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Council for Geoscience

INSIDE:

CCUS-01 Geological Characterisation - A significant milestone for CCUS pilot testing towards South Africa's Just Energy Transition

Figure 1: Group photos of CGS, Mzansi Drilling and Govan Mbeki municipality teams at the milestone event that celebrated the completion of the 1800 m deep stratigraphic borehole.

In May 2024, South Africa achieved a significant milestone in its journey towards a Just Energy Transition with the completion of a crucial Carbon Capture Utilisation and Storage (CCUS) stratigraphic borehole. Located on a subdivision of Farm Goedehoop 308 IR in Lebohang (Leandra) town, Mpumalanga Province, this 1800 m fully cored borehole marks a pivotal step forward for environmental sustainability and technological innovation in the region.

The project was funded jointly by the South African government and the World Bank Group and implemented by the Council for Geoscience (CGS). The drilling operation was entrusted to Mzansi Exploration and Mining (Pty) Ltd. and took place between October 2023 and May 2024. The conclusion of drilling was celebrated with a ceremony on 10 May 2024, attended by the CGS Board, local executives and the Executive Mayor of the Govan Mbeki Local Municipality, Councillor Nhlakanipho Zuma.

Prior to commencement, rigorous environmental and social impact assessments were conducted under the auspices of the Department of Forestry, Fisheries and Environment (DFFE), ensuring compliance and positive community relations. The project's Safety, Health, Environment, and Quality (SHEQ) officers played a critical role in maintaining operational safety during the challenging Highveld rainy season, achieving a remarkable safety record of zero on-site accidents and environmental audit scores exceeding 95%.

The primary objective of drilling borehole CCUS-01 was to obtain new core samples and conduct comprehensive geological characterisation to augment existing historical data. Exceptional core recovery rates exceeding 98% with over 95% quality were achieved, crucial for analysing the Ventersdorp and Witwatersrand Supergroups at depths of 1086 m and 1 668 m respectively.

Integral to project success was interdisciplinary collaboration, leveraging advanced technologies and scientific methodologies previously unexplored in South Africa's geological landscape. A pivotal initiative included a 3D seismic survey conducted in collaboration with the University of the Witwatersrand across the Lebohang area, augmenting the understanding of geological formations critical for sustainable CO_2 storage.

Innovative seismic approaches such as wireless sensors and broadband sources were deployed, revolutionising subsurface imaging capabilities and enhancing geological characterisation. Concurrently, conventional downhole geophysical logging and Vertical Seismic Profiling (VSP) utilising Distributed Acoustic Sensing (DAS) technology provided additional insights into formation properties and structural integrity crucial for CO_2 injection strategies.

The geological significance of basaltic Ventersdorp lavas in CO_2 storage via mineral carbonation was underscored, alongside potential storage in deep saline

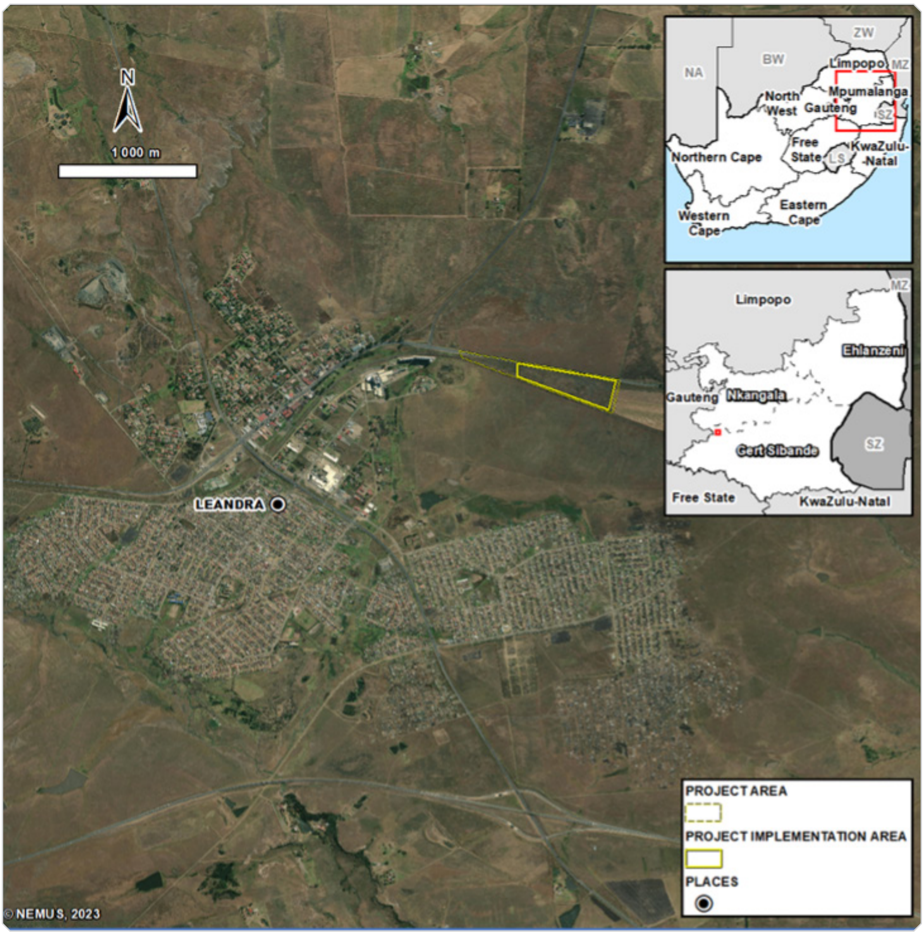

Figure 2: Location of CCUS project site near Leandra town in Mpumalanga Province, South Africa, on a portion of Farm Goedehoop 308 IR ceded to CGS for the CCUS project adjacent to Leslie Ext. 8.

Figure 3: Vertical Seismic Profile (VSP) data acquisition using optic fibre and an 8-ton mini vibroseis truck as seismic source.

Figure 4: Recovery of a full 3 m core run on contact between Transvaal and Ventersdorp Supergroups.

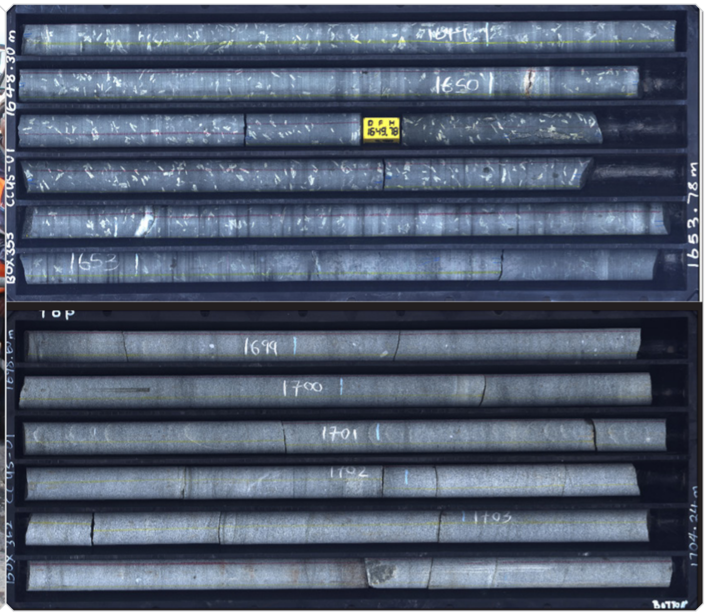

Figure 5: Porphyritic lava towards base of Ventersdorp (Top) and quartzite from Witwatersrand (Bottom). Images from Intellicore.

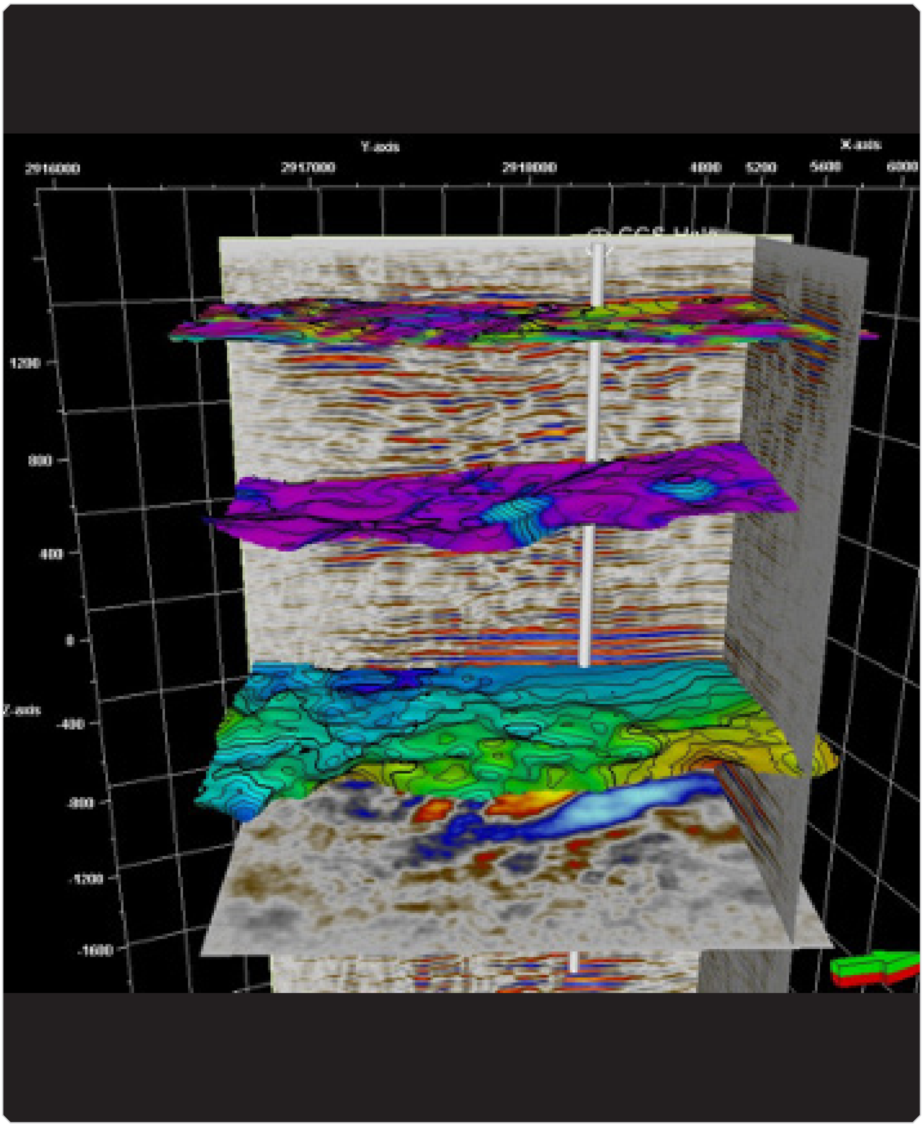

Figure 6: 3D seismic model of the Lebohang area, on the section intercepted by borehole CCUS01, indicating major structural setting at the base of the Karoo and Transvaal Supergroups.

aquifers within the Witwatersrand Group, offering diverse options for sustainable carbon management.

Looking ahead, the project's next phase includes constructing a pilot plant for test injections of anthropogenic CO_2, aligned with ongoing feasibility studies. Strategic partnerships with industry leaders such as Sasol, Exxaro and ArcelorMittal, as well as the Development Bank of Southern Africa, ensure robust technical and financial support for Phase 2, aiming to establish operational readiness by year end.

The successful demonstration of CCUS technology will bolster South Africa's efforts to reduce CO_2 emissions. It aligns with the nation's commitment to a Just Energy Transition policy framework, exemplifying a decisive step towards sustainable energy solutions and environmental stewardship.

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CGS engages with global leaders at the International Geothermal Impact Summit 2024

The International Geothermal Association (IGA) Impact Summit 2024 was held from 23 to 24 April 2024 in The Hague, Netherlands. The IGA is well known for organising the World Geothermal Congress held every three years. Despite the longstanding history of the World Geothermal Congress,

It was acknowledged that investment and growth in the geothermal industry has remained limited. Following the 28th Conference of the Parties to the United Nations Framework Convention on Climate Change) (COP28) in Dubai, a resolution to triple renewable energy generation by 2050 was reached. This target, however, cannot be met solely by wind, solar and hydro energy, but will need the realisation of geothermal energy.

Key challenges

Risks associated with geothermal development and perceptions of high failure rates can be linked to several key factors: refer to figure 2 (1) Available funding, in particular initial capital costs linked to geological exploration and drilling requirements. (2) The extended period needed to develop geothermal projects and to exploit the geothermal resource. (3) Lack of standardisation of geothermal exploration and development methodologies.

Geothermal funding

Several presentations and panel discussions focussed on the challenges of securing funding for geothermal exploration and the preliminary stages of geothermal development. Exploration costs include the collection of the requisite integrated geological data and information, while the preliminary stages of development entails drilling costs. Geothermal drilling is comparable to oil and gas drilling programmes where drilling involves the sinking of ultra-deep wells with wide diameters. Financing of oil and gas projects operates at slim

Figure 1: International Geothermal Association (IGA) Impact Summit held at the Fokker Terminal, The Hague, Netherlands, from 23 to 24 April 2024 (pic courtesy of IGA).

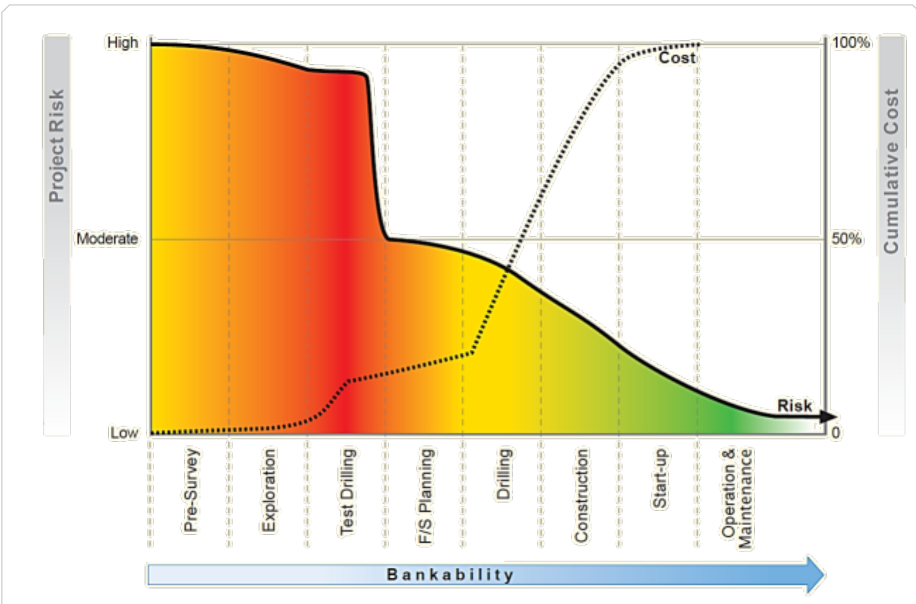

Figure 2: Geothermal energy risk curve. Graph highlights risk of failure vs progression of cost of investment needed for geothermal energy deployment (Gehringer and Loksha, 2012).

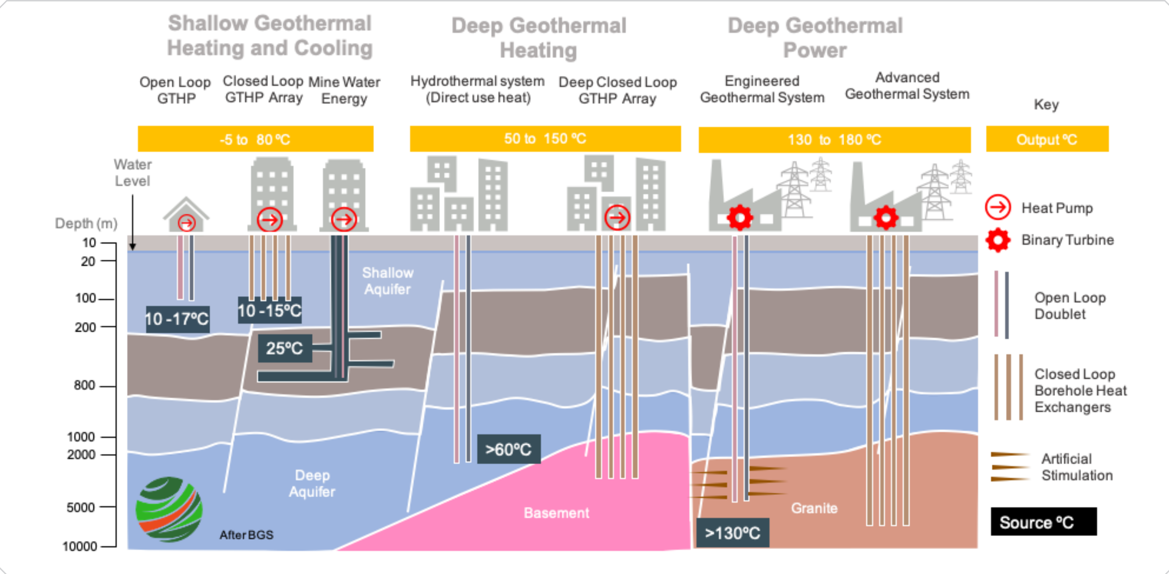

Figure 3: Schematic overview of mechanisms employed to extract geothermal energy (BGS, 2022).

margins and is highly dependent on significant returns. Similar returns for geothermal energy are not guaranteed because of the limited number of large-scale geothermal projects. Furthermore, the availability of oil and gas drilling rigs and associated equipment for geothermal development is limited and would have high mobilisation costs. Geological surveys are well-placed to resolve this challenge as they could collect and curate geothermal-oriented data and information that can increase confidence levels and derisk geothermal investment.

Project timeline

Geothermal projects may have long timelines. These include the required time for geological data collection, ultra-deep drilling associated with well construction, and the associated infrastructural procurement and development. The latter can also be hindered by the lack of readily available geothermal systems. Environmental and geological baseline considerations are important, hence full Environmental Social Impact Assessments (ESIA) are needed to define baseline conditions and enable public certainty and support. Policy certainty is vital, which includes attaining similar incentives and advocacy support as is typically given to other renewable energy systems. These incentives, when linked to local and regional energy generation strategies, can have a significant bearing on the project timing. Finally, extended project timelines can also be exacerbated by failure to attain off-take agreements for heat and power generation. Robust project planning and adaptive management are essential to navigate unforeseen variables effectively.

Standardisation

Different mechanisms are currently employed to exploit geothermal energy (Figure 3). This broadly includes: (1) hydrothermal systems, (2) enhanced geothermal systems, (3) advanced geothermal systems, and (4) closed-loop geothermal systems. In general, hydrothermal systems refer to high enthalpy systems where groundwaters are heated to and above boiling point. These systems are generally limited to active volcanic regions. Enhanced and advanced geothermal systems refer to low to medium enthalpy systems that may require some additional reservoir engineering to enhance fluid flow within the reservoir. Finally, closed-loop systems also target low and medium enthalpy systems but avoid much reservoir engineering and aim to develop a fully encased system that does not directly interact with the surrounding country rock.

The IGA Impact Summit focused on low to medium enthalpy geothermal systems, which offer diverse methods for energy extraction. This may include the development of a multiple-well design, e.g., with an injection and production well. Another option is to have a single impeccable geothermal system design.

Each system has several benefits and limitations. However, geothermal development requires some level of standardisation for the rationale to optimise efficiency, reduce costs and ensure effective deployment.

Opportunities

Despite various challenges highlighted at the IGA Impact Summit, the industry views geothermal energy development as a promising solution for global clean energy needs. Geothermal energy offers a consistent energy supply, unlike wind and solar power, which are weather-dependent. Comprehensive geothermal exploration involves extensive geoscientific efforts, providing valuable data for both energy production and industries like mineral development. Additionally, geothermal projects can benefit from the technology and expertise of the oil and gas sector, which is likely to slow down due to climate change efforts and depleting hydrocarbon reserves. This synergy can accelerate geothermal advancements, making it a crucial part of the future clean energy landscape.

Geology

At the IGA Summit, consensus was reached that the successful development of geothermal energy hinges on the availability of high-quality geological data. Geological data and information regarded as being highly advantageous for geothermal development includes subsurface heat flow, heat productivity and geothermal gradient information. Important geological data and information includes structural information and knowledge on how the structures control the development and evolution of permeable pathways. The Council for Geoscience finds itself in an ideal position as much of this data has been collected on the integrated geoscience mapping programme. This data and information can be tailored to enable a geothermal exploration market. Moreover, the Council for Geoscience has an extensive network that has enabled the collection and curation of integrated geoscience data in much of the SADC region.

Transferability of expertise

A constant discussion points during the IGA Impact Summit revolved around the close relationship between various geoscience experts that can support geothermal energy development. Regarding geological knowledge, this includes considerations that certain tectonic domains share similar geodynamic processes. These shared geodynamic processes may then enable the development of shared geothermal signatures and controls. Therefore, research and development should consider this and increase optimisation while limiting duplication.

Shared technological advances are also possible. This includes similarities regarding the needs of geothermal energy development and those present within the oil and gas industry, considerations toward drilling and down-the-hole investigation technologies, reservoir development and characterisation, and the ability to exploit and deliver the generated energy. This link was further highlighted by the considerable number of oil and gas representations during the IGA Impact Summit. The oil and gas industry agreed that its large generation capacity transition would pivot on specific geothermal energy generation research and development.

Funding

Regardless of the disconnect between the finance sector and the development of geothermal energy, finances remain available and unspent within the renewable development sphere. These funds are available through various European Union and World Bank funding vehicles. Several discussion points focussed on the challenges faced by financiers and difficulties in directing funding toward the idealised and untapped sources of geothermal energy. One deal was closed at the IGA Impact Summit, committing funds to a geothermal project that had just completed the initial phases of exploration, e.g., exploration drilling and downhole heat flow measurements. The financiers noted that their funding commitments rested on the possibility of taking advantage of the substantial opportunity for geothermal energy. The first significant geothermal energy (low to medium enthalpy) project would define much for the industry.

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Multidisciplinary Core Logging Techniques - Perspectives from borehole CCUS-01

The Council for Geoscience recently concluded the drilling of the 1800 m Carbon Capture Utilisation and Storage (CCUS-01) characterisation borehole in Leandra, Mpumalanga. This marks a significant milestone for the characterisation of the pilot site, where various in-depth geoscientific techniques will be utilised to ascertain reservoir properties of the Ventersdorp and Witwatersrand Supergroups and determine with a greater degree of accuracy and confidence the storage capacities of these lithologies. The aim of this article is to discuss the core handling and core logging techniques used on the drilling site and highlight lessons and experiences from CCUS-01 drilling.

The CCUS-01 borehole intersects three lithostratigraphic Supergroups representing 2.7 billion years of historical geological accumulation in the area, starting with Central Rand quartzites and conglomerates of the Witwatersrand Supergroup at the base of the borehole. Here, the Ventersdorp Supergroup consists of intact basaltic flows that range from a basal ultramafic zone to alternating porphyritic, amygdaloidal and fine-grained sequences. The dolomites and minor cherts of the Transvaal Supergroup are overlain by conglomerates and shales that highlight a significant change in the Transvaal depositional environment. Fluvial sedimentary sequences of the younger Karoo Supergroup are consistent with the north-eastern Karoo Basin deposition of alternating sandstones, shales, mudrocks and minor coal seams that are intruded by dolerite sills.

Figure 1: NQ core tray with core of the dolomite successions starting from a 639.39 m to 644.17 m. The numbered annotations indicated various labels on the core trays.

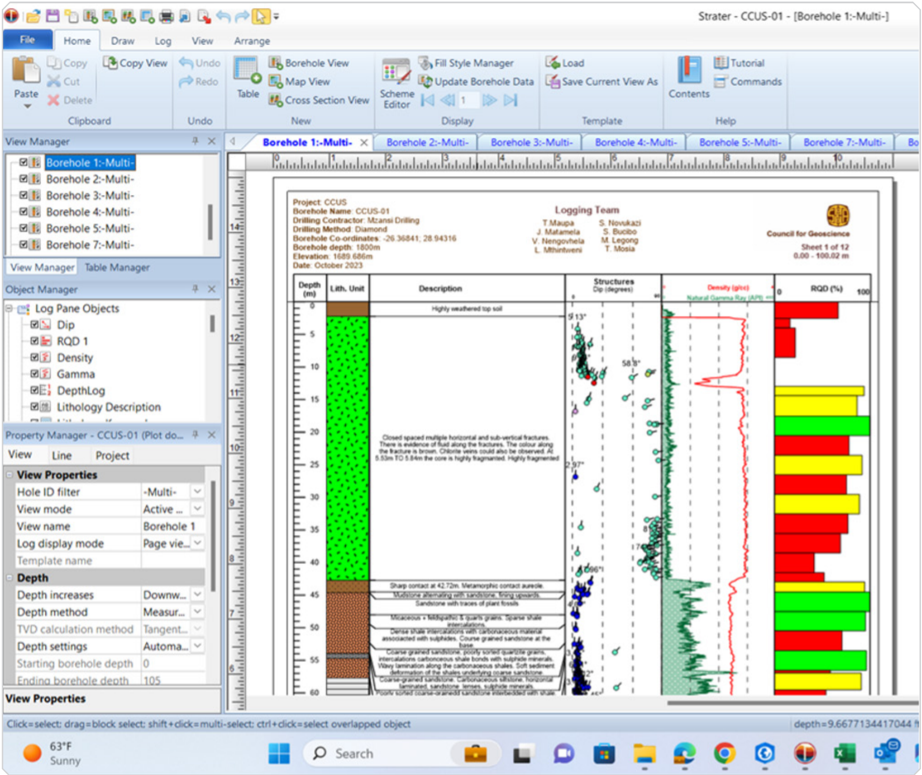

Figure 2: Borehole view and command tabs from Stater 5 highlights the initial page of the CCUS-01 log sheet. The log shows depth, lithological unit, geological descriptions, geological structures, density, natural gamma and RQD.

Core handling:

- Core marking was conducted prior to geological logging. The initial step was to ensure core locking of all the core pieces in the tray before the core can be marked with two lines: red to indicate the right side of the core and yellow the left side. These marks are to ensure accurate placing of core in the core boxes and prevent misplacing core pieces should a core box be dropped. In that case, core fragments can easily be placed back into their correct position in the core channels using these lines as a reference. Metre marks were measured relative to the driller's blocks.

- A double-line blue marker was used to highlight areas of mechanical fractures induced by the drillers or the core logging team. These markers are used to distinguish between natural and induced fractures. This step is particularly important for geotechnical logging and rock quality designation calculations.

- Core box labelling is important for borehole curation. A few key details are written on the core trays to ensure accurate depth recording and sequential core box stacking. Top and bottom depth marks on the core boxes are essential for digital core curation using the hyperspectral scanner in the National Borehole Core Depository (NBCD).

- Core photography was used to provide a visual curation of the core on-site, using a Canon EOS 600D camera in natural lighting. The camera was mounted in a vertical position above the core boxes to achieve a surface normal to the photography direction. Core tray images provide a comparative benchmark for core quality before and after transportation to the Council for Geoscience NBCD in Donkerhoek, Pretoria. Differences observed can be used to improve core loading and transportation standards.

Core logging and lithological log construction:

Four core logging techniques were utilised for in-depth, multidisciplinary core logging on-site and at the NBCD. Geological logging mainly involved primary core descriptions which includes descriptions such as lithological name, grain size, colour, weathering, fabric, hardness, discontinuity surface spacing, and stratigraphic horizon. This also involved descriptions of the discontinuity surfaces, including their type, separation,

Figure 3: A close-up image of a complete point analysis showing elevated silica (Si), aluminium (Al), iron (Fe), calcium (Ca) and magnesium (Mg) signatures.

Figure 4: The CGS on-site logging team posing with 4.5 m long drill core of the porphyritic Ventersdorp Supergroup basalt. From left: Sifiso Bucibo, Vhuhwavhohau Nengovhela and Mahlatse Legong.

fracture filling (presence or absence), roughness and orientation. Other data recorded in the borehole log was drilling method and size, core recovery, rock quality designation (RQD), fracture frequency and standard tests which were conducted separately by the drilling and geotechnical logging team. Downhole geophysics was conducted in four phases for the entire project. The optic televiewer, density, electrical resistivity, electrical conductivity and natural gamma techniques were used to conduct standard in-situ tests to determine/ confirm the lithological contacts, fractures and borehole condition. Downhole geophysical methods were also used for quality control and quality assurance of the borehole. From these techniques, areas with high fracture zones and weathering were easily identified by density and electrical conductivity measurements. Lastly, XRF was conducted on the entire borehole using the Olympus DELTA professional analyser. The analyser configuration includes a 40 kV X-ray tube, advanced silicon drift detector, specialised filters and multi- beam optimisation with a wide elemental detection range. The X-ray Fluorescence (XRF) data collected highlights the geochemical signatures at every sampling point.

Datasets acquired through geological, geotechnical and downhole geophysics were collated to reconstruct and graphically represent the CCUS-01 borehole. This activity was performed with the aid of Stater 5 (Golden Software package). Data acquired from geological logging that is shown in Figure 1 includes lithological unit, lithological description, and structures. Density and Gamma were acquired through downhole geophysical technique and RQD was obtained through geotechnical logging. All the datasets were captured in a Microsoft Excel spreadsheet and then imported to the Strater 5 golden software.

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Contributing to South African Quaternary Research at the 24th SASQUA Biannual Congress

The Southern African Society for Quaternary Research (SASQUA) hosted its 24th Biennial Congress in the Cango Valley, situated at the base of the Swartberg Mountains near Oudtshoorn in the Western Cape Province, from 20 to 24 May 2024. The congress centred on the theme ‘Exploring the links between humans, climates, and environments through the Quaternary’. Researchers highlighted recent studies, emphasising the Council for Geoscience’s (CGS) contributions to Quaternary science in South Africa.

CGS scientists presented both posters and oral reports, sharing findings from the CGS’s onshore and offshore mapping programs, investigations into Cenozoic-related geohazards, and the role of Quaternary science in South Africa's nuclear industry. Poster presentations by

Figure 1: Council for Geoscience staff showcasing their research findings at the 24th Biennial SASQUA Congress. Conference attendees also attended a one-day educational field trip to the Cango Caves.

Dr Hayley Cawthra, Sashan Manikam, Wilhelm van Zyl, Adrian Williams,and others demonstrated the CGS's ongoing commitment to acquiring high-resolution hydroacoustic data on South Africa's continental shelf. This innovative data is crucial for identifying submerged erosional and depositional palaeoshorelines, offering insights into offshore palaeolandscapes, particularly on the False Bay and the Wild Coast shelves. Debbie Claassen presented a case study on the regional correlation of emergent palaeoshorelines along the southwest Cape coast, supporting the notion of a tectonically stable continental margin. Dr Rebekah Singh discussed the vulnerability of Cenozoic sediments to wind erosion along the Wild Coast, while Ponani Mthembi highlighted extensive multi-year geological mapping efforts by the CGS that focused on demarcating and subdividing Cenozoic deposits in the Southern Kalahari Geomorphic Province in the Northern Cape. Debbie Claassen concluded the conference with a talk on the role of Quaternary science in the development of South Africa's nuclear industry.

The congress also featured a one- day educational field trip to the Cango Caves and Bloomplaas Cave where an active excavation is in progress, offering delegates a glimpse into the region's rich geological and archaeological history. Dr Hayley Cawthra was acknowledged for her service as SASQUA President from 2022 to 2024. She will continue to serve on the SASQUA executive committee as past-president for the 2024-2026 term. Dr Marc Humphries has been elected as the new SASQUA President and Dr Brian Chase as Vice President.

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ArcGIS Pro Basic Workshop

The ArcGIS Pro Basic Workshop was conducted in-person at the War Room at the Council for Geoscience (CGS) head office on 22 and 23 May 2024, and online for regional offices on 5 and 6 June. A total of 45 geographic information systems (GIS) users attended in-person and eight users online.

The workshops were conducted by Ntsako Mhlarhi and Amy Summersgill from the Knowledge Management Unit.

The ArcGIS Pro Basic Workshop was intended for individuals with limited or no previous GIS or ArcGIS experience. The workshop included both theory and practical exercises, intending to make the workshop sessions as interactive and hands-on as possible.

The intended objectives were for the GIS users to extend their foundational GIS knowledge, get comfortable with ArcGIS Pro and understand the fundamental concepts of geospatial analysis and mapping.

The Workshop introduced techniques and general best practices for using ArcGIS Pro in these areas:

The workshop introduced techniques and general best practices for using ArcGIS Pro in these areas:

- Creating a new project
- ArcGIS Pro interface and navigation
- Importing ArcMap project in ArcGIS Pro Interface
- Coordinate reference system
- Adding XY data
- Coordinate conversion
- Georeferencing
- Digitising
- Basic spatial analysis tools
- Basic layouts and map composition
- Sharing project package

The ArcGIS Pro Basic training was a resounding success, equipping participants with valuable skills in the basic principles of geographic coordinates and map projections, georeferencing, geospatial analysis, data editing, layouts and map composition. We are confident that the knowledge gained will contribute to a smooth ArcMap—ArcGIS Pro migration and improve data visualisation within CGS. At the end of the workshop sessions, attendees were asked to fill out a survey, the results of which are shown in Figures 3, 4, and 5.

Every GIS user should note that the ArcMap will have limited licenses that cannot be borrowed. The GIS users are encouraged to take advantage of the workshops and migrate to ArcGIS Pro at their earliest convenience.

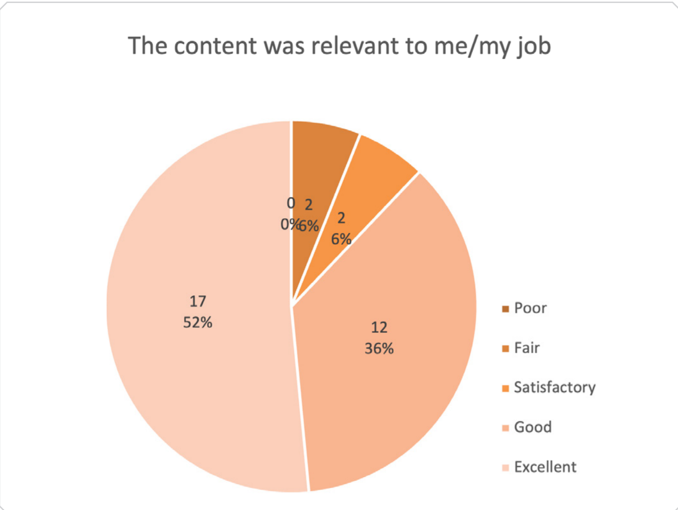

Figure 1: Survey results on the overall relevance of the content for attendees' day-to-day job activities.

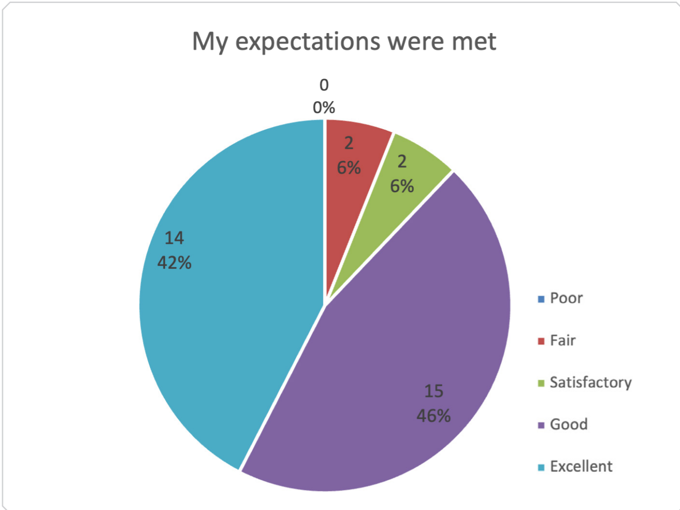

Figure 2: Survey results on attendees' expectations.

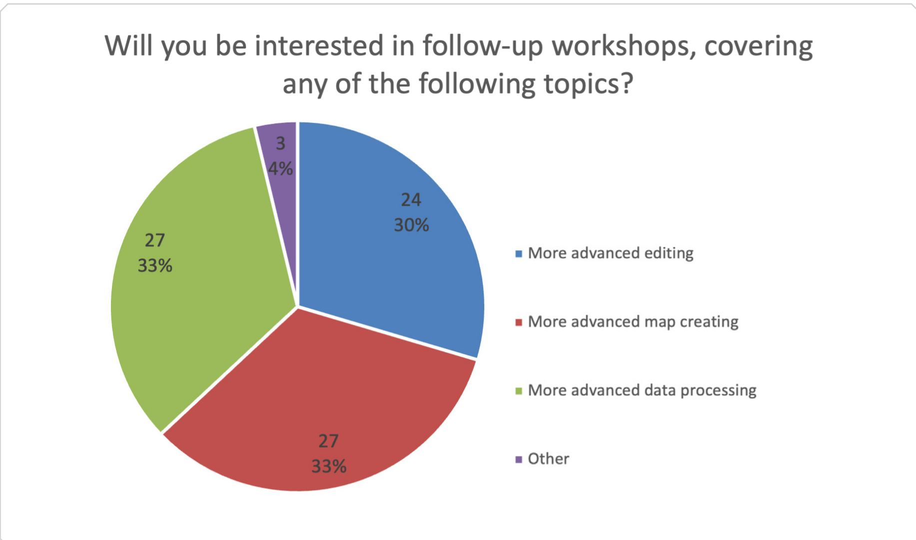

Figure 3: Survey results on attendees' interest in follow-up workshops for specific topics.

Please note: Contact Knowledge Management directly with requests for customised workshops.

Dates for upcoming ArcGIS Pro workshops
24 – 26 July – Intermediate
11 – 13 September – Advanced
An email will be circulated closer to the time with a link to a sign-up form.

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Snake Awareness Training

The Council for Geoscience (CGS) provided snake awareness training to employees on 13 June 2024 to assist with snake handling, ophidiophobia, anxiety and first aid.

The training was led by Nick van der Walt and Bernadette van der Walt, professional advanced life-support paramedics with over 17 years of experience in prehospital emergency care.

The training was held at the CGS Pretoria head office. It involved theory, practical demonstrations and assessments. Staff gained knowledge on the basic biology of snakes such as how they smell, move, reproduce and track their prey. Snake identification was conducted with live snakes and interactions with the venomous puff adder, snouted cobra, black spitting cobra and rinkhals. Emphasis was placed on snake bite treatment with basic first aid measures that can be applied before hospitalisation. These include pressure bandages, tourniquets for neurotoxic bites, limb immobilisation and CPR (cardiopulmonary resuscitation). Staff enjoyed the practical aspects, which involved snake handling techniques, correct usage of equipment and what to do with a captured snake. At the end of the day most fears of snake handling were conquered (admittedly only to a certain extent in some cases!).

Snake awareness plays a critical role in ensuring that CGS staff members can assist with snake conservation. This allows the CGS to send out the right message: instead of killing snakes, rather have a problem snake removed to prevent possible snake bites. The training also contributes to meeting occupational health and safety requirements by teaching employees what to do in the event of a snake encounter or snake bite.

Figure 1: Nick van der Walt demonstrates the famous fangs used for biting and injecting venom into its prey.

Figure 2: Snake eyes come in different shapes and colours. Snakes with rounded pupils (diurnal species) are most active during the day.

Figure 3: Fear Factor! CGS staff handling various snakes.

If you would like to be added to the CGS mailing list, please send an e-mail to:

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