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Australian Government
Department of Industry, Science and Resources
Cooperative Research Centres Program

How current South Australia Mineral Exploration Policies may impact on the unrestricted use of mineral exploration technologies being developed within the Mineral Exploration Cooperative Research Centre

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Submission date:29th of September 2021

ABSTRACT

This research project investigated how current mineral exploration policies in South Australia may impact on the unrestricted use of mineral exploration technologies currently being developed and tested within the Mineral Exploration Cooperative Research Centre (MinEx CRC: www.minexCRC .com.au). MinExCRC is developing new, faster, and cheaper coiled tubing (CT) drilling equipment. The drill rig used uses less water and has a significantly environmentally smaller footprint drill pad than another on the market. New sensor technologies are being developed alongside the CT drill rig that will allow for collection of several types of real-time data (e.g., geochemistry, seismics, petrophysics) that can then be used in active drilling campaigns.

This project conducted a policy audit on how current mineral exploration policies would impact on the full utilisation of technologies being developed within MinEx CRC. Data was gathered through a series of 5 interviews with mineral exploration policy experts; MinExCRC mineral exploration technology developers (currently responsible for development of drilling equipment and execution of campaigns), and Industry leaders that will deploy, commercialise, and utilise the technology and equipment in future. The project focused on South Australia where a significant effort is underway in development of MinExCRC technologies including the CT drill rig and sensor technologies. A drill testing campaign of the CT drill rig was undertaken in South Australia in late 2021.

TABLE OF CONTENTS

Word count 6008

EXECUTIVE SUMMARY

Meeting the increasing demand for mineral resources is an ever-increasing challenge for explorers. As mineral reserves continue to be depleted, it is important that we not only think of how we will substitute materials we use but also, explore essential exploration technologies of the future that will aid effective mineral exploration. Ultimately, for technologies namely: Program One Drilling technologies; Program Two Drilling Data; Program Three The National Drilling initiatives; NDI Data portal. that are being developed by MinExCRC – technologies which enable cheaper drilling and faster compilation of real time geochemical data as well as, more environmentally friendly technologies that have less water usage requirements than current technologies-–it is imperative that policies and regulatory compliance e.g., drilling permits and exploration licenses, and land access allow, not only for drilling a specific area as is currently the case but, have provisions that give mineral explores of the future some room for flexibility and ability to change drilling direction as new data is presented.

To best understand the environment that technologies will be utilised, it is important to have a full grasp of the nature of compliance that would be required when technologies and campaigns are deployed and executed. A degree of awareness of both current and future planed technologies as well as, the regulators priorities particularly, environmental and suitability policy goals imbedded in Programs for Environment Protection and Rehabilitation (PEPR), will be highlighted in this project. A policy audit of historical and current exploration policies focusing on elements that enable mineral exploration technologies freedom to operate and the requirements for exploration licenses on technologies currently in development and their future operations show that, there is a risk that some of the technologies being developed by MinExCRC might face challenges when deployed in on ground activities in the field. This project thus, interviewed (Group A) technology development experts, (Group B) Industry experts, and (Group C) Government Policy experts to get some perspective on the mineral exploration policy land scape and how historical and current policies have impacted new mineral exploration technologies.

Analysis of the legal framework that inform policy and the regulation for mineral exploration technologies in South Australia and the interviews conducted in this study revealed that, a more agile policy environment sensitive to great advancement in technology is needed to ensure continued innovation in exploration; the development of more technologies– that have a low environmental impact, and that can offer real-time information necessary for precise targeting– are developed and deployed for utilisation in on ground activities, and a symbiotic relationship between technology developers and the regulator is crucial.

INTRODUCTION

It's All Copper, Copper, Copper, Copper, Copper, Copper," -Ivanhoe Mines Founder Robert Friedland

Global extraction of metal and mineral commodities grew by at least 75% between 1970 to 2017 as global demand and consumption of copper, aluminium, zinc, and nickel surged from 26.7 to 100 billion tonnes during the same period (Rogich and Matos, 2008)[1]. By 2050 metals and minerals demand is expected to exceed 185 billion tonnes (Gonzalez-Alvarez, Goncalves and Carranza, 2020). The global Covid-19 pandemic has accelerated this demand for ferrous metals further prompting Jeff Currie, Head of Commodities Research for Goldman Sachs, to proclaim 2020/21as'the dawn of a commodity new super cycle'[2] due to the exponential increase in copper prices (Erten and Ocampo, 2012). In addition, current post-pandemic recovery policy plans by various national governments, have ensured an estimated $16 trillion in investment in sustainable carbon neutral infrastructure and green technologies as well as, to meet decarbonisation targets that will require new, sustainable, and reliable sourcing of high-grade ore. The US recovery and renewed commitment to the Paris Climate Agreement coupled with China's commitment to carbon neutrality by 2060–which has seen China stockpiling surpluses of copper, aluminium, and iron– has further contributed to the surge in base metal price increase. In April 2021 there were Copper supply concerns, a 25% reduction in delivery which consequently increased prices to $9088/t and a predicted $11000/t by December 2021 ($15000/t in 2025). This led to predicted future estimates of 900%, an increase in demand of aprox. 8.7million tonnes by 2030.

Meeting the increasing demand for mineral resources is an ever-increasing challenge within the minerals value chain. Strategic solutions have included examining the circular economy, strategies for recycling, and waste reduction. The Green Peg Project—part of the EU's Horizon 2020 Life Cycle Assessment Project —is a quantitative assessment of the environmental performance of products analysed individually over their useful life, beginning with an examination of environmental aspects associated with exploration techniques as well as life cycle assessment of individual minerals mined and the circular economy[3]. However, whilst these strategies are commendable, extraction associated policies need to stretch much more because this is insufficient to meet the global commodity demand. Global Mineral explorers need to find more large, high quality (Tier1) ore deposits such as the Chuquicamata Cu deposit in Chile, the South Australian Olympic Dam iron oxide-copper-gold (IOCG) deposit (see: *Figure 1a) and b* & Figure 2a) & b)Neil Hume and Henry Sanderson FT June 8 2021[4]).

In Australia, mineral and energy resources contributed 50% of Australia's exports and 7% of GDP in 2017-2018. However, the future of this contribution is at risk due to the declining discovery of

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[1] Based on consumption for 25 metal and mineral, on a country-by-country and year-by-year basis, between 1970-2004

[2] "2021 Commodities Outlook: REVing up a structural bull market", Nov. 18, 2020, https://www.goldmansachs.com/insights/podcasts/episodes/12-15-2020-jeff-currie.html [Accessed 27/06/2021]

[3] Life Cycle Assessment allows a quantitative assessment of the environmental performance of a product over its life cycle (ISO 14044 a) https://www.iso.org/obp/ui/#iso:std:iso:14044:ed-1:v1:en [Accessed 28/06/2021]

[4] "**Copper boom: how clean energy is driving a commodities super cycle"** by Neil Hume and Henry Sanderson June 8 202**1** https://www.ft.com/content/40907aa6-354e-42f8-8d51-8cc01f0e9687 [Accessed 27/06/2021]

major, new mineral deposits. South Australia currently produces approximately ¼ of Australia's mined copper production (~263 000 tonnes/annum: DSD, 2014; BREE 2013). In addition, the Olympic Dam is host to several other known IOCG deposits (Carrapateena, Prominent Hill, Hillside, Khamsin[see: *Figure 1a & b* (Brotodewo *et al.*, 2021; Tiddy *et al.*, 2021)*]* and is considered highly prospective for additional IOCG discoveries. However, the rocks that are considered prospective for IOCG mineralisation are extensively buried by barren 'cover' sediments that are unrelated to the mineral deposits themselves. Consequently, technological developments in exploratory drilling and detecting the footprint of mineralising systems under cover, have become increasingly valuable (Gonzalez-Alvarez, Goncalves and Carranza, 2020). Future mineral exploration innovation and technological advancement will focus on 1) digitisation and automation 2) the development of remote sensing, geophysical, and geochemical technologies 3) new exploration approaches 4) data analytics maximising the value of data and drilling through cover. (Bailey and Giles, 2019; "MinEx CRC : A new frontier in mineral exploration," 2019; Gonzalez-Alvarez, Goncalves and Carranza, 2020). This type of technological development is occurring with concerted research and development efforts[5] MinEX has a lot more technology coming online however, there is a risk that this technology will not be able to be fully utilised unless more agile regulatory frameworks can be developed.

The exposed areas of rock within Australia, particularly Western Australia, would be considered mature for exploration, however the undercover regions in South Australia, are immature in exploration. In the last 20 years exploration research in South Australia has also extensively focused on geochemical signatures of mineral systems that aid exploration due to the geophysical nature of the highly prospective IOCG deposit [see Figure 1(a) & (b) & Figure 2 (Brotodewo *et al.*, 2021; Tiddy *et al.*, 2021). The highly prospective proterozic rocks undercover in the "Olympic Cu–Au Province in the northern and eastern Gawler Craton" hosts the Gawler Craton, that contains an extensive iron oxide–copper–gold (IOCG) mineralisation, including the giant Olympic Dam deposit[6], the large Carrapateena, and mineralisation and Prominent Hill deposits (see Figure 1a)&b) Figure 2a) & b) below) (Brotodewo *et al.*, 2021; Tiddy *et al.*, 2021). The depth of the Olympic Cu–Au Province geophysical targets limit exploration thus, additional methods are required to assess mineral potential such as the use of use of zircon chemistry "as a from a barren basal diamictite overlying the Carrapateena IOCG deposit is assessed to fertility indicator was also demonstrated for porphyry Cu deposits" (Brotodewo *et al.*, 2021).

[5] MinExCRC: www.minexCRC .com.au [Accessed 27/06/2021]
[6] "The IOCG mineralisation is hosted within highly tial and recognise proximity to mineralisation. Zircon from mineralised zones of the Car-prospective Proterozoic rocks of the Olympic Cu–Au Province in the northern and eastern" (Brotodewo *et al.*, 2021)

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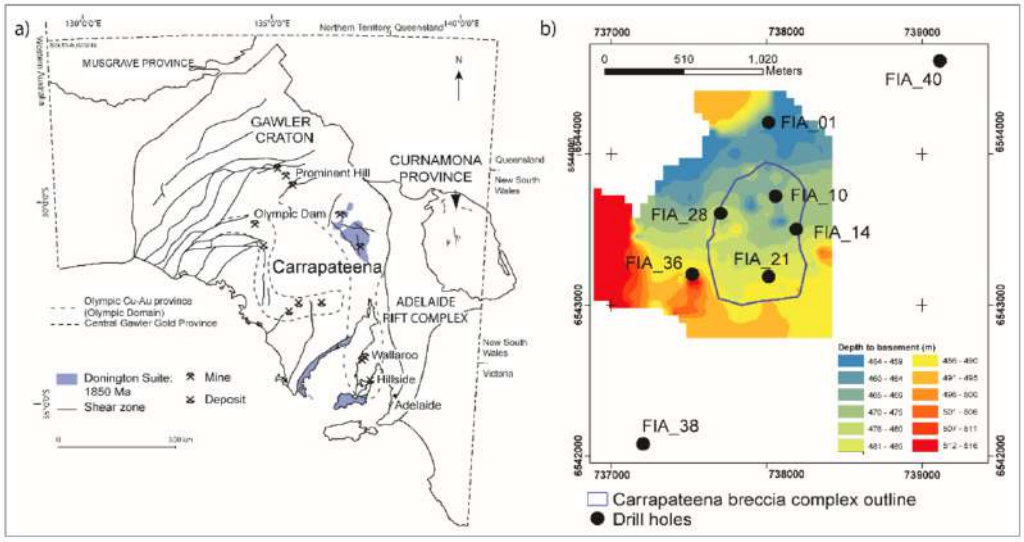


Figure 1 (a) "Map of the South Australian Gawler Craton displaying key mineral deposits and the distribution of Donington Suite plutons within the basement. (b) is the outline of the Carrapateena Donington Suite plutons within the basement and the outline of the Carrapateena orebody over a depth to basement map. The location of drill holes from which orebody over a depth to basement map; the location of drill holes from which samples of the basal diamictite in the overlying cover sequence were taken are shown; the location samples of the basal diamictite in the overlying cover sequence were taken are shown, and the location of the Carrapateena deposit is highlighted in (a)" source: Recognising Mineral Deposits from Cover; A Case Study Using Zircon Chemistry in the Gawler Craton, South Australia (Brotodewo *et al.*, 2021).

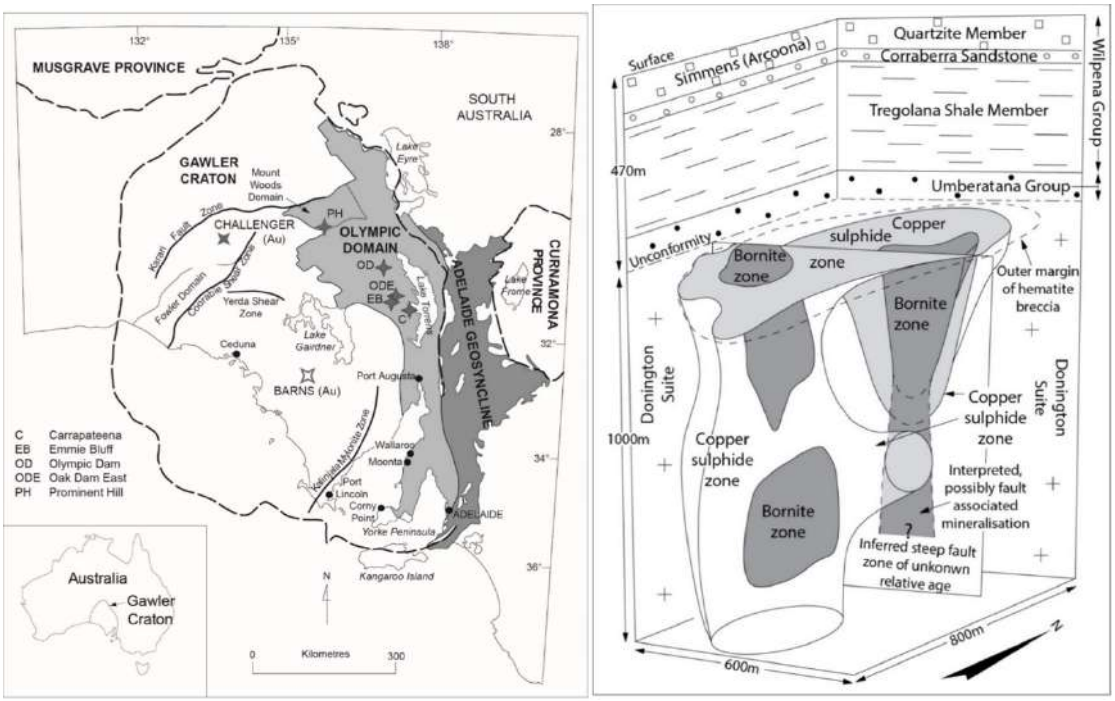


Figure 2 a) Geological map of the Gawler Craton showing the location of the IOCG-rich Olympic Domain as well as selected major deposits including Olympic Dam, Prominent Hill and Carrapateena b) Schematic section of the Carrapateena IOCG deposit and overlying cover sequence materials of the Umberatana Group and Wilpena Group source: (Tiddy *et al.*, 2021)

How current South Australia Mineral Exploration Policies may impact on the unrestricted use of mineral exploration technologies being developed within the Mineral Exploration Cooperative Research Centre MinExCRC.

SECTION 1.

METHODOLOGY

This research project was undertaken to investigate how mineral exploration policies and legislative frameworks in South Australia may impact the full utilisation of technologies being developed within the Mineral Exploration Cooperative Research Centre (MinExCRC). The project involved data collection through a series of interviews of key MinExCRC personnel, a government, and industry representative involved in development and implementation of mineral exploration regulations and guidelines within South Australia and with industry representatives who have been involved in mineral exploration programs.

This project has been approved by UniSA Ethics under application 203976 and it used a qualitative research approach to gain insight into the structure and objectives of MinExCRC projects; exploration in South Australia, as well as, to discover how current South Australian policies impact the full utilisation of new technologies currently being developed by MinExCRC. The ethics approval was sort from both UCL and UniSA and in order to facilitate the interviews efficiently, particularly during the pandemic. Each interviewee was contacted requesting their participation in the interview and later a draft summary description of the research (to provide context and scope) and an interview protocol were sent to each participant in advance. All interviews were recorded and transcribed. Participants were invited to participate in this project as experts in the development of mineral exploration technologies, the exploration industry, and government policy. This study aims to highlight first-pass indication, of existing barriers in utilizing the technologies being developed within MinExCRC and form the basis for further studies in development of agile regulatory frameworks required for adoption of emerging technologies.

Participation in the project involved participants taking part in a video conference interview using software that is appropriate to their organization (e.g., Teams and Zoom). The interviews took 45 -1 ½ hours and were scheduled to accommodate the experts' availability. A Participant Information Sheet with further information was attached to invitation emails and signed consent was sort from participates before the interview. Data was collected via semi-structured interviews of 5 Australian geoscientists in research academia, government policy (government official) , and exploration industry expert. The Interview participants were selected through expert purposive sampling (Etikan et al., 2016).Organisations targeted for interviews were Majors and Junior exploration company representatives, MinExCRC engineers and geochemists and a government representative from the South Australian Ministry of Energy. The participants were identified through the networks of C. Tiddy who is an Associate Professor in Geosciences at UniSA. The purpose of the selection process

Word count 6008

was not only to remain within scope given the time constraint of the project but, to ensure relevance to MinExCRC as well as, the experiences of diverse expertise with in the exploration ecosystem whilst allowing the themes under discussion to remain relevant to the topic in discussion. The questions asked aimed to focus on the professional insight and experiences of the respondents thus, thematic analysis was adopted to analyse the data. (Braun & Clarke, 2006; Grbich, 2013).

The interview protocol (see Appendix A) was designed for a professionally diverse pool of just 6+ interviewees originally. However, given the limited scope and ethics approval for the research, the 5 Interview participants were organised as follows:

Group A : MinExCRC experts.

Group A questions aimed to examine the objectives and value of MinExCRC to South Australian exploration and how its programs may be constrained by existing policy and legislative frameworks. The questions were designed to factor in technical due diligence aspects from the tactical team to assess MinExCRC project strengths and weakness especially in assessing some of the shortcomings of potential Life cycle plans e.g., ore grade, resource reserve picture, tonnage etc.

Group B: The Government

Group B questions form the major theme of this project. The set of questions for the South Australian government representative were designed to get clarity and perspective of the South Australian exploration policy landscape. Transition and prob questions aimed to gain an informed perspective on the purposes of the instruments used by the Department of Mining and Energy (DEM) when drafting its exploration policy tool kit. The aim of Group B questions was to further explore how the department is making allowances within its policy framework for agile exploration policies, that enable the development and future deployment and use of new exploration technologies in a rapidly changing industry.

Group C: Exploration Industry

The third and final group of interviews aimed to examine the efficiency drivers for Juniors and Majors and how MinExCRC technologies are being received, absorbed, commercialised, and used in South Australia exploration. The questions also explored the relationship that Juniors and Majors have with MinExCRC and concerns they have in the practical deployment of MinExCRC technologies.

The interview protocol (see Appendices A) was an instrument for conversation and inquiry. Questions were tailored for the specified groups and the interview protocol followed a three-phase approach that ensured that, firstly, given the broad nature of exploration policies in South Australia, the interviews remained within scope of the research and specific to MinExCRC highlighted earlier. Secondly, the interview protocol design enabled the opening up of other avenues for future research, for example , into how future technologies are impacted by current and legacy exploration policies. Finally, the interview protocol provided a reflective approach and a useful basis through a series of key questions that were followed by transition questions, probs and towards the end, closing questions

as a way to begin to get feedback on South Australian exploration policies as they pertain to utilisation of technologies currently being developed by the CRC.

In many ways the research aims to give a clear overview of the drivers encouraging exploration alongside highlighting the legislative and policy barriers that impede exploration (Gruenhagen and Parker, 2020). This research also explored the mineral exploration patenting trends so as to map out innovation trends that are specific to exploration and assess how exploration policies have adapted to advances in exploration technologies (Fernandez, 2021). Most top patent filings into the Australia mining industry fell into 3 categories namely: exploration, mining, and refining. 6034 patents were filed for exploration technologies; 2804 and 75 patents filed for refining metallurgy respectively, and 4585 for mineral processing in 2017*(see: Hidden Gems– a Patent Analytics Study on Innovation in the Australian Mining Sector 2019).*

Selection and identification of articles, exploration regulatory frameworks , exploration laws and policies in South Australia relevant to MinExCRC –and by extension Exploration in South Australia more generally– aimed to follow consistently, a systematic process set out by the Mining Act of 1971; the South Australia Framework for Responsible Exploration , and the sequential order of research programs that MinExCRC has developed and will be developing in the future namely: Program One Drilling technologies; Program Two Drilling Data; Program Three The National Drilling initiatives; NDI Data portal. Thus, the overall research objective was to use existing South Australia Exploration legislative provisions, legal framework, policies, and regulation as well as The Minerals Council of Australia's Enduring Value Framework to evaluate how they coexist with MinExCRC technology development. There are limited peer reviewed articles specifically for MinExCRC on this topic. Therefore, to ensure that valid and current state of knowledge on exploration technology in Australia, more generally, and in South Australia, more specifically, articles selected are related to the different MinExCRC research programs and the interview protocol.

Word count 6008

SECTION 2.

CURRENT GLOBAL, AUSTRALIAN, AND SOUTH AUSTRALIAN EXPLORATION TRENDS

"New greenfield discoveries are urgently required to ensure that an ongoing pipeline of mineral resource projects are available to meet future demands"- *The Council of Australian Governments*

The S&P estimates that, in 2020 5.8 billion was raised for primary exploration and 1762 companies with budgets of $8.5b (a 10% decline) globally, are actively exploring. This is a significant drop by a 1/3 from 2012 when investment in exploration peaked to $35.2b7. None the less, it is an increase from 2016 figures. In June 2021 exploration expenditure rose by 16% during the COVID pandemic according to data released by the South Australian Department of Treasury [see Ta*ble 1Australian Mineral Exploration Expenditure , Seasonally Adjusted].* Projects reporting drill results decreased year on year and in 2020 minor base metals (cobalt and molybdenum) were down 80%; specialty metals, were down 46%; lead-zinc, down 37%; and copper, down 10%. PGM and silver projects increased, however, by 120% and 17% respectively. Furthermore, as discovery rates have declined, the cost of discovery has soared. Richard Schodde of MinEX Consulting estimates that, the cost of discovering an ounce of gold in the last 20 years which was $20, now costs $40 highlighting the importance of MinExCRC cost effective drilling programs. In addition, Australian exploration budgets were $1.37b a 10.3% decline from previous years and this might need to be addressed from a policy perspective.(Wojcik, 2021). Furthermore, decline in exploration market share means, the 50% contribution in minerals and energy export (approximately 7% of GDP) made by the Australian mining industry is under threat if well delineated resources remain stranded and unexplored. However, there are glimmers of hope.

In the last 4 years Australia's exploration market share has doubled, and drill holes have become deeper [see Table for Meters drilled below]. Australia continued to lead in exploration and Australian projects increased by 12%. Holes drilled increased by 20% to 16,482 and Western Australia remains the most explored state taking two thirds of the exploration budget of $897 million compared to $85.3 million in South Australia(Wojcik, 2021). Therefore, the question of this project goes beyond the technical question for exploration policies and technological utilisation. It gives us an avenue to examine how South Australian exploration policies and legislative frameworks impact, not just full

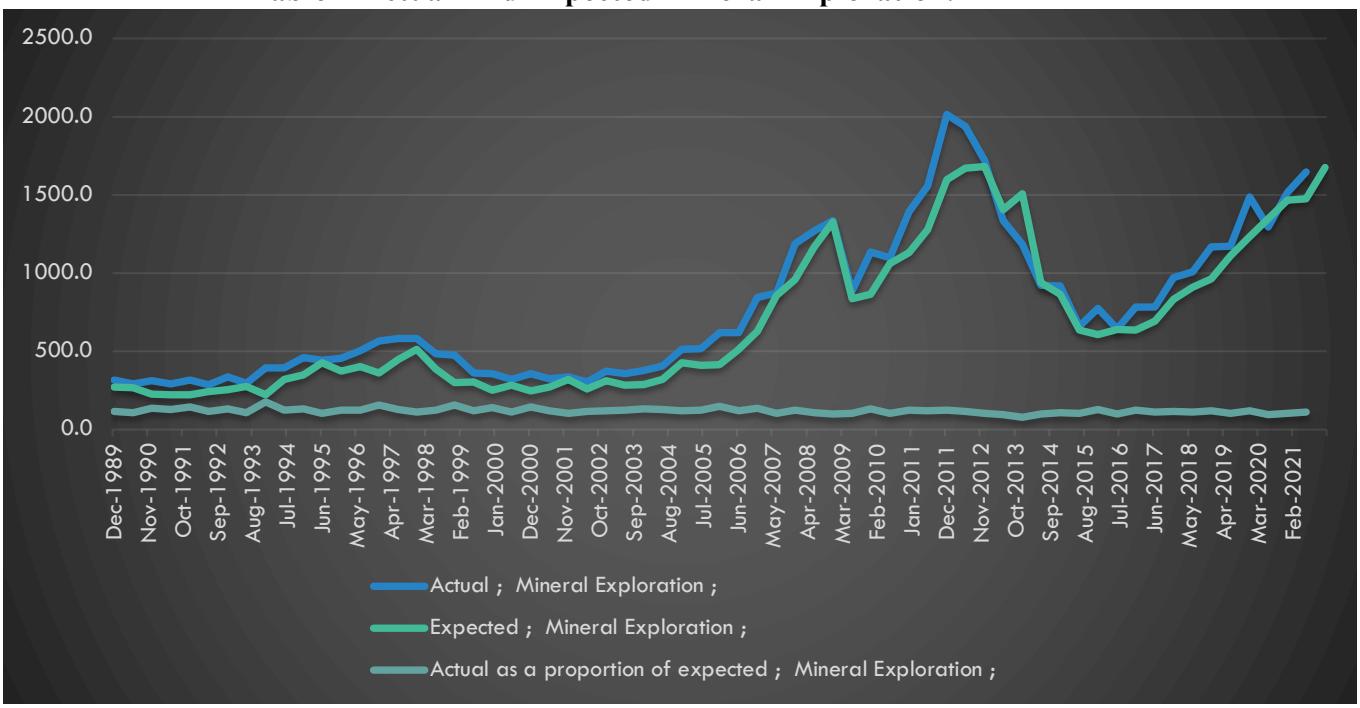
[7] **Australia Mining By The Numbers** https://www.spglobal.com/marketintelligence/en/news-insights/research/chart-watch-australia-mining-by-the-numbers [Accessed 18/09/2021]

utilisation of technologies being developed within MinExCRC but also, the extent to which exploration facilitated by technological advances, has on the budget allocated to exploration, and by extension, the growth of exploration industry in South Australia and globally.

Table 1 Australian Mineral Exploration Expenditure , Seasonally Adjusted

Source of figures : *Mineral and Petroleum Exploration, Australia Quarterly statistics on mineral and petroleum exploration expenditure by private organisations in Australia*

Table 2 Actual And Expected Mineral Exploration.



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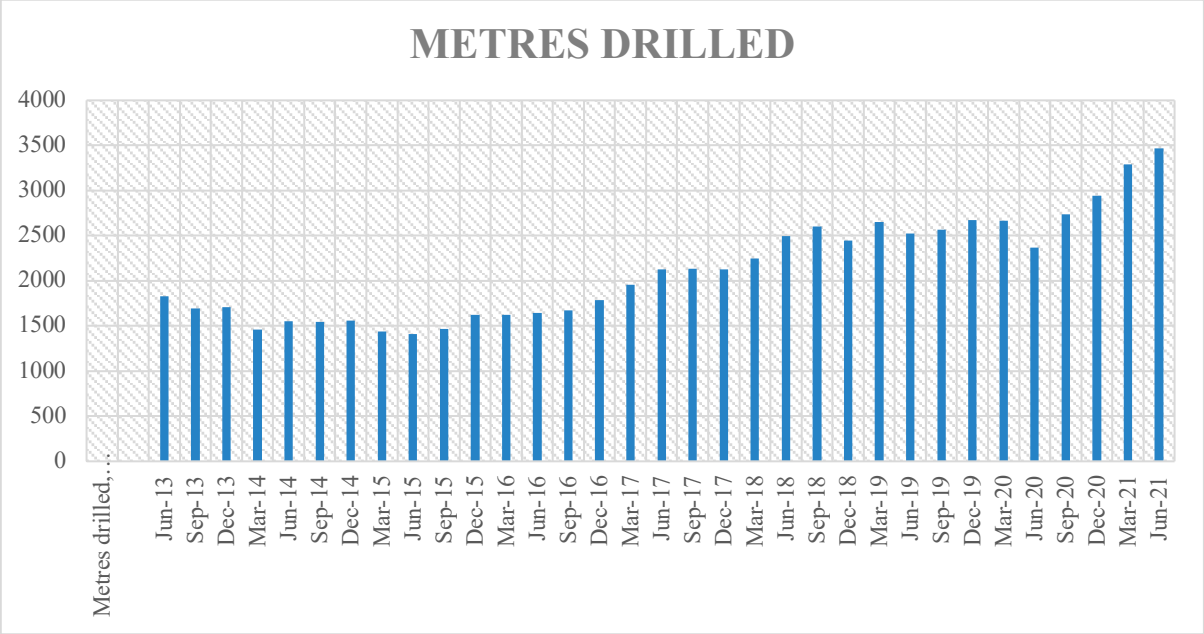
Source of figures : *Mineral and Petroleum Exploration, Australia Quarterly statistics on mineral and petroleum exploration expenditure by private organisations in Australia*



Source of figures : *Mineral and Petroleum Exploration, Australia Quarterly statistics on mineral and petroleum exploration expenditure by private organisations in Australia*

How current South Australia Mineral Exploration Policies may impact on the unrestricted use of mineral exploration technologies being developed within the Mineral Exploration Cooperative Research Centre MinExCRC.

SECTION 3

3.1 MinExCRC BACKGROUND & CONTEXT.

The Cooperative Research Centre that began in 2016 with a series of projects supported by research support, the exploration industry, and METS –created programs to find new drilling, AI, geochemical and geophysical data, and field operations technology solutions that would address the threat of declining mineral discovery in Australia– culminated to become MinExCRC on the 12th of April 2018. By December 2018 after meeting federal government requirements and the Commonwealth Agreement , MinExCRC had signed in September 20188 the expansion of its board and the appointment of the board of directors and the adoption of the constitution was finalised in December 2018. In January 2019 9 projects began with the aim to improve competitiveness, productivity, advance exploration technology, and environmental sustainability in line with national and South Australian priorities (Pigram, 2018; "MinEx CRC : A new frontier in mineral exploration," 2019). To date The MinExCRC has received A50m in federal government funding and A218m in research funding from BHP, Anglo American South32, and Barrick collectively committing A$165m (cash and in-kind) over the next 10 years, for a total budget of A$218m ("MinEx CRC : A new frontier in mineral exploration," 2019b). Its governance structure is highlighted below in Figure 3 Governance Structure Of MinExCRC(Source: ("MinExCRC Annual Report," 2019).

[8]Funding for medium to long-term, industry-led research collaborations https://business.gov.au/grants-and-programs/cooperative-research-centres-CRC -grants

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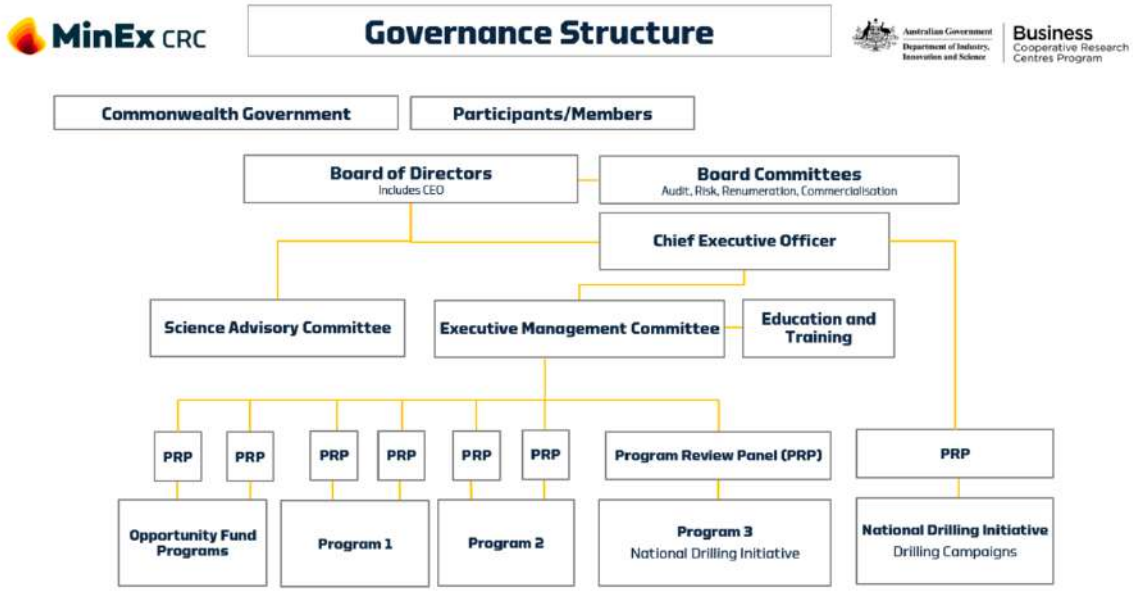
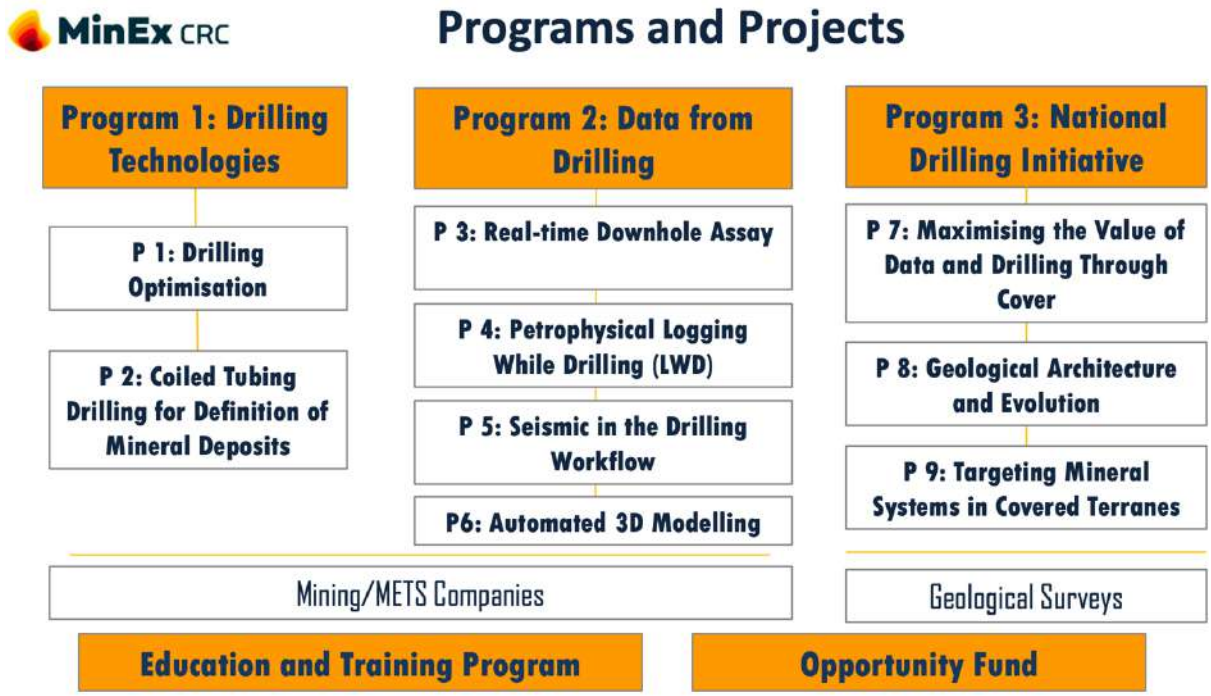


Figure 3 Governance Structure Of MinExCRC Source: "MinExCRC Annual Report," 2019

3.2 MinExCRC Projects :



MinExCRC- Developing Future Technologies source Andrey Bailey Minex CEO 2019 presentation

Program 1 developers' primary focus is on targeting "conventional mineral exploration drilling technologies and trying to optimise or make conventional drilling technologies more efficient, commercially viable and attractive, and an ambition for the 10 years is to be 50% more productive over the duration of MinExCRC and 50% to continue the development of the coiled tubing drilling technologies for mineral exploration that started in the DET CRC " (MinExCRC representative).

How current South Australia Mineral Exploration Policies may impact on the unrestricted use of mineral exploration technologies being developed within the Mineral Exploration Cooperative Research Centre MinExCRC.

Barriers to full utilisation of technologies: Adaptations need to be carried for newer technologies to comply with existing regulations. Coil tube drilling, which has been trialled and utilised in an Australian context, is limited by the time it takes to get drilling approval. Furthermore, the bureaucratic nature of drilling program approval. In addition, adaptation of training of drillers (VET) and geologists (university/organisation in-house) to use the technologies as well as flexibility in being able to be dynamic with drillhole placement are 2 aspects that would improve the utilization of new technologies. Amalgamation or centralisation of standards and regulation and application procedures for approval from DEM instead of having numerous applications in different departments would ensure some degree of efficiency for the deployment of technologies. (MinExCRC representative).

It's useful to state that, current legislation does not impede on exploration technologies coming to market. MinExCRC experts felt that it would be useful if each State/Territory's in Australia would have some form of flexibility almost similar legislation and standards in how an organisation was going to undertake a drill program (e.g., from environmental, logistics perspectives)

3.3 Examples of MinExCRC Projects

Program 1

Project 1: Drilling technologies
Drilling Optimisation and Automation

The diamond and RC drill rig recording system (iDrill) was designed to improve accuracy and sampling rate of percussive drilling. This project was developed in collaboration with McKay Drilling a MinExCRC partner in Pilbara Western Australia at the McKay Schramm Reverse Circulation (RC) rig and is led by Mr Soren Soe (Richard, 2021). The main objective of the drilling projects is to redesign, develop, and engineer technologies in minerals and petroleum for drilling optimisation and automation drilling performance, and in time field parametric analysis.

50 top-of-hole sensors were loaded into one shaft of the McKay Schramm Reverse Circulation (RC) rig and 'data were recorded at 10Hz, 1kHz and 20kHz while drilling two ~180m drill holes over 2 days of drilling with spatial precision detailed time resolution to allow calculation of fine scale between the drill bit and formation i.e., depth of penetration measured per hammer impact'(Richard, 2021). This data provides optimisation inputs of RC drilling, a vital step towards 'drilling automation and for recovering rock property information from drilling data' (Richard, 2021)

Source: MinExCRC- Developing Future Technologies Andrey Bailey Minex CEO 2019

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Project 2: Coiled Tubing (CT) drilling for discovery and definition of mineral deposits

Existing coiled tube drilling technology used particularly in petroleum exploration were adapted to for mineral discovery and resource definition for brownfields and Greenfields drilling at depths > 500m Initially, 3D modular plastic multiple purpose fabricated prototypes were developed for downhole sensing platform for Coiled Tube drilling. This was useful for experimentation and iterative improvements in sensory design, "component interactions, connections between modules and integration with the bottom hole assembly prior to manufacturing in the final material" (B. , F. S. , S. S. and Z. H. Y. van der Hoek, 2019b)[9]. Min Ex CRC researchers modified project results to 1000 m depth and engineering calculations, that include "including material strength, fatigue, operating stability, hydraulic systems requirements and power budgets" , on the CT rig based on the existing RoXplorer® in response to the increasing depth increase demand for CT drilling capabilities.(B. , F. S. , S. S. and Z. H. Y. van der Hoek, 2019a, 2019b)

In collaboration with South Australian manufacturing company Century Engineering, MinExCRChas built the CT Drill rig platform that takes into considering the modification specification, "transport, tramming, drilling and maintenance".
(B. , F. S. , A. S. , Z. H. Y. and S. S. van der Hoek, 2019; B. , F. S. , S. S. and Z. H. Y. van der Hoek, 2019b, 2019a; Chen, 2019).

Source: Source: MinExCRC- Developing Future Technologies Andrey Bailey Minex CEO 2019

Project 20 Hydraulic processing system (HPS) for CT Rig integration

The fluid hydraulic monitoring unit (*iFluid*) designed and commissioned in early 2019 developed to provide consistent and reliable fluid properties to quantify downhole drilling hydraulics , is six times larger than conventional fluid hydraulic monitoring systems and measures drilling fluid hydraulics directly at shear rates up to 6000/s(Hakami, 2020).
Through a series of experiments designed to test the online fluid system at the Dynamic loop experiment facility at Curtin University conducted by MinExCRC, fluid viscosity was measured and controlled in real-time using the automated dosing system, and a drill hole-maintained system to simulate an increase in viscosity, researchers were able to adjust the algorithms and improve the automated dosing system. The Hydraulic processing system (HPS) for CT drilling, was designed for multiple drilling holes and to be market leader in the drilling market. The HPS is a truck-mounted, long distance, one man manned, a low cost environmentally friendly, safe, self-contained mobile unit capable of rapidly self-cleaning and replenishing drilling fluid, began in 2020 and field trials were done in 2021 (B. , F. S. , S. S. and Z. H. Y. van der Hoek, 2019b, 2019a)

Source: Source: MinExCRC- Developing Future Technologies Andrey Bailey Minex CEO 2019

Project 20.1 Centrifuge optimisation for fluid management in coiled tubing drilling

Before the Centrifuge optimisation for fluid management in coiled tubing drilling technologies were developed by MinExCRC, Hydraulic Processing Systems were incapable of treating copious amounts of fluid for drilling cuttings that are brought to the surface for analysis . This inevitably resulted in bigger fluid volume requirements and unrepresentative sampling. The multidisciplinary engineering experimental centrifuge characterisation design and workflow, designed by MinExCRCat Curtin University's Centrifuge

[9]Sample Integrity to 1000m. Interim for the Definition of Mineral Deposits. MinExCRC Report 2019/003, 40p. (Submitted March 2019).

facility(Hakami, 2020) developed a customisable centrifuge within the hydraulic Processing Unit (Chen, 2019; van der Hoek, 2019; Hakami, 2020)	
Project 20.2 HPS accelerator and fines sampling research This project commenced in April 2020. The solids removal unit (SRU) provided in-kind by MinExCRCParticipant Imdex Limited has been delivered to the University of South Australia and rewired to run from mains power. Commissioning of the SRU for experimental work included the installation of a 12 MinExCRCAnnual Report 2019-2020 adjustable-flow, external feed pump with flow meter and adjustable-frequency vibration motors with vibration sensors. In the first experiments using a drilling fluid designed for CT drilling (viscosity inversely dependent on shear-rate), we were able to tune the shaker operating parameters to deliver a near 10-fold improvement on the flow of drilling fluid through a 141µm screen which meets the MinExCRCProject 2 target particle size for sampling from the CT drill rig. Further research will be aimed at testing the performance of the shaker with fluids containing drill cuttings and reducing the mesh size to capture particles smaller than 140µm.	
Project 3 Real-time downhole assay The aim of MinExCRCProject 3 was to design and build a downhole laser-induced breakdown spectrometer (LIBS) prototype that could take real-time measurements of analyses on the surfaces of rock samples. The prototype comprised of the main three main components i) laser electronics ii) the spectrometer and iii) the optical focussing system (see: MinExCRCAnnual Report 2019/2020). The use of custom-designed components allows the prototype to be scaled and optimised for downhole trials, including a platform for up hole communications. The investigation into the suitability of LIBS for downhole analysis included experiments focussing into effects of drilling and optical transmission. The results of which, concluded that for typical concentrations used in CT drilling (0.3 wt% C-Trol solution) there was no significant effect on the peak intensity of the LIBS spectrum (MinExCRCAnnual Report 2019/2020). However, the wavelength dependent component of the optical signal experienced a loss 30%-100% (MinExCRCAnnual Report 2019/2020) loss in intensity when transmitted through 10mm of 0.3 wt% C-Trol solution.	 Source: Source: MinExCRC- Developing Future Technologies Andrey Bailey Minex CEO 2019

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Project 4 Petrophysical logging-while-drilling

In the 2019 annual report, the prototype of downhole powerline communication (PLC) device was designed with a suitable baud rate of >100 KB/sec MinExCRCAnnual Report 2019/2020 to collect types of petrophysical data. The responses of the logging-while-drilling electromagnetic (EM) tool simulator was modelled to interpret data from the surrounding rock formations; as a result, this data was utilised in the design of the final user interface.

The current development pathway of the device follows three stages of progression. The first, to complete a series of field trails. The second is to integrate an EM sensor that is low-power and able to investigate the electrical conductivity and magnetic susceptibility of the drilled substance. The last stage is to use a high-power EM system to enable the construction of EM fields about the drill site MinExCRCAnnual Report 2019/2020. The recovery of seismic signal falls under a recommended MinExCRCopportunity fund project, that was discussed by the Science Advisory Committee in April 2020 MinExCRCAnnual Report 2019/2020.

The preliminary tests demonstrated the robustness of the slim line TCG sensor when subjected to frequencies of up to 10Hz and accelerations of 10g MinExCRCAnnual Report 2019/2020 where there was no perturbances in measured signal. The results showed the expected proportional relationship between signal counts and distance from the source of radioactive caesium 127 gamma

A further redesign of the TCG sensor will include modifications to the electronics and housing to enable testing in the field trials in 2021. Other improvements include incorporating real-time imagine and trajectory control.

'New geophysical logging-while-drilling (LWD) sensors and real-time subsurface reconstruction algorithms will be designed to integrate within exploration or mining workflows. The research has two linked components; (i) development of new sensors for real-time multi-parameter LWD with a CT drill rig and (ii) automatic subsurface reconstruction for steering towards a target (geo-steering) based on geophysical sensing while drilling. This research will extend the reach and value of every meter drilled into a 3D search space ahead of and around the drill bit'- **Project 4: Petrophysical Logging While Drilling (LWD*)***

Source: MinExCRC- Developing Future Technologies Andrey Bailey Minex CEO 2019

SECTION 4

South Australian Exploration Law, Regulation, And Policy

Context: Exploration Policy in South Australian:

Mineral policies and legislation in Australia are the responsibility of the individual states. South Australian Exploration policies (001)[10] and regulatory instruments, The Accelerated Discover Initiative (ADI)[11], The Growth State–Our Plan for Prosperity a South Australia business and state partnership arrangement[12], and OPAL (M002)[13], are designed for the rational development of the State's natural resources as well as, to anchor the State's wider goals for exploration including existing and future development of commodity strategies aimed at increasing productivity. The South Australian Government aims to balance development within its planning system(s) and ongoing access to long-life valuable extractive mineral resources. To support this ambition, the state has dedicated sustained exploration expenditure of $300 million a year by 2025 alongside setting up good standard agreements to drive exploration in line with The Resource Area Management Plan (RAMP) created by the Department of Energy and Mines.

[10] Exploration and Mining regulation 001 December 2020
https://sarigbasis.pir.sa.gov.au/WebtopEw/ws/samref/sarig1/image/DDD/MPOL001.pdf [Accessed 29/09/2021]
[11] The Accelerated Discovery Initiative (ADI)
https://www.energymining.sa.gov.au/minerals/about_us/initiatives/accelerated_discovery_initiative [Accessed 29/09/2021]
[12] The Growth State–Our Plan for Prosperity https://www.growthstate.sa.gov.au [Accessed 29/09/2021]
[13] Working conditions under the Mining Act and Opal Mining Act
https://sarigbasis.pir.sa.gov.au/WebtopEw/ws/samref/sarig1/image/DDD/MPOL002.pdf [Accessed 29/09/2021]

How current South Australia Mineral Exploration Policies may impact on the unrestricted use of mineral exploration technologies being developed within the Mineral Exploration Cooperative Research Centre MinExCRC.

Figure 4 South Australia Rare Earth Prospects And Deposits Fact Sheet 28 minerals

With the current commodity cycle and sharp increase in commodity prices, the Department of Energy and Mines (DEM) has seen a sharp increase in uptake in joint venture agreements and 20-30% increase in on the ground activity. Consequently, there has been an increase in licence applications and exploration programs primarily, copper related exploration in the 2020/2021 because and explained SA Government Representative in the interview, " South Australia is a copper jurisdiction". In addition, unlike Western Australia, South Australia is not viewed easy to access reserves. As a result, on the ground activity has predominately followed non-traditional prospective minerals. South Australia has also seen an increase in on the ground activity for "hale and hale sight, graphite, rare earths elements (see Figure 5 fact sheet 28) [14]" (SA Government Representative).

4.1 South Australian Government Exploration Policy priorities.

South Australian Mineral Exploration Policy and regulation is designed to balance regulation of exploratory activity, the needs of the industry, and future exploration activity for future generations of Australians. SA mineral resources legislation is " an old-style Act" (SA Government representative)

[14] SARIG https://sarigbasis.pir.sa.gov.au/WebtopEw/ws/samref/sarig1/image/DDD/ISM28.pdf [18/09/2021]

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has only ever been reviewed 5 times at least once every 30-40 years . This has a real impact on how new technologies being produced within the exploration industry and research facilities can be utilised in on the ground activities. The Department for Energy and Mining (DEM) through the South Australian Geological survey, is keen to speed up exploration for programs but the regulator has to weigh this with its societal and sustainability responsibilities.

4.2 Amendments to the Mining Act

The Leading Practice Mining Acts review that ushered in The *Statutes Amendment (Mineral Resources) Bill 2019*, which then became an act of the South Australian Parliament on 17 October 2019, is the 6th comprehensive review undertaken in South Australia. 85 recommendations that include clarification of benefits for landowners that would ensure that, 'restricted land' increase buffer zones to 50% (400m-600m for high impact exploration and mining operations section9) thus, increasing the obligations on mining leases; the native title scheme Part 9B Mining Act that aligned the Mining Act with the *Commonwealth Native Title Act 1993, and* the Programs for Environmental Protection Rehabilitation (PERP) under the Part 10A principal Act are all structured to give clarity to both prospective explorers thus, increase exploration activity, and to expand environmental and societal obligations.

The Mining Act 1971 *Mines and Works Inspection Act 1920* and *Opal Mining Act 1995*, and associated regulations, commenced on 1 January 2021. Amendments to the Mining Act clarify 10 key components to the principal Act namely, exploration licences, mining lease terms, exempt land, landowner rights, mining register, PERP (environmental considerations) how DEM will manage multiple exploration licence applications for the same area, and how licence owners to an agreed tenement can surrender a portion of their exploration licence to a third party bought to an end exploration subsequent exploration licences . Exploration Licences now have earlier expiration periods, and the Amending Act now stipulates licence retention period of 6 years upon which a licence can be renewed for a further 6years. However, a further renewal of the licence will reduce the area under exploration to 50% in the last 6year licence (Government Representative).

Throughout the development of current policies, DEM has cherry picked various components from other jurisdiction and the Government Representative. admits that the department is still playing catchup and the publicly available regulatory guidance will need improvement as DEM implements 'internal processes, terms of reference and guidelines that go with the policies'(Government Representative). However, the policy rationale remains the same i.e., to ensure, 'the sanctity of the tenement because the tenement holder is paramount; ensure oversight that the public and community now expect in South Australia; offer clear guidance that ensures that the third tier down from the regulations and policies has clarity on what is expected for junior exploration sector in South Australia,

and crucially, increase compliance which had been constrained due to under resourcing in the department (Government Representative).

SECTION 5

The Industry

"In Australia, the right to the minerals is vested in the crown, which is the state governments, on behalf of the people. So, landowners don't own the minerals under the ground, as opposed to some other countries. And so, for the government on behalf of the people to promote development promotes exploration on their behalf... that's the basic exploration model and it's worked very well for Australia over, you know, over – well, over 100 years."– Industry representative

Over the years MinExCRC has seen the number of Junior and Major exploration companies supporting the original deep exploration drilling programs as well as future technologies increase precisely because they agree with all the objectives of the CRC and view MinExCRC programs as an extension of R&D. Companies want ' faster, cheaper drilling, real time analysis while drilling' so that they make decisions in real time on whether or not they have hit the target ore or intersected some very interesting mineralogy, alteration, and geochemistry, 20, 30, 40 metres deep' before the rig is moved (Industry Representative).

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The GIS system [15]put together by the DEM has been an invaluable compendium of data and over the years saved exploration geologists time when fine tuning their exploration programs. Other advances in geophysical targeting particularly at greater depth with greater sensitivity as well as mapping the ore deposit using Prof Raimondo's 3D visualisation/ Project LIVE MM [16] will improve ore deposit targeting.

IMPEDIMENTS TO UTILISATION OF MINEXCRC TECHNOLOGIES

5.1 Social pressures of mining (Community expectations)

In their study to measure public perceptions of established and emerging technologies in Australia, Lacey, Malakar McCrea& Moffat (2019) ascertained that, the choices of which technologies are developed, adopted, and deployed by the industry reflected the critical interfaces between mining and society(Lacey et al., 2019). In their study they tested the general Australian public's awareness and perceptions of the impacts of mining technologies and hypothesised their study as an "intermediate variable between self-rated knowledge and acceptance" following several studies that had demonstrated that citizen perceptions of the negative impacts of mining on the environment and society had direct impact on the degree to which mining and mining technologies are accepted (see Moffatt et al., 2017, 2018, Huijts et al.2012 and Volken et al. 2017). In their study, *Public perceptions of established and emerging mining technologies in Australia*, they found that, "people's acceptance of technologies is directly affected by how they perceive the impacts of those technologies. Therefore, the relationship between perceived impacts and acceptance of technologies is hypothesised to be linear"(Lacey *et al.*, 2019). Lacey, Malakar McCrea& Moffat (2019) postulate that, "high levels of self-rated knowledge about mining technologies generally increases acceptance of those technologies, though results vary between different mining technologies" (Lacey *et al.*, 2019).

Lacey, Malakar McCrea& Moffat (2019)'s study had echoes in the interview with the industry representative that was interviewed. Community expectations have changed in the last 20 years. Updated *Mining Act 1971,Mines and Works Inspection Act 1920 and Opal Mining Act 1995,* and DEM's, revised regulations and guidance material aim to reserve ' exempt land' much of which is pastoral lands outside cities were the majority exploration takes place because there is societal, cultural, as well as environmental obligation to do so. The new guidance places more burden on licence holders which means, the holder of a mining tenement –which includes an 'exploration licence, mining lease, retention lease or miscellaneous purposes licence' (see: Legal Services Commissions South Australia)– should also seek social licence " as an extension of their land access requirements". This is done

[15] South Australian Resources Information Gateway (SARIG) https://map.sarig.sa.gov.au [Accessed 27/08/2021-29/09/2021]
[16] Project LIVE MM https://www.projectlive.org.au [Accessed 27/08/2021]

through legally accurate formal notifications to " landowners and aboriginal claimant groups" before filling a formal approval, alongside continued extensive community engagement, and communication as the exploration program continues. The acceptance of exploration technologies deployed will depend on how South Australians perceive, not just the economic benefits of exploration but, the impact of the technologies deployed. Over the years, airborne systems, satellite systems, and land-based exploration technologies have improved, and the industry representative ascertained that, from an exploration technological perspective, there did not seem to be any barriers for the development and adoption for new exploration technologies. However, some lessons can be gleaned from the Lake Torrens Argonaunt exploration .

The authorisation of the Argonaunt exploration program (which uses diamond drilling) by Kelaray to explore for ore bodies in the surface of the highly prospective Lake Torrens –containing IOCG orebodies (see Figure 1a) & b) (Brotodewo *et al.*, 2021) an ore body that has high concentrations of iron and copper minerals in close proximity to Oz Minerals Carrapateena copper and gold mine–within an area considered sacred by Aboriginal nations, brought into sharp focus section 23 of the Aboriginal Heritage Act[17] and ground disturbance in sacred sites. Despite Kelaray's continued assurances to the community that, the drilling crew was in the process of "testing environmental protection equipment, undergoing training for specialist equipment and receiving site inductions" the optics of 20 truckloads of "drilling equipment, accommodation units, ground protection matting, and ancillary vehicles" delivered on site was a stuck visual reminder to the community of the environmental impact of exploration. The approval of the exploration program by Premiere Mr Marshall, and the subsequent opposition to the exploration program, highlighted the importance of effective community engagement and the need to effectively balance the cultural heritage and the economic benefits brought through exploration.

5.2 Land access

There are currently specific requirements around drilling (ground disturbance).Exploration Licence holders in South Australia have a statutory obligation to identify any social, economic, and environmental impacts of their exploration before conducting exploration. The legal framework for

[17] Section 21 of the Act makes it an offence to excavate land for the purpose of uncovering any Aboriginal site, object or remains without authorisation. (See South Australia **Aboriginal Heritage Act 1988)**
Section 23 of the Act makes it an offence to damage, disturb or interfere with any Aboriginal site; or
(b) damage any Aboriginal object; or
(c) where any Aboriginal object or remains are found—
(i) disturb or interfere with the object or remains; or
(ii) remove the object or remains. (See South Australia **Aboriginal Heritage Act 1988)**

land access is set out in the Part 10A and Section 70B of the Mining Act 1971 and the Mining Regulations 2020 (the Mining Regulations). In preparation for Mineral Exploration PEPR as specified in MDO13, MG22 provides guidelines for tenement, exploration licence, mineral claim holders, and retention lease. The notice of entry and notice of advance exploration operations Licence holders are required to follow 3 steps enter into a written agreement with and offer the landowner (as defined under section 6) a Notice of Entry Form 21, 21 days before accessing the land. The explorer also issues a Notice of use of declared equipment Form 22 for equipment that would be used during exploration . Prior to any activity taking place and wait for 42 days after serving the notice, and objections are lodged in the first 3 months more than the 42-day notice period even after the explorer has entered the land (see MG4 guideline and DEM's Mining Act Compliance and Enforcement).

These requirements are not always useful and will make agile drilling (a technology out of MinEx) difficult to utilise. "Ground disturbing activities whether it is shallow drilling, deep drilling, digging trial pits or even pits for drilling wastes, require specific compliance" commented the industry representative. Each drill has to get approval, access track for the site, an environmental and an accurate rehabilitation plan (The Generic Program for Environment Protection and Rehabilitation - Low Impact Exploration). This ultimately means, that it typically takes 2-3months for a drill hole or drill suite to get approval. For these regulatory reasons, determining where (drill sites), how (faster, cost and environmentally efficient drilling technology), and when drilling will occur (i.e., decisions in real-time, being able to assess the data before the drill rig moves away becomes critical from a time and cost perspective. From an industrial perspective, CT drilling (fast drilling); Logging tools (Real-time geochemistry and mineralogy), and Downhole geophysical tools – (real-time targeting) are crucial exploration technologies for the future. The industry is eagerly waiting on Au – development of the LIBS system in particular.

5.3 Training requirements

Additional pressures and risks highlighted the Annual Report 2019-2020 (page4-5) e.g., events in the market that could lead to a reduction in funding for the CRC are some CRC risk factors outside of mineral exploration regulations/policies that could impact on utilisation of new technologies. The most important risk is how the technologies will be used in the field and whether there is adequate training for the people to use these technologies. If technology taken up by Service Provider and taken up by a commercial company, there is also going to be an effort required (by MinExCRC or after commercialisation, by the deploying company) to get the technology accepted by the exploration community (e.g., from JORC code perspective) as being viable and repeatable. It has taken 5+ years to be able to report pXRF data in company ASX releases. (Industry representative) Utilisation thus, becomes a gradual process rather than just one company taking over and formalising that process. There is also a need for training to be formalised for new technologies being provided by MinExCRC because this will be an impediment that will take some time to get over. "when the technologies are

developed, their uptake will depend on the time needed to train users on the ground to utilise these technologies and training programs for drillers would need to be in cooperated and formalised into the new facilities being provided to the MinExCRC" (Industry representative).

Often companies do not usually operate the equipment. Instead, they outsource the drilling to service providers (e.g., drilling companies). If the technology is vastly different from what is currently in the market and the VET training and education of drilling personnel is not available or inadequate, it would delay the commercialisation and deployment of technology. The profiles of next generation drilling operators is very different from the profile of present-day drilling operators. Current systems are more digitised, so the education level needs to be much more comprehensive and intense compared to contemporary drillers. (MinExCRC representative) .

Section 6

Conclusion

Recommendations for the future utilisation of exploration technologies:

It's important to note that, The South Australian Government has actively supported the development of new technologies and MinExCRC has gained a global reputation[18]. The Department for Energy and Mining (DEM) is keen to speed up exploration and has started to see a shift in activity and exploration techniques used during The COVID pandemic in 2020, from historically single collar holes to multiple wedges of single holes that save time, money, and improve efficient rates. From a national and federal level. So, there is goodwill but, more needs to be done to bring policies in line

[18] Is Canada losing the exploration game? The hurdles to increased exploration spending in Canada by Virginia Heffernan https://magazine.cim.org/en/projects/is-canada-losing-the-exploration-game-en/ [Accessed 17/09/2021]

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with current technological trends. Creating agile forward looking regulatory frameworks that are informed by the continued exploration technological change and a combination of consultation and **soft law**[19] (*nonbinding less costly agreements fit for a fast-changing technological advancement that are easily rapidly adopted, amended, modified, or even renounced. and technological development so that future technologies*) designed to meet policy goals, at the same time, solving technological compliance time-lag issues for the exploration industry that will need to commercialise, deployed, and utilise the technology would not only ensure the future utilisation of MinExCRC technology but, encourage even more innovation within the mining industry(Lacey *et al.*, 2019; Ediriweera and Wiewiora, 2021).

How the involvement of mineral exploration companies that use the regulations/policies could help in developing more agile regulatory frameworks

Contribution from the Exploration Industry has the potential to yield a more agile policy and regulatory environment particularly in the South Australian context in which, as stated earlier, exploration policies have only ever been reviewed 6 times since the Commonwealth was formed and thus, the regulator has historically struggled to keep pace or to respond effectively to change in technological advancement. Involving the exploration Industry as well as the public would create an informed public and an understanding of technologies currently being developed by MinExCRC, giving some room for a more mature and nuanced discussions that balance environmental, cultural, economic, and societal needs, and the benefits of exploration, particularly in a resource scarce world. As the MinExCRC representative highlighted 'deeper engagement with traditional landowners and with Aboriginal groups that will demonstrate respect community cultures, alongside asking for permission in appropriate ways; understanding the language and showing respect of traditional norms e.g., by naming tools or localities using indigenous language to raise awareness of new technologies' (MinExCRC representative). This would help towards smoothing out some of the social licence to Operate challenges that exploration companies have faced in the past.

End-user involvement in MDTD (Medical Device Technology Development) policy for example, has proven to be of great value in Medical Technological development because it limits policy redesign; ensures continued policy improvement; reduces costs, and ensures market acceptance and greater probability for commercial success for new medical device technologies developed. Using the 7 phases of industrial design, Hani &De Marcellis-Warin (2016) tried to identify where in the

[19] "The term soft law is used to denote agreements, principles and declarations that are not legally binding. Soft law instruments are predominantly found in the international sphere". ECCHR https://www.ecchr.eu/en/glossary/hard-law-soft-law/ [Accessed 17/09/2021]

process of technological development end-users and policy makers would be involved. The involvement of policy makers in technological designed ensured greater uptake (companies are more confident of quicker less bureaucratic processing of government permits and licence approval for technologies that have built in compliance and government approval);agility (future policies would keep pace, evolve, and be actively responsive to changes in technology), and enabled intelligence gathering by the regulator (i.e., policy is informed by technological development).

Policy instruments

The Canadian Mineral tax Credit (METC)[20] was designed to help Canadian exploration firms raise excess funds. METC offers 15% credit as an incentive for Junior Exploration Companies and allows Juniors to transfer the tax credit to their investors who then in turn Over the years, the Canadian Federal Government estimates that, $505 million in equity was realised through METC. METC has allowed exploration companies some financial flexibility to fund R&D and it has been attributed for discoveries at Ekati and Diavik in the Northern territories. A similar tax incentive would be of great value particularly if its directed towards the development, as well as, raising greater public awareness of exploration technologies.

To The Department of Energy and Mining's credit, the new revised regulation set up alongside the amendments to the Ming Act that came into effect this year, offered clarity and a range of options for achieving the DEM's policy goals. However, The Department of Energy Mining is always catch up and the Government representative rightly ascertained that, South Australian mineral resources legislation is " an old-style Act and offered suggestions on how this might practically changed. This has implications on how current and future new technologies being developed are developed, deployed, and utilised. Therefore, having what the OECD calls, Anticipatory Regulatory environment[21] such as the Canadians' Advisory Committee on Regulatory Competitiveness (which can be set up with in MinExCRC) would offer the regulator a unique seat at the table where future exploration technologies are being created. The Regulator can thus, "scan the horizon for high-impact innovations with significant regulatory implications and use this to help target future reforms". [see: *Agile Regulation for the Fourth Industrial State A Tool Kit for regulators December 2020*[22]]. Furthermore, introducing fit-for-purpose regulatory frameworks[See: **OECD Shaping the Future of Regulators *The Impact of***

[20] Mineral Exploration Tax Credit https://www.nrcan.gc.ca/science-data/science-research/earth-sciences/earth-sciences-resources/earth-sciences-federal-programs/mineral-exploration-tax-credit/8874 [Accessed 29/09/2021]

[21] The Anticipatory Innovation Governance https://oecd-opsi.org/projects/anticipatory/ [Accessed 29/09/2021]

[22] Agile Regulation https://www.oecd.org/gov/regulatory-policy/agile-governance-for-the-post-pandemic-world-wef-oecd-joint-event.htm [Accessed 29/09/2021]

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Emerging Technologies on Economic Regulators][23] and a principle-based approach particularly of proportionality, and the utilisation of soft law (which enable the policy makers to quickly update and keep pace with technology advancement) with in the regulatory and policy framework would, represent a clear ability to assign risk and responsibility in a complex technologically changing 21st Century environment that will need more ore bodies to be found to meet future demand. [See: **Public consultation on the draft OECD Recommendation for Agile Regulatory Governance to Harness Innovation July 2021]**[24]

To conclude, It is important that, The Department for Energy and Mining continues to place sustainability and environmental goals at the heart of regulation and policy. However, as valuable as environmental protections are, land use legislation, often fails to consider the mineral potential of protected areas. A more balanced, considered, and consultative approach, particularly with the Industry and exploration technology developers, that allows for some degree of regulatory certainty would be useful in the future, particularly as the environmental credentials and capabilities of exploration equipment continue to improve.

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Appendices

A. **INTERVIEW PROTOCOL**

Project Title: Impact Of Current Government Policies On Future Mineral Exploration Using Developing Technologies

SECTION A: (All interviewees)

Introduce self and supervisor to interviewee.
State the purpose of the project and the interview itself.

How current South Australia Mineral Exploration Policies may impact on the unrestricted use of mineral exploration technologies being developed within the Mineral Exploration Cooperative Research Centre MinExCRC.

Question 1. What is your name, job title, the organisation you work for?

Question 2. How long have you been in this role?

Question 3. Can you please describe your job role?

SECTION B: (Questions grouped according to organisation that interviewee is affiliated with)

Group A: MinExCRCRepresentatives

Question 1. What are your responsibilities within MinExCRC? Probes:

- - Can you please describe the objectives of the Program you are leading within MinExCRC?
- - Can you outline the expected outcomes from the Program you are leading, including an overview of

  the technologies being developed and what they will be used for?
  Question 2. What does your Program within MinExCRCneed to do to meet stakeholder expectations?

  Probe:

- How does your Program communicate technology developments and receive feedback from sponsors? Question 3. Can you describe how the technologies being developed in your Program would be utilised in

an unrestricted environment?

Question 4. Are you aware of the general policy and legislative frameworks under which mineral exploration is conducted?

Probe:

- How familiar are you with these policies and legislative frameworks?

Question 5. Do you think that current exploration policies and legislative frameworks are a barrier to mineral exploration today?

Question 6. Do you think that current exploration policies and legislative frameworks will be a barrier to mineral exploration in the future?

Question 7. In your opinion, how do you think exploration policy can be designed to enhance the development and utilisation of new mineral exploration technologies?

Question 8. What economic barriers do you anticipate from a governance perspective in supporting operators in the development and implementation of new and novel technologies in the mining sector?

Question 9. Does the current mineral exploration policy framework also act as a barrier when conducting technical due diligence?

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Question 10. In your opinion, how do you think Australian governments could assist with allowing the full utilisation of technologies being developed within MinExCRC?

Probe

- What role should the Government both from a national level and federal level be playing to ensure the full utilisation of MinExCRCtechnologies

Group B: Department for Energy and Mining (Government) Representative

Question 1. What are your responsibilities within your Branch in the Department of Energy and Mining?

Question 2. How do you see the current state of mineral exploration in South Australia?

Question 3. Can you briefly describe the purpose of the mineral exploration policies and legislative frameworks within South Australia?

Question 4. Is your Branch aware of recent and/or ongoing developments in mineral exploration technologies, for instance, technologies being developed within MinExCRC?

Question 5. Has your Branch consulted MinExCRCor any other organisation that is developing technologies for mineral exploration in the process of updating policies and legislative framework under which new mineral exploration technologies would need to operate?

Question 6. Do you think current mineral exploration policy or legislative frameworks in South Australia hinder mineral exploration activity or adoption of new technologies in any way?

Probe:

- Are there any other mineral exploration policy toolkits that you are looking at from other jurisdictions that could assist with enhancing mineral exploration in South Australia?

Question 7. What improvements do you think could be made to the current mineral exploration policy framework to increase mineral exploration activity within South Australia given the increasing demand of metals for which South Australia prospective for?

Question 8. What improvements do you think could be made to the current mineral exploration policy framework to increase utilisation of mineral exploration technologies within South Australia?

Question 9. What do you think the role of the government should be in the future shaping mineral exploration policy architecture?

Probe:
- Should these be addressed at a national or federal government level?

Group C: Industry Representatives

Question 1. What are your responsibilities within your organisation?
Question 2. What is the relationship between your organisation and MinExCRC?

2

How current South Australia Mineral Exploration Policies may impact on the unrestricted use of mineral exploration technologies being developed within the Mineral Exploration Cooperative Research Centre MinExCRC.

Question 3. What return is your organisation hoping to get from this relationship? Question 4. What are your experiences in conducting mineral exploration?

Probes:

- - What barriers did you face in conducting these activities?
- - Could these barriers be addressed with improved policy frameworks?

Question 5. How aware are you of the technologies being developed across MinExCRC? Probe:

- Are there any particular technologies that you are interested in?

Question 6. What do you think the barriers are in being able to fully utilise the technologies being developed within MinExCRC?

Probe:
- Should these be addressed at a national or federal government level?

SECTION C: (All interviewees)

Thank you.

Briefly outline how the interview data will be used in student dissertation, which will be made available to interviewees later in the year after it has been submitted and finalised.

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