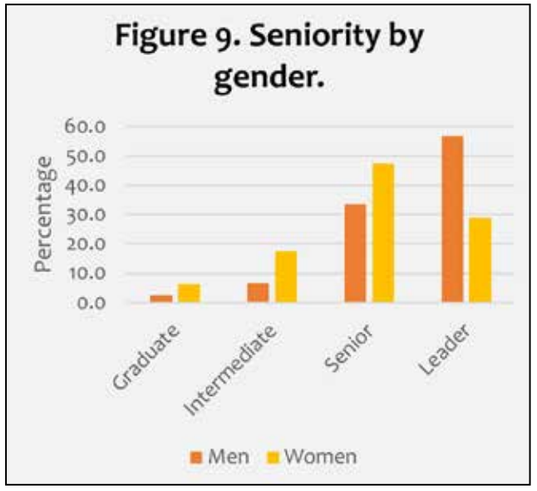
The majority of AusIMM professionals operate at Levels 3 and 4 (85.4 per cent). As expected, greater seniority, as reflected in higher level appointments, attract greater remuneration (Figure 7). The majority of Level 4 positions attract earnings in excess of $180 000.

Work patterns

The 2019 PERS collected data on the way in which professionals work in terms of their work/home proximity. Almost half of all professionals (48.3 per cent) categorise their work pattern as a local daily commute and a further 13 per cent work from home. Just over one-fifth are in fly in, fly out (FIFO) or drive in, drive out (DIDO) work arrangements and 7.5 per cent live remotely (including in outback and mining towns). These work arrangements can be challenging for both mining organisations and their employees.

In an effort to identify policy initiatives that could respond to these challenges, AusIMM explored the experience of its FIFO and DIDO professionals. While most respondents reported positively on local amenities,





'Twenty-nine percent of respondents rated skill shortage as the key barrier to continued growth in the industry.'

almost one quarter (24.7 per cent) identified professional development opportunities as requiring improvement. Improving professional development was recognised as a priority by 44 per cent of all respondents and is a major strategic focus for AusIMM.

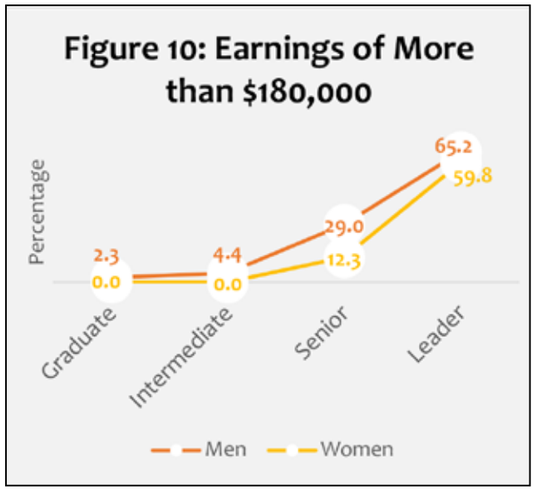
Diversity and inclusion

AusIMM and its members strive to ensure that the resources sector supports equity and diversity. To this end, AusIMM continues to provide detailed information on gender parity.

Earnings vary between men and women, as depicted in Figure 8. Substantially fewer women earn in excess of $180 000 and substantially more earn between $90 000-$180 000.

In part, this is likely to be a reflection of women's lower seniority (Figure 9). However, there is some evidence that, within the same professional level, women earn less than men.

Figure 10, which depicts the proportion of professionals earning over $180 000 by responsibility level and gender, suggests a discrepancy between remuneration provided to senior men and senior women. Further, senior women (71.6 per cent) are more likely to earn between $90 000-$180 000 when compared to men (55.7 per cent).



Differences in perceived inclusivity also persist with 27.9 per cent of women (compared to 14.1 per cent of men) indicating that they felt their industry was not very inclusive. AusIMM will continue to support initiatives designed to strengthen gender equity and inclusivity. AusIMM will again conduct its Women in Mining Survey in 2020 as part of this commitment.

Speakers at the Melbourne event. L-R: Prof Robin Batterham, Lord Mayor Sally Capp, Chris Dodd, Dr Amanda Caples, Stephen Durkin, Magdalena Ball, Janine Herzig, Prof Edward Buckingham, Stephen McIntosh and Michelle Ash.

AusIMM's Thought Leadership Series report

Following the highly successful inaugural Thought Leadership Series in 2018, AusIMM visited five locations across Australia in 2019 to bring together industry professionals to discuss the future of our sector

The series featured keynote presentations from Australia's Chief Scientists and panels exploring how science and technology is shaping the future of the resources industry.

This article is an excerpt of a longer report that looks in more detail at each of the topics covered by the keynote speakers and panellists across the event series.

The full report can be downloaded at **tls.ausimm.com**.

Summary of key themes

Ongoing advancements in science and technology have profoundly changed the resources sector. As the industry becomes more digitised, highly skilled professionals will play a key role in shaping the future of mining. Speakers and panellists discussed the rapid change we are experiencing as we move through the fourth industrial revolution, where analytics, robotics and automation are becoming regular features of mining operations.

A key theme across the series was collaboration, not only within the resources sector but between different industries. Collaboration will be key in helping professionals in traditional resources roles adapt to the future industry and allow the sector to embrace innovation and data-led decision making.

Along with this comes the responsibility to engage with the cultures and communities in which our sector operates. With a continuing shift away from the phrase 'social licence to operate' towards a discussion about 'social value', the Series highlighted a need for the industry to not only consider the impact of their operations but to make a meaningful and lasting contribution to communities. Part of this discussion is to explore what social value means in an automated and technologically advanced mining sector.

Underpinning the discussion in all locations was an inherent optimism around the resources industry. Not only because ongoing innovation will lead to further efficiencies and allow the industry to deal with more complexities, but because Industry 4.0 will see the role of highly skilled professionals become more important than ever as technological advances continue.

The Hon Bill Johnston MLA at the Perth event.

'A key theme across the series was collaboration, not only within the resources sector but between different industries.'

A dramatically changing industry landscape

The Series emphasised that technological advancement in the mining industry has been potent and wide-reaching. The impact of this is felt across the life of mining operations from design to closure. Examples include the introduction of new machinery, such as drones and robotics, that have improved productivity and efficiency; and the use of cloud computing, sensors and data analysis that can help make better decisions and re-evaluate workplace processes.

One of the most pertinent issues discussed was not just how the mining industry is taking on new technologies for individual processes, but also how we are using these advancements to fundamentally shift the industry. Mining3 CEO Professor Paul Lever believes 'we've been aggressive about taking on new ideas, but we haven't been good at investing in those, and taking them forward, and getting the full benefit out of some of those advancements.' There are opportunities across the entire supply chain around autonomous vehicles, virtual reality, drones and digitisation. The industry needs to shift its thinking to find far-reaching value from these technologies.

Delegates at the Melbourne event.

Role of the professional as an agent of change

Across the different panels, the consensus was that the resources sector will have to continue to embrace transformation in its workforce to include a more well-rounded knowledge base, rather than having circumscribed technical knowledge for each discipline. The focus needs to be on harnessing STEM techniques and also working to 'humanise this technology... to revolutionise the mundane,' Monash University Director of Engagement Professor Edward Buckingham said at the Melbourne event.

For a lot of the Series speakers, this means moving away from siloing our professionals into specific disciplines. BHP's Calvin Snodgrass noted the focus will be 'not so much [on] skillset, but mindset,' noting that 'we're going to be competing for the best, most creative thinkers and problem solvers.' Professionals will have to be more agile and multi-skilled and will also have to be open to disruptive change. Much of this comes down to the way we teach mining disciplines in university, ensuring graduates feel empowered to think more broadly.

Shaping the future – challenges and opportunities

In Adelaide, BHP Head of Supply Olympic Dam Nathan Flaman noted the potential challenges of collaboration, specifically around sharing ideas and the implications for intellectual property. However, the series uncovered an agreement among panellists that there has to be a genuine

Delegates at the Perth event.

and ongoing culture of collaboration that fosters innovation to ensure the entire industry can continue to thrive.

Yokogawa Australia & New Zealand MD Russell Palmer also commented at the South Australia event that 'collaboration should be between industries and not just within industry,' which means taking inspiration from other markets on innovation and also adopting expertise from professionals that may not have a mining-specific background. South Australian Chief Scientist Professor Caroline McMillen also commented that non-mining industries would likely begin to enter the mining sector to help with the move into Industry 4.0.

A sustainable industry in a global context

Increasingly, a major influence on the resources industry is the conversation around sustainability and social licence to operate. Monash University's Professor Edward Buckingham at the Melbourne Series event encouraged a shift toward using the term 'social value' as opposed to 'social licence' as the latter implies a restrictive, legalistic approach. Social value implies a focus on 'understanding what the local community wants, how they perceive you' and the ongoing value the industry is delivering to communities.

Northern Star Executive Manager of Capability & Culture Peta Slocombe says the true integration of this social value is when environmental, social and governance criteria compliance is seen as 'everybody's responsibility and part of the culture.' This also creates a shift where operating with social value in mind is not just an obligation but an aspiration of professionals and organisations.

'A major influence on the resources industry is the conversation around sustainability and social licence to operate.'

The importance of the Thought Leadership Series

Forums such as AusIMM's Thought Leaderships Series provide a platform for sharing ideas, challenging current ways of thinking, and most importantly, encouraging collaboration within and across industries. AusIMM has a key role to play in enabling collaboration and being the Trusted Voice of credibility, influence and respect in the resources sector.

Now in its second year, the Thought Leadership Series is firmly established as a forum for leadership and networking, with attendees saying they would be interested in attending future events. It also generated a wide range of interest from the audience in how we can continue the discussion on bringing advancements in science and technology into the resources industry.

AusIMM was pleased to receive support from our Thought Leadership partners BHP, PwC, Monash University, Rio Tinto, IMARC, UNSW, The University of Western Australia, Government of South Australia - Department for Energy and Mining and Northern Star Resources.

Mt Isa, Queensland.

Reflections, involvements and observations on my time in the mining industry

This is an edited speech that was originally delivered at the AusIMM North West Queensland Branch sixth annual regional conference.

Ian Goddard HonFAusIMM, AusIMM President 2002-03

It is wonderful to be here in Cloncurry. One of the risks of having retired people speak is that they tend to look backwards more than forwards. Perhaps it is because the past was more exciting and longer lasting than the future looks like being.

I will try to strike a balance in this speech by exploring several aspects of the past, the present and the future.

Cloncurry has a long relationship with the mining industry and was established to service the Great Australia Mine 150 years ago. My own history with the district started in 1950, when my schoolteacher father was transferred to Cloncurry School. My father and brother made a trip to Mt Isa to visit the mine, which was quite an adventure.

I spent a Christmas vacation at Mount Isa as a student, just after the big strike, returned two years later for a big mining conference and then commenced employment in 1968 as a miner after graduation.

It was a great place to work, full of challenges and advancement.

AusIMM North West Queensland Branch

The AusIMM North West Queensland (NWQ) Branch has had a long and illustrious history. I believe it was established as the Mount Isa Branch in 1932.

There have been some notable industry figures associated with the branch. Julius Kruttschnitt, who led the mine from the difficult early days in 1930 until the mid-50s, was AusIMM President twice and was awarded AusIMM honours. I heard it said recently that he is one of the few Chairpersons of a major company who continued to live on the mine site.

Sir George Fisher and Sir James Foots were also both President on more than one occasion and received numerous awards. AusIMM's current President, Janine Herzig, started her career as a metallurgist at Mount Isa.

In fact, if you go back through the records, AusIMM Presidents having associations with this branch have filled that role for more than ten per cent of the Institute's existence. The region is one of the training grounds for the industry and AusIMM.

In the Institute, we need people to step up and take the leadership positions if we are to have a vital and growing professional society. It is good to see that the NWQ Branch continues to do that.

AusIMM's role in the modern industry

AusIMM is just as relevant today as it was 125 years ago.

In upholding knowledge, standards and values of resources professionals, AusIMM requires that when renewing each year, you recommit to continuing professional development (CPD). This is available in many ways, including attending conferences. If you just look at a few that are available this year, you can see some are based on commodities, some on activities and some are more strategic.

Many members are not able to attend conferences. There are old and new ways to get access to the information. There are monographs, conference volumes and handbooks. Through new digital offerings from AusIMM, more content will be accessible from afar. I believe the success of AusIMM's award-winning Online Professional Certificate in JORC Code Reporting will lead to more training being made available by this method.

The social side of AusIMM membership has always been important. Branch meetings have a good balance between technical offerings and the opportunity to share knowledge and experiences in an informal way. Not only could you find the solution to a technical or a staffing issue at these events, there is a good chance you will make long-lasting friendships.

AusIMM Code of Ethics

Members must agree to abide by AusIMM's Code of Ethics each year as well. These are fairly obvious requirements for a professional to adhere to and guide them in their working life. There are two specific clauses I would like to mention.

Clause 8 refers to continuing professional development, but it also brings in the aspect of mentoring. I have had some very good mentors during my career, as I hope you have. It is our responsibility to make sure we fill that role for others. It does not have to be hierarchical, nor do those whom you mentor need to be in the same organisation.

Clause 9 covers compliance with laws and regulations. This should be self-evident, but most of the complaints about unprofessional behaviour arise from this clause, especially as it relates to the JORC Code. I was on the Ethics Committee for 16 years and have been on JORC for 13 years, so I am familiar with the types of breaches which have been reported. Most arise because of ignorance of the requirements of the JORC Code or a misinterpretation. The penalty is most likely to be a requirement for education or a warning. Where it is evident that there was intent to circumvent the clauses, then the penalties are much harsher, even leading to expulsion.

The JORC Code

The Australasian Joint Ore Reserves Committee (JORC) is overseen by its parent bodies AusIMM, the Australian Institute of Geoscientists and the Minerals Council of Australia.

JORC is a principles-based Code for the Public Reporting of Exploration Results, Mineral Resources and Ore Reserves. Public Reporting is for the purposes of investment and its definition in this sense is wide ranging.

Clearly, not everybody has a role as a Competent Person for their company, but the work of many resources professionals feeds into information to be considered for the release of exploration results or the declaration of a Mineral Resource or Ore Reserve. For that reason, it is important that professionals are aware of the Code and its contents.

The Committee has recently begun the process to update the Code. There will be a lot of consultation with the many stakeholders throughout the process. Emerging issues will be considered, as a lot has happened since the last update in 2012.

As well as the JORC Online Professional Certificate course I mentioned, AusIMM has also developed a JORC Code Essentials course for directors, company secretaries and investment advisers. This need was recognised by JORC and the AusIMM as a number of the alleged breaches were not committed by the Competent Persons, but by company officers, who are not necessarily bound by our Code of Ethics or familiar with the Code.

CRIRSCO

The JORC Code was the first such Code in the mining industry and it continues to be used and respected throughout the world. In 1994, Australasia joined with Canada, South Africa, the UK and the USA to form The Committee for Mineral Reserves International Reporting Standards (CRIRSCO). JORC is the National Reporting Organisation for Australasia and has been a major contributor to CRIRSCO's activities. Peter Stoker and I are the representatives. Like JORC, it has no legal standing and the committee is based on voluntary efforts.

CRIRSCO aims to achieve best practice in the international Public Reporting of Mineral Exploration Results, Mineral Resources and Mineral Reserves (what JORC calls Ore Reserves are known as Mineral Reserves in the rest of the world).

To do this, CRIRSCO has listed a number of actions: promotion, representation, reciprocity of recognition, uniform best practice and exchange.

There are now 14 members of CRIRSCO, with at

least six countries well on the way to meet the membership criteria.

CRIRSCO also has a strategic relationship with the International Council on Mining & Metals, which provides some funding for its activities. ICMM is an international organisation dedicated to a safe, fair and sustainable mining and metals industry, with 26 members (major mining companies from around the world) and 35 regional and commodities associations. I will talk more about ICMM and its work later.

General industry observations

I would now like to touch on some issues which affect the industry, AusIMM and its members. These are my **personal** observations and do not reflect the views of AusIMM or JORC, for example.

Competent Person

Under the definition of what constitutes a Competent Person, the third paragraph requires that you stick to your area of expertise. In Australasia, we prescribe a standard of five years of relevant experience in the style of mineralisation or type of deposit or activity being reported. Some countries have seven and one has ten, while some require a certain number of years in a position of responsibility. In the Society for Mining, Metallurgy and Exploration (USA), you must be in a special category of membership to be a Competent Person.

The aim of these measures is to lift the standards on what is a self-declared status. Other countries have legislation for a certificate, which is granted by a committee each time the person wants to be a Competent Person. I do not think we need to go there, but society and political regulation might mean we have to move from self-assessment to more prescription.

My view is that we should have a requirement for attendance at a course of instruction on the JORC Code. AusIMM's recent JORC Online Professional Certificate course is a very good example. Note that the certificate you get for passing the course does not make you a Competent Person. It just means that you did the course.

I would see the next step would be to make it compulsory to be a Chartered Professional in your field. The requirement to complete a certain number of CPD hours and have that audited should mean that you are keeping up to date with your specialisation.
The JORC Code training would be incorporated into the CPD requirement.

Resources

There is no requirement to do a study of any sort to declare a Resource. There must be a reasonable prospect of eventual economic extraction (RPEEE) (more likely than not) and that the Modifying Factors have been at least considered. There should be a discussion of the technical and economic support for the cut-off assumptions applied.

Any problem is more likely to arise with Inferred Resources, particularly if the company is keen to have a declared resource to promote its prospects.

The Australian Securities and Investments Commission (ASIC) looks very hard at forward-looking statements. If you declare a resource, you are saying that there are reasonable prospects for eventual economic extraction and you must have reasonable justification for saying so. It is conceivable that ASIC might push for a more rigorous basis for the declaration of a resource in the future.

We must remember that in this field, we are surrounded by uncertainty. For this reason, we talk about estimation of Resources and Reserves, not calculation. So much depends on judgement, based on scarce data.

Unfortunately, critics have said that we in the minerals industry do not have a good track record in achieving the results that might have been expected from published Resources and Reserves. There are many reasons for that, but we must guard against too much optimism. Sometimes there are project champions who are desperate for a project to be developed. There needs to be a balance from some who can challenge statements and conclusions, who have the tools to look at the 'what ifs'. Reserves must be reviewed if there are material changes in the values of parameters used.

Safety

It is a fundamental right to expect that you will return home safely after a day's work. It is our professional obligation to do all we can to ensure the safety of our employees and colleagues. This requirement is the number one clause in the Code of Ethics. Whether you are designing a stope or a reagent system, safety implications must be foremost in your mind, just as it is when you are a supervisor.

Recently, we have had major tailings dam failures overseas and here in Queensland, we have had a number of tragic fatalities in the coal mines. These have focused society's attention on our industry. We must meet its expectations and demands.

I mentioned the ICMM earlier. Because of the pressure from investors, their 26 members have committed to an audit of all their tailings storage facilities. In Queensland, there is talk of extending the industrial manslaughter provisions in legislation to the mining industry.

We must try to eliminate the possibility of fatal accidents, through engineering, systems or training. Much progress has been made in removing the operator from the action through remote control and automation, but it seems we have a way to go before we reduce the dangers workers face to an acceptable level with zero harm.

Acceptance by society

ICMM has a lot to say about how the industry must gain this acceptance. It appears that in some circles, the term 'social licence to operate' has lost favour. I still consider the term useful because, without the acceptance of the community, it is very hard to operate. I learnt that frequently in Papua New Guinea, Indonesia and New Zealand, where community opinions can be somewhat forcefully put to you.

The ICMM has ten principles, which all members sign up to, that focus on sustainable development. Safety to achieve zero harm is number five. ICMM is currently developing guidance on how members will validate the performance expectations at the operational level including through independent third-party assessments.

We have to accept that there are many in our society who do not share our views about mineral extraction. We like to think of ourselves as objective people with a science or engineering background, who can see a rational argument and act accordingly. However, we are human as well.

There has been enough evidence of late with public disturbance to know that slogans and wild claims can appeal to those not familiar with the matter and can gain wide acceptance. There is a gulf between the attitudes of those in the inner cities and those in non-urban areas. I note the decision by a consulting firm to stop providing services to Adani and the Minister's reaction to that.

I have been disturbed by some of the attitudes expressed by my grandsons, which have been instilled in them by their teachers. The school room in the cities is not mining friendly, I fear, but I will not apologise for being part of the industry.

How to counter that is a difficult task, but grumbling with like-minded people will not change attitudes of the public at large. If it becomes necessary, we have to pick the right issue and mount a cogent, credible, concise argument, using whatever media we have, making sure our actions and words are defensible.

Technology

The technology we use in the industry is evolving at a rapid and increasing rate.

The rocks and minerals are the same as ever. Just as in centuries past, we still have to mine the ore, liberate the valuable particles, concentrate them to get a saleable product and market it. Success still depends on infrastructure – access to power, water, transport and communications. However, how we do all these activities has changed.

In my half century in the industry, I have seen computers go from a curiosity to an essential part of work and life. Our ability to measure parameters and apply control systems has transformed our management of processes.

Whenever I read the *AusIMM Bulletin*, I am fascinated by the new approaches and pieces of equipment that have been developed. Recent articles have covered the path to autonomous mineral processing operations, managing abandoned underground mines with robots, composite or variability samples for metallurgical testing, and digital optimisation lessons taken from other industries. The last one is particularly important as it stresses that we should be more outward looking.

I eagerly wait for my copy of *Resourceful*, a magazine from the CSIRO showcasing their research into the minerals industry. A recent copy has articles on ultra-fine soil sampling, data analytics and a sensor to detect gold online while the plant is running. There is also their large program for finding mineral deposits under deep cover.

All of these new and refined techniques will help to ensure that the Australian minerals industry will continue for many decades to come. We are the leader in so many technologies.

Conclusion

In conclusion, I would like to:

- encourage you to undertake CPD so that you can operate at the level of professionalism that society demands
- remember the AusIMM Code of Ethics and, in particular, review it if you are placed in a situation that does not feel right
- remember that we are the guardians of AusIMM's reputation and integrity
- get familiar with the JORC Code, even if you have only a peripheral contact
- put something back into the Institute for the support it has given you
- have a mentor; be a mentor
- develop friendships which can last well beyond your working life.

Enjoy your career. It might be a bumpy road and lead you in ways not expected, but it is a great industry. If you can be in a project from conception to production, it is a wonderful experience. You all can feel proud you are making a valuable contribution to Australia's society, environment and economy.

India

Key facts

- **Population:** 1 369 055 400
- **Land area:** 2 973 193 km²
- **Natural resources:** iron ore, bauxite, coal, mica, diamonds, natural gas, oil
- **GDP:** US$2.726 trillion (2018)

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

With more than 1500 mines in operation and only 20 per cent of the country's reserves mined, India has the potential to become an even bigger player in the resources industry

Ryan Leaver, Marketing and Editorial Assistant, AusIMM

The seventh largest country in the world by land mass, and second largest in Asia (behind only China), India has an ever-growing population already well beyond one billion people. This figure accounts for roughly one-sixth of the world's total population and is again second only to China (1.43 billion).

India's population is expected to grow even more and is projected to overtake China's within the next five years.

One of India's most notable landmarks is the world-famous Taj Mahal, one of the Seven Wonders of the World. The Taj Mahal was built in the 17th century by Mughal Emperor Shah in honour of his favourite wife after her passing in 1631.

Image: CRS PHOTO/Shutterstock.com.

Mining in India

Within the nation's large population sits many successful industries, including the mining industry, which provides over 700 000 job opportunities. India is home to 1531 operating mines and produces 95 different minerals; the nation is a world-leading producer in iron ore, bauxite, coal, chromium and other minerals. Overall, the mining industry is very diverse in India.

The 95 minerals that India produces can be broken down into the following categories: four fuel-related minerals, 10 metallic minerals, 23 non-metallic minerals, three atomic minerals and 55 minor minerals (including building and other minerals).

India is the world's second largest producer of crude steel, third largest producer of coal, and fourth largest producer of iron ore. The crude steel produced in India in 2018 sat at more than 106 million tonnes.

Mining's contribution to India's total GDP has gradually decreased over time, dropping from 1.93 per cent of the GDP in 2012-13 to 1.53 per cent in 2017-18. This is due to the fast-growing nature of other industries, such as services and agriculture.

Furthermore, compared to other mature mining nations such as Australia and Canada, India's exploration spend is low. India accounts for only two per cent of the world's global exploration spend, while Canada and Australia account for 14 and 13 per cent respectively.

'India is home to 1531 operating mines and produces 95 different minerals; the nation is a world leading producer in iron ore, bauxite, coal, chromium and other minerals.'

Trade and finances

Currently standing at US$2.726 trillion, India's GDP has increased every year since the Global Financial Crisis, having dropped from US$1.217 trillion to US$1.199 trillion in 2008.

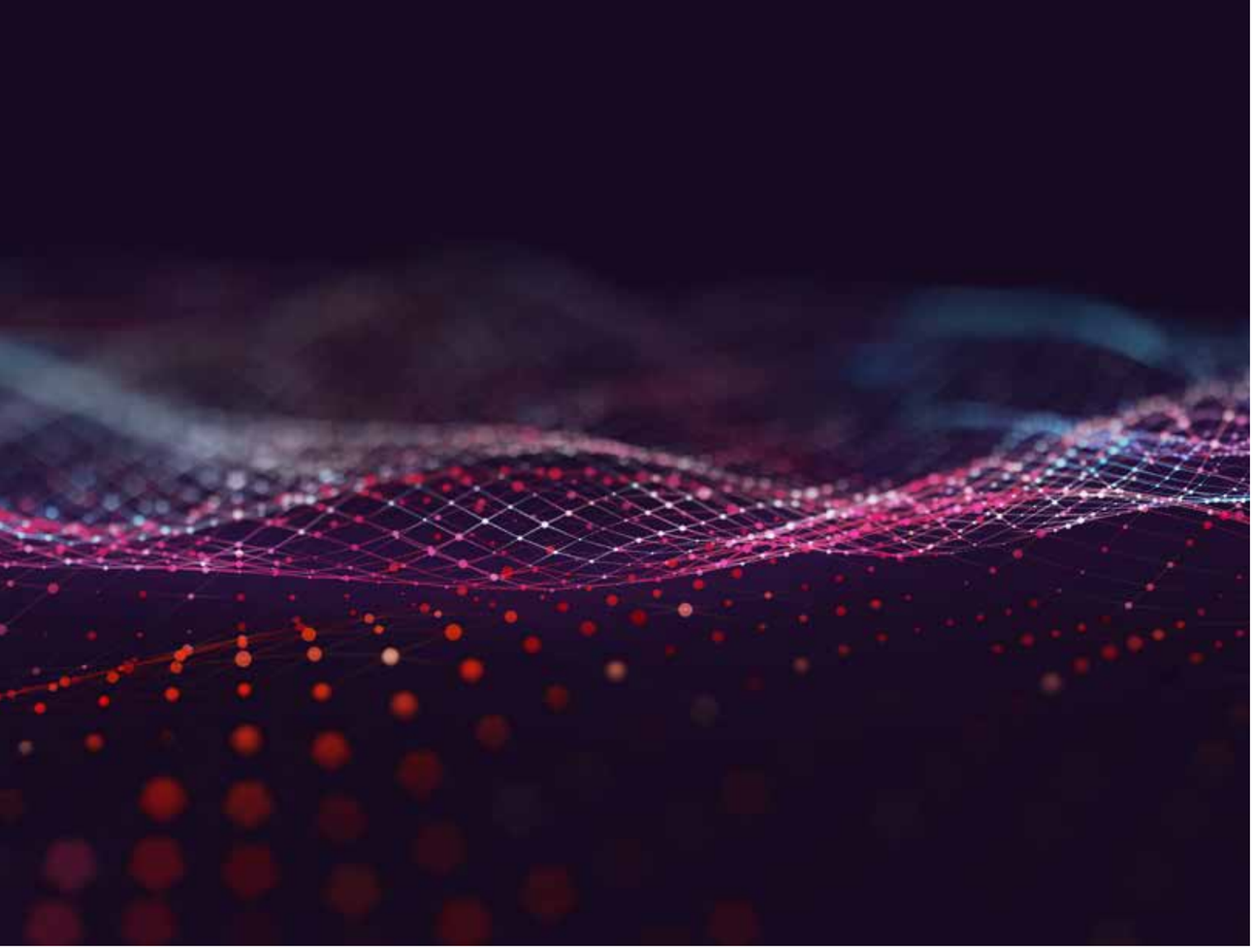
2017 saw India export US$292 billion worth of goods, which was far outweighed by the import number of US$417 billion. This resulted in a negative trade balance of UD$125 billion, a significantly different number to the positive trade balance of US$340 million that the country experienced in 1995.

India's trade partners stretch all across the globe, with goods being both imported from and exported to many different countries. India's top export destination is the US, whilst the country they import the most goods from is China.

India is currently Australia's fourth top trading partner, and through mining and METS there are continual opportunities for both countries to benefit. In the METS sector particularly Australia has the opportunity to supply India with underground mining equipment, simulation and training (including virtual reality), safety equipment and much more.

Conclusion

A proud country going through continual growth, India is already one of the largest influencers not only in the resources industry, but also in the global economy.



Changing the face of mining

Social licence continues to be the top business risk for the mining and metals industry today. While it is promising to see the industry start to embrace new ways to more effectively engage communities, one could argue that the inherent problem still remains: the way we mine.

Jonathan Law
MAusIMM, Director of CSIRO Mineral Resources

Economies of scale over the past 50 years have seen mines become increasingly larger and larger.

With the deepest mines extending kilometres below the surface, large scale mining is a feat of engineering that has enabled unprecedented rates of production.

But this focus on producing high volumes for as little cost as possible has led the industry down a path that's out of step with community and environmental expectations.

Large-scale mining operations lead to large volumes of waste in tailing dams, as well as waste rock facilities that store barren material moved to access ore. These are high risk and, given recent disasters, are genuine causes for community concern.

Equally problematic is the large footprint of open pit mines. No one wants one in their backyard and questions remain over what to do when the mine is ultimately closed.

A more recent trend is consumers questioning whether the metals in their smartphones or other products are ethically sourced.

This is the industry's current predicament. The old way of operating is not sustainable long-term – a complete mine redesign is needed for a true triple bottom line approach.

Moving away from large open pit mining to digitally-enabled precision or 'keyhole' mining that is discreet, low waste and low emission is the future.

Of course, bulk commodities where the valuable product forms the bulk of the orebody, such as iron ore and coal, provide very different challenges to lower grade ores where the opportunities for change are greater.

Future mines will be low capital, fully autonomous and based on whole value chain decision-making.

But how will the industry get there? At the heart of new mine design is a greater understanding of the ore, waste and broader rock mass. If we know exactly what is in the ground, and where, before we dig it up then the mine can be designed in such a way to maximise value with minimal land disturbance and waste.

Accurate knowledge of ore deposits has been a huge challenge and gap to date. But this gap is rapidly being filled thanks to real-time sensing to understand ore variability at all scales.

Two other key areas are essential: the ability to make fast value chain-based decisions, and integrating the real and virtual world using Industry 4.0 solutions.

Many of the technologies that form part of the puzzle are progressing at pace: rock cutting, renewable energy, autonomous vehicles, drones, 3D printing and self-assembling robots.

The key challenge is integrating all these technologies to enable a fundamentally different approach to mining rather than simply making today's large-scale operations more efficient.

Miners are understandably focused on digitising and automating what they're currently doing, because complete transformation of an existing mine is extremely difficult. The industry is tied to their capital investments with golden handcuffs.

'Future mines will be low capital, fully autonomous and based on whole value chain decision-making.'

This means real transformation can only happen in the design of new mines. This, coupled with the current disequilibrium and tension between mining capital, social and environmental implications, leaves the industry's door wide open to disruption from outside players.

New technology entrants with a mine design solution that's more environmentally or socially acceptable can circumvent barriers to entry. If they can adequately manage risks and compete with capital returns to secure their own resource or supply chain, it will fundamentally change the industry.

But the transformation towards a true triple bottom line approach won't be isolated to the way we mine; it will extend to market dynamics.

We can expect to see a shift from global markets to contracted supply of raw materials or metals linked to the unique mine footprint of each supplier. There are already signs of this happening in the market.

Major metal consumers, such as tech giants, are moving to control whole value chains right through to product delivery. If not securing their own supply, it may prompt innovative producers to secure a price premium for more environmentally sustainable commodity products.

As the boundary between the value in the resource versus the value in the enabling technology is blurred, new entrants can disrupt the industry in the same way that Uber did with no cars and Skype with no telephone infrastructure.

While mining industry players seem content with the evolution of digital technologies, the risk is competition from new technology entrants with capital and no existing market constraints.

Mining's future lies with those prepared to challenge every aspect of production and rethink mine design using technology as an enabler.

This article originally appeared in CSIRO's *Resourceful* magazine. Visit **csiro.au/resourceful**.

Image: QtraxDzn/Shutterstock.com.

The benefits of formal mentoring programs

When properly managed, formal mentoring programs provide a range of opportunities for both mentors and mentees at all stages of their careers

Dr Ali Burston
Managing Director – Metisphere

Although the goals of a mentoring relationship may differ according to context, all good mentoring partnerships involve the transfer of knowledge between a less experienced individual (the mentee) and the more experienced mentor. Mentors can provide insight and expertise to support the mentee's individual growth and maturity (Allen and Eby, 2007).

Types of mentoring

There are generally two forms of mentoring, outlined below.

Informal mentoring

Informal mentoring typically consists of unstructured sessions with someone the mentee has (or hopes to have) a long-standing relationship with (Inzer and Crawford, 2005). The focus of discussion in these mentoring relationships varies, and is often topical or related to current circumstances. Momentum throughout an informal mentoring relationship is driven through the strength of the connection between mentee and mentor. If that connection cannot be maintained, the mentoring relationship will likely decline in frequency and quality (Gilmore, Coetzee and Schreuder, 2005).

Formal mentoring

Formal mentoring follows a structured framework to assist in several key areas:

- learning and development
- matching of mentors and mentees
- providing formal support for all participants to thrive (Inzer and Crawford, 2005).

Formal programs often consist of participant training to define the scope of the program, suggestions for fostering better communication, and expectations of the mentee to drive outcomes (Allen, Eby and Lentz, 2006; Eby and Lockwood, 2005). Momentum throughout a formal program should be driven by the mentee.

Benefits of participating in a formal mentoring program for mentees

For a mentee, a formal mentoring program encourages self-driven learning and accountability. A mentee is expected to develop agendas and complete tasks or homework. In our experience, formal mentoring programs must clearly articulate mentee expectations and provide tools to enable the mentee to reach their specific goals. This is a key differentiator between informal and formal mentoring program frameworks. Without core accountability, it may be difficult to produce the same level of tangible outcomes within a specific timeframe.

Benefits for new professionals

For new professionals, being mentored can provide a valuable kick-start to a pathway of career fulfilment. Typical benefits for early-career professionals include learning how to navigate workplace politics, setting career goals, and deciding what kind of experiences will benefit you the most to gain early career exposure (Hess and Jepsen, 2009).

Benefits for mid-career professionals

For professionals with strong work experience who are en route to building a career pathway, mentoring conversation topics may be more advanced. Benefits of formal mentoring programs for mid-career professionals include improving technical knowledge, improving leadership and influencing skills, and planning for the next career phase (Isabella, 1988). A mentor can provide practical tools and strategies to help someone transition from a junior role into roles with higher expectations and accountability (Pirotta, 2009).

Benefits for experienced professionals

Professionals with significant work experience may benefit from using a mentor to act as a sounding board, broaden networks or improve specific management skills. Often conversations provide a high-level insight into how better to achieve specific milestones, promotions or appointments (Gilmore, Coetzee and Schreuder, 2005). Alternatively, mentees may explore transitioning into a different role, organisation or industry, and insights from a mentor in the desired field can accelerate that process technically, psychologically and strategically.

Benefits of participating in a formal mentoring program for mentors

Mentoring can be a satisfying and fulfilling experience if entered into for the right reasons. If mentor motivations include genuinely wanting to 'give something back' and positively contributing to another person's professional career journey, then there can be a host of ancillary benefits for the mentor.

Learning about and reflecting on individual strengths and weaknesses

Mentoring can be a very reflective process. Often the advice we give is not the same advice we always follow. Mentoring provides the opportunity for mentors to reflect on their advice, and perhaps initiate strategies to enhance their personal attributes.

Engaging with the next generation

In a rapidly changing work climate, mentors can greatly benefit from engaging with different generations to develop insight, understand values and learn a different generation's 'purpose' in the world. This can help mentors to become more adaptable leaders. Sometimes there are structural and physical disconnects that keep senior and junior people within the organisation apart (hierarchy and office layout, for example). Bypassing this divide can provide a unique opportunity to understand the motivations and drivers of the mentor's own junior employees (Allen, 2003; Parise and Forret, 2008).

Improving the talent pipeline

Assisting less experienced individuals to thrive in their careers will create more capable and competent professionals going forward. By assisting in the career development of the next wave of future leaders, mentors can take a sense of pride and accomplishment by passing on their learnings and experiences and helping create a more sustainable and knowledgeable future workforce.

Additional benefits

Research also suggests mentors benefit from:

- enhanced job satisfaction (Ghosh and Reio, 2013)
- enhanced organisational commitment (Ghosh and Reio, 2013)
- an intrinsically rewarding experience (Allen and Eby, 2007)
- improved leadership capability (Allen and Eby, 2007)
- higher work performance (Ghosh and Reio, 2013).

Finally, a question that we regularly get asked is, 'we have an internal mentoring program – why participate in an industry mentoring program?' The answer is simple: the agenda. Internal mentoring programs have a specific focus on attracting, retaining and developing talent within the organisation. A key focus of an internal mentoring program may involve fostering a graduate through the organisational structure and assisting them to build internal networks to embed themselves within the business.

But industry programs have an agenda to attract, retain and develop talented individuals to strengthen and shape the industry. Industry mentoring programs provide an opportunity for mentees to have a mentor that is outside of their normal network and who does not have an agenda within their workplace. Put simply, their mentor's advice and guidance is not driven by their organisation's agenda, and the opportunity to have an unbiased sounding board is extremely valuable.

AusIMM Mentoring Program 2020

The AusIMM is launching its inaugural mentoring program next year. The aim of the program is to develop a structured, sustainable process that supports mentees through career guidance and direction by sharing experiences, developing career goals and forging exceptional mentoring relationships that last beyond the duration of the program.

The five-month program includes a comprehensive matching framework conducted by a registered psychologist. Successful applicants will be provided with the opportunity to learn and receive career guidance from a mentor that is fully invested in their career and development.

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

It's time to better manage biodiversity in Australia

An overview of strategies that can help mitigate project risks and improve your organisation's biodiversity footprint

Tara Kennedy
Senior Environmental Consultant, Golder

For any mining or oil and gas development, managing biodiversity and environmental values effectively is essential to securing project approval. Managing biodiversity is also a major factor affecting reputation and social licence. But beyond this narrow perspective, we need to recognise that our local approach to biodiversity matters in a global context – and that, in Australia, there's room to lift our game.

A global crisis

Today across the globe, one million animal and plant species are threatened with extinction within decades. The loss of biodiversity is escalating worldwide, and the impacts reach much further than many of us imagine.

Biodiversity is not solely an 'environmental' issue. When we lose biodiversity, the natural processes that provide us with safe food, breathable air and clean water are threatened. This has serious economic, developmental, social and security implications, as well as moral and ethical complexities.

This breadth of impact is clear in the 2019 Global Biodiversity Assessment Report of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, which anticipates that the continuing decline of biodiversity and ecosystems will undermine progress towards 80 per cent of the assessed targets of the United Nations' Sustainable Development Goals relating to poverty, hunger, health, water, cities, climate, oceans and land.

This makes managing and conserving biodiversity one of our greatest and most urgent global challenges. We will need transformative change across our economies, politics, technologies and culture to get anywhere near to slowing the decline.

Local action

Given the urgency, seriousness and scale of the challenge, Australia needs to prepare to make a bigger contribution toward a solution. We have a role to play, yet regulators, environmental specialists and local communities across Australia agree that we're not doing well enough yet.

As the rate of vegetation clearing accelerates, biodiversity continues to decline. In most states, we don't have enough data to understand our current biodiversity values. If there is no comprehensive evidence benchmarking the current quality and extent of native vegetation, the community is not able to understand whether current laws have been effective or whether conservation measures on public or private land are contributing to better biodiversity outcomes.

Existing frameworks for biodiversity management are complex and difficult for the community to navigate and are not always implemented widely enough. In some cases, the information and knowledge needed to evaluate the effectiveness of the legislative framework and supporting mechanisms is poor.

Because the level of regulation and scrutiny is set to increase, we're going to need to step up. In New South Wales for example, tighter environmental management expectations have already been legislated (in the form of the Biodiversity Conservation Act 2016) and are likely to be a harbinger of things to come in other jurisdictions. Upcoming changes will transform project management, so it is time to build your awareness of how best to manage biodiversity impacts.

New South Wales in the lead

All Australian states and territories have a range of legislation designed to require or encourage landholders and developers to conserve biodiversity by ensuring that new developments avoid or minimise impacts on biodiversity. Where that isn't possible, proponents may be required to offset the impacts through various conservation measures. That isn't new, but what we see in NSW is a significant strengthening of the requirements.

The NSW framework emphasises that best practice comes from a hierarchy of avoiding, minimising, mitigating or managing impacts, rather than offsetting. Biodiversity offsetting, where negative impacts for one location are offset by positive impacts elsewhere, is sometimes the only option, but it needs to be done well, and only as a last resort.

The best way to approach the 'avoid-minimise-offset' hierarchy is to involve specialist biodiversity expertise in the project right from the start, so that the ideal environmental approach can be built into the design from its earliest stages. Incorporating biodiversity considerations into the early project planning and design stage is something that still only happens sporadically.

An important introduction in the NSW legislation is the concept of serious and irreversible impacts. If such impacts are expected, consent cannot be granted to proceed with the project. It is therefore critical to identify these potential impacts as early as possible, so proponents can modify the project design accordingly.

Another change in NSW is an expansion of the types of projects that trigger assessment and, potentially, offsetting. In most Australian jurisdictions, the types of projects that require offsets are generally those deemed major or significant, whereas small-scale development is generally exempt. In NSW, if any development is likely to significantly affect threatened species, it must be assessed by an accredited person and could potentially require offsetting. This dramatically expands the number and types of projects that must assess biodiversity impact and may potentially require offsets – up to an additional 6000 projects per year. It is likely that the time and cost associated with meeting these requirements will motivate proponents to modify or reconsider their project footprint.

Many aspects of the NSW framework could be applied in other jurisdictions to achieve more effective biodiversity outcomes – and that's likely to be simply a matter of time. If other jurisdictions move to adopt some or all of these features, it is expected to lead to more effective biodiversity outcomes across the nation.

Ways to manage project risks

Poor management of risks and impacts to biodiversity can result in delays, additional costs for projects, and could tarnish a company's reputation in the community. To avoid such risks, consider some of these strategies:

- include biodiversity considerations as early as possible in project planning and design
- avoid and minimise biodiversity impacts wherever possible
- develop appropriate systems and tools to manage biodiversity impacts throughout the project lifecycle
- build awareness with internal stakeholders of the importance of biodiversity management.

Incorporating these strategies into your operations can help mitigate the risks to your projects and improve your organisation's biodiversity footprint – and you'll be taking the crucial positive local action that all adds up to a far more substantial national contribution to this pressing global challenge.

About the author

Tara Kennedy is a Senior Environmental Consultant at Golder, based in Brisbane. With an environmental law background, Tara has worked on a variety of large infrastructure, mining and oil and gas projects for government and private clients. In addition to a detailed understanding of the legislative policy frameworks that underpin environmental management in Australia, Tara also has expertise in stakeholder engagement, capacity building and training. Most recently, she has been working in collaboration with the NSW Office of Environment and Heritage to implement the new framework for biodiversity management and offsetting.

About Golder

Renowned for technical excellence, Golder is a leading specialised employee-owned engineering and consulting firm with over a half century of successful service to its clients. With over 165 offices in more than 35 countries, Golder's 6500 professionals are driven by a passion to deliver results, offering unique specialised skills to address the ever-evolving challenges that earth, environment and energy present to clients across the infrastructure, mining, oil and gas, manufacturing and power sectors.

How to find high-grade talent

As a leader, a high-grade team is more fundamental to your success than a high-grade orebody. Here we explore the most overlooked sources of talent.

Richard Fortune
MAusIMM, Director, Alto Partners

The term 'war for talent' was first coined by McKinsey in 1997 to highlight the truism that good people are the foundation of business success (Michaels, Handfield-Jones and Axelrod, 2001).

The phrase inspired a generation of mercenary recruiters. Armed solely with a headset and loud pinstripes, they indiscriminately plundered the ranks of stable companies. Many careers died, and companies suffered.

More than twenty years later, the truism still stands, but no one's career needs to die. To examine a better way, let's take the metaphor away from the battlefield and into the goldfields.

Think like a gold miner

If you really want to succeed as a gold miner, you must look for gold in places that your competitors have not looked. You are not going to find the mother lode combing through the mullock heap with everyone else. Likewise, you will have to look where others have not for high-grade talent.

Look deeper

It's worth considering the lack of visibility and accessibility of high-grade talent.

Successful people are focused and busy, which means they are rarely looking for jobs, let alone applying to a job posting or divulging their situation to a competitor.

Many make themselves invisible and inaccessible if they can help it. They may appear in conference publications, industry journals or news releases. However, many of them will not build an internet presence unless their work requires it.

Typically, they are heavily guarded and require a peer introduction for access. They then need to be approached with a timely, insightful and compelling proposition.

Many recruiters, particularly internal recruiters, are under enormous pressure to deliver on two metrics: cost and time. Accordingly, they simply do not have the time or the leverage to cultivate an external network and access this hidden market. For this reason, LinkedIn has become very popular, as it provides access to candidates with an online presence outside known networks.

It may surprise many recruiters who rely heavily on LinkedIn that, according to AltoPartners research, less than 40 per cent of mining industry personnel are present on LinkedIn. This figure is based on employees reported in 2018-19 financial year annual reports (excluding contractors) versus total employees listed on LinkedIn company pages. These figures correlate with organisation charts and market maps.

Of those who are present on LinkedIn, only around half are estimated to be active monthly users (Kemp, 2019), meaning that less than 20 per cent of the market will be engaged through LinkedIn by the average recruiter in a typical four week recruitment cycle. Figure 1 highlights a selection of mining companies and the percentage of their full-time employees not on LinkedIn (excluding contractors).

In short, 80 per cent of the talent market remains untapped by many who lack the awareness, time or commitment to search deeper. Herein lies an opportunity for significant competitive advantage.

Look over the horizon

If you have been in the same industry, region or role for a while, check you have not become the proverbial 'frog in the well', who lived its entire life in a deep dark well, assuming it was the whole world. We can be limited by our own experiences: our school, our state and our industry.

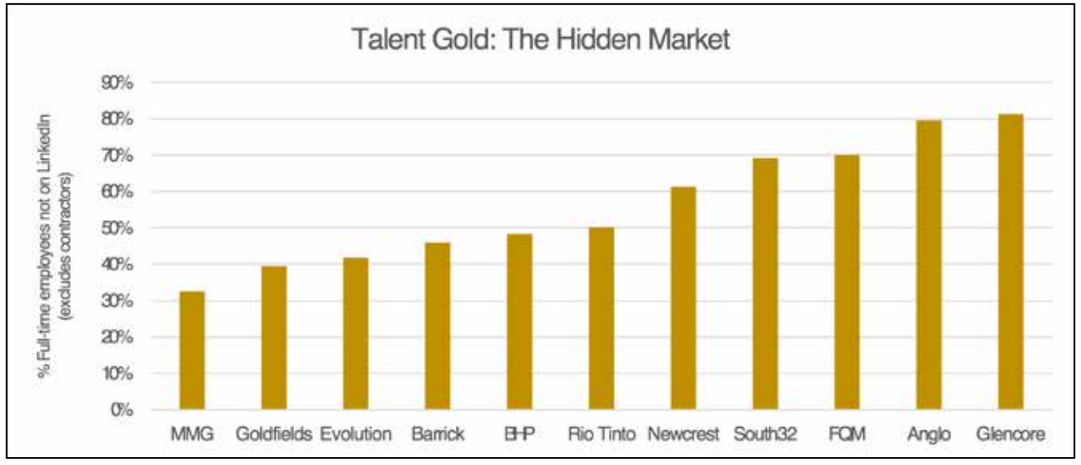


Figure 1. Selection of mining companies and the percentage of their full-time employees not on LinkedIn (excluding contractors).

Resist the temptation to hire the first candidate who falls into your well. That candidate you fortuitously bumped into at the airport lounge may be a disaster, not destiny.

Get a second option and a second opinion. Discount any confirmation bias and look for any red flags. Effective due diligence now will save you and your company in the future.

Look outside your well. There are some amazing people over the horizon, and they may bring new ideas, perspectives and constructive diversity to the team. They may set higher performance benchmarks than you thought possible.

When it comes to mission critical assignments like building a mine or designing a mill, these clearly require track record and deep domain experience in mining. Every other appointment should be challenged with some lateral thinking.

Look in front of you

Conversely, you may have overlooked the best person sitting right in front of you. The famous saying 'no prophet is accepted in his hometown' highlights a limiting belief: we would rather look for our solution elsewhere than receive insights from those familiar to us.

We carry many limiting beliefs in the form of prejudices, assumptions and biases. For example, we may assume wrongly that a particular individual doesn't have the ability to lead, or be an innovator, when in reality it is because they haven't been given a chance to do so.

These beliefs should be challenged. An objective framework and an external perspective may illuminate hidden talent and unrealised capability in your very own team.

On this point, you may remember the late Sir Arvi Parbo. An Estonian refugee and mature-age student, he rose through the ranks of Western Mining Corporation to become Chairman and Managing Director in just eighteen years.

Look in the mirror

Finally, and most importantly, look in the mirror. Would you want to work for yourself? Are you creating an environment where talent will thrive? It's no use recruiting high-grade people only to lose them. Exceptional people need a bigger vision, a driving sense of purpose, strategic input and the opportunity to provide dynamic thinking. Furthermore, as with all employees and organisations, to get the best out of your staff you must ensure you have created an environment built on mutual respect and organisational clarity.

In this sort of environment, you will not only attract talent, you will help create it.

AltoPartners provides executive search and leadership advice to boards through 57 offices across 34 countries. Richard Fortune is a Director of AltoPartners Australia, and he is the leader of the firm's Natural Resources Practice.

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Adapt and perish: is the mining industry ready for the blockchain revolution?

Blockchain has the potential to transform contemporary businesses and entire societies. But is the resources industry ready to adopt the technology, or does it remain a buzzword with an unproven business case for mining?

Dr Andrzej Gwizdalski, Lecturer and Honorary Research Fellow, UWA Business School

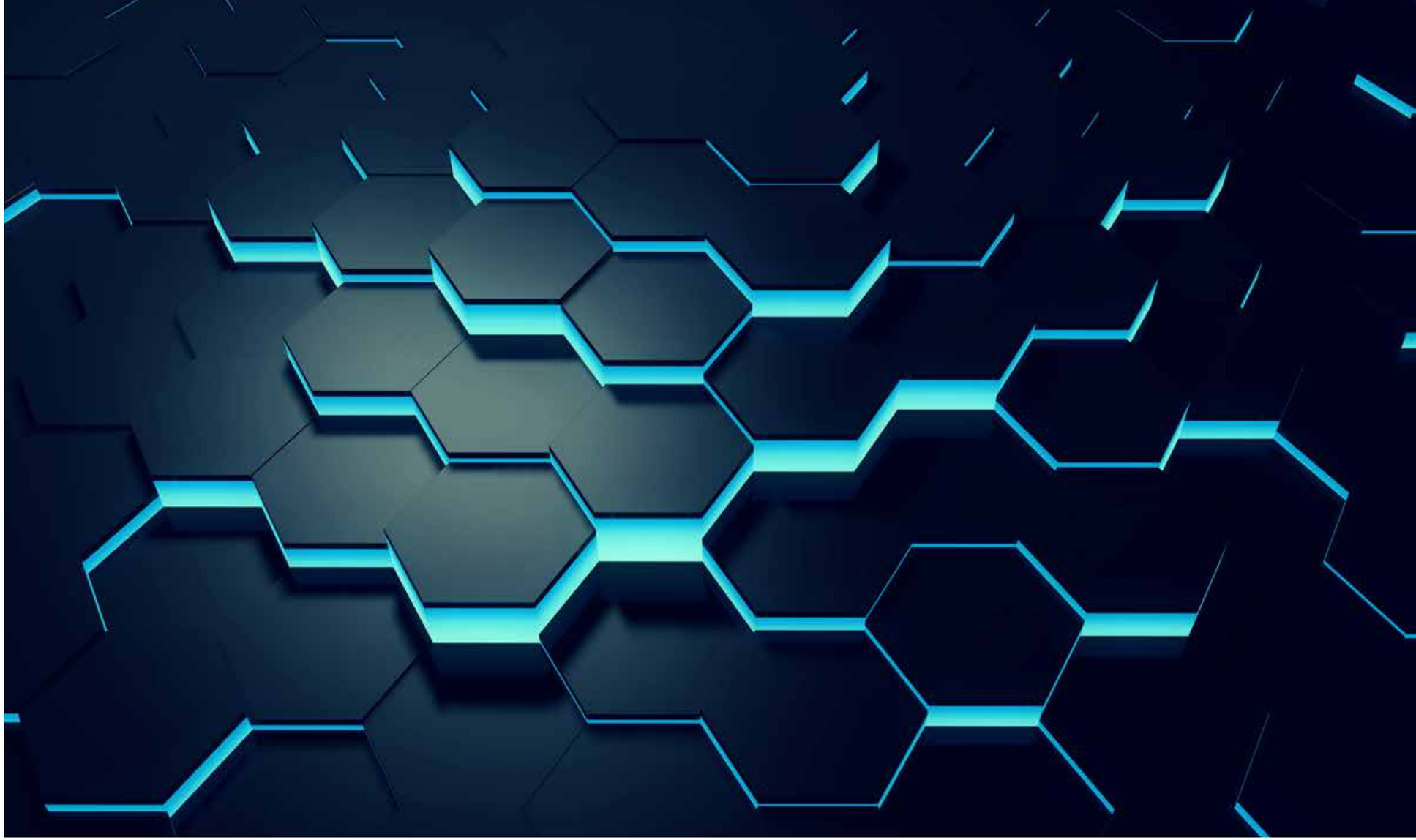

Image: Ink Drop/Shutterstock.com.

There is little doubt the mining industry must keep adapting to a progressively digital and automated environment as determined by Industry 4.0 (Dodd, 2019; Gooch, 2019; Sirinanda, 2019). Blockchain is 'at the heart of Industry 4.0,' or as Tapscott and Tapscott say, 'blockchain is the revolution that will deeply transform contemporary businesses and entire societies' (2016).

Efforts have been made, both globally and locally, to explore blockchain technologies for streamlining mining processes (Brightmore, 2019; Harris, 2018; Weiland, 2018). However, the technology is still nascent, greatly overhyped and often misunderstood altogether (Warren and Deshmukh, 2019). It may take many years for the true blockchain adaptation to take place, but the mining sector should most definitely not ignore it. The best way to prepare for the future is to learn about blockchain now.

What is blockchain?

In the last few years, blockchain has become an overhyped buzzword without a standard definition. Almost any digital technology coupled with a few 'magic' words such as 'smart contracts' or 'cryptography' could pass as blockchain technology. The current environment thus encourages us to be cautious of blockchain marketing tricks and blockchain consultants, even those hiding behind the names of recognised global corporations.

Instead of investing in blockchain solutions, it might be wiser and more strategic to first invest in learning about the technology from reliable sources. When in doubt, it is always good to critically reflect on the key fundamental features that have made the technology distinctly innovative.

Blockchain can be defined as a particular type of shared database: a ledger. Although not as futuristic sounding as artificial intelligence, robotics or the Internet of Things, ledgers – such as the Babylonian clay tablets or double entry bookkeeping – have allowed for significant civilisational advancements and were essential for the development of the modern capitalist economy (Yamey, 1964). Trusted institutions, such as governments, banks and auditing firms evolved in parallel with ledgers. These third-party central institutions are required for recording, verifying and storing information of high value, such as records of financial transactions exchanged among peers in a global digital economy.

Blockchain has changed thousands of years of history based on centralised ledgers. Blockchain allows for direct peer-to-peer transactions to be securely recorded in a ledger shared by a network of computers that does not require any trusted third parties for validation. Instead, individual transactions are directly recorded and cryptographically secured in a data storage unit, known as a block. The block of data is then validated by one of the winning computers that first solves a particular mathematical problem set by the network's software. To solve the mathematical puzzle, the competing participants need to use valuable

‘To properly reflect the innovative and decentralised nature of blockchain technology, any true blockchain model would probably behave like the Bitcoin system.’

resources, such as computing power and electricity. This investment proves commitment and disincentivises cheating (the proof-of-work makes any misbehaviour economically unviable). At the same time, honest behaviour (correct block validation) is economically incentivised by a reward of the network’s native money. Once the block is validated, it is added to the longest chain of valid blocks (hence the name blockchain) and the ledger is automatically updated across the network of thousands of computers. This particular type of decentralised open public ledger has proven highly secure, immutable and resistant to censorship efforts.

However, not all distributed ledgers are created equal. The simplified description of blockchain above refers to the ingenious open public Bitcoin system introduced anonymously by the person or group of people known as Satoshi Nakamoto (2008). Nakamoto’s intention was to create a decentralised system of electronic peer-to-peer cash transactions that cannot be stopped by third parties such as banks and governments. A decade later, it looks like Nakamoto has not only achieved their goal but has also created the technological foundation known as ‘the internet of money’ (Antonopoulos, 2016).

The internet of money, blockchain solutions and industry

The Bitcoin system (of which bitcoin currency is an integral part) soon captured the imagination of code developers, entrepreneurs and established tech companies. They all seemed to have their own ideas about blockchains magically solving their business-specific issues, such as saving costs by removing intermediaries, streamlining transactional processes, verifying the provenance of goods in a supply chain and even curing cancer.

Most of the currently proposed blockchain solutions for the mining industry fall into this category (see Weiland, 2018). Vitalik Buterin (2014) was the first to address the innovative visions of decentralised autonomous enterprises by expanding on Nakamoto’s single-purpose innovation (decentralised money) and creating a general purpose open blockchain, called Ethereum. General purpose blockchains can, in theory, decentralise and automate everything and this makes them potentially attractive to enterprises, including those in the resources sector.

However, the open public nature of blockchain technology was generally not well received by businesses and governments, who preferred a more private and business-friendly version. In response to the demand, dozens of private blockchains owned by corporations and consortia have since emerged and offered technology that is proprietary, regulated and controlled by trusted third parties. But wasn’t the original blockchain innovation all about avoiding trusted third parties? Good question.

Decentralised versus private models

It is likely that most of the blockchain solutions out there in the market have little to do with Nakamoto’s innovation, as Halaburda (2018) points out. The word ‘blockchain’ was never mentioned in the original Bitcoin publication. This is because blockchain is not a single piece of technology that could be extracted from the Bitcoin system and freely applied to a current business model.

To properly reflect the innovative and decentralised nature of blockchain technology, any true blockchain model would probably behave like the Bitcoin system. The open public Bitcoin blockchain is a complex system that entails a network of computers, open software constantly updated by dedicated developers, cryptography, game theory, economic incentive mechanisms and a community that is not governed by a central authority. Bitcoin does not have a CEO, headquarters or customer service. It is an autonomous decentralised system. It is a system that was not created to work for centralised institutions but to challenge them by giving more power to individuals. It is not a system that can be controlled by a single business or a consortium and regulated by any legislation. This is where the great divide of blockchains begins. Those who believe in unstoppable decentralised and autonomous organisations embrace the open public blockchains (arguably the only blockchains). Those who opt for a traditional business-friendly ledger that can be centrally controlled by select authorities and owned by a business or a consortium are likely to choose the so-called ‘private permissioned blockchains’. However, the name ‘blockchain’ in the latter case is fundamentally confusing; instead, the term ‘distributed ledger technology’ (DLT) is becoming more commonly accepted.

It would be an exaggeration to say that all private distributed ledgers have no value and their proponents are disingenuous actors. These solutions often exist as a result of technological and regulatory limitations. Furthermore, the main limiting factor seems to be the traditional business model based on proprietary values and organisational culture that knows no other forms of governance but centralised ones. A truly innovative blockchain solution is unlikely to achieve its full potential in such an environment.

Instead, the current enterprise blockchain innovations are rather incremental and still at the level of proof-of-concept rather than mass adoption. Their main intended value proposition is to save costs by offering cheaper ways of verifying transactions and replacing old intermediaries with new ones (Catalini and Gans, 2016).

However, if the governance model remains centralised, the same and even better cost-saving effects can be achieved with current technology, namely relational databases, such as Oracle and MySQL, as noted by expert developers (Greenspan, 2015; Song, 2018). Of course, relational databases do not have the same marketing appeal or buzz as the term ‘blockchain’. They do not sell to naïve investors or enterprises who are willing to pay premium dollar for having the latest technology, even if they don’t really understand it – or need it.

Despite this, truly decentralised blockchain technology is not over. Quite the opposite. Decentralised, autonomous organisations are on the rise among emerging technologies as assessed by Gartner research (Smith and Burke, 2019), but their adoption requires a long-term horizon. This is consistent with the definition of blockchain as a long-term foundational technology rather than a short-term disruptive gadget, in line with Iansiti and Lakhani (2017). Unlike disruptive technology that offers quick cost-saving gains over competitors, foundational technology is more substantial and longer lasting as it enables other technologies and solutions to emerge. An example of foundational technology is the TCP/IP internet protocol that was created in the early 1970s and took almost a quarter of a century to mature and enable the digital economy we are enjoying today.

Preparing for the revolution

To prepare for the blockchain revolution properly, one needs to approach it from a broader interdisciplinary perspective and a longer-term viewpoint. This is not about buying the latest software and doing facade restructuring, supported by trendy buzzwords displayed ostentatiously on one’s website. Proper preparation for blockchain involves the ability to reach deeper and answer challenging questions about organisational capabilities, cultural values and philosophical paradigms, and perhaps most importantly, to assess your (and your organisation’s) mental readiness to let go of the central locus of control and ‘perish’.

‘Proper preparation for blockchain involves the ability to reach deeper and answer challenging questions about organisational capabilities.’

A few quick suggestions may be of help in the meantime:

- Learn about blockchain technology as much as you can; preferably from reliable sources (not profit-driven). Consequently, be sceptical of anyone (this article included) telling you about blockchain solutions. Instead, conduct your own research.
- Start thinking about your long-term strategy and organisational capabilities that may require letting go of your current business model. Not ready to go that far yet? Then be prepared for a new type of competition that may emerge from nowhere one day and take over your business. Taxi drivers did not believe that a mobile app with no real car fleet could take over their business.
- Start slowly and use the tech that already works; for example, you could explore how to pay salaries in cryptocurrencies, like bitcoin, to your staff. This may attract the right kind of people who will help you with the transition. New Zealand is already legally doing it. Talk to your politicians about legislative changes to enable this option. You do not want to be left behind.

About the author

Dr Andrzej Gwizdalski designed and teaches one of the first Master level units on blockchain in Australia, BUSN5001 ‘Blockchain and Distributed Ledger Technologies in Business’.

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

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The impact of digitalisation in mining applications

In a challenging market pushing towards a 'servitisation' model, digital transformation can provide mining industries with the tools to mitigate changes in global demand

Maria Wilson PhD, Global Leader, Data Driven Advantage, Howden

Many air and gas handling applications today operate against the backdrop of challenging markets. Digitalisation has become a key driver in mining to optimise processes and maximise the value of existing applications. Attention has shifted towards emerging technologies to optimise investments on equipment, improve safety at mines and reduce environmental impact.

The digitalisation trend has seen a steady move towards a servitisation model, ie product strategies delivered through or by a service. This is now starting to be very disruptive not only in organisations that are already service-centric, but also in areas that are product intensive. As a consequence, miners are seeing a push towards product strategies delivered through manufacturing industries, which not so long ago used to operate using a 'demand and supply' business model, but are now affected by the societal evolution of Industry 4.0 and the advent of the industrial Internet of Things (IoT).

While the implications of digitalisation are disruptive in more than one way, technology adoption happens at a remarkable pace. In fact, it may be argued that this fast adoption rate is also responsible for yet another unanticipated cultural shift. Research shows that manufacturing companies piloting new technologies to support the emerging servitisation model do not spend a lot of effort in measuring financial outcomes. Rather, they embrace the need for such technologies as vital in the quest for improved performance, with pressure to avoid being left in the wake of the digitalisation wave.

The broad consensus is that the opportunities to reduce costs and digitally transform far outweigh the risks of rapid technology adoption supported by IoT products previously unseen in mining.

Digital technology trends: the digital twin

One of the key strategic technology trends in mining is the digital twin. Digital twin models handle large volumes of historical data, and are supported by the advent of cloud technology that can store an effectively infinite volume of data.

Digital twin models are continuously evolving digital profiles comprising historical data superimposed on the current behaviour of the equipment. The digital twin is based on cumulative, real-world measurements across a wide range of operational parameters. Such measurements help create a digital performance profile that will support actions in the real world, leading to design improvements and changes in the manufacturing and operation of the asset.

While in theory the concept is sound and can enable real value, in practice deploying such digital twin models at full scale is challenging for a number of reasons:

- The digital profile is relying on the existence of historical data, and large amounts of it, to create an accurate representation of the equipment. In air and gas handling applications, the right or sufficient data to build the digital profile may not always be available.
- Accessing and processing raw data in a way that is relevant for equipment performance is not always possible. Creating the digital profile involves data tagging of events in the operational history of the asset. Looking for both efficient operation and failure modes can be a daunting task, especially for machines deployed in the field for some time.

- Historical data can only be a resource for already installed equipment; newly commissioned equipment does not have a digital performance profile from the beginning.

The new generation of digital twins

In air and gas handling applications in the resources sector, end users are typically focused on:

- detecting equipment failure before it occurs and identifying the root cause
- understanding the impact of change in operating conditions on the equipment and process performance
- moving critical equipment maintenance strategies from reactive to fully predictive
- optimising energy consumption to reduce costs and carbon footprint
- maintaining continuity of equipment operating history between several iterations of the mine plan and changes to personnel.

A digital twin model designed to solve physical issues faster by detecting them sooner, predict outcomes to a much higher degree of accuracy, and evaluate performance of the equipment in real-time, may help companies realise value and benefits iteratively and faster than ever before.

This value starts with having a complete digital footprint of the product from design and development through to the end of the product lifecycle. This, in turn, may enable an understanding of not only the product as designed, but also the system that built the product and how the product is used in the field.

With the creation of the digital twin, manufacturing companies may realise significant value in the areas of speed to market with a new product, improved operations, reduced defective equipment, and emerging new business models to drive revenue.

One feature of the new generation digital twin approach is the source of the historical data. While superimposing digital profiles on real-life application data is the true enabler of value, revisiting the source of the data for the digital half of the model may result in a game-changing approach.

Traditionally, we think of historical data as operational data recorded and used to average a past behaviour. But what if the historical data is replaced by a design data set that includes the design principles of the equipment, the intended performance at the best efficiency point, and the CAD model with simulation values of the desired process and relevant air and gas properties?

A digital profile populated by such data will depict a 'theoretical' performance map of the equipment as per its design intent. Superimposed on the real-life operational data from the sensors, this information will enable the mapping of the current operation in respect to the equipment's best efficiency point, without processing any historical data. Isolating and analysing the difference between the two data sets will optimise equipment performance to match operational requirements.

For operations with pre-existing historical data, these patterns can be pre-populated and the recorded operational data may be used as a subset to assess the asset performance to date, which when mapped to the design data, can be indicative of the asset's remaining life.

Driving business value with digital twins

Digital twins may help equipment manufacturers with asset fleet management, but improvement in operational efficiency and insights into operation will require time and a lot of data gathering and processing, and therefore multiple years to realise financial benefit. In light of this, setting on a path of digital transformation that is focused on solely building digital twin models should be done with the longer-term business benefits in mind, driven by customer and organisational KPIs.

Once these objectives are clearly defined, a wider enterprise readiness assessment may be required in order to identify other IoT initiatives that are focused on leveraging the full value of the digital twins. In this way, digital twins can offer strong potential to achieve the desired value improves and support improved decision making. The risk, especially in organisations that do not have a strong suite of IoT equipment, is in the absence of clear objectives. In this case, it may be difficult to transform an organisation's digital journey into a data collection and storage driven process.

Image: Twinsterphoto/Shutterstock.com.

Artificial intelligence and augmented reality

In air and gas handling applications in the resources sector, digital twins of rotating equipment can deliver more value if focused on critical performance goals, such as efficient/optimised operation and elapsed/remaining operational life. These goals can be achieved by coupling the digital twin with the two emerging 'A' IoT technologies – artificial intelligence (AI) and augmented reality (AR).

AI stands out as a transformational technology and questions about what it is, and what it can do, are still being explored. The definition of AI is ever evolving and extensive research in the field has mapped these capabilities to specific industries and problem types.

As more asset performance data is analysed and interpreted through digital twins, AI-enabled maintenance strategies will continue to increase, changing the operation of equipment to data-enabled decisions and actions that result in optimised performance and the avoidance of unplanned downtime.

AI-enabled strategies will allow equipment behaviour learning and automation of digital analytics to deliver situational analysis that responds to changing operating conditions. This results in clear business value around asset performance optimisation, predictive maintenance opportunities and extending operational life of the equipment.

AR, though still in its infancy, is another quickly evolving technology that superimposes a computer generated three-dimensional model on the viewer's real world, providing a hybrid view of the physical and digital.

With AR transforming volumes of data and analytics into images or animations that are overlaid on the real world, it can deliver great customer value. AR allows a digital object to be placed in the customer's physical environment, providing a detailed experience of the internal features that would otherwise be difficult to see, enhancing the understanding of fundamental principles of operation and design. Secondly, AR enhances product perception, with 3D thinking and visualisation rather than 2D that helps facilitate the real-time display of the equipment with operational and digital twin data.

Furthermore, AR has the potential to fully immerse the digital twin into the physical world, focusing on real equipment and process performance indicators. The not-so-distant future of AR will no doubt see a full immersion of the customer experience from end to end, connecting sales to design and manufacturing through to installation and operation into a space where the data is displayed right in front of you, in real time.

Conclusion

We are witnessing a truly global uptake of digital trends where mines are faced with increasing pressure to transform their traditional operations and foster a digital culture. In a challenging market pushing towards servitisation, digital transformation can provide mining industries with the tools to mitigate the changes in global demand. This involves mining operations developing the capabilities they need to provide services and solutions that supplement their traditional product offerings.

The biggest limitation of digitalisation in this space is the data, either too little or too much of it, and only a clear data strategy can yield a successful digital transformation journey that adds business advantage.

One approach is by driving digital transformation through customer KPIs with a focus on the business value. This approach can enhance customer operations and can be achieved with the new generation of 'smart' digital twins with pre-populated design data to reflect the equipment's best efficiency point, as well as deviation from intended operation conditions. This data strategy focuses on the right operational data, setting the scene for performance optimisation, and can be further enhanced by enabling the smart digital twins with advanced IoT technologies like AI and AR, thus delivering business value according to predefined KPIs.

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The importance of autonomous technology training

With the huge potential for new technology to revolutionise mining operations, high-quality training of personnel is needed to ensure safety and efficiency

Sunil Kumar, Training Coordinator, RCT

Across the global mining industry, there is an ever-increasing adoption of smart technology. Gone are the days where miners worked in isolation, digging up earth and hoping to strike pay dirt. Now, every stage of the mining process is jam-packed with technology designed to improve the mining process and safeguard mining personnel.

The inevitable uptake of smart technology, advanced communications infrastructure and autonomous machinery has created the need to ensure employees are suitably trained and confident in using this technology.

What should be covered in autonomous technology training?

When it comes to autonomous technology, employee training can be categorised into two streams: equipment operators and maintenance personnel.

In general, comprehensive operator training should focus on equipment functionality, and be designed to impart all necessary knowledge to the operator so they can get the most out of the equipment.

Maintenance training should delve deeper into the underlying technology. This may include teaching mine site personnel to replace components and conduct other minor maintenance works. As an extension of this, RCT also offers an advanced maintenance package for select customers, which teaches suitably qualified mine employees to service individual components and carry out the type of activities that RCT's specialised technicians would carry out on a site visit. By properly training and empowering mine site employees to do this work, efficiency can be improved.

'Using autonomous technology in hazardous environments is a clearly favourable outcome.'

Health, safety and training

Personal safety has been one of the key drivers behind an uptake of training programs in the global mining industry. Most countries that we work in have stringent laws governing people working in hazardous environments. Furthermore, in recent times there has been a noticeable cultural shift inside mining companies who want to protect their workers and safeguard their operations.

Using autonomous technology in hazardous environments is a clearly favourable outcome, because a lot of the work where autonomous technology can be deployed involves removing people from contact with dust, smoke, extreme weather, chemical particles and long shifts – often in confined working spaces such as underground operations.

But in order to use autonomous technology properly, personnel need to be well-informed about standard operating procedures to avoid serious incidents involving machines and people.

Getting the most out of new technology

Properly trained personnel contribute significantly to operational efficiency and productivity because technology is only as good as how it is used. In our experience, most people underutilise the technology that they possess.

A simple example, in a non-work context, is the smartphone, which has the power and potential to improve personal productivity multi-fold if used optimally. But most people only use about 10 to 15 per cent of the features and capabilities available on their devices.

This same principle applies to autonomous technology in the mining industry, where new equipment may not be being used efficiently, or to its fullest extent. But with proper training, good operators can become great operators, and mine site productivity can increase multi-fold.

The generation gap and the future of training

Training is equally essential for both younger workers – who are traditionally more technologically savvy – and older workers, who are generally in the process of adapting to new technologies in the mining industry.

Autonomous technology is going into every mine and is deeply embedded in new mine infrastructure. Therefore it is important that the entire workforce be upskilled.

Going forward, face-to-face training delivered on mine sites or in offices remains important, and will be complemented by online training portals which will enable educators to reach remote mine sites that are difficult to access physically. Online training also has the potential to focus more on repeat trainings and refresher modules, where a level of knowledge (and a relationship with the trainer) already exists.

A gateway to healthier environments in WA's hard-rock underground mines

A recent health and environmental study of existing conditions in a hard-rock operational underground mine could greatly benefit the wider industry

Emeritus Professor Odwyn Jones AO FAusIMM, Clinical Professor Bill Musk AM, Chris Davis FAusIMM, Martin Ralph

Recent applied research work carried out at one of Western Australia's (WA) underground gold mines has produced some very interesting and informative data. If acted upon, this health and environmental study of existing conditions in a hard-rock operational underground mine could greatly benefit the wider industry.

The program consisted of two research projects which were presented to a public forum held on 29 July 2019. The research projects comprised a field study of the atmospheric conditions at worksites and other stationary monitoring stations sponsored by both the Minerals Research Institute of Western Australia (MRIWA) and the WA Department of Mines, Industry Regulation and Safety (DMIRS) (MRIWA Research Report 495, 2019); and a health impact study sponsored by the DMIRS, the first component of which has been published by Mengran Du et al (2019).

Review of health impact study findings

- Exposure to Diesel Exhaust Emissions (DEE), whilst reducing due to improved ventilation practices and technological advances in engine design and after-treatment devices, is still a major threat to the long-term health of underground miners in hard-rock mines.
- The study indicated that the 80 participating underground miners were exposed to significantly greater levels of elemental carbon (EC), volatile organic compounds (VOCs), nitrogen dioxide (NO_2), lung-deposited surface area (LDSA) and nanoparticles than the control group of 20 surface personnel.
- Underground miners demonstrated a decline in lung function during working shifts caused by exposure to DEE, and whilst these changes of themselves are too small to cause symptoms, repeated small changes can accumulate to cause irreversible damage (as with cigarette smoking).
- Pre- and post-shift urinary biomarkers increased during the shift for underground miners, which provided a measure of the body's uptake of polycyclic aromatic hydrocarbons (PAHs), a carcinogenic toxin stored in the kidneys, liver and fat.
- A statistically significant increase in systolic blood pressure of underground miners occurred across the shift. Although the increase was within the bounds of error of the measurement technique, if the increase is repeated each shift, it has the potential to increase the risk for cardiovascular events.
- Numerous CpG sites (regions of DNA) were identified in blood samples of underground miners; some of which can induce biochemical alteration to DNA. Of the 29 methylated CpG sites, 12 were known to be associated with chronic diseases including cancer and cardiovascular diseases.

Further details and the full study can be found in the published paper.

Health surveillance measures and procedures

The requirements for a health surveillance system are clearly defined in the 'DMIRS Safety Guidance about risk-based approach to health surveillance.' It states that:

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- employers need such a system to 'identify changes in the health of workers' exposed to hazardous substances
- 'risk-based health assessment or biological monitoring is required where workers are exposed to hazardous agents - chemical or other substances that can lead to ill health or disease'
- such systems 'should also ensure that control measures in the workplace are effective and provide... safe work practices' (DMIRS, 2019).

Furthermore, it lists the following common examples of the elements of health surveillance systems:

- recording occupational and medical history
- providing health advice
- facilitating physical examination
- maintaining records of exposure
- providing and recording respiratory (lung) function tests
- carrying out biological monitoring to ascertain the extent to which chemicals have entered the human body following exposure (DMIRS, 2019).

Reference is also made to the fact that the approved person (who could be a medical practitioner) responsible for the surveillance system may require workers to undertake additional surveillance. Both the worker and employer must be notified of the results and need for remedial action (DMIRS, 2019).

Based on decades of concern regarding the health hazard to underground mineworkers exposed on a regular basis to diesel engine exhaust fumes, confirmed more recently by research evidence of its specific health impacts, there is every reason to recommend that such a health assessment and surveillance system and associated procedures be established in WA for underground mineworkers exposed to diesel engine exhaust fumes.

Ideally, such a health assessment and surveillance system should be managed and operated by an autonomous body. The information collected should be integrated with existing X-ray surveillance for pneumoconiosis and retained indefinitely in order to allow follow-up of the workers for the occurrence of cancers and deaths.

Digital all-electric mines

As Andreas Nordbrandt, Atlas Copco's President of Underground Rock Excavation Division stated two years

ago, 'our customers' future is electric.' He emphasised that it's becoming realistic to visualise 'zero-emission electric equipment' replacing diesel-powered mobile equipment sooner rather than later (Mining Journal, 2017).

At the same time he stated that 'the company's immediate plans are to expand its portfolio of electric powered equipment including loaders, drill-rigs and haul trucks' and while admitting to higher up-front costs, he emphasised the advantages of lower mining costs and potentially considerable savings in ventilating and cooling in the deeper mines.

A report in the *Guardian* newspaper (2017) stated that 'legal claims over exposure to diesel fumes at work are growing as unions warn toxic air in the workplace is a ticking time bomb on par with asbestos,' with the UK's largest trade union (Unite) establishing a diesel emissions register for employees to record their exposure.

Surely now is the time for the WA mining industry and its regulators to develop its own 'Clean Air Plan' for underground mines, including guidelines for the replacement of diesel-powered mobile equipment with electric-powered equivalents as soon as practicable.

Currently the Canadian market is leading the charge, starting with Kirkland Lake Gold's Macassa operation, where battery-electric machines were installed in 2013 (Tollinsky, 2013). These machines have continued to maintain high performance levels and currently the Macassa mine accounts for more than 80 per cent of Kirkland Lake Gold's production (Goodbody, 2019).

More recently, both Goldcorp's Borden gold project and Glencore's Onaping Depth nickel-copper project are being developed as fully electric operations due mainly to high ambient rock temperatures and the increasing costs of ventilation to cope with the health hazards of diesel-engine exhaust fumes (Leonida, 2017).

The Global Mining Guidelines Group (GMG) published 'Recommended Practices for Battery Electric Vehicles (BEVs) in Underground Mines' in 2017. These guidelines highlight the issues needing careful consideration prior to embarking on replacing diesel-powered mobile equipment at existing mines with fully electric systems or planning the development of new fully electric mines.

As we move further into the digital age, electric equipment will become the key to new, more efficient and energy-saving ways of extracting ores from the deep and ultra-deep underground mines. The deeper the mine, the more attractive fully electric systems become, by overcoming many of the challenges of coping with high *in situ* rock temperatures and the extra heat, humidity and toxic diesel engine exhaust fumes.

Support for all-electric mines is coming from many quarters with the International Council on Mining and Metals planning to minimise the impact of underground diesel engine exhaust by 2025 (ICMM, 2018). Further evidence of the extent and speed at which electric vehicles are reaching global markets is provided by Epiroc, Sweden's mining equipment manufacturer, which aims to electrify all its underground machines within five years.

'As we move further into the digital age, electric equipment will become the key to new, more efficient and energy-saving ways of extracting ores.'

However, at present battery-powered vehicles cost about twice as much as their diesel counterparts, making the switch to electric vehicles prohibitive. Epiroc's willingness to lease batteries for its new vehicles largely overcomes this problem by reducing the initial outlay to little more than that of an equivalent diesel machine.

Recommendations

- A health assessment and surveillance system and associated procedures should be established in WA for all underground mineworkers exposed on a regular basis to diesel engine exhaust fumes. While the elements of such a system have already been mentioned, it is important to emphasise the need for regularly monitoring elemental carbon (EC) and, if at all possible, nanoparticle concentration and distribution, as well as lung deposited surface area (LDSA) and airborne concentrations of the gases produced by diesel-powered vehicles.
- Standards and guidelines for EC for longer working shifts and rosters need to be made much clearer.
- More attention needs to be given to the design of ventilation of development headings in order to improve the volume of the ventilating airflow reaching the face and its effectiveness in removing and diluting the toxic and noxious products produced by diesel engines.
- Bearing in mind the toxic mixture of chemical compounds in diesel engine exhaust, the likelihood of mineworkers developing 'Multiple Chemical Sensitivity Disorder' should also be explored, since it is an emerging disabling illness characterised by chronic adverse effects from exposure to low levels of chemicals (Martini et al, 2013). Consequently, much more attention must be paid to preventing such poisoning, including ensuring the exhaust cleaning devices are in good repair and that an effective ventilation system is in place.
- More detailed and extensive study of the correlation between EC and nanoparticle concentration, and ageing of diesel particulate matter (DPM) as it travels through the ventilation circuit is required.
- When working in hazardous environments the role of education and training for all relevant personnel cannot be over-emphasised. This entails instruction in hazard recognition and control measures, safe work practices, monitoring systems and preventative measures, etc. Such training for management, mineworkers, regulators and researchers ensures there is a common language for effective communication.
- Increased use of SF6 tracer gas studies is justified based on the assumption it represents, in large measure, the movement of ultra-fine particles.
- Continuing use of computational fluid dynamic (CFD) modelling is also justified since it appears to give good agreement with SF6 tracer gas studies and assists in improving and optimising key areas in the ventilation circuit.
- As stated earlier, the medium to longer-term future lies with digital all–electric mines and, consequently, it is timely for the industry and its regulators to develop guidelines for the future development of new all-electric mines and/or the replacement of existing diesel-powered fleets with their BEV equivalents.

Closing comment

Strong claims are being made for the benefits of 'new technology diesel engine' (NTDE) technology with catalysed diesel particulate filters in greatly reducing particulates and toxic emissions. But its penetration into the off-road diesel engine market will inevitably take many years (Vermuelen, 2017). However, using such technology may be confounded by the increase of NO2 emission and release of reactive ultrafine particles (Karthikeynan et al, 2013).

This confounding challenge of increased NO2/NO ratios which occur with oxidation catalysts, causing deteriorating air quality, is a matter of considerable concern for those responsible for diesel-powered mobile equipment in underground mines. As stated by Cauda et al in 2012, 'in mine environments with inadequate ventilation where local "dead spots" exist in work areas, it would be possible for NO2 levels to rise to problematic levels faster with the use of a DOC than without.'

'When working in hazardous environments the role of education and training for all relevant personnel cannot be over-emphasised.'

Consequently, until the final removal of diesel-powered equipment from underground mines, there is no alternative but to establish a well organised and managed health surveillance and monitoring system whereby employers can adequately exercise their duty of care for the continued health and wellbeing of mineworkers.

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From compliance to commitment: a key opportunity for the global mining industry

In the lead up to the AusIMM Underground Operators Conference in March 2020, Roy Slack, President of the Canadian Institute of Mining, Metallurgy and Petroleum (CIM) and Underground Operators keynote speaker, shares his insights on the future of underground mining and the best way to head towards a safe industry.

With 35 years of experience in mine construction, design and development around the world, Roy is passionate about securing the mining industry's place as a global leader for change.

"Our industry is on a journey from compliance to commitment. From a state where we strive to just meet regulatory requirements, to a place where we meet and far surpass those requirements – not because we are legally required to do so, but because it is a moral imperative."

Slack says that because young people have been raised in a time of rapid change, they are much more accustomed and acclimatised to deal with it. He says this means it's an exciting time for fresh talent and new ideas to build the future of underground mining.

"Today's youth are entering the industry, or have the opportunity to enter our industry, at a time of great change. Change in technology, change in how we deal with people, change in the overall business model that is mining."

As the mining industry rapidly transforms with new technologies and exciting innovations, Slack believes the whole sector needs to get on board with a fresh way of thinking.

"We need people that thrive on change, that embrace and know what to do with it."

Slack has been active in numerous safety initiatives over the years, as well as being appointed to the Province of Ontario's first Prevention Council advising the government on workplace safety and chairs the CIM Safety Committee.

A strong advocate for protecting workers, Slack says the opportunity for change in technologies will create a real sense of support and safety in the workplace for all professionals.

"I am excited about the huge potential of emerging technologies to make our workplaces not just safer, but safe. Technology has always been an important part of safety, but the more recent applications of the technology available to us add a whole new perspective on our journey to zero injuries.

"Process, culture and technology; together protecting our people and ultimately achieving a safe workplace."

Read the full interview with Roy Slack online at: **www.ausimm.com/roy**

Next generation pioneers ready to tackle the Explorer Challenge.

What the Explorer Challenge means for the future of exploration

Can crowdsourcing and consensus targeting revolutionise discovery?

Holly Bridgwater MAusIMM, Industry Lead - Crowdsourcing, Unearthed

The Explorer Challenge was Australia's largest open data crowdsourcing competition to date. OZ Minerals provided a $1 million prize pool and more than six terabytes of private and public exploration data to a globally distributed community of geologists and data scientists, who then developed groundbreaking approaches to predict mineralisation and identify exploration targets at the Mount Woods tenement in South Australia.

As economic mineral deposits have become increasingly difficult to find, explorers are seeking new approaches, innovative processes and ways of working that can drive up the discovery rate and speed up the exploration lifecycle, resulting in a more sustainable and efficient future for mineral exploration.

Despite exploring extensively around Prominent Hill over the past decade, OZ Minerals are yet to find another economic orebody in the area. The company wanted to find fresh insights and ways of working differently with their data. The Explorer Challenge provided approaches to mineral exploration that they never would have imagined internally, including ways to fuse datasets together, combining multiple layers of information, and making predictions based on the extensive datasets.

However, the Explorer Challenge was not the first crowdsourced exploration competition. Goldcorp ran the first iteration in 2000, followed by Integra Gold in 2015. The sporadic nature of these competitions makes them seem like one-off, independent events, with no clear links to driving widespread industry change or impact.

Is the Explorer Challenge any different? I certainly think so, for the following reasons.

'Exploration geologists understand that the physical environment in which we work is incredibly complex on many levels.'

The concept of consensus targeting: increasing confidence, reducing risk

If you ask a geologist to tell you the level of uncertainty associated with their model and the targets they generate from it, you may get a blank look. What if an investor asked, 'why are you drilling that target rather than this one; can you put numbers on why it is better?'

Exploration geologists understand that the physical environment in which we work is incredibly complex on many levels. This complexity means that there are millions of potential models that could legitimately represent the formation or signature of an orebody, but it is not feasible for the human brain, or even computers, to generate them, let alone test them. The result? We usually end up with one model that the exploration team broadly agrees on, that we know is wrong, yet think is good enough. We rarely have any understanding of the real uncertainty associated with this model and how it may compare to other alternative models. If we did, we would arguably significantly improve our ability to select targets and increase our discovery rates.

The consensus approach developed through the Explorer Challenge starts us down this path. This method allows us to compare and contrast alternative models and attach a level of confidence to our targets, just not in the way you might imagine.

As a scientist, if you think about comparing models, you might think about comparing their technical validity. Which one is more geologically sound and honours physics? Which one uses data more effectively? Perhaps you might also think, which model was created by the most expert geologist in this field, who has seen the most deposits? Again, quantitatively, it is very hard to compare in this way.

The consensus approach relies on relatively simple statistics – that the collective opinion is better than any one individual opinion or prediction (Surowiecki, 2004). This hypothesis is only valid for complex problems and environments like geology or hurricane prediction, where you can never truly determine that one model is better than any other because your environment constantly changes. Conversely, challenges that involve simple predictions do not benefit as much from aggregated predictions.

The consensus approach also relies on key inputs to be statistically relevant. Approaches entering the consensus must be independent, diverse, and trusted (ie technically valid).

In the practical case of the Explorer Challenge, this means combining the targets created by many different models into one. Figure 1 is a heat map of the 400+ targets generated in the Explorer Challenge, with clear hotspots where multiple models have predicted targets in the same area.

How would you feel if five geological models and five machine learning models all independently predicted the same target? I would argue that you would feel significantly more confidence in that target, as opposed to a target that was only predicted by one model.

The data can further be interrogated to see which approaches produced which targets. What did traditional geological approaches predominantly predict? Versus machine learning, versus specific machine learning techniques like neural networks and random trees?

We can now put a number on the confidence we have in our targets, based simply on how many valid approaches predicted them. This significant change can impact not just how we explore, but how we attract investment.

By using a crowdsourcing approach, the Explorer Challenge provided an environment that enabled consensus through several key factors:

• independence – the models were all developed completely independently and avoided groupthink

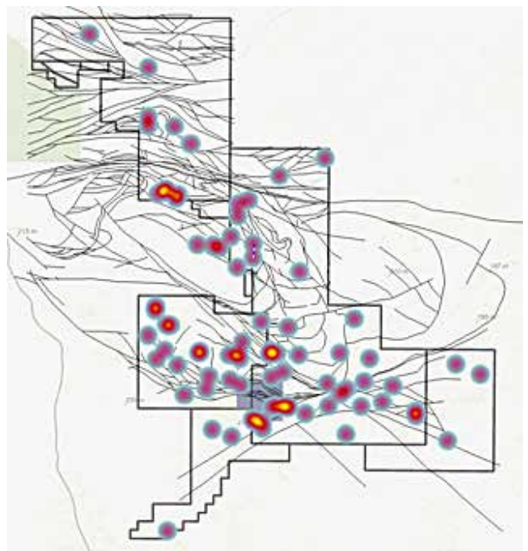


Figure 1. Explorer Challenge consensus target heat map.

‘The consensus approach demonstrated in the Explorer Challenge provides a step change in the way we apply confidence to our targets.’

• synchronisation – hundreds of models were developed at the same time in parallel

• diversity – The models were created from different interpretations of data based on different, yet relevant, experience

• trust – the models were reliable as technically relevant and valid

• aggregation – the outputs of the models (the targets) were able to be aggregated meaningfully.

However, some key factors remain unanswered, namely:

• Conditions of entry – in the Explorer Challenge, submissions were subjectively judged on their technical robustness by experts in geology, mathematics and data science. Submissions deemed valid gained entry into the consensus model, with a total of thirty-seven models making the cut. The subjective nature of this approach introduces bias into the process. How could this be avoided? What does it mean to objectively qualify a model that can be included in the consensus as valid?

• Scale – what is a target on regional, local and deposit scale in a consensus model? How close do targets need to be to be considered the same? What is a target? In the case of the Explorer Challenge, we asked people to submit their top targets for economic mineralisation of base metals, with specifics on size and dimension.

• Delivering value to the expert community – for the consensus approach to really scale, meaningful incentives and rewards need to be provided and available for the expert community. If not, they will not continue to engage. This requires a new understanding of value transfer and a new business model.

Into the future

The consensus approach demonstrated in the Explorer Challenge provides a step change in the way we apply confidence to our targets. While more testing is needed, if proven, this method could drastically improve our discovery rates by enabling us to focus on quantifiably better targets.

The drill program at Mount Woods commenced in early Q4 2019, where the top consensus targets from the Explorer Challenge are being tested with an initial program of ~6 holes for 3000 m, to be followed by further drilling in H1 2020. During this program, OZ Minerals will live stream assay data to a select group of data scientists, which will enable predictions of drilling results to be made in near real time and significantly increase the amount of information available to geologists to make faster and more informed decisions.

The crowd approach has two other additional benefits, which may be more crucial drivers of adoption in the short term:

• Speed – the typical role of an exploration geologist is largely project management and execution. I would guess that 10-20 per cent of their time is spent on real interpretation and geological work. The crowd provides a way for quick interpretation and feedback on data, which is particularly relevant for small, time-constrained teams.

• Instant access to hundreds of experts – in an industry where we are used to hiring one or two consultants to support our internal teams, the crowd provides a unique way to get quick feedback from a much wider group of experts, all at the same time. This is particularly relevant when we are looking for multiple deposit styles or have higher uncertainty in the geological environment.

Conclusion

The crowdsourcing approach to exploration targeting generates hundreds of independent models and targets from data scientists and geoscientists around the world in just a few months. When the best of these are combined into one aggregated target map, this can reduce uncertainty, dramatically shorten the exploration lifecycle and may significantly increase mineral discovery rates.

So, what do you think? Do you agree that collective wisdom will shape the future of our industry? We would love to hear your point of view. Join Unearthed’s Exploration Newsletter to discover more: **unearthed.link/FoEN**.

Thank you to all the next generation pioneers who took part in the Explorer Challenge. The knowledge and input you provided is driving significant positive change to our industry.

Reference

Surowiecki J, 2004. The Wisdom of Crowds, 336 p (Doubleday).

Pioneers from the Explorer Challenge

Michael Rodda, Jesse Ober, and Glen Willis.

First prize ($500,000) – **Team Guru**

Michael was the data scientist for the team, Jesse has a background in environmental science and GIS, and Glen has a background in process engineering in the field of oil and gas and a keen interest in data science.

Team Guru deployed interpretable machine learning models for mineral exploration using geochemistry, geophysics and surface geology.

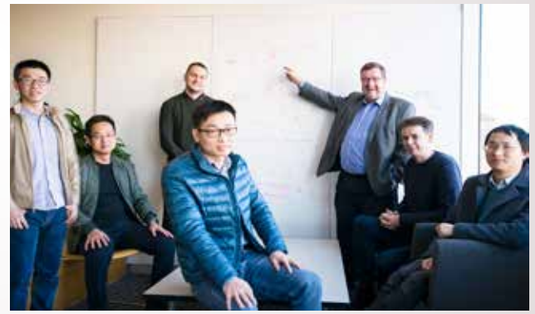
The team have invested their prize money in creating their business, Caldera Analytics, to build out their model and develop a global database of open data for use from tenement acquisition through resource definition.

Second prize ($200,000) – **DeepSightX**

The DeepSightX team exploited multi-disciplinary skills at the intersection of artificial intelligence and geoscience. Researchers from the Australian Institute for Machine Learning (AIML) and the Institute of Minerals and Energy Resources (IMER), both hosted by the University of Adelaide, collaborated with industry experts in minerals exploration (Austrike Resources) and geoscientific modelling (Gondwana Geoscience).

DeepSightX used a multidisciplinary approach to generate an AI model, DeepSight, which provides promising exploration targets in the Prominent Hill Region (PHR) supported by best practice geoscience.

DeepSightX has also created a business to continue focusing on this industry challenge. They will continue development on their solution, which uses machine learning to optimise drilling by reducing the number of drill holes and improving drill hole positioning.



Dong Gong, Javen Qinfeng Shi, Zifeng Wu, Hao Zhang, Ehsan Abbasnejad, Lingqiao Liu, Anton van den Hengel, Karl Hornlund and John Alexander Anderson.

Third prize ($100,000) – **Cyency**

Cyency has a strong data science and geoscience background. Hugh has been practising deep learning for several years, Derek has been involved with the technical and software side of mining for more than ten years, and Chris is an experienced geologist who is always looking for innovative ways of doing things.

The team started with their results from the Data Science Stream of the Explorer Challenge. They had a set of models that were good at predicting mineralisation across Australia, so they ran them over the tenement, applied several data science techniques to estimate a set of candidate points, and selected the top ten.

Cyency is currently working with a large Australian mining company to develop this technique and apply it to other areas. They use applied deep learning and image processing techniques in their approach.

Hugh Sanderson, Derek Carter, and Chris Green.

Special Feature: Exploration

'The pilot program contains 400 per cent more geoscience data than was previously available to industry online.'

Queensland leads the charge to modernise data-driven exploration

The Geological Survey of Queensland is committed to enabling data-driven exploration in the state, and is running two new initiatives designed to modernise and make available large amounts of geoscience data

Drew Cox, Project Manager, Geoscience Data Modernisation Project, Geological Survey of Queensland

In June 2019, the Geological Survey of Queensland (GSQ) launched a pilot of the GSQ Open Data Portal. The pilot contains 400 per cent more geoscience data than was previously available to industry online.

The pilot has 1264 seismic surveys and 7275 geochemical data sets for industry to search and download. It is the first release from the Geoscience Data Modernisation Project (GDMP), which aims to publish all open file geoscience data held electronically by GSQ by December 2020.

GSQ aims to enhance data-driven exploration in Queensland by bringing data from six separate systems into a single open data portal for the first time. Anyone will be able to find target data using spatial, text or facets search tools.

The GSQ portal uses a data catalogue to integrate metadata from different data types. This enables fast and easy searching, filtering and downloading through a standard web browser. The format of the metadata also supports machine learning and artificial intelligence. The catalogue itself is based on international and national data standards to ensure its quality and longevity.

Image: dozik/Shutterstock.com.

Once complete, the portal will have 12 types of geoscience data including geophysical, geochemical, hyperspectral, seismic, ASTER, 3D models, QPED data, map collections and wireline logs. The pilot only has seismic and geochemical data at present. Other data types will be added throughout 2020.

The pilot currently has limited functionality for searching and downloading. This will be expanded as the project progresses through the remainder of 2019 and 2020. You can provide feedback through the 'Support and feedback' link on the portal website at **horizon.gsq.digital**. To make sure the project is driven by the needs of industry, users are encouraged to provide feedback.

Practical benefits have already been seen from the pilot. Prior to June, two GSQ geologists spent most of their time responding to industry requests for seismic data which they copied onto hard disks and mailed out. Now everyone can self-serve and find and download the data they want from the portal. This produces savings in time and money for both industry and GSQ.

New Industry Reporting Guidelines

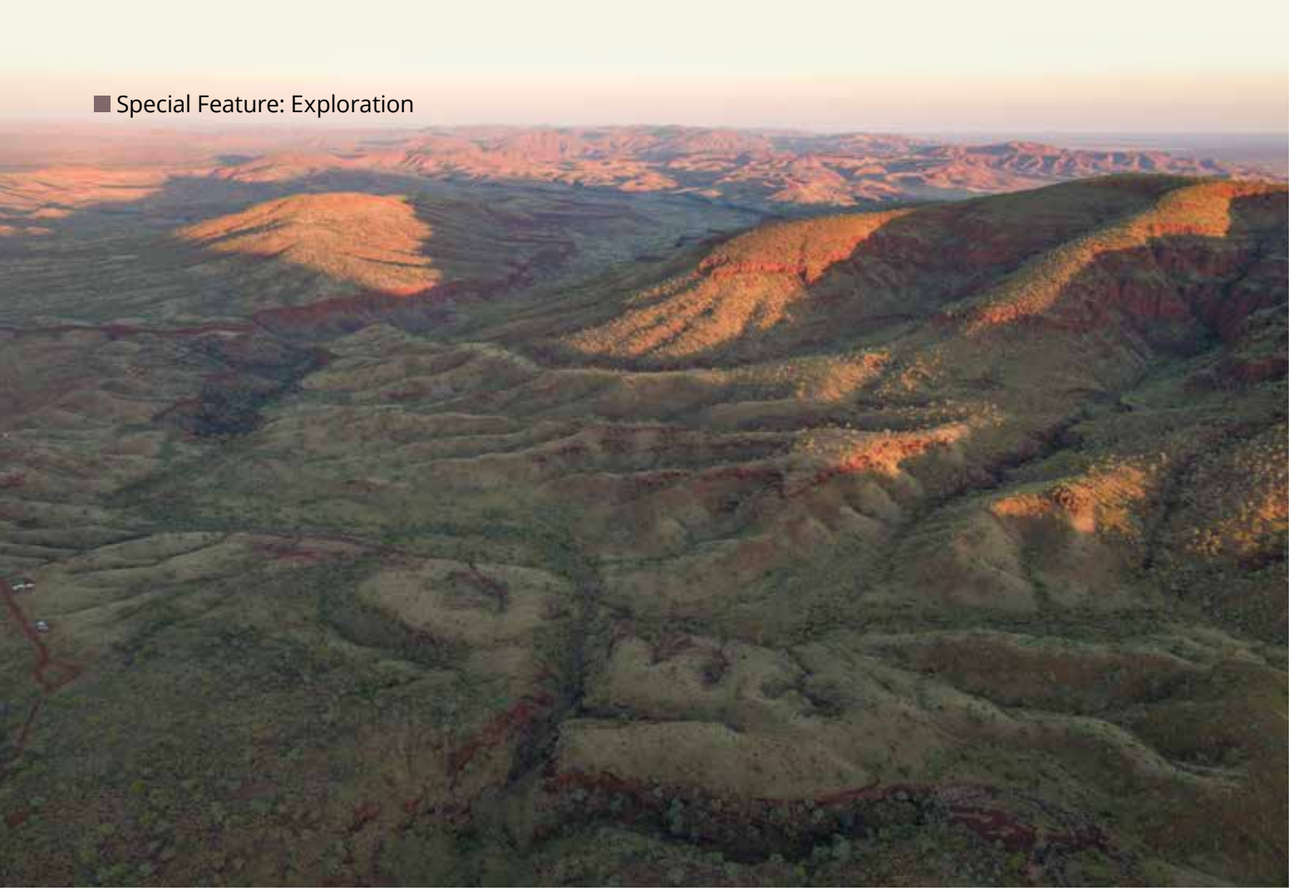
GSQ is also running another initiative to support data-driven exploration by industry. This initiative is centred on improving the quality of geoscience data which industry has been requesting for many years.

GSQ is currently seeking feedback on new Industry Reporting Guidelines, which require industry reports and associated data to be provided in a structured, itemised format using Excel templates. This new data can then be automatically quality checked prior to being accepted and stored. This quality-improved data will then flow back to industry after the relevant confidentiality period has expired.

To support the new Industry Reporting Guidelines the GDMP will be building a new data submission portal to replace QDEX Reports.

GSQ is committed to enabling data-driven exploration in Queensland. The GDMP and the new Industry Reporting Guidelines are two initiatives in progress which will make a real difference for the resources industry in Queensland.

This article was originally published by the Queensland Exploration Council via the QUREX Gateway.
Visit **qurex.com.au**.



Geological detective story leads to breakthrough

A new technique for geochronologists and sedimentologists will be put to the test in late 2019, providing unique information on the source of sedimentary rocks throughout Western Australia

Government of Western Australia Department of Mines, Industry Regulation and Safety

Accurately dating and tracking down the origin, or provenance, of rocks is critically important knowledge for explorers when targeting deposits. During the past two decades, geoscientists have used uranium-bearing minerals called zircon in sediment (detrital zircon) for the isotopic dating of rocks, because the uranium isotopes change to lead at a well-understood rate.

Uranium-lead zircon dating has come to be known as the 'gold standard' for geochronology, but it is far from perfect, as the Geological Survey of WA (GSWA) Chief Geoscientist Dr Simon Johnson found when trying to establish the provenance of sediments in the Edmund Basin. That quest led to a geological detective story, which highlighted using lead isotopes in potassium (K) feldspar – one of the most common minerals in the earth's crust – as a more accurate alternative in certain situations.

Dr Johnson said zircon suggested that the Edmund Basin sediments had come from the Gascoyne Province to the south, despite evidence from rocks showing the direction of river currents, which indicated they came from the north. Being extremely hardy, zircons can survive a number of cycles of uplift, erosion and deposition, sometimes ending up in a location nowhere near their source.

'We knew that using detrital zircons can be an issue because they get recycled, and then recycled again and again, and sometimes they're telling you the wrong answer when you're looking for their provenance,' Dr Johnson said.

'We wanted to work out a way to use other minerals or methods to support or reject the story being told by the zircon.'

In a happy coincidence, a former colleague at GSWA, Professor Chris Kirkland, who is now working with the Centre for Exploration Targeting (CET) at its Curtin University node, was looking into the lead isotope composition of K-feldspar as an alternative to compare with zircon. He wanted a project to test the new method and approached Dr Johnson, who jumped at the chance to use the laser-ablation mass spectrometer at the John de Laeter Centre to solve the Edmund Basin mystery.

The K-feldspar compositions proved that the zircon and K-feldspar were definitely coming from different sources, but it did not completely solve the story because it did not prove where the sediments were actually coming from.

The question nagged at Dr Johnson and Professor Kirkland.

'It's not coming from the south. We proved that – it's clearly coming from the north, so we had to think about what sources of K-feldspar there would be in the north,' Dr Johnson said.

'We hunted around in our collections of samples from the core library to find a potential source and in the end, the only samples left to analyse were granitic rocks from within the sedimentary basins which are part of the Pilbara Craton.

'We did a few of those, and then we got that perfect match, proving that the sediments were coming from the north.'

But the detective work wasn't quite over – where had the zircons really come from?

'The zircon story is ultimately correct, the zircons are really coming from the south, but it's a two-stage process,' Dr Johnson said.

'They came from the south from an older period of time, where the granitic rocks were uplifted and the zircons eroded into a sedimentary basin in the north, and then during the deposition of the Edmund Basin, the northern basins were uplifted and the zircons were recycled.'

In a complementary study, Dr Imogen Fielding, a PhD student at Curtin University at the time (now GSWA's Phosphate Geochronologist), was examining the timing of gold mineralisation in an area of the Pilbara hosting the Paulsens, Belvedere and Mount Olympus gold mines – the same area that was uplifted to provide the sediment to the Edmund Basin.

'Dr Fielding's study has shown that uplift, erosion, sediment transport and gold mineralisation were synchronous,' Dr Johnson said. 'The combined studies show that precisely defining the source region of a sedimentary basin may aid in identifying regions of highly prospective crust.'

'The combined studies show that precisely defining the source region of a sedimentary basin may aid in identifying regions of highly prospective crust.'

These results sparked publication of a paper – 'The complexity of sediment recycling as revealed by common Pb isotopes in K-feldspar' – with Dr Johnson and Associate Professor Kirkland as lead authors, in the prestigious *Geoscience Frontiers* magazine.

Three-year project to create statewide lead isotope map

As a result of the Edmund Basin breakthrough proving the worth of measuring the lead isotopes of K-feldspar, the GSWA is partnering with the Australian Research Council (ARC), Professor Kirkland at Curtin University, and medium-tier gold miner Northern Star Resources to carry out this technique in the Eastern Goldfields and the Northern Carnarvon and Canning Basins.

The three-year, $682 000 project is being funded by the ARC ($352 000), the State Government's Exploration Incentive Scheme ($180 000) and Northern Star Resources Ltd ($150 000), and will start this financial year. The project will also involve the creation of a lead isotope map of WA. The map project will run in conjunction with a Geoscience Australia project which is collecting lead isotope data in mineral deposits across Australia. 'Both our datasets will be amalgamated to produce a state and nation-wide lead isotope map,' Dr Johnson said.

This article originally appeared in the Winter 2019 issue of *Prospect*, published by Department of Mines, Industry Regulations and Safety, Government of Western Australia.

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Image: Alf Manciagli/Shutterstock.com.

$2 million in new grants to encourage exploration of greenfield areas in NSW

The New Frontiers Cooperative Drilling program is managed by the Geological Survey of NSW and is part of the state's strategy to promote investment in its mining and resources sector

Geological Survey of New South Wales

Explorers now have an additional $2 million incentive to search for deposits of traditional and high-tech metals across NSW, with a new round of grants to help cover the costs of exploration drilling now on offer from the NSW government.

Deputy Premier and Minister responsible for Resources John Barilaro said the third funding round of the New Frontiers Cooperative Drilling program will reimburse successful applicants for up to 50 per cent of their per metre drilling costs, up to a maximum of $200 000.

The funding boost brings the total amount allocated to the program to $6 million, with applications open until 31 December 2019.

'Our goal is to make NSW the number one state for new mineral exploration and resources investment across the nation, and we're doing that by providing greater certainty for the mining sector,' Mr Barilaro said.

The New Frontiers program is managed by the Geological Survey of NSW (GSNSW), the state's premier geoscience agency. Dating back to 1875 and borne out of the NSW Department of Mines, the GSNSW is the oldest continuously operating government agency in NSW, reflecting the state's long history with the mining and resources sector.

The department, based in Maitland, is charged with promoting the sustainable, and socially and environmentally responsible, exploration and development of the state's geological resources, as well as supporting informed land use decisions.

A key deliverable under the state government's NSW Minerals Strategy, the New Frontiers program is designed to support the long-term sustainability of the NSW exploration sector by directly supporting mineral exploration for Group 1, 2, 6 and 10 minerals, particularly in greenfields areas.

The program will encourage exploration activity that will test new geological ideas and models, and/or exploration in regions under significant cover. It will also help improve understanding of NSW's mineral resource potential, in order to fully realise the economic resource potential of the state.

Geological Survey of NSW Executive Director Dr Chris Yeats said previous rounds of the grants program proved successful, with many projects reporting positive results.

'At the Impact Minerals Red Hill project near Broken Hill in far west NSW, the first Cooperative Drilling hole struck a 30 metre-wide zone of high-grade platinum group metals, which lead to a $5 million joint venture investment,' Dr Yeats said.

'Another project south of Orange in the NSW Central West intersected multiple intervals of gold mineralisation in four Cooperative Drilling holes, and in Jindabyne, in the NSW Snowy Mountain region, Cooperative Drilling holes within a recently discovered gold-arsenic quartz vein system showed a gold and copper system open in all directions.'

'The NSW Government understands the key role that our minerals industry plays in regional NSW and the importance of mineral exploration to ensure the continued prosperity of this important industry into the future. I encourage all potential explorers to apply.'

For more information on the New Frontiers Cooperative Drilling grants program, visit **www.resourcesandgeoscience.nsw.gov.au/cooperative-drilling**

'A key deliverable under the state government's NSW Minerals Strategy, the New Frontiers program is designed to support the long-term sustainability of the NSW exploration sector.'

Our mineral heritage: past, present, and looking to the future

This is an edited excerpt of a presidential address delivered at AusIMM's 1990 Annual Conference, held in Rotorua, New Zealand

Sir Arvi Parbo AC Kt HonFAusIMM, AusIMM President, 1990

I propose to speak today about our mineral heritage. In common usage, 'heritage' refers to the past. It means the discoveries, the developments, the mines and the processing plants, the benefits, the consequences and the human experiences flowing from these. The history of the industry, inseparable from the history of the countries in which AusIMM operates, is a rich background of which we can all be proud.

But there is also a much wider meaning to mineral heritage. Our past has left us with the ability to create and operate world-scale enterprises generating wealth for the community, the ability to offer satisfying and challenging careers in a wide range of skills to our young people, and the willingness to follow adventurous and challenging vocations in remote areas, away from the big cities, at a time when the mentality of many is to get the most for the least effort and at the least inconvenience to themselves.

The industry continues to be the repository of the pioneer spirit and a vital contributor to improving the life of the people in our countries. Thus, while our mineral heritage has much to do with the past, an essential part of it is how we use this rich past to build and shape our future. It is in this broader context that I am speaking today.

The Institute

AusIMM was formed in 1893 in Adelaide, South Australia. At this time the mineral industry in Australia and New Zealand had already been very active for more than 50 years: the South Australian copper discoveries, the New Zealand gold rushes from Coromandel to Otago, the great Australian gold discoveries, the Tasmanian base metal finds and the discovery of Broken Hill had all happened before AusIMM was formed. The discovery of gold in Kalgoorlie was actually in the same year. The first significant mineral discoveries in Papua New Guinea and Fiji came later, in 1922 and 1931 respectively.

At the time of giving this speech, the Institute has 39 branches: 34 in Australia, three in Papua New Guinea, one in New Zealand, and one in Fiji. At the end of 1989 there were 7840 members, including more than 200 women.

AusIMM is the association of all the technical professionals in the mineral industry. While the name, for historical reasons, mentions mining and metallurgy only, the Institute in fact embraces many other mineral and petroleum industry disciplines: geoscientists, engineers, chemical engineers, and so on.

While AusIMM represents individual professionals, the industry as such is represented by other organisations. In Australia, the Australian Mining Industry Council is the national industry organisation, the Chamber of Mines being the equivalent in the states. The members of these organisations are companies.

AusIMM is all about people, and in recognition of this are the AusIMM Awards to members.

AusIMM Awards

AusIMM Awards recognise outstanding service to the Institute, the industry, and the profession. The awards are a part of our mineral heritage. The conferring of Honorary Fellowships to 'persons of distinction', both within the Institute and outside, is the longest established tradition. To date 69 Honorary Fellowships have been awarded.

The Institute Medal, which is the highest award, is for 'eminent services to the mineral, mining, metallurgical or petroleum industries'. Fifty such medals have been bestowed since 1935.

The annual President's Award, introduced in 1974, recognises 'some specific sphere of a technical nature rather than a managerial role'. There have been 15 Presidents Awards given so far.

More recently established awards include the Sir Willis Connolly Memorial Medal to 'notable communicators', given jointly by AusIMM and a group of members calling themselves the Barbarians after the patron saint of German miners, St Barbara, and the G B O'Malley Medal which is the highest award to a student member for a technical paper. So far, four and two of these medals have been awarded respectively.

The award citations and proceedings at award ceremonies, published in the *AusIMM Bulletin*, are a valuable biographical record.

The past

The Institute established a Mineral Heritage Committee late in 1984. The committee has the aims of recording and preserving essential features and artefacts of the past and reminding us all that the present soon becomes past.

The first mineral heritage seminar was held in Adelaide in March 1986, the proceedings of which were published by the South Australian Department of Mines and Energy. The second seminar was held in Sydney in July 1988.

In 1987 the Institute established the Australasian Mineral Heritage Trust to support:

- research and recording of mineral history in Australasia
- preservation, restoration and identification of sites, equipment and the like
- research, evaluation and categorisation of records and archival data and other information
- establishment and support for museums, exhibitions and displays
- encouragement of donations, bequests and legacies.

The activities of the trust were initiated with the publication of the Leslie Bradford Golden Jubilee Oration.

Both the committee and the trust maintain in close liaison with organisations such as the Australian Mining Industry Council, companies in the industry, the Chambers of Mines, the Australian Mineral Foundation and AMIRA. The subject is so vast and the effort necessary to make even modest progress so great that we cannot afford to duplicate what is being done.

'The industry continues to be the repository of the pioneer spirit and a vital contributor to improving the life of the people in our countries.'

Valuable work in heritage recording and preservation has been done in the past by individuals, companies and local bodies in various mining centres. One outstanding example is in Queenstown in Tasmania where a combined effort by the Mt Lyell Mining and Railway Company, the state government and the Municipality of Lyell in 1983 erected the unique plaza of sculptures by Steve Walker and other exhibits at Miners' Siding to commemorate 100 years of mining in the vicinity of Queenstown. There are other impressive commemorative monuments and preserved relics in Australia and New Zealand including Morphetts' Engine house at Burra, the Ivanhoe headframe at Kalgoorlie, the miners' cottages at Moonta, the mining plant at Ballarat, the Government Battery at Coromandel and other structures here in New Zealand.

In addition to the many physical relics which can be preserved, there are also the written and oral histories. Historical accounts such as those by Professor Geoffrey Blainey in Australia and Professor John Salmon in New Zealand are invaluable.

The stories are about the successes and failures, the marvellous discoveries and the unsuccessful endeavours, those who struck it rich and those who didn't. The stories are more about people than events and are particularly rich in the wonderful humour that is a characteristic of the people in the industry. It is not companies or organisations who do things, it is people. This is where members of the Institute must make a major contribution as a part of their responsibilities as professionals.

Members in positions of authority in mineral industry enterprises have a particular role in this. We should

ensure that no company discards or destroys historical records or mining relics without making sure that those of unique value are preserved in a suitable manner. We should encourage the recording of company histories and contribute towards more general works on broader historical aspects of the industry.

Much remains to be researched and recorded about the early mineral developments, but there are also more stories waiting to be told about the more recent finds and developments: about iron ore, manganese, aluminium, oil and gas, nickel, copper and uranium, coal, mineral sands and so on. It is essential that they be told. It bears repeating that it is largely the responsibility of members of the Institute to see that this happens.

It is by knowing, respecting, and drawing inspiration from the past that we can cope with the future in a way in which our successors can in due course be proud of our achievements. It is very appropriate that New Zealand mineral heritage will be the subject of an address by G G Thornton at this conference. New Zealand has a mining history second to none and New Zealand mineral industry professionals have a proud record of contributing to the industry at home and outside their own country.

The present

The industry and AusIMM are well and active. The President in 1989, Professor Alban Lynch, inaugurated two new branches at Roxby Downs and Ok Tedi.

The anti-development and anti-mining campaigns of recent times have slowed down and, at times, deferred mineral projects but have not stopped the industry's growth.

This is not grounds for complacency. We in the industry have generally not been very good at overcoming the negative attitudes and establishing a positive climate of public opinion ourselves.

We have considered what has been said and come to the conclusion that much of it does not make sense. What does not make sense cannot be pursued far in our professional activities so we tend to conclude that it would also disappear in the public arena.

This is a serious misunderstanding, because in politics there is no such thing as an automatic rejection of what does not make sense. Great empires have been founded on false ideas. Given enough pressure from particular interest groups, accompanied by skilful media handling, what does not make sense has an excellent chance of becoming law affecting the industry. Much of it has.

Most of the industry's activities take place in remote areas, a long way from the large urban population centres. The large majority of people probably never see a mine, an ore treatment plant, a smelter or a refinery, and do not have first-hand knowledge to test the validity of the misinformation so ably distributed by the opponents. Far from assuming that everybody understands what we do, we must regard it as a part of our professional responsibilities to explain our activities and the industry to the public.

Curiously, some of the opposition to today's mineral developments is on the grounds it would interfere with relics from previous mining, which are now a part of national heritage. At Bendigo in Victoria, a group is proposing to have 40 local government areas, with a population of more than 400 000 people, declared a World Heritage area because it includes the best surviving examples of the 19th century gold rush era in the world.

By contrast, when permission is given to new mining projects, the usual conditions are that everything has to be razed to the ground at the end of mining and covered over to resemble the original conditions. No-one has so far been able to explain this paradox to me.

As I have just reviewed, AusIMM is probably more conscious than any other group of the importance of preserving our mineral heritage. This can be done sensibly, without excluding areas the size of some European countries from future mining or other economic activity. Preservation of unique features of our past does not require neglect of the present.

A part of our heritage is the responsibility to ensure that we and our successors can continue to make the great contribution to the community made by our predecessors in the past.

The future

How can we as AusIMM members live up to this responsibility?

In its now nearly 100 years of existence, AusIMM has been a highly respected body fostering technical progress and excellence and nurturing professional and ethical standards, professional education and the professional standing of its members. We must continue and strengthen all these activities. High professional and public standing and respect are essential to achieving our aims. We must work tirelessly towards this.

But in the changing political and community environment we must also become active participants in public policy formulation affecting our industry and members. Policies are becoming far too important to be left to politicians.

The key to being able to discharge our responsibilities is in ensuring that we are the premier professional body in the mineral industry. We must attract a high proportion of those eligible for membership as our members. While accurate numbers are not available, we believe that it is realistic to think in terms of doubling the membership to 15 000 over a number of years.

It is particularly important to have a high proportion of the eligible students and young graduates as our members. The present becomes the past sooner than we like; the leadership of AusIMM will soon be in the hands of today's students.

To achieve these aims we must work relentlessly to make the Institute relevant to its members' needs and aspirations. Greater membership will in turn make it easier to achieve this and will enable the Institute to speak with enhanced authority.

The training and education of young men and women to join the ranks of the professions has never been more important than now. We have first class people today, but the sometimes defamatory attacks against the industry by small but noisy groups create the danger that other occupations are coming to be seen as offering a higher standing in the community, particularly by those who live in the big cities. There is the danger that the mineral industry may not attract enough of the best young people in the future.

The Institute is doing something about this.

The AusIMM Education Endowment Fund established last year (1989) is now operational and the first scholarships have been awarded. It is focused on attracting high calibre students to study the disciplines relevant to the industry and on establishing and maintaining contact between the industry and the students during their studies.

It is particularly important that the company sponsored scholarships do not stop at simply providing the money. Continuing liaison by the companies with the students is essential in gaining the greatest benefit from the investment and the effort. For scholarships that are not named, AusIMM must act in this capacity.

The Education Endowment Fund is up and running, but the effort is limited by the funds subscribed. More financial contributions are needed to build on the good beginning.

'The training and education of young men and women to join the ranks of the professions has never been more important than now.'

For mainly taxation reasons, the fund's activities are at present limited to Australia. Ways need to be found to extend it to the whole area covered by the Institute.

I have already mentioned the importance of participation in public policy forums. Other organisations – AMIC, the Chambers of Mines and so on – represent the industry in this. We represent the technological professionals.

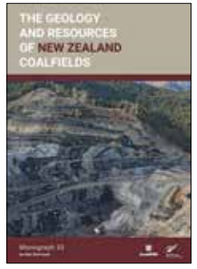
Our authority is partly in knowledge, and partly in the number of voices we are able to muster. The leaders of the Institute will speak as often possible, but we need more voices: the more the better. I urge all members of the Institute to speak up whenever they can, particularly before audiences not familiar with the industry. We must not think that our individual voices are insignificant and cannot influence the course of events.

Public opinion is the most important force in a democratic society. Our individual voices, sounded often enough, and provided there are enough of them, will add up to a powerful chorus. I conclude as I started: our heritage is as much about the future as about the past. Our industry and professions have the responsibility to continue being great contributors to the community in the future, as they have in the past; this is an essential part of our heritage.

There are forces opposing this, which must be overcome as we overcome many other difficulties and adversities in our professional lives. Success in this is largely up to ourselves, the members of the Institute.

I look forward to working with you all in meeting this challenge.

The Geology and Resources of New Zealand Coalfields (AusIMM Monograph 33)



Alan Sherwood

Reviewed by Dean Fergusson MAusIMM CP (Geo)

It's rare to see a monograph written by a sole author, but I can't think of any other practicing coal geologist in New Zealand aside from Alan Sherwood that has the breadth of knowledge, literary skill and professional character to carry this off.

Monograph 33 is an authoritative, some might say overdue, update on NZ coal deposits and the resources they contain. It runs to 279 pages and is supplemented with six appendices. The colour maps, cross-sections and photographs that abound throughout are pleasingly consistent in format and high quality. It is also somewhat pleasing to see that New Zealand Petroleum and Minerals have supported something tangibly connected with its indigenous coal.

Monograph 33 is many things: a dedication to perhaps New Zealand's greatest coal geologist, Dr Pat Suggate; an overdue consolidation of the NZ Coal Resources Survey (NZCRS) findings; a contemporary classification framework and update of NZ coal resources; a geological overview of the numerous coal deposits, some almost forgotten; and an acknowledgement of the coal geologists who have explored and described our wonderful collection of coal basins since the latter half of the 19th century.

While relatively young and diminutive compared to the continental coal basins that dominate world coal production, I don't think you'd find the variety of geological settings and variability of NZ coal basins in many other countries. This aspect, along with the unique interplay between dynamic, tectonic controls and the resultant impact on basin structure, stratigraphy, coal rank, type and quality are well captured in Monograph 33.

Throughout the book, Alan demonstrates his comprehensive knowledge of the history of the discovery, exploitation and utilisation of this now maligned, but still necessary 'transitional' energy source. Thankfully, it is an irreplaceable ingredient in steel making. The author outlines how coal was intrinsic to the industrialisation of New Zealand and the foundation of its economy through the 20th century, at least up until the discovery of large gas fields in the Taranaki basin in the 1970s. I'm pleased that the work on the non-conventional uses of coal, and lignite, and the need for CO2 sequestration is given some coverage. This account may not be the last word on that front.

Section 1 presents a sub-continental framework for describing the geological setting of the various coal regions and classification of coal quantities they contain, essentially using the Australian Coal Guidelines. This is a commendable attempt to plug the gap in knowledge of NZ's coal inventory that developed following the NZCRS. The classification is basically sound and the division of Inventory Coal into two sub-categories based on likelihood of becoming JORC Resources is certainly provocative. The many philosophical and practical challenges with presenting an updated inventory are clearly articulated.

Sections 2 and 3 provide a systematic summary of every known coal deposit in the country. This is no mean feat and the abundant references cited are a treasure trove. I can't help thinking the Monograph would have been more useful, and more representative, had the geological investigations, estimation practices and project assessments that were carried out after the coal resources survey been given more emphasis. Capturing the lessons learned (and not learned) from the several modern coal mines developed, mined through to end-of-life or closed would be highly relevant and beneficial to the current operators. It would also provide a perspective on the level of investigations required to accurately assess the feasibility to operate NZ's unique coal deposits.

Monograph 33 gets close to being a definitive synthesis of NZ coal deposits and will remain the standard reference for decades ahead. Filling the gaps in the latter part of the story should be the challenge for the current generation of coal geologists, if they're up for it. The legacy of Alan's wonderful treatise is that it is a worthy basis for at least one subsequent edition.

Metals are where you find them: Geologist's travels through six continents

Peter Laznicka

Reviewed by Neil Phillips FAusIMM

Professor Peter Laznicka is the creator of Data Metallogenica, an unrivalled mineral collection from ore deposits worldwide. I have appreciated using this collection in my research and teaching, and we should regard it as a national treasure.

This is a fascinating book covering Laznicka's lifetime from humble beginnings in (what was then) Czechoslovakia to a career in mid-western Canada and then a new career in Australia. It is a serious economic geology book and yet written in a non-technical way, with many anecdotes and life stories from Nazi-occupied Europe to Communism to the world today with its opportunities and challenges.

Over the course of his career, Laznicka has been able to record and collect ore samples and information from deposits from all continents. Some of these deposits are familiar, many hardly known, and they are described in his book systematically to include history and cultural setting, mining and geology description.

The global coverage produced by Laznicka broadens our rather focused snapshot of economic geology in 2019. Today we might focus on Australia, South Africa, Brazil, Chile and basically much of the southern hemisphere. Laznicka reminds us of the enormous mineral wealth that has come out of USA and Europe; also, that much of Asia's substantial production is used domestically and we tend to overlook this. All these areas have contributed to our geoscientific heritage today through our ways of mining, ways of looking at ore genesis and a veritable stream of terms. Each of his deposit examples holds information that we need to incorporate into our descriptive and genetic models for ore deposits.

This book is arranged by continents primarily, and then by geographic districts; this forces many different ore types of a single district to be seen together in some meaningful and interesting contexts. The book could also be useful as a first reference if travelling to a new country and reading up on the mineral deposits one might expect; this is aided by the wonderful collection of photos of scenery, mines and ores.

The author leaves two themes in my mind. The best geologist is the one who has seen the most rocks; and extended field work, as opposed to day field trips, is an integral component of undergraduate and career learning. Laznicka reminds us that ores are still rocks (albeit special ones) and are amenable to petrological methods. Finally, we should not forget the 'economic' in economic geology.

This is a personal memoir or a travelogue of the author's impressions. As the introduction says 'Peter Laznicka, born in Prague, lectured at the University of Manitoba and around the world, consulted for the resources industry, then co-founded, in Australia, the Data Metallogenica expert system about world's mineral deposits, supported by miniaturised rock and ore samples.' I admire someone who can write a book like this on a lifetime of study and travel; even more impressive is when the author can do so in more than one language. Naturally, there are some grammatic idiosyncrasies, but this did not take away from my enjoyment of reading.

The book is available to download via **metalsin6conts.net**.

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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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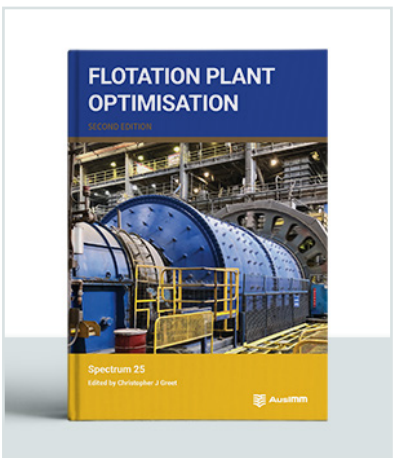

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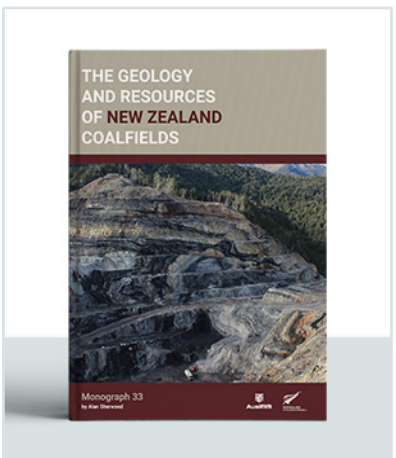

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