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INSIDE:

CGS commemorates Women's Month

Figure 1. CGS Women's Day celebrations: women in Geoscience.

The CGS hosted a Women's Day workshop on 26 August 2020 at River Meadow Manor in Pretoria to celebrate the contribution of women to the organisation. The event was organised under the theme "Women in the workplace: Lean in Circles", to give women the opportunity to showcase their achievements, to encourage one another, to work to overcome obstacles and to focus greater attention on their rights and gender equality. Events such as the Women's Day workshop are held to foster opportunities for women and their families to build resilience, and to increase their independence.

South Africa prides itself in the strength and resilience of women and their contribution to society. Similarly, the CGS as an organisation creates opportunities for all its employees to thrive in their respective fields. In August every year, the spotlight is focussed on women. Therefore, the Communication and Stakeholder Relations team of the CGS coordinated this vibrant workshop that attracted women from the CGS head office and regional offices alike. All the women looked beautiful and participated with enthusiasm in the programme of the day.

Ms Nondumiso Dlamini, the programme director, handled the event with humour and immediately made everyone feel at ease. Ms Nthabiseng Mashale opened the workshop with an invocation, followed by Ms Mahlatse Mononela who gave a warm welcome address.

Ms Mononela outlined the objectives of the workshop and encouraged everyone to enjoy themselves and to participate in everything the event had to offer. She reminded attendees that the workshop had been organised as a token of the CGS's appreciation for their contribution. In between the various presentations, the women were regaled with a sumptuous lunch while being serenaded by the band and their lead singer, Ms Valentine. Her

melodious voice lit up the room and it was not long before everyone was up and dancing. Ms Refilwe Monoko delivered a message on behalf of the CGS Management team, winning over the audience with her sincerity and encouragement. Ms Monoko reminded the women that, even though they were enjoying themselves, they should not lose sight of their responsibilities at work and at home. She also urged the attendees to prioritise their mental health and finances. Next on the programme was a representative from Careways who gave an inspiring talk on emotional intelligence, illustrated with real-life anecdotes to which everyone could relate. Ms Mapaseka Mokwele, affectionately known as Ausi Pasi, the guest speaker, did not disappoint. She encouraged everyone to write down their dreams and goals for the year and to choose an accountability partner. She encouraged everyone to check in regularly with their accountability partner to ensure that they and their partner stayed on track towards achieving their goals.

Ms Angel Monnakgotla ended the event with inspiring poetry, inviting the ladies to participate in the reading. Ms Ané-a Harding closed the workshop with a vote of thanks. The Women's Day workshop was a resounding success, affording the women an invaluable opportunity to socialise with one another outside the office environment and to acknowledge one another's achievements.

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Implications of a Just Transition for future energy demands

A growing economy requires a sustainable and accessible energy supply. In South Africa, coal remains a major contributor to energy generation, with more than 72.1% of all energy needs in the country generated from coal, and 91% of all electricity produced by coal-fired power plants (Figure 1). The role of coal in the South African economy remains critical to ensure the operation of all key sectors, and to secure the livelihoods of many who participate in micro-economic industries linked to the coal mining value chain, ultimately contributing to the fiscal well-being of the country. In order to ensure the continued operation of these sectors of the economy, it is imperative to ensure the ongoing availability of coal resources in the country.

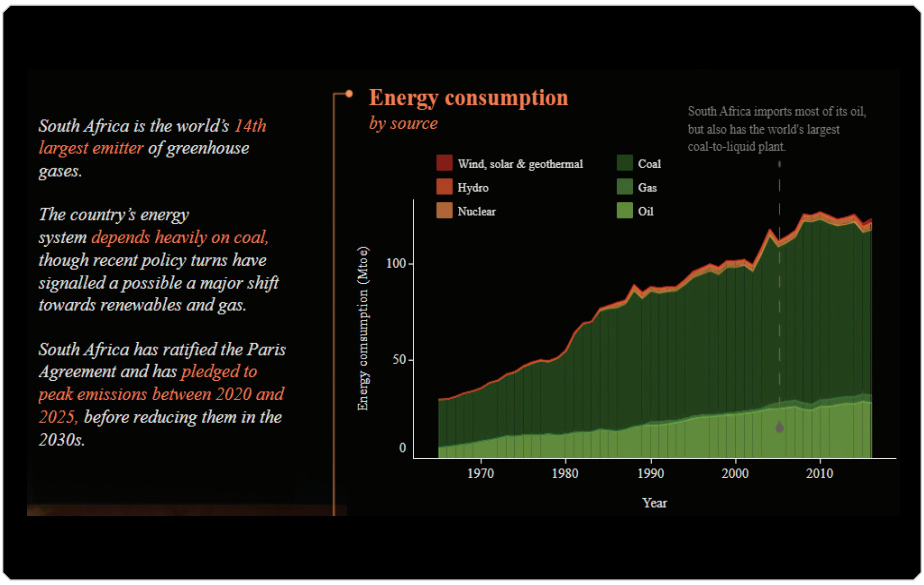

Figure 1. Infographic depicting energy sources in South Africa.

During the McCloskey Southern Africa Coal Conference (2022), South Africa's coal was identified as being among the best in the world. The country exports 25% of the 250–260 million tonnes it produces annually. This makes South Africa the fifth largest coal producer in the world and the third largest exporter of coal. Moreover, South Africa's remaining coal resources will last well over 100 years at present rates of consumption. These resources are largely concentrated in the Witbank and Highveld coalfields, with lesser amounts in coalfields such as Ermelo, the Free State and the Springbok Flats. South Africa's energy supplier, Eskom, estimates the country's coal reserves at 53 billion tonnes. At the current production rate, it is anticipated that the coal reserves may provide a secure coal supply for the next 200 years.

As the world seeks to navigate to a position of lower carbon emissions, the debate around the definition of a "Just Transition" in the South African context has become critical in decision making at industry and government level. A key element in this discussion is

understanding the role, importance and impact of coal on South Africa's energy mix and its contribution to the socio-economic and developmental imperatives of the nation.

Recent debates on a transition to clean energy sources envisage a shift away from the South Africa's overwhelming reliance on hydrocarbons. This view is impacting negatively on the coal industry, resulting in several major mining companies and banks divesting from coal. This tendency is further heightened by the position taken by South Africa's largest energy producer, which is shifting its focus to the repurposing of coal-fired power plants while seeking other suitable alternatives to coal as an energy source.

It is argued that the use of fossil fuels should be phased out because of environmental concerns posed by the burning of coal. In this regard, South Africa's power producer, Eskom, recently expressed concern that the mining and burning of coal are having a detrimental impact on the environment. Significant advances in technology have allowed for an assessment of the effects of producing energy from coal. This information is used to guide engagements with international and local industries on how to control the use of fossil fuels, and on how to phase out coal altogether in future (Figure 2). However, Eskom's goal of closing twelve coal-fired power stations by 2030 could severely impact the contribution of the commodity to the economy of South Africa. Mining companies find themselves under increasing pressure to dispose of their coal assets and to decarbonise their value chain.

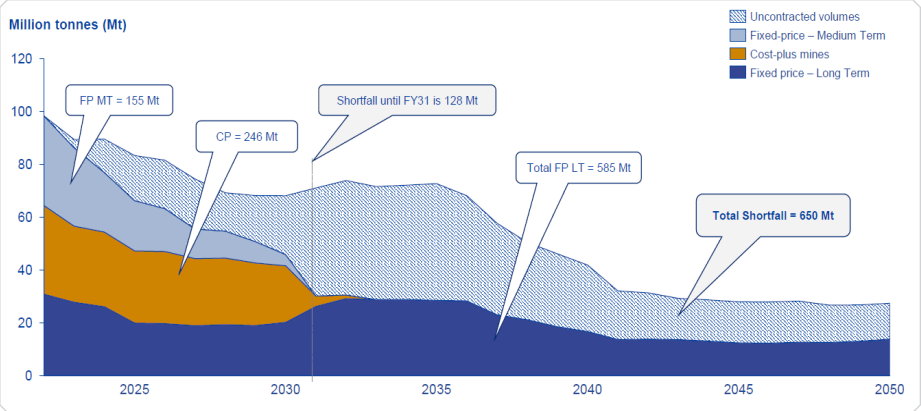

Figure 2. Projected coal demand in South Africa by 2050.

Figure 3. Extracts from the Paris Agreement — Net zero by 2050: a roadmap for the global energy sector report and the integrated resource plan of the Department of Mineral Resources and Energy.

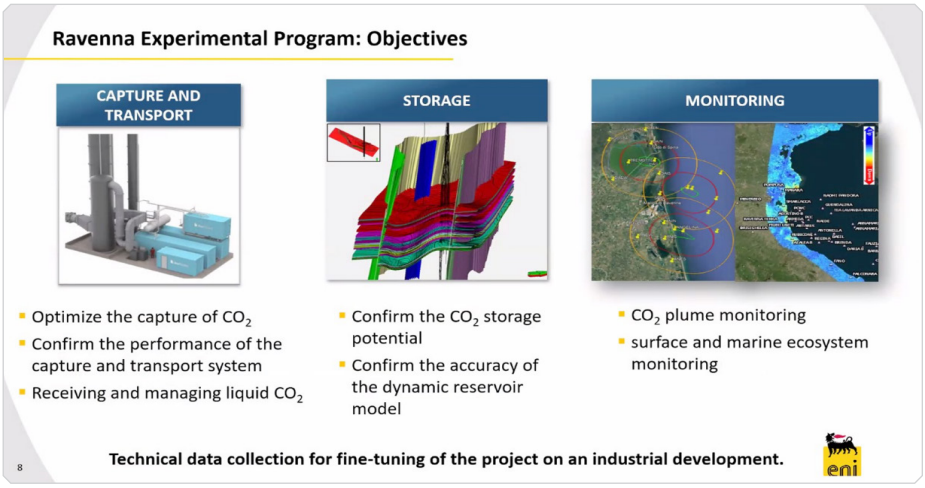

Figure 4. CCUS developmental path.

It is therefore becoming increasingly important to return to the founding principles upon which the country's energy plan is built and by which it is governed by (Figure 3).

In recent months, the Minister of the Department of Mineral Resources and Energy, the Honourable Gwede Mantashe, held a coal colloquium at the CGS head office where the he encouraged the delegates present to find solutions in response to the coal crisis.

In particular, geoscientists were asked to consider how they might harness geoscientific research to respond to this challenge. While it remains imperative for the world to reduce levels of carbon emissions, many African countries are faced with an energy dilemma where they have traditionally relied on coal for energy generation, against the backdrop of creating energy security, affordability and sustainability.

As an organisation, the CGS can make a meaningful contribution to the State by providing solutions informed by scientific research. The CGS is tasked with finding solutions and generating new knowledge, while communicating its findings to stakeholders in response to societal challenges. For example, research undertaken by the CGS into carbon capture, utilisation, and storage technologies (Figure 4) could potentially reduce the nation's carbon footprint and provide a means of extracting secondary resources. This has the potential to form the basis of a transition to clean coal while embracing a path to lowering coal emissions. The probable incorporation of clean coal and carbon renewal technologies in coal mining could reignite the coal industry and secure South Africa's economic expansion while developing a pragmatic and cost-effective model for the country.

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Data management portal — making prudent geoscience data dissemination and management possible

INTRODUCTION

A common perception is that geoscience data is difficult to access and that it is only useful to long-standing stakeholders of the CGS. Some people are unsure about where they can access geoscientific information or whether the data they are looking for even exists. In response to these challenges, the CGS has implemented strategic state-of-the-art information and communication technology infrastructure providing a platform for an interactive Web Data Management Portal where users can access and download geoscience data using desktop and mobile devices.

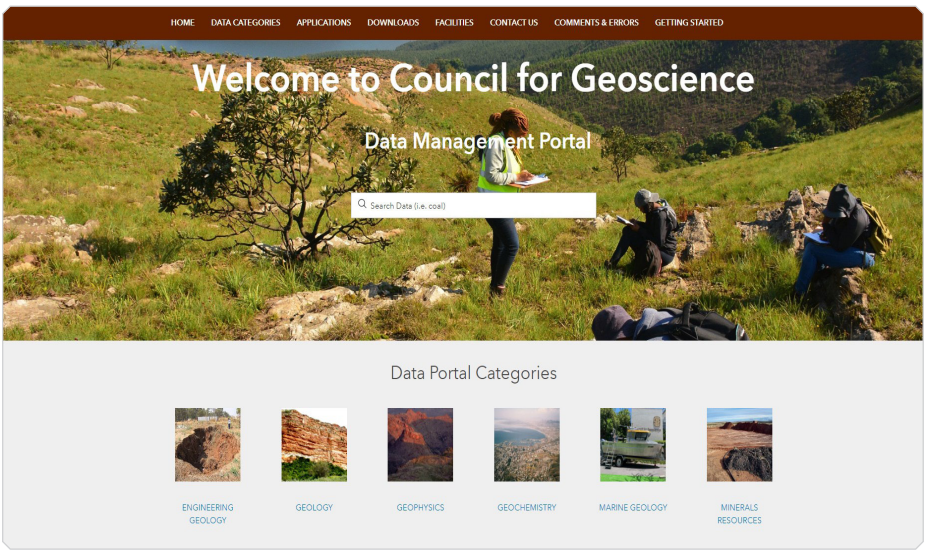

Figure 1. CGS GIS Data Portal landing page

The Data Management Portal was officially launched by the CEO of the CGS, Mr Mosa Mabuza, following the Annual Junior Indaba conference. In addition, the Minister of the Department of Mineral Resources and Energy, the Honourable Mr Gwede Mantashe, introduced the portal during the 2022 edition of the Investing in Africa Mining Indaba.

The primary purpose of the Data Management Portal is to provide an accessible platform where geoscience data produced by the CGS can be shared with a wide spectrum of stakeholders and the public. In addition, the portal is designed to expedite data custodians' and administrators' workflow when sharing geoscience data, and aims to stimulate post COVID-19 exploration activities. The Data Management Portal also serves the objectives of the Promotion of Access to Information Act (Act 2 of 2000) and the Spatial Data Infrastructure Act (Act 54 of 2003).

The data hosted on the portal is currently freely available, as stipulated by the CGS Data and Information Catalogue. Moreover, the data is constantly being updated as it becomes available, and as the CGS Data and Information Catalogue expands.

DELIBERATIONS

The Data Management Portal is a Web-based geographical information system application designed specifically to manage and share geoscience data online. The portal is user friendly and has responsive functionalities to enable data interrogation and subsequent download

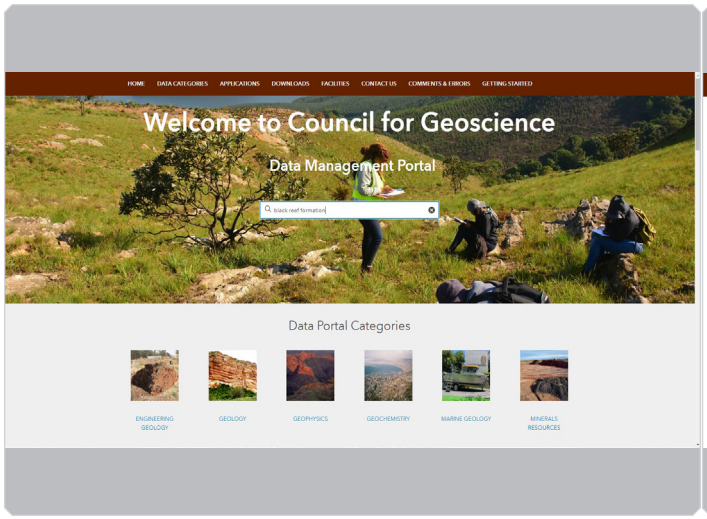

Figure 2. Users type in keywords to guide their search.

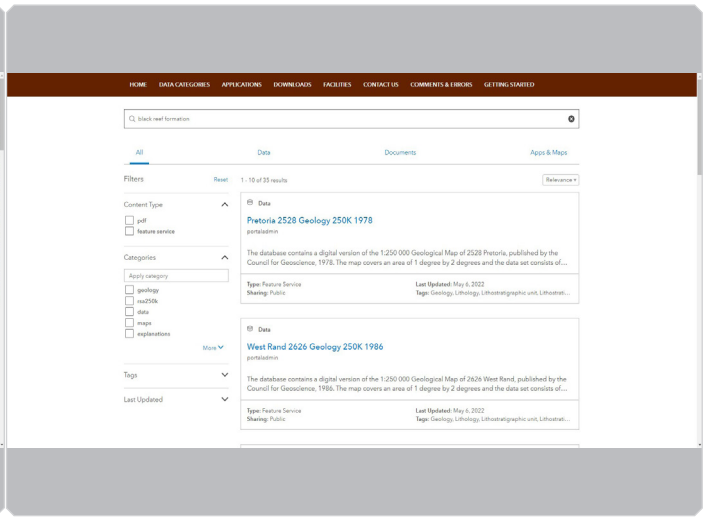

Figure 3. Result of a client search.

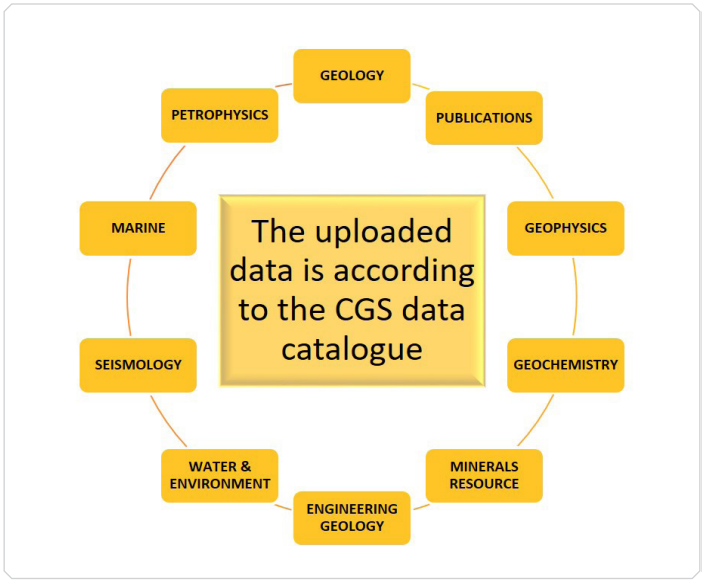

Figure 4. Catalogue themes.

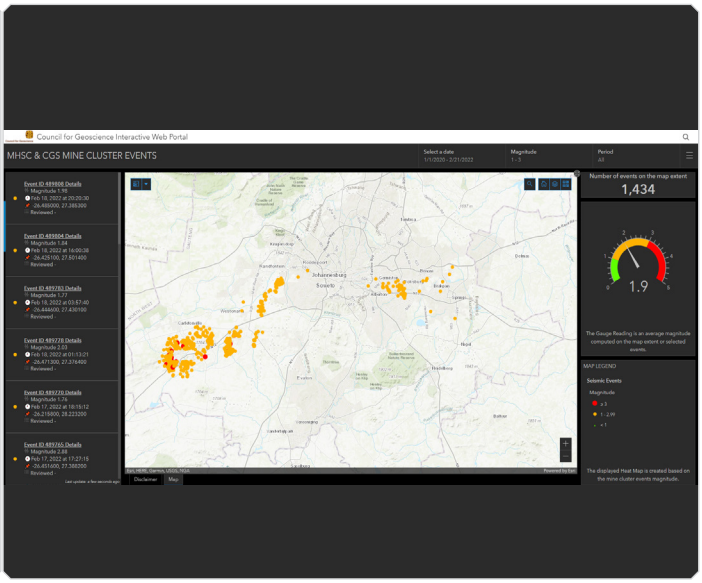

Figure 5. The portal enables live tracking of seismic activity.

for offline usage. Through the portal, users can easily search for data by using keywords such as “major cities”, “geoscience disciplines”, “maptiles”, “geology”, “lithology” (comprising “supergroups”, “groups”, “formations”, “members” and “suites”), or by searching publication names and types and data categories and types (Figures 2 and 3).

The available data is mainly accessible in four data formats: digital data (shapefiles and geodatabases), maps (published maps in PDF format), map explanations (in PDF format) and other CGS publications (in PDF format). The geoscience data is categorised according to the CGS data catalogue themes (Figure 4).

The portal also hosts Web applications (referred to as dashboards) and Web maps. Using these tools, users are able to access live data such as that tracking seismic activity in South Africa (see Figure 5) and use common map tools and export functions (for custom maps) for data such as the 1:1 000 000-scale geology map of South Africa (Figure 6).

To access the downloadable data, users are required to register an account and sign in to the portal using the same credentials they used to register. To create an account, users navigate to the download page, click on “sign up now” and follow the on-screen instructions (Figure 7). After creating an account, users sign in (Figure 8), in order to download data. The data and information are strictly aligned with criteria listed in the CGS Data and Information Catalogue (on the official CGS website and accessible at https://www.geoscience.org.za/index.php/2019-03-13-12-40-41/price-catalogue).

The Data Management Portal is an interactive Web-based application that provides access to geoscience data produced by the CGS. Users can interact with the interactive and Web-based maps and dashboards to export data and custom maps and to access to live datasets. The portal is constantly being updated with new data, maps and applications. The portal is a cost-free service provided by the CGS, and offers freely available geoscience data to the public.

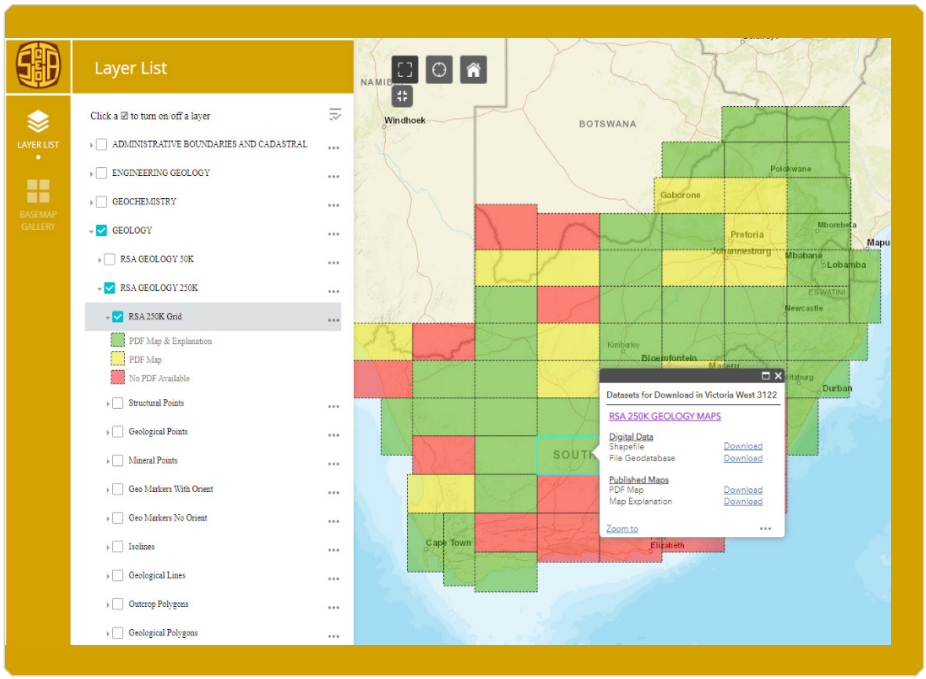

Figure 6. Common map tools and export functions built into the portal.

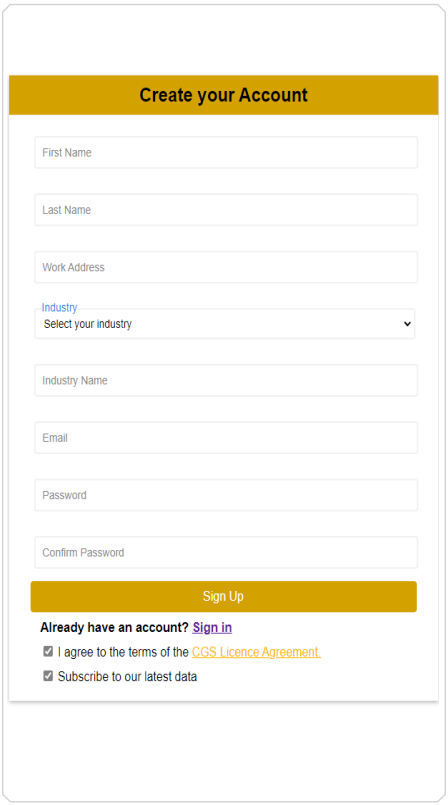

Figure 7. Users create an account to access information.

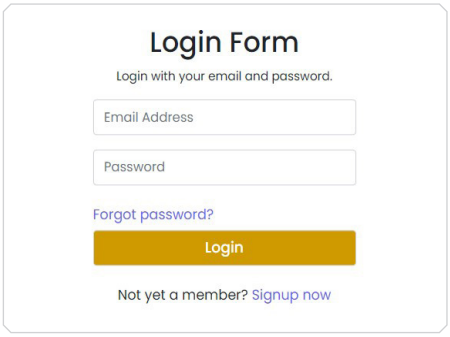

Figure 8. After creating an account, users can log into the portal.

OUTCOMES AND WAY FORWARD

The Data Management Portal is an interactive Web-based application enabling users to access geoscience data produced by the CGS. Users can access the portal by clicking on the link https://maps.geoscience.org.za. For any queries regarding the portal, users are advised to contact portaladmin@geoscience.org.za.

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Programming and its uses in geoscience

As geology is evolving into a more quantitative science, basic programming skills are becoming an increasingly important asset for geoscientists. These skills provide scientists with the ability to acquire, manipulate and visualise growing digital datasets, enabling them to create new and innovative solutions to solve problems using simple programs to expand or even replace expensive commercial software packages. Ultimately, these programs use automation to help scientists save time and enable them to develop entirely new ways of working with 2-D and 3-D mapping components. Scientists with a background in programming can create customisable tools to solve a specific problem, and these tools evolve as their needs change. There are five key programming classifications that can be explored based on the needs of a specific project or task.

Automate time-intensive tasks: Scientific programming can be used to automate tasks that might otherwise have taken weeks, months, years, or simply have been impossible to do by hand. For example, a program was created to automatically georeference historical 1:50 000-scale scanned maps to speed up the process of interrogating older datasets and facilitate batch processing.

Modify and update research: If a scientist can write clean code, it can be modified by multiple users and rerun repeatedly. For example, a program that is able to automatically detect faults and lineaments on aerial photographs and satellite images will make it possible to export these detected lineaments as shapefiles to be interrogated in ArcGIS.

Share methods with the public and other researchers: Open-source code or programs are easy to share, making science more open and reproducible. Researchers are able to share their exact methods with other scientists and the public. This allows for transparency in processing and propels science forward by enhancing access to new data manipulation techniques.

Document workflows: Certain programs or pieces of code allow users to easily document their workflow and to auto report on progress made. Users use comments to explain every step of the process (to their future selves or to others); greatly facilitating future updates or manipulations. Managers and task leaders are also better able to track multiple projects.

Enable collaboration: Programming makes collaborating easier. For example, an algorithm was developed to derive benthic habitats by integrating marine geophysics and biological science with machine learning techniques. The k-means clustering algorithm incorporated a number of geological and biological datasets including marine geophysical data layers, such as multibeam bathymetry and backscatter supplemented with sidescan sonar. This data was then ground-truthed using drop camera footage, sediment grab samples and remotely operated vehicle biological footage.

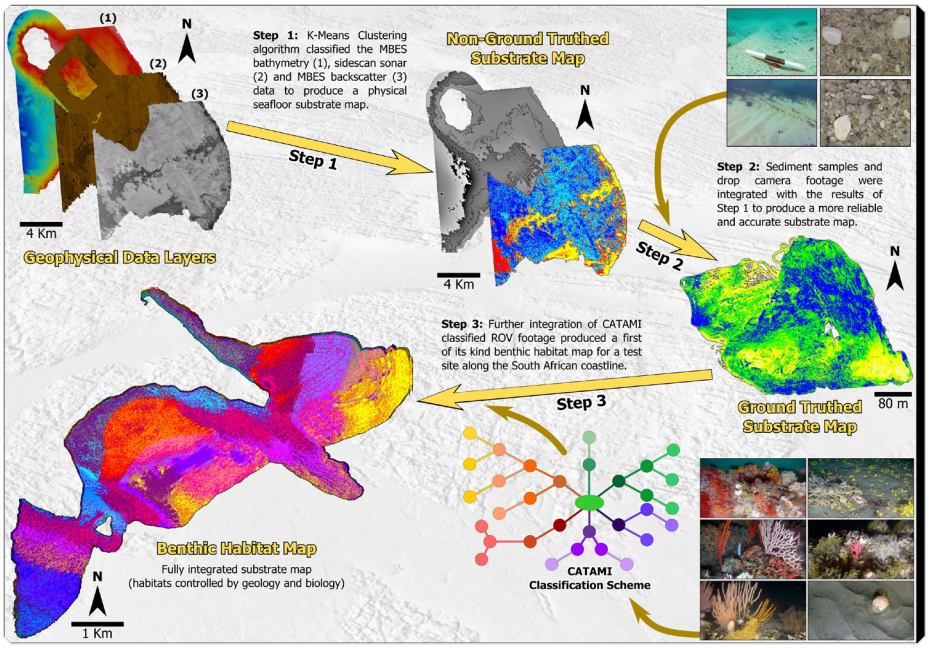

Figure 1. Overview of the processes and methods used to classify multibeam bathymetry and multibeam backscatter data. This image highlights the multiple steps and input datasets required in order for the machine learning algorithm to create a reliable and accurate benthic habitat map.

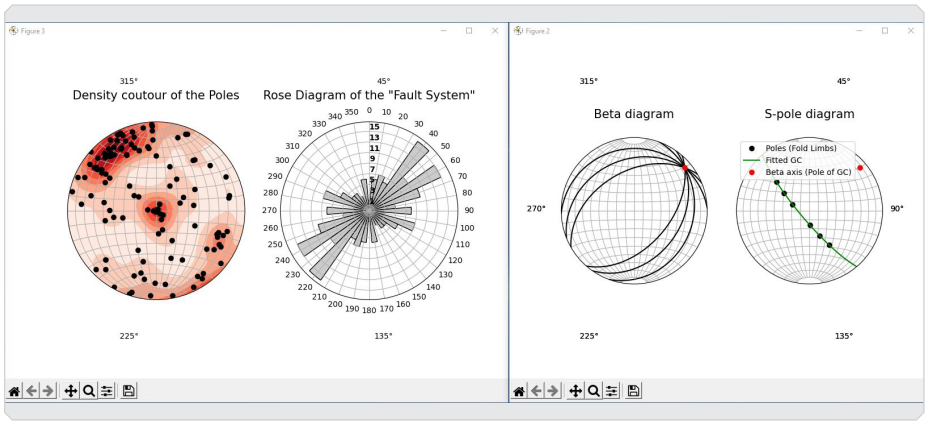

Figure 2. Exported image from a stereonet program, using theoretical examples to highlight a few of the capabilities.

Capabilities and applications of useful programs, languages and repositories for programming

Python is only one of a number of programming languages. Other languages that may be used are JavaScript, Java, C, C#, C++ and R, to name a few. Python is by far is the most widely used and is regarded as the main programming language nowadays because it is easy to learn, due to its simple syntax, large library of standards and toolkits, and integration with other popular programming languages such as C and C++. Python can be used to manipulate arrays and scientific data (shapely, rasterio, and fiona) and to visualise data (matplotlib and numpy) and there are tools dedicated to remote sensing and geophysics (geopandas and pyproj). In addition, there are a number of repositories such as GitHub, PyPI, BitBucket and SourceForge, providing an array of programs that are available to download, test and use.

Two examples of programming to aid geoscience mapping currently being tested at the CGS are a stereonet and palaeocurrent program, and SediStats. These are both Python-based programs and this programming language, as previously mentioned, provides a number of tools that can be downloaded quickly to analyse, plot and report geological data. The first program uses mplstereonet and provides lower-hemisphere equal-area and equal-angle stereonets for matplotlib. The program is able to provide different methods to produce contoured orientation density diagrams, and has a number of utilities to parse structural measurements in either quadrant or azimuth form. The program is also able to plot palaeocurrent data as rose diagrams to highlight flow vector types, standard deviation and mean values, to name a few outputs.

SediStats uses a number of libraries including matplotlib, numpy, pandas, tkinter, openpyxl and skimage, for example. The program calculates

and plots the cumulative grain size distribution curve derived from the settling tube and incorporates this information with the fines and gravel fractions. The program derives a cumulative weight percentage plot, grain size distribution and sediment classification plot as well as sample statistics, cumulative weight percentiles and size distribution percentages.

Machine learning is an important tool, used in the geosciences to create new ways of interrogating data. These techniques are based on computer modelling processes and their multiple manifestations, and are able to combine task-oriented studies, cognitive simulations and theoretical analysis to interpret and understand a wide variety of datasets. Through the use of statistical methods, algorithms are trained to make classifications or predictions, uncovering key insights within data mining projects. Modules such as scikit-learn and tensorflow in Python allow users to make predictions and estimates using complex algorithms.

Future of programming in geoscience

Along with the evolution of data science theory and methodology, the upgrading of computational facilities and capabilities and the thriving of big data, open data, smart data and science to facilitate data-driven geoscience discovery will be integral in the future. Open data and open science will be the new normal and include open access to publications, open-source software programs, open samples, and open workflows. “Smart” and “big” datasets refer to the application of metadata and semantics to add more machine-readable structures in data generation and collection, as well as to deploy intelligent algorithms to improve the precision of data discovery and analysis. There is an increase in large-scale data science projects that cross the boundaries of disciplines and rely on the collaboration of researchers from different institutions, as well as high-performance computing facilities. These projects require efficient infrastructure for data storage and transmission and large software programs for data management and processing.

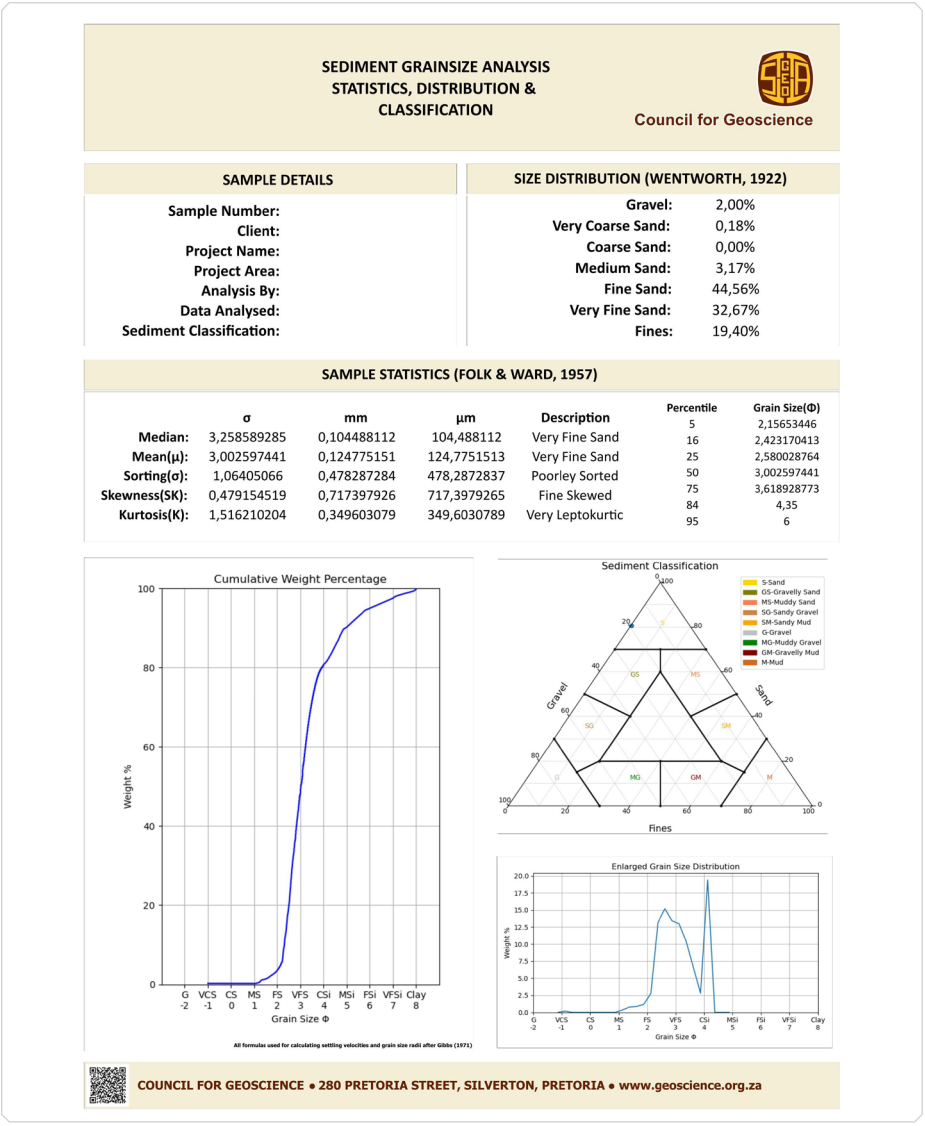

Figure 3. Exported image from the SediStats program, using sediment data collected offshore in False Bay in 2019.

One of the most promising trends for the future of the geosciences is in the realm of modelling. This research makes use of a wide variety of models, such as conceptual, physical, and numerical models, and, more specifically, artificial neural networks, agent-based models, coupled models, and hierarchical models. The more accurate and complete the algorithms that power such models become, the better the models will be. The future of scientific programming is particularly promising because of the number of exciting possibilities. Geoscientists are creating geoscience analysis, visualisation, modelling, and data management tools that will be used for decades to come. The publication of programs empowers scientists to manage their research products as valuable scientific assets in an open and transparent way, enabling broader access by other scientists, students, decision-makers, and the public. Improving the documentation and dissemination of research will also accelerate the pace of scientific discovery by enabling others to build on published work. The increase in efficiency and speed has utterly altered modern geoscience, and geoscience programming is, without a doubt, our path to the future.

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Minamata Convention — a recent global mercury assessment report

CGS scientists working on the air quality task under the Integrated Research in Mine Closure (IRMC) project in the Water and Environment Unit of the CGS received a National Research Foundation grant to attend the online International Conference on Mercury as a Global Pollutant (ICMGP). The conference was hosted in Cape Town from 25 to 29 July 2022. The scientists also attended the pre-conference workshops covering themes such as research capacity strengthening, new methods of measuring mercury (Hg) species, estimations of mercury emissions from coal units, reduction/elimination of mercury in artisanal gold mining and data processing and modelling.

Figure 1. Cape Town, the host city for the ICMGP-2022.

Hg is a naturally occurring chemical element widely known to cause harm in various ways to exposed people globally, especially to women and children. Three forms of mercury that are significant in this regard are elemental Hg (HgO), inorganic Hg compounds (HgII) and organic Hg compounds such as methylmercury (MeHg). Human exposure both to the elemental and inorganic mercury species commonly happens in proximity to sources of Hg, such as artisanal gold mining areas, waste tailings and coal-fired power plants. People are also exposed to Hg contamination through the regular consumption of mercury-contaminated seafood.

Figure 2. Human exposure to mercury species usually occurs around artisanal gold mining areas and through the food chain.

The conference reflected on progress made in controlling mercury through the Minamata Convention. The Minamata Convention is a multilateral environmental agreement that addresses specific human activities contributing to widespread mercury pollution. The convention, adopted in October 2013, was signed by 128 countries within a year. The agreement came into force in August 2017. South Africa, which had become a signatory in 2013, ratified the convention in 2019.

Key findings arising from United Nations Environment Programme assessment reports of 2002, 2008, 2013 and 2018 are:

- Human activities have increased total atmospheric Hg concentrations by about 450% above natural levels, with 17 key sectors being of concern.
- Estimated global anthropogenic emissions of Hg into the atmosphere for 2015 were about 20% higher than had been the case in 2010.
- The third-highest emissions (about 16%) occurred in sub-Saharan Africa with artisanal gold mining having contributed about 38% of the total global emissions. South America and sub-Saharan Africa were identified as the most prolific contributors.
- Stationary combustion of fossil fuels and biomass is responsible for about 24% of the estimated global emissions with coal burning accounting for about 21% of the output.

• Artisanal gold mining was the single-highest contributor of mercury pollution to the terrestrial and freshwater environments in 2015.

Subsequent to the ICMGP, Dr Lynwill Martin from the South African Weather Service, who had chaired the ICMGP-2022 Organising Committee, invited the CGS team to participate in the South African Mercury Network (SAMNet). The objectives of SAMNet are:

• To develop a coordinated mercury observation network in South Africa (and later throughout Africa through AfriGEO) to determine the status and trends in atmospheric mercury concentrations and the wet, dry and total atmospheric deposition of mercury;

• To provide accurate and reliable baseline mercury data in the air, soil, rain, streams and sediments;

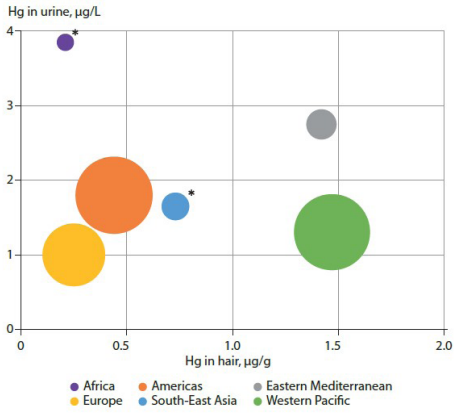

Figure 3. Bubble plot of hair and urine Hg levels from studies on background populations. The size of the bubble reflects the sample size and the asterisk shows that Hg levels for the urine samples of the background populations were not available.

• To use this high-quality data to validate local and regional model inputs with partners;

• To contribute to capacity building and other requirements for the implementation of the Minamata Convention.

The conference came at an appropriate time for the air quality task scientists, following the team's recent addition of the mercury species as a particulate matter pollutant of interest to its research activities. Currently, local research on Hg is very limited. Thus, the CGS's interest in participating in and advancing this research is likely to be very valuable to the South African public and to industry.

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Mineralogical association of South Africa X-ray fluorescence workshop

The CGS Analytical Services Unit team attended an X-ray fluorescence (XRF) workshop on 23 June 2022. The Mineralogical Association of South Africa (MINSA) presented the workshop at the Wirsam scientific facilities in Johannesburg. The following topics were discussed at the workshop:

• Basics of XRF and the various spectrometers: WDX, EDX and hand-held instruments

• Optimal spectrometer calibrations

• The importance of sample preparation and

• A tour of the laboratory.

Upon their return to the CGS, the Analytical Services team (Figure 1) shared their experience and knowledge and highlighted areas of improvement with their CGS colleagues.

Figure 1. (From left to right): Mosotho Bopape, Nontobeko Magwaza, Thando Masmola, Koena Ramasenya, Maggi Loubser (facilitator) and Kgaogelo Mashishi.

X-ray fluorescence spectrometry (XRF) is a non-destructive analytical technique used to determine the elemental composition of various sample types such as soils, stream sediments, ores and industrial materials. The analysis of major and trace elements in geological materials using XRF analysers is undertaken by measuring the fluorescent (or secondary) X-ray emitted from a sample when it is excited by a primary X-ray source. Each element in a sample produces a set of characteristic fluorescent X-rays (a "fingerprint") that is unique to that specific element. The resulting fluorescent X-rays can be used to detect the abundance of elements present in the sample. There are two main XRF methodologies, namely, energy dispersive XRF (EDXRF) and wavelength dispersive XRF (WDXRF). Currently, the Analytical Services Unit operates two wavelength energy dispersive XRF spectrometers to support the Integrated Multidisciplinary Mapping Programme and commercial projects of the CGS.

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Kalkkop impact crater palaeolake: a bridge between past, present and future

The aim of this project was to provide a high-resolution proxy record of fluctuating climates and ecosystems during the deposition of the finely laminated Kalkkop crater lake sediments. Climate is an important parameter that exercises a strong control over the characteristics of and vegetation around lakes. The vegetation environment holds clues about the kind of climate in which the lake formed. Such information can be gleaned, for example, by examining pollen. In general, crater lakes are closed systems, and their hydrochemistry is archived in the geochemistry of the palaeolake precipitates. In addition, sand and dust are circulated by the wind and washed into the lake. Organic remains representing specialised fauna and flora thrive in such lakes, supplemented by pollen blown in from the surrounding area, becoming preserved in the lake sediments and providing a direct record of contemporary biodiversity. Analysis of the lithofacies and palynology, combined with their chemical and C- and O-isotope composition, may record regional and local fluctuations in the atmosphere, lithosphere, hydrosphere and biosphere in the time scale of lacustrine deposition.

The Kalkkop impact crater (32°42'30"S and 24°25'56''E) is one of three confirmed craters found in South Africa. The crater is situated ~51 km southwest of the town of Graaff-Reinet on a low-

Figure 1. 1992 borehole at the centre of the crater

Figure 2. Google Earth image of Kalkkop showing the calcareous palaeolake fill, a roughly circular feature with a slight bulge on the eastern aspect

relief plain, in the semi-arid Karoo biome of southern South Africa. The crater palaeolake deposits are about 650 m wide at the surface and 90 m thick at depth, potentially providing a long and detailed record of palaeo-environments during the timespan of deposition. The Kalkkop impact crater is very hard to locate or identify on land, but is clearly visible from Google Earth and satellite imagery owing to its conspicuous shape.

Since the discovery of the site in the 1940s, several exploratory boreholes have been drilled through the succession in search of oil and diamonds. Previously, the crater was thought to represent an explosive diatreme. The last boreholes were sunk in the 1990s and the impact origin of the crater was conclusively demonstrated. Planar deformation features were identified in the breccia from the crater floor, and Re-Os isotope evidence was demonstrated for a small meteoritic component in the breccias. A sample from the base of the lacustrine carbonate deposits was dated using U-Th series methods, giving an age of 258 ±25 ka, thought to represent the age of the early part of lake deposition (and, by inference, the approximate age of the impact).

The thick Kalkkop succession is dominated by whitish limestone which overlies brecciated Karoo Supergroup sandstone and mudrocks with a diffuse contact. The succession is, in turn, capped by a pedogenic calcrete (the calcrete only occurs at the top of the succession and is associated with plant roots in places). During the present study, the 1992 drill core was sampled for geochemical analysis (stable isotope, Sr-isotope analysis and X-ray diffraction (XRD)) and then sampled for pollen analysis before being logged in detail. The borehole was sampled at systematic intervals ranging from 1.8–3 m. The samples were collected from the top to the bottom of the core (0–89 m). At 70–88 m, most of the core is missing, accounting for the lack of data. Closer examination of the core revealed considerable variation. Some sections of the core are finely laminated, sometimes on a submillimetre scale, whereas the core appears more massive in character elsewhere. Fragments of

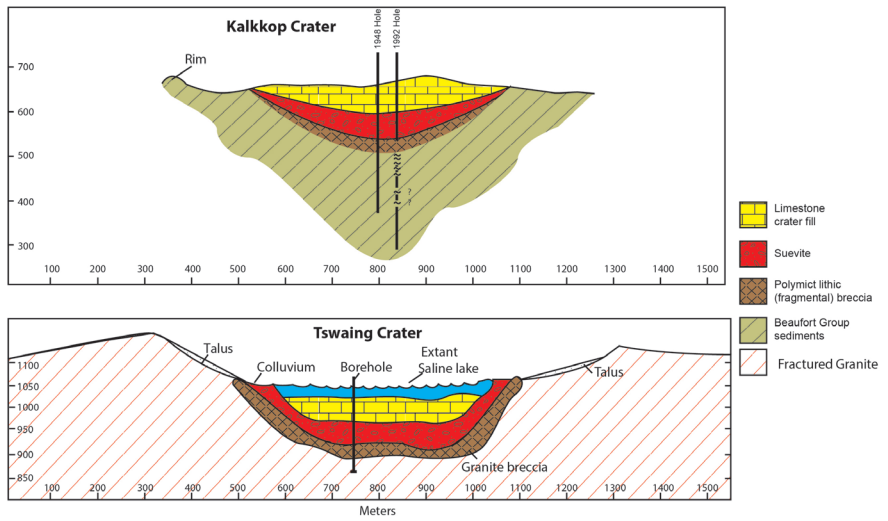

Figure 3. A comparison cross sections image of the Kalkkop and Tswaing craters

Karoo Supergroup rocks, ranging from centimetre to submillimetre scale, are present throughout the succession. The crater lake deposits (i.e. the top 89 m of the core) were found to be mainly carbonates. The lower part of the carbonates is dominated by calcite, whereas the upper part is dominated by dolomite.

The age of the crater also had to be taken in to consideration, because the crater rim had been almost entirely removed by erosion, with only ~2 m high remnants in the south and northeast. The remnants are fractured and faulted with locally developed small-scale gentle folds. No ejecta blanket was reported and this feature is assumed to have been eroded since the impact. The presence of debris flow deposits comprising angular clasts of country rock near the top of the lacustrine succession indicates that the rim had still been largely intact towards the end of the lacustrine depositional phase. By contrast, the ~250 ka Tswaing impact crater, some 900 km to the northeast, is relatively pristine, and contains an extant saline lake. These observations, allied with palynoforms indicating the periodic presence of subtropical forest in the currently semi-arid Kalkkop environs, suggest a Neogene age (6.3 ±1.6 Ma) rather than a Quaternary age. It has been suggested that denudation rates just north of Graaff-Reinet are 1–4 m/Myr, with some authors suggesting even lower denudation rates further inland (south of Laingsburg) (<0.4 m/Myr). The crater rim would have been sharply elevated above the surrounds and gravity would have played an important role in erosion (as opposed to a slow wearing down of a low-relief area, for instance). In addition, the rocks comprising the rim (mainly weakly resistant mudrocks) would have been completely shattered. Thus, the erosion rate was probably higher than the regional rate. For an erosion rate of 8 ±2 m/Ma, removal of the 50 m high crater would have taken place at ~6.3 ±1.6 Ma, (i.e. latest Miocene age). However, it is conceivable that the crater is significantly older if the lower erosion rates apply. Thus, while a relatively old age is preferred for the Kalkkop crater, we are unable to offer an explanation as to why the U-Th age is too young. The U-Th age appears to have been obtained by means of alpha spectrometry as opposed to a more modern mass spectrometric method.

The strong correlation between the $\delta^{13}C$ and $\delta^{18}O$ in the lower part of the Kalkkop succession suggests non-equilibrium precipitation at high degrees of evaporation. This is consistent with the arid conditions. The upper part of the core consists of carbonate precipitated

in isotope equilibrium with the lake water during less arid conditions. Apart from the lowest few metres of the carbonate sequence, precipitation was from strongly evaporated water with $\delta^{18}O$ values >zero. There is no systematic change in $\delta^{13}C$ in the upper part of the core and, therefore, there is no evidence to support a change in proportion of C3 to C4 vegetation. Therefore, the succession of the Kalkkop crater lake is a potential climate proxy.

This study is has been published in the following publications: CGS Bulletin 149 and the South African Journal of Geology and the Inkaba Publication, 154.

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PanAfGeo2 project: strengthening geological surveys in Africa through geoscientific training

PanAfGeo-2 (2021–2024) is a continuation of the widely recognised PanAfGeo-1 project, which took place from 2016–2019. The project comprised 42 training sessions for 1 068 geoscientists from 49 African countries, and generated notable impacts at an institutional and technical capacity level on the African continent. PanAfGeo2 aims to strengthen African geological surveys through the development of innovative geoscientific training programmes in partnership with the Organisation of African Geological Surveys (OAGS).

Figure 1. PanAfGeo2 attendees in Pointe-Noire, Republic of the Congo.

The PanAfGeo-2 project online kick-off meeting took place on 25 and 26 November 2021. The event attracted about 70 representatives from nearly 50 countries across Africa and Europe. Participants included representatives of various African and European geological surveys, the African Union Commission, the European Union (EU), the United Nations Educational, Scientific and Cultural Organisation (UNESCO) and the Minerals Africa Development Institution (MADI), to mention a few.

Figure 2. Some of the attendees of the Pan AfGeo2 special session at the 2022 Mining Indaba.

The PanAfGeo2 project initiative is subdivided into eight work packages (WP), namely WP-A: geoscientific mapping; WP-B: mineral resources assessment; WP-C: artisanal and small-scale mining; WP-D: new frontiers in geosciences (geoheritage and geothermal energy); WP-E: geohazards and environmental management of mines; WP-F: georesources governance

and OAGS/GSOs institutional strengthening; WP-G: geoscientific information management and WP-H: communication, dissemination and dialogue.

The project aims to host approximately 40 training sessions and ten workshops throughout the four-year project lifecycle. Since the kick-off meeting in November 2021, a number of scientific training sessions have been conducted, including training on geohazards and environmental management of mines (WP-E) in Cameroon from 3–9 April 2022, and a geoheritage training session (WP-D) in the Republic of the Congo from 13–18 June 2022.

To increase the visibility of this initiative, the team and representatives from member countries attended the Mining Indaba in Cape Town and hosted a special session aimed at fostering collaborations and partnerships between the EU and Africa. In addition, the PanAfGeo team attended the Prospectors and Developers Association of Canada (PDAC) event in Canada with the Euro Geological Surveys (EGS) team.

In July 2022, the PanAfGeo2 team, led by Dr David Khoza and Ms Celine Andrien, met with the African Union Commissioner for Economic Development, Trade, Tourism and Minerals, His Excellency, Ambassador Albert Muchanga, in Zambia for a joint EU-Africa meeting, with a view to accelerating collaborations between the two entities.

PanAfGeo2 is currently running a #PanAfGeo photography competition, with the theme ***"What does the PanAfGeo project mean to you?"*** The competition invites entrants to ponder how PanAfGeo is likely to benefit them, their geological survey, their society and country. Ten finalists will see their photo printed in high resolution, framed and exhibited during the final meeting of the project in 2024. Winners will be announced during that meeting and on the PanAfGeo website and social media platforms. Interested photographers can enter the competition by submitting an application to Céline Andrien — celine.andrien@eurogeosurveys.org; cc — tracey@dancyenergy.com

Figure 3. (a) Dr David Khoza from the CGS giving a talk at the PanAfGeo2 special session at the 2022 Mining Indaba; (b) PanAfGeo2 booth at the 2022 Mining Indaba.

Figure 4. OAGS and PanAfGeo2 team with the African Union Commissioner for Economic Development, Trade, Tourism and Minerals, His Excellency, Ambassador Albert Muchanga, in Zambia.

Some of the upcoming geoscientific trainings in the third quarter of 2022 include:

Upcoming PanAfGeo 2 geoscientific training sessions	Tentative dates
Field geological mapping (WP-A)	31 August–28 September 2022
Geoscientific information management (WP-G)	12–23 September 2022
Cartographie géoscientifique (WP-A)	10 October–6 November 2022
Gestão de informação geocientífica (WP-G)	7–18 November 2022

More information regarding upcoming geoscientific trainings can be found on the PanAfGeo website at https://panafgeo.eurogeosurveys.org/ or on our social media platforms — LinkedIn: PanAfGeo Project Phase 2; Twitter: @PanAfGeo; Facebook: PanAfGeo.

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Quarterly technical workshops: the organising team's experiences

The purpose of the quarterly technical workshops (QTWs) is to showcase ongoing projects within the CGS and to allow scientists to share their experience of and progress with the respective projects.

The QTWs are well organised and provide a platform where a variety of CGS projects are discussed. They allow scientists representing different scientific disciplines within the CGS to interrogate projects that do not necessarily fall directly within their purview. The CGS projects showcased during the QTWs represent the work of the Geoscience Technical Programme (GTP) of the CGS. The discussions after the presentations are always insightful and allow the presenting scientists to broaden their scope of work and to capture and implement new ideas. Often, external speakers are invited to the QTWs to share their experiences relating to topics relevant to the GTP with the science community at the CGS. In this way, CGS scientists are able to engage and share ideas with external stakeholders while establishing collaborative working relationships. The CGS offers these external speakers a token of appreciation for their participation in the workshops.

The overall attendance of the QTWs has been very good, with each QTW attracting at least 70 attendees online. Before the COVID-19 pandemic, more than 60 attendees attended the workshops in the auditorium.

Organising the quarterly technical workshops

Scientists are always eager to submit abstracts whenever a call for QTW submissions is sent out. The call for abstracts attracts contributions across the board from senior and juniors scientists alike. This willingness to participate in the QTWs shows that scientists take pride in their work and do not shy away from having their outputs scrutinised. It is important for senior scientists to encourage emerging scientists to participate in platforms of this kind. It is equally important for senior scientists to give balanced feedback to ensure that early-career scientists can develop into critical thinkers. As members of a research organisation, CGS scientists appreciate the importance of conducting research and sharing their work at platforms such as the QTWs to enhance their research skills and knowledge, with a view to making the world a better place.

Benefits of the quarterly technical workshops

Some of the benefits of the CGS QTWs are:

- Scientists are given an opportunity to discuss current CGS projects.
- CGS scientists learn about other geoscientific work that may be of interest to them and that may result in collaborations with external scientists.
- Young professionals gain personal and career development opportunities by gaining experience in presenting in public to fellow colleagues and receiving feedback about their work before sharing it with professionals outside the CGS.
- Scientists gain a better understanding of the work that other colleagues are doing at the CGS.
- Scientists are motivated to perform better by seeing their peers succeed. By supporting their colleagues, they are also motivated to pursue excellence.

External speakers/stakeholders

Several external speakers have presented at the CGS workshops. The participation of external scientists may give rise to collaboration and inspire CGS scientists. Some external speakers who have presented at CGS workshops since 2019 include Dr Humbulani Mundalamo who presented on "*Mine waste management in the Giyani Greenstone Belt*"; Dr Graham Begg who gave a talk on "*Geodynamic and lithospheric controls on Ni-Cu-PGE deposits*"; Dr Stephane Chevrel on "*Hyperspectral surveying: a tool for identification and mapping of asbestos mine waste water in South Africa*", and Prof. Musa Manzi who gave a presentation on "*New ways of exploring the subsurface with seismic solutions*".

Figure 1. Dr Humbulani Mundalamo from the University of Venda presenting on mine waste management in the Giyani Greenstone Belt Project.

Figure 2. The CEO, Mr Mosa Mabuza, introducing Mr Donovin Liebegot (left above). Mr Liebegot demonstrating reading seismic events (right above). Dr Taufeeq Dhansay and Tebogo Mello handing Mr Liebegot an appreciation gift from the CGS (below).

The presentations by external speakers have stimulated intensive scientific discussions among and attracted interest from CGS scientists.

The CGS CEO, Mr Mosa Mabuza, invited Mr Donovin Liebegot to demonstrate software that he had designed to enable visually impaired scientists to read seismic events.

CGS internship presentations 2019

An internship technical workshop was held on 17 and 22 October 2019 as an example of self/career development of young professionals. The purpose of the workshop was to give CGS interns the opportunity to present their work at a constructive forum and to have this work evaluated by experienced scientists. Interns from all disciplines of the CGS, including scientific and support units, gave presentations. The workshop was arranged by the Human Resources Unit of the CGS, supported by a panel of senior and specialist scientists who acted as moderators.

The talks presented were of a very high standard, with each presenter presenting their topic with confidence. Talks covered topics such as geoscience mapping,

Figure 3. Mr Albie Steyn (top left), an intern from the Water and Environment Unit, presenting on acid mine drainage and clogging in drill bits due to iron and manganese. Ms Valencia Mashiloane (top right) presenting stakeholder work nationally and internationally. Ms Tonia Mahlako (bottom left) and Ms Fikiswa Jama (bottom right) presenting their work in the Human Resources Unit.

economic geology, geochemistry, water and environment, engineering geohazards, geophysics, human resources and stakeholder relations. All presenters responded well to questions, further demonstrating the effectiveness of the CGS internship programme.

The new normal: new opportunities

During the national lockdown imposed as a result of the COVID-19 pandemic, the presentation platform changed from in-person conferences to a hybrid model of in-person and online talks. Attendees were also given the flexibility to attend the workshops virtually (online) or physically (in person). This increased the overall attendance of the QTWs to over 90 attendees. This model presented its own challenges such as connectivity glitches and internet issues. These challenges needed to be resolved as it was becoming apparent that in-person presentations had been replaced by an online platform for the foreseeable future. At the same time, however, the online model also holds advantages as it makes it much easier to invite external speakers to the workshops.

The organising team and CGS management would like to thank all the presenters for the talks they have given so far, and we look forward to many more QTWs in future. In addition, the CGS would like to thank the QTW organisers as well as the ICT team for ensuring that the workshops are not interrupted by equipment failure or loadshedding and other technical issues.

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Analysis of the corporate performance of the CGS over the past five to ten years

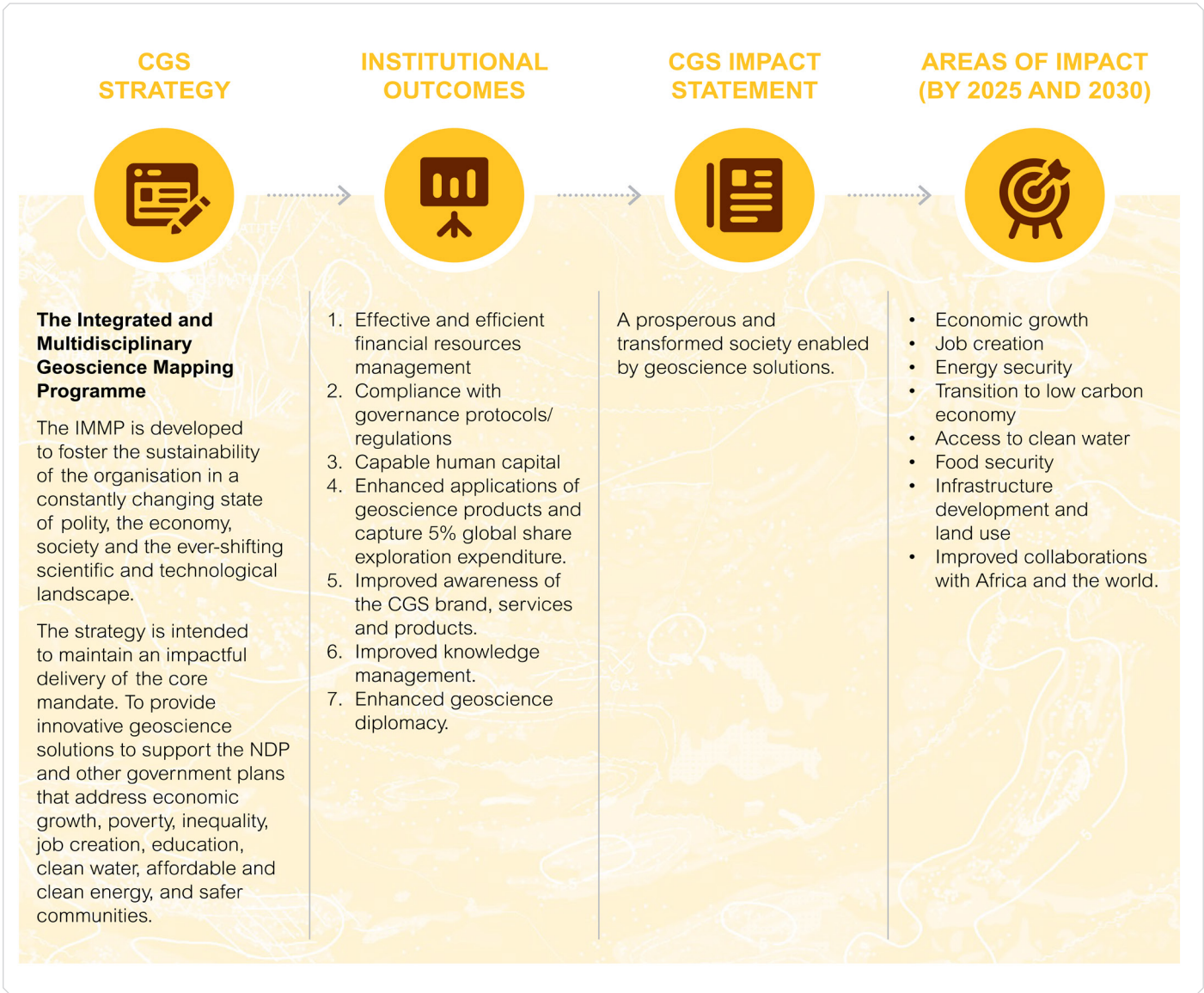
About the CGS

The CGS is the legal successor of the Geological Survey of South Africa, which was formed in 1912 by the amalgamation of the former surveys, the oldest of which — the Geological Commission of the Cape of Good Hope — was founded in 1895. The Geoscience Act No. 100 of 1993, as amended, established the CGS in its present form. The CGS is listed as a Schedule 3A Public Entity in terms of the Public Finance Management Act (PFMA) (Act No. 1 of 1999).

CGS strategy

The CGS strategy (i.e. Integrated and Multidisciplinary Geoscience Mapping Programme – IMMP), adopted in 2017/18, encourages the sustainability of the organisation in a changing ideological, economic and technological landscape. The IMMP is intended to maintain an impactful delivery of the core mandate of the CGS and provides innovative and responsive geoscience solutions to support the National Development Plan 2030 and other government plans that address such national development imperatives as economic growth, poverty, inequality, job creation, education, food security, optimal land use, environmental stewardship, clean water, affordable and clean energy and safer communities.

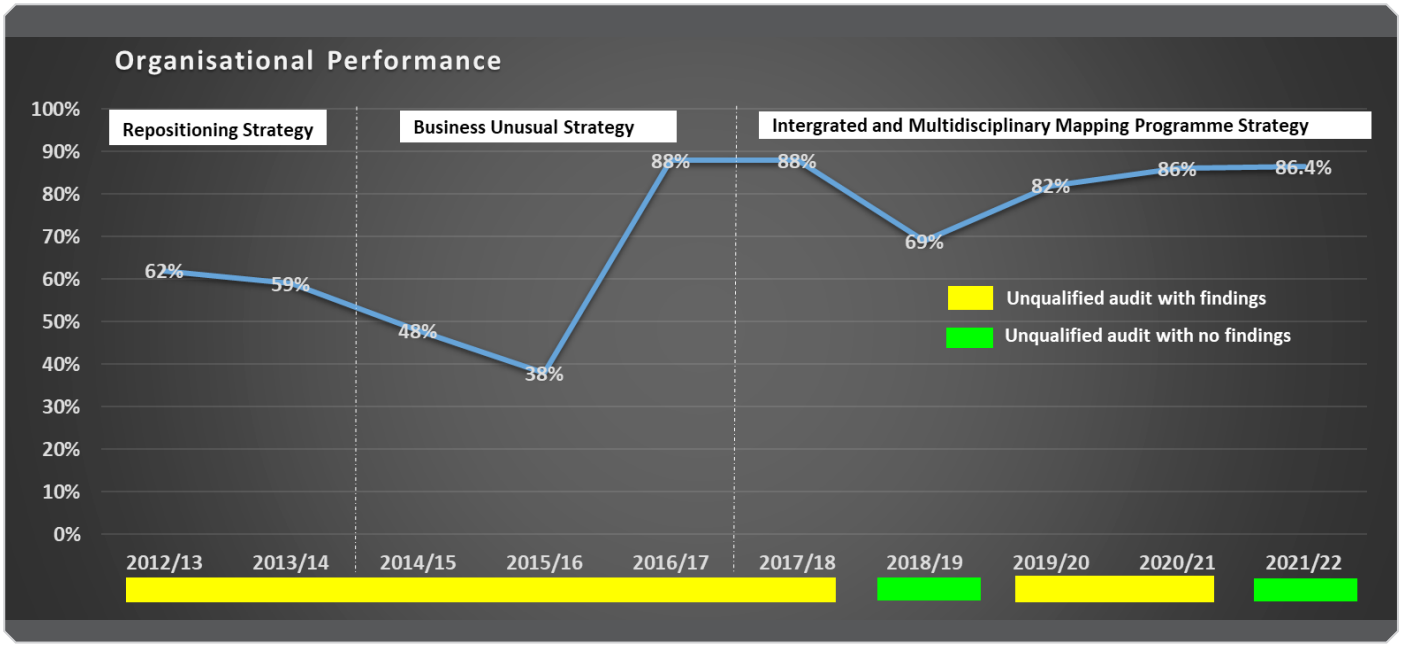
The financial year 2021/22 represented the fifth year of continuous implementation of the current phase of the IMMP as an instrument of delivery of the strategic re-orientation of the CGS, which decisively focussed on the implementation of its mandate, inscribed in the founding legislation,

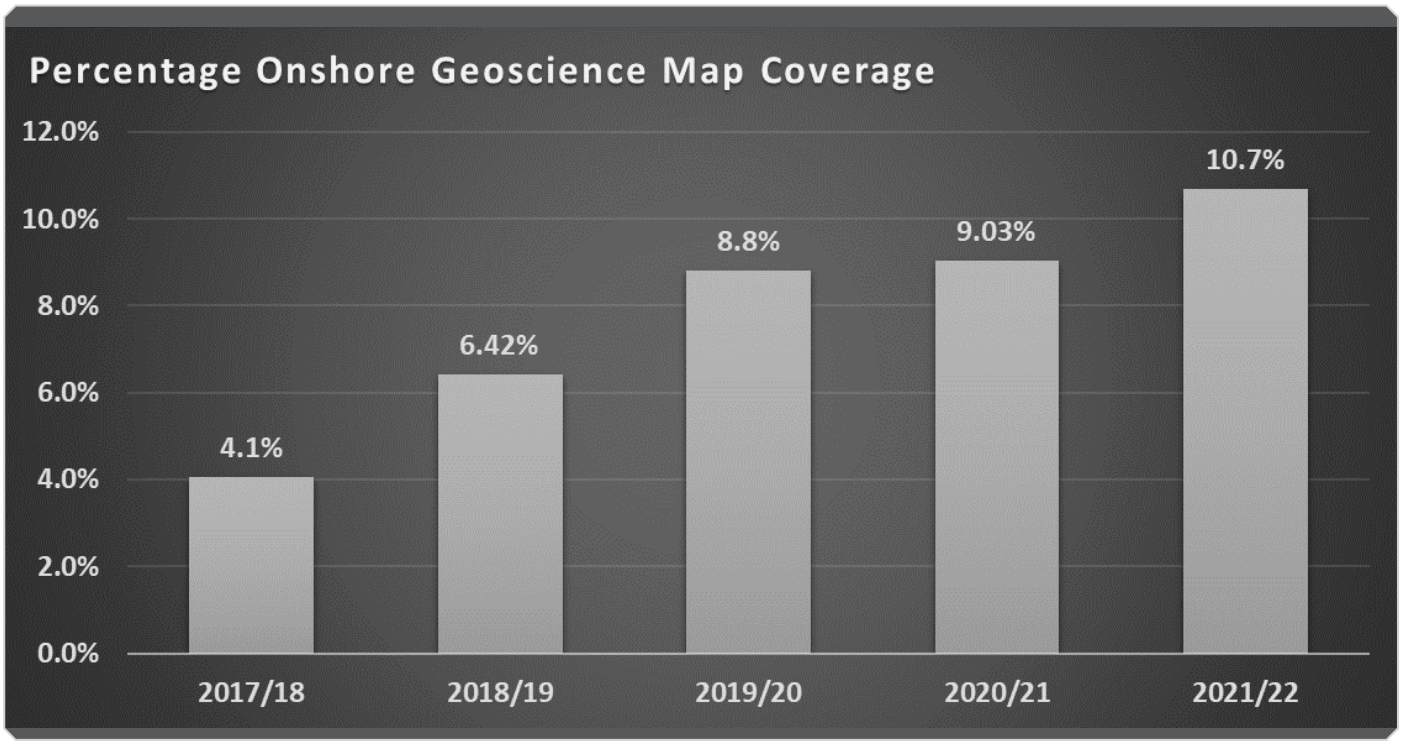


the Geoscience Act, No. 100 of 1993, as amended. The diagram below summarises the organisational performance of the CGS for the past decade. It shows how the organisation has evolved in terms of achieving the targets set on the approved annual performance plans as well as the audit outcomes. The CGS is pleased to announce its attainment of an unqualified audit outcome with no material findings (a clean audit) for 2021/22. Moreover, through the effective implementation of the strategic programmes, the organisation realised an overall performance of 86.4%. The effectiveness of internal controls is continuously strengthened to attain a clean audit by the end of the medium-term strategic framework (MTSF) 2019–2024. For the CGS to contribute to Priority 1 of the MTSF (a capable, ethical and developmental state), an external quality assurance review was conducted in line with the international standards for professional practice for internal auditing, and the CGS has received the overall opinion that the internal audit activity "generally conforms to the standards and code of ethics".

Contributions of the CGS to the National Economic Recovery and Reconstruction Plan (ERRP).

- The IMMP of the CGS is implemented through the Geoscience Technical Programme, among others, which focusses on accelerated economic





recovery projects. These include ongoing detailed mapping at a scale of 1:50 000 and key projects focussing on the critical minerals of the future, including base and precious metals (for example, nickel, cobalt, chromium and gold), rare-earth elements and coal. Onshore map coverage has increased to 10.7% from below 5% since the implementation of the IMMP.

- The intricacies of the South African geological landscape present opportunities for the discovery of tier-1 mineral deposits needed to support the demand to fulfil the current and imminent global growth. For instance, South Africa has abundant geological terranes often buried beneath thick sediments, as seen in the Northern Cape Province, that have not yet been fully characterised. The CGS published the one-of-a-kind Orange River pegmatite prospectivity map in 2021/22. This area is a known source of lithium and rare earths in the Northern Cape Province. The map will contribute significantly to much-needed information for the battery and renewable energy industries.

- The CGS officially launched its survey boat known as the R/V (Research Vessel) Nkosi. The boat was acquired to augment the marine geoscience programme of the CGS which aims to map the South African continental shelf (offshore) in the highest resolution based on modern technology, at various depth scales. In 2021/22, the marine geoscience programme mapped the outer parts of the 1:50 000-scale sheet 3318CD between Melkbosstrand and Llandudno in the Western Cape Province. The high-resolution data collected will contribute to the offshore geoscience map coverage of the country which is currently at 0.05%.

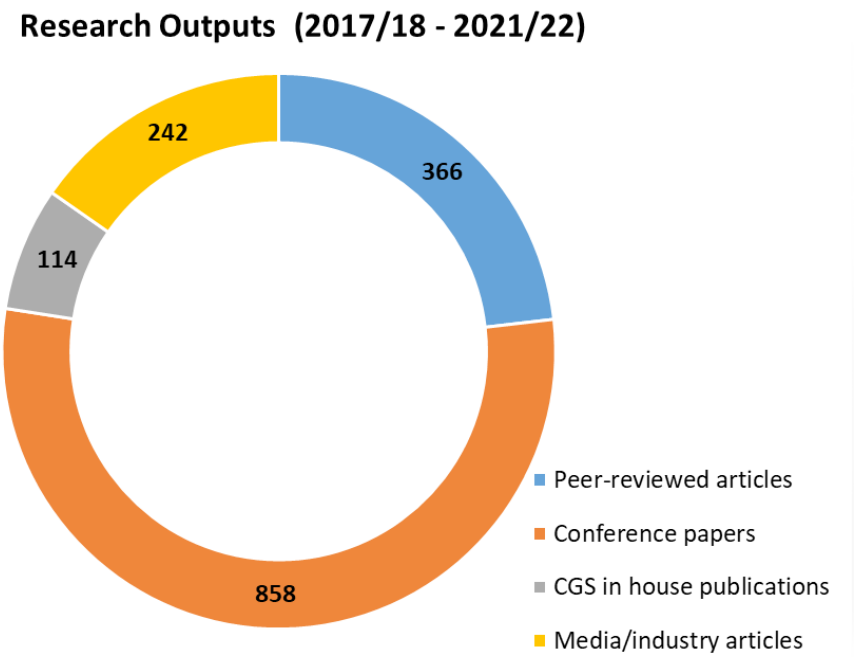
Applications of the geosciences beyond minerals and energy

- The two shallow boreholes drilled and donated by the CGS to the Beaufort West Municipality in February 2018 during the geo-environmental baseline assessment studies (part of the Karoo Deep Drilling Programme) continue to provide water to the Beaufort West Municipality. To date, the municipality has extracted and distributed well over 835 million litres of water, which is equivalent to 10% of the municipality's monthly capacity.

- In support of integrated district development planning and infrastructure development, the CGS developed the first 1:10 000-scale development suitability map around Giyani. This map will be presented to the relevant authorities in support of infrastructure development and land use.

- The CGS implemented various infrastructure and land use thematic projects in support of the MTSF priorities 5 (spatial integration, human settlements and local government) and 6 (social cohesion and safe communities). These programmes seek to enhance the deployment of the recently adopted One Plan District Development Model approach. In these efforts, the CGS has also produced a crushed aggregate potential map of southern KwaZulu-Natal which indicates the most prospective areas for aggregate exploitation. In addition, several microzonation models have been produced, which serve as a basis for evaluating site-specific risk analysis essential to the safety of critical infrastructure.

Geoscience research outputs: For an improved geoscientific domain through effective knowledge management



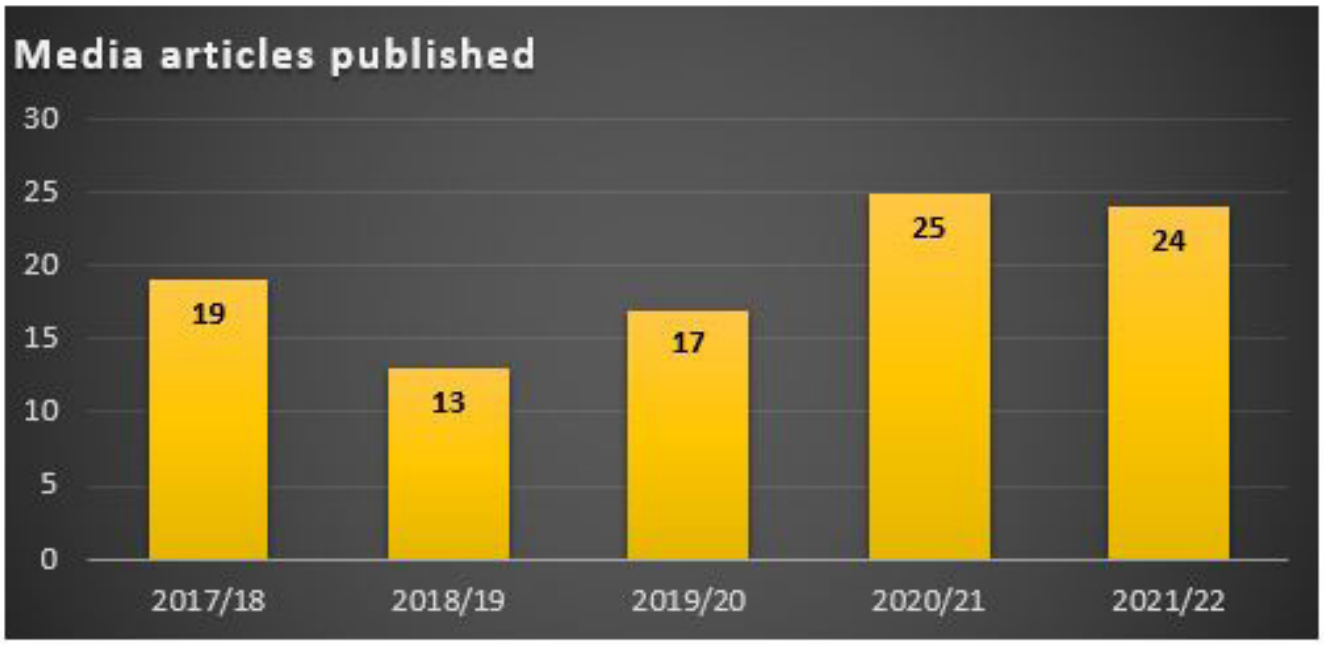
Contributions to energy security and the Just Transition to a low carbon economy

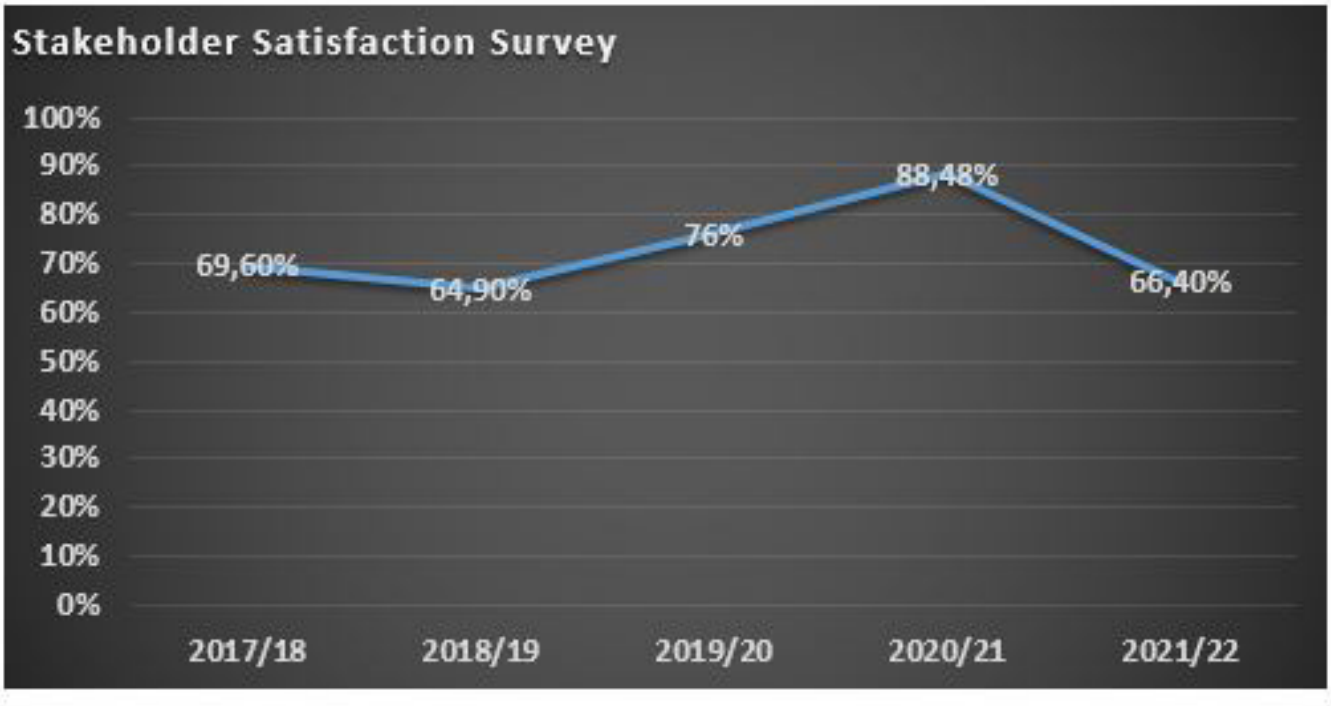
- As an implementing agency for the carbon capture, utilisation and storage project for South Africa, the CGS secured a state-owned piece of land in the Mpumalanga Province for the proposed pilot plant in the year 2021/22. The site selection was supported by a basic assessment report and detailed structure, seismic and subsurface geological characterisation. Samples collected from existing boreholes were analysed for their mineralogical, petrological,

geochemical and, importantly, their reservoir properties.

- The exploration strategy for the mining industry of South Africa and its Implementation Plan 2022 was published in April 2022 by the Minister of Mineral Resources and Energy. These policy documents seek to attract investment through a reinvigorated mining exploration strategy encouraging mineral exploration, clean technology, processing and mining supply and services sectors. In further support of the exploration activities in South Africa as well as the ERRP, the Department of Mineral Resources and Energy has allocated an additional R500 million to the CGS to support the proposed exploration work. The funds will be transferred to the CGS in two tranches — R200 million during 2023/24 and R300 million in 2024/25.
- To support one of the strategic initiatives outlined in the exploration

Media publications and stakeholder satisfaction survey: For an improved awareness of the CGS brand, services and products.



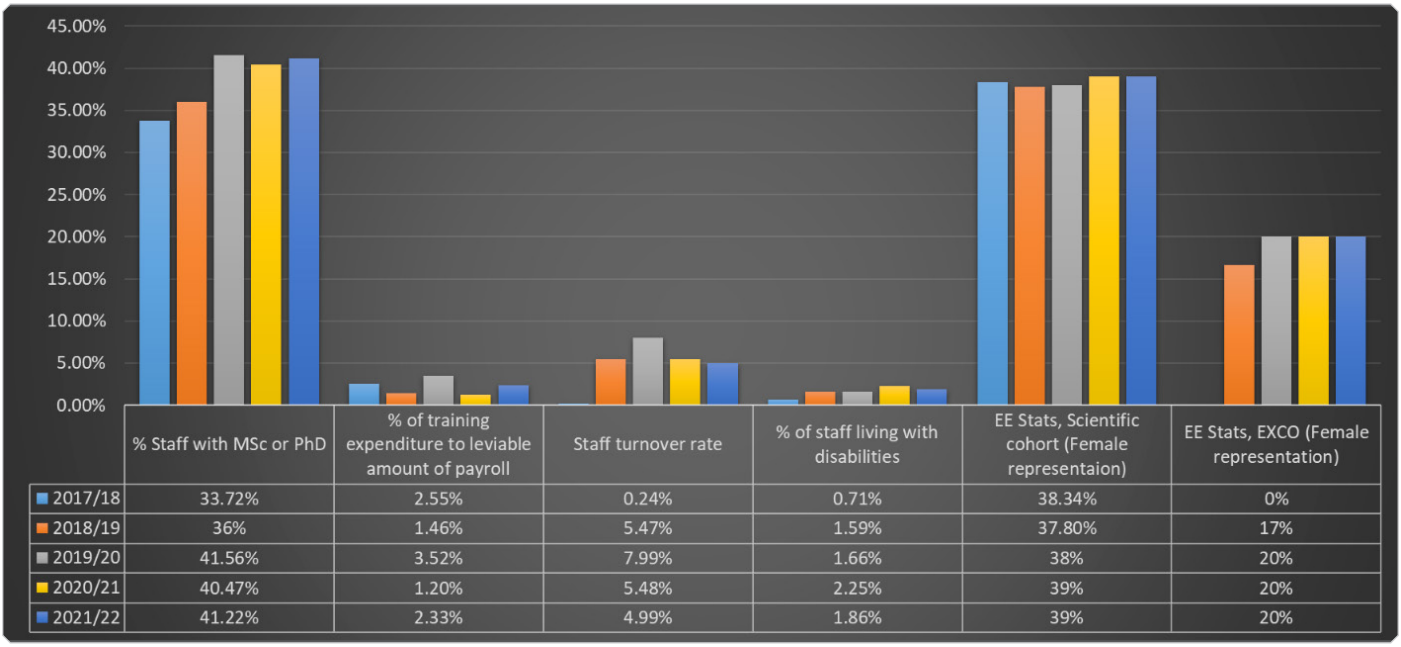


strategy for the mining industry of South Africa, the CGS has launched a geoscience data portal, which was developed to ensure geoscience data and information records published by the CGS in the form of maps, documents and databases are made available to stakeholders and clients. The geoscience data portal can be accessed at https://maps.geoscience.org.za.

- The Geoscience Act Regulations 2022 were published for implementation.

Towards building capable human capital

Capable institutions are built on strong foundations. Below is a summary of the human resources target achievements over the past five years.



	% Staff with MSc or PhD	% of training expenditure to leviable amount of payroll	Staff turnover rate	% of staff living with disabilities	EE Stats, Scientific cohort (Female representaion)	EE Stats, EXCO (Female representation)
2017/18	33.72%	2.55%	0.24%	0.71%	38.34%	0%
2018/19	36%	1.46%	5.47%	1.59%	37.80%	17%
2019/20	41.56%	3.52%	7.99%	1.66%	38%	20%
2020/21	40.47%	1.20%	5.48%	2.25%	39%	20%
2021/22	41.22%	2.33%	4.99%	1.86%	39%	20%

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