

## GEOPHYSICS BOOK PUBLISHED FOR MINING LEADERS

The CSIR – through a team led by principal researcher and geophysicist Dr Michael van Schoor published a guidebook on geophysical methods aimed at decision-makers. Titled, Deep-level gold and platinum mining – the application of geophysics in South Africa, the book is aimed at users with limited geophysical experience or knowledge who need a better understanding of the various geophysical methods to address common deep-level gold and platinum mining problems. Therefore, the book will serve as a much-needed source of training material for mining professionals and potentially mining students at tertiary education institutions, as well.

It has been found that although in-mine geophysics is key to mining safety and optimal extraction, few companies employ mining geophysics experts. Consequently, the application of geophysical technologies to specific deep-level mining problems has not been fully exploited. The aim of the book is to address this gap. The book is published by Springer and is available via the following link:

<https://link.springer.com/book/10.1007/978-3-031-09491-0?sap-outbound-id=772637413F0E426B70540B8C74CD0138F103C582>



## SKILLS AND TRAINING OFFERINGS

Because of its many years of research experience, the CSIR is well-positioned to provide training in the broader field of mining geophysics. This may include once-off training workshops, focusing on the application of relevant technologies. In future, this training will also involve more extensive technology transfer and related hands-on training.

## MINING AND CIRCULAR ECONOMY

The CSIR embarked on a study that forms part of a broader CSIR cross-unit project titled, "Identifying Opportunities for a more Circular South African Economy – A Resource Perspective." The Circular Economy is an evolving concept that has gained traction over the past four to five years with business and government leaders. This concept also emerged in the new South African policy and various official documents of significance, including: the White Paper on Science Technology and Innovation, the 3rd National Waste Management Strategy, and the new draft Decadal Plan.

The current linear economy of South Africa adopts a take-make-waste model. This essentially means that resources are extracted from the natural environment and used to make products, which are often utilised for only a short period of time, before being discarded back into the environment. This process results in huge amounts of wastage such as waste materials, water, and energy (Nahman, et al., 2021).

In contrast to the linear economic model, a Circular Economy "entails keeping materials and products in circulation for as long as possible through practices such as reuse and repurposing of products, sharing of underused assets, repairing, recycling and remanufacturing" (Schroder, 2020) (Figure 2). A Circular Economy also aims to gradually decouple growth from the consumption of finite resources (Nahman, et al., 2021).

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## FOCUS ON Innovation in the Mining Industry

### CSIR supports growth and revitalisation of mining industry through driving innovation and modernising mines

The Council for Scientific and Industrial Research (CSIR) has its eyes on revolutionising the future of mining operations on the continent and globally. As the partner of choice for public and private mining companies, original equipment manufacturers (OEMs) and the international mining community, the CSIR through its suite of scientifically backed mining community prides itself in being able to respond to industry needs with agility.

The CSIR offers the mining sector a variety of bespoke services and solutions for different parts of the mining value chain, including:

- Competency-based safety training using immersive technologies;

- Independent safety compliance testing services, in support of a zero harm mining initiative;
- Technical services such as rock engineering, high-resolution geophysical tools and platforms to support zero harm, efficient operations and maximise resource use;
- Digital and automation capabilities, which include; digital twinning technologies and data analytics services; and
- Supporting mining operations with creating an environmentally substantiable industry, leading in topics such as mining environmental control services, circular economy and hydrogen mining mobility.





## TECHNOLOGIES FOR COMPETENCY-BASED MINE SAFETY TRAINING

*Virtual reality training technology provides mining trainees with near-real emergency experiences.*

The CSIR has developed competency-based training to improve the occupational safety of mining employees through the application of immersive fourth industrial revolution (4IR) technologies such as (augmented reality and virtual reality). The use of these technologies provides mineworkers with simulated, immersive and experiential training, which recreates a safe training environment that increases workers' ability to retain information.

This approach is set to contribute to the safety of South Africa's mineworkers as it improves their understanding of hazardous underground incidents. The newly developed tool puts the worker in near-real emergency situations, such as underground fires and explosions. Personal responses are evaluated to assess whether the worker reacts appropriately to the threat.



## NEAR REAL-TIME, RISK-BASED DIGITAL TOOL TO SUPPORT COLLISION PREVENTION OF TTMS FOR SAFER AND MORE EFFICIENT MINING OPERATIONS

*A near real-time risk prediction tool in support of collision prevention of Trackless Mobile Machines (TMMs), which digitally predicts the performance of traffic management systems, enhancing safety and productivity in mines.*

The digital platform is designed to enhance safety in underground and open pit mines, while balancing production requirements by creating a digital map of the traffic interaction activities. This novel technology uses digital twin, artificial intelligence, machine learning and other data analytic techniques and can be used

for both production and strategic decision support in existing operations, brownfields or greenfield projects to evaluate existing control measures and plans in optimising for both safety and production.

Examples of these are assessing the effectiveness of traffic management systems as well as plans, optimising mine layout in relation to safety risk exposure and fleet management.

Acting like a training assistant, the TMM technology possesses an astounding ability to identify customised driver training requirements for a productive workforce. This digital tool enables continuous improvements in TMM safety, productivity and cost reduction for existing operations and mine-life planning.



## TESTING THE FUNCTIONAL PERFORMANCE OF SCSRS IN THE SOUTH AFRICAN MINING INDUSTRY

Since 1996, the CSIR has had a state-of-the-art testing facility primarily for assisting the industry to address the shortcomings of the self-contained self-rescuers (SCSRs) functionality, as well as provide technical guidance to the mining industry. The CSIR is the only approved testing authority mandated by the Department of Mineral Resources and Energy (DMRE) through Regulation 16.4 of the Mine Health and Safety Act, 1996 (Act 29 of 1996) to monitor the functional performance of SCSRs in South Africa.

SCSRs are a source of oxygen for mineworkers during underground fires and explosions or toxic gas leakages. In case of emergency, mineworkers use the devices help them breathe as they escape from the irrespirable atmosphere to the nearest place of safety or refuge chamber.

The testing facility has tested more than 45 000 SCSRs since its establishment in 1996. This number translates into annual SCSR testing of between 2 500 and 3 000 units sampled from more than 200 underground mines in South Africa. Through its involvement in providing independent regulatory compliance testing, the industry benefited from the annual monitoring programme. The CSIR's annual sampling and testing of SCSRs has contributed to improved SCSR designs and better care and management of these devices

at the mines. As a result, the rate of SCSR failures in South African mines has significantly declined from 28% in 1996 to 0,2% in 2021. This achievement is attributable to the technical guidance provided to the DMRE, mine operators and SCSR manufacturers, particularly on technology improvements.

The CSIR has a solid relationship with the mining industry (DMRE), SCSR OEMs, mining companies, the South African Bureau of Standards (SABS), mines rescue services, as well as small, medium and micro enterprises (SMMEs), which has yielded meaningful collaboration with some SMMEs and SCSR OEMs. Additionally, the CSIR plays a strategic role in SCSR research, development, and innovation (RDI) by providing product development testing for the OEMs and conformity assessment testing for the SABS. The CSIR is an active member of the SABS Development National Committee (SABS TC94 / SC15, personal protective equipment – respiratory equipment) and a technical advisor to the DMRE Tripartite Technical Committee (TTC). The organisation's contribution in various industry forums has led to:

1. Revision and publication of SANS 1737, Body-worn escape type breathing apparatus – SABS TC94/SC15;
2. Publication of Guideline for Management of SCSR – TTC on SCSRs;
3. Publication of Incidents Reporting and Investigation (annexure to Guideline for Management of SCSRs) – TTC on SCSRs; and
4. Publication of research – Assessment of the ergonomic design of SCSR devices for use by women in mining.

The CSIR has innovation capabilities in SCSR technologies. The inventions include:

1. SCSR nose clips;
2. SCSR mouthpiece;
3. SCSR mouthpiece integrated with a breathing tube; and
4. SCSR experiential trainer.

## INTEGRATED HIGH-RESOLUTION GEOPHYSICAL TOOLS AND DECISION PLATFORM

The CSIR has developed in-mine geophysics capabilities since the 1990s, technologies like ground penetrating radar (GPR), electrical resistance tomography (ERT) and borehole radar. These novel technologies are used to address a range of mining problems, such as mapping the continuity and characteristics of the orebody ahead of mining, the optimal extraction industry objective and mapping the stability and integrity of the hanging wall of excavations (to contribute to the zero-harm industry objective).

As an institution that embraces mine modernisation through the adoption of 4IR technologies, the CSIR is continually finding ways to explore new geophysical technologies and/or applications. One of the technologies being explored is a UAV-based GPR capability that is currently being established to enable the mapping of cavities and other hazardous geological structures of geotechnical interest in areas that are difficult to survey using ground-based methods.

The CSIR is also exploring the integration of different technologies, such as GPR and LIDAR – to provide higher resolution images of mining excavations and sites. Some technologies like, ERT, can also be used for dynamic monitoring, for example, of tailings storage facility highwalls to provide advance warning of possible failures.

The inventions listed above were licensed to an SMME for commercialisation. The CSIR has innovation capabilities in SCSR technologies. The inventions include:

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2. SCSR mouthpiece
3. SCSR mouthpiece integrated with a breathing tube.
4. SCSR Experiential Trainer

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