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## Southern African Oil and Gas Conference 2025: A Crossroads for Energy and Environment

The 4<sup>th</sup> Southern African Oil and Gas Conference, held in Cape Town from 19 to 20 March 2025, convened industry leaders, policymakers, scientists, and activists to the region's energy future. Hosted at Century City Conference Centre, the event focused on Southern Africa's potential as a significant player in global energy markets, while also highlighting the contentious debates surrounding fossil fuel development.

Minister of Mineral and Petroleum Resources, Gwede Mantashe's, keynote address emphasized the region's substantial untapped oil and gas reserves. He cited estimates from the Petroleum Agency of South Africa (PASA),

which suggest that South Africa alone holds 27 billion barrels of oil and 60 trillion cubic feet of gas offshore. Minister Mantashe highlighted the potential economic benefits, including job creation and increased government revenue, as key drivers for accelerating exploration and development. He emphasized the government's commitment to a balanced energy mix, where natural gas plays a transitional role in the country's energy strategy. The minister also highlighted the importance of developing domestic resources to reduce reliance on volatile international energy markets.

Various panel discussions took place over the two-day conference. Haajierah



Figure 1: Honourable Minister Gwede Mantashe giving the keynote address at the 4<sup>th</sup> Annual Southern Africa oil and Gas conference.



Figure 2: Ngqondi Nxokwana and Haajierah Mosavel from the Council for Geoscience attending the conference..



Figure 3: Haajierah Mosavel joined the panel discussion: Harnessing new technologies for oil and gas by exploring cutting edge technologies that ensures the sustainable hydrocarbon development while supporting a balanced approach to energy production and environmental responsibility. Left to right: Khatija Kapdi (Dentons SA), Haajierah Mosavel (CGS), Adrian Strydom (SAOGA) and Johan Brandt (Burnstar Technologies, Virtual).

Mosavel, of the Council for Geoscience participated in a panel discussion focused on Harnessing new technologies for Oil and Gas. Haajierah focused on the IMMP (Integrated Multidisciplinary Mapping) approach of the CGS with high impact projects such as CCUS (Carbon Capture Utilisation and Storage), geothermal and hydrogen as the new silver bullet to enroute net zero emissions. The conference also focused on recent discoveries in neighboring Namibia, such as the Venus-1 find, which have increased interest in regional exploration. These developments have the potential to significantly boost the economies of Southern African nations.

The conference highlighted the region's significant energy potential and the complex interplay between economic development and environmental stewardship. As Southern Africa navigates its energy future, the challenge will be to balance the immediate benefits of fossil fuel development with the imperative of sustainable and equitable energy solutions. The ongoing dialogue between industry stakeholders, government officials, and civil society will be crucial in shaping the path forward that addresses both economic and environmental concerns. Looking ahead, the South African government plans to advance its Gas Master Plan, aiming to integrate natural gas into the national energy infrastructure through projects like gas-fired power plants and expanded pipeline networks. While these initiatives are expected to stimulate economic growth, they also raise questions about the long-term environmental implications and the pace of transition to renewable energy sources.

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# Sedimentology and seismic architecture of the northern portion of the offshore Orange Basin, South Africa

The western seaboard of South Africa has a theoretical CO<sub>2</sub> storage capacity of up to 60,000 Mt in the Orange Basin (Figure 1). Expanding on previous assessments, this study focused on a detailed sedimentological and seismostratigraphic analysis of the northern offshore Orange Basin to identify sand rich zones for potential CO<sub>2</sub> storage. An MSc study funded by the Council for Geoscience (CGS), used legacy pre-processed single-channel 2D seismic data and well reports provided through the University of KwaZulu-Natal's academic license with Petroleum Agency SA (PASA). The study area is covered by a dense grid of reprocessed 2D seismic profiles (Figure 1). A total of two hundred and seventy-five seismic lines in varying vintages, were selected based on their strike and dip orientation, as well as their coverage of existing exploration wells (AE-1, A-F1, and AO-1) (Figure 1). These seismic lines were used to map and interpret seismic reflectors, indicating potential sequence boundaries or unconformities, and to assist in extrapolating petrophysical and sedimentological data from well intersections.

The Orange Basin spans the offshore boundary between Namibia and South Africa and lies along a volcanic passive margin. This margin, located off the southwestern coast of Africa, is bounded by two key morphotectonic structures: the Walvis Ridge, which extends offshore near the Namibia-Angola border, and the Agulhas-Falkland Fracture Zone (AFFZ) to the south (Figure 2). The Late Jurassic breakup of West Gondwana, likely driven by activity from the Tristan da Cunha hotspot, triggered extensive flood basalt volcanism. The basin records the evolution of South Africa's volcanic-rifted passive continental margin, encompassing the rifting and subsequent separation of the South American and African plates from the Late Jurassic to the present.

Sedimentation in the study area includes both syn-rift and drift phase

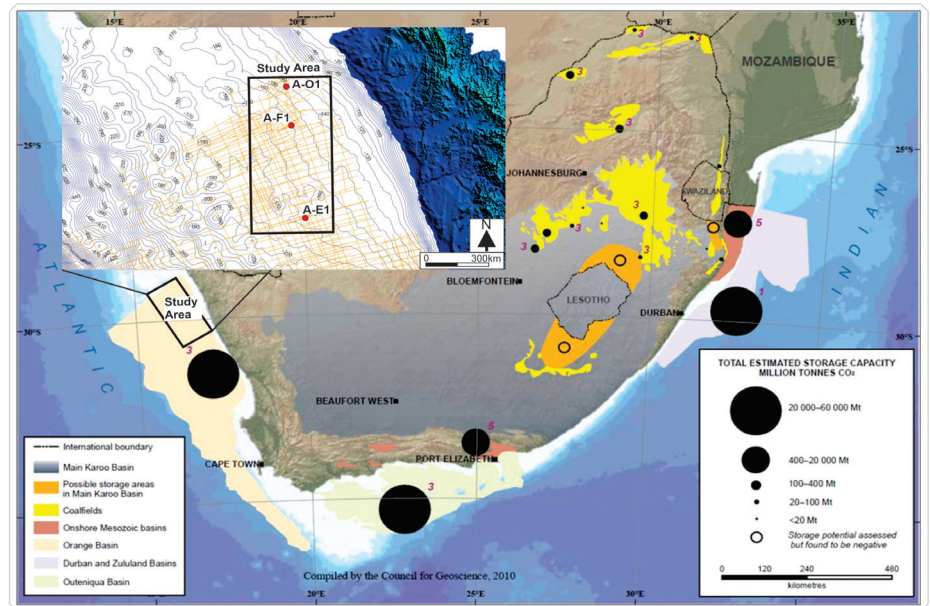


Figure 1: Locality map detailing the study area within the Orange Basin. The seismic data in the offshore Orange Basin (South Africa) is managed by the Petroleum Agency South Africa. The seismic lines covering the study area were utilised for this study (PASA, 2008). Note the Country-scale Assessment of Mesozoic sedimentary basins (Viljoen *et al* 2010).

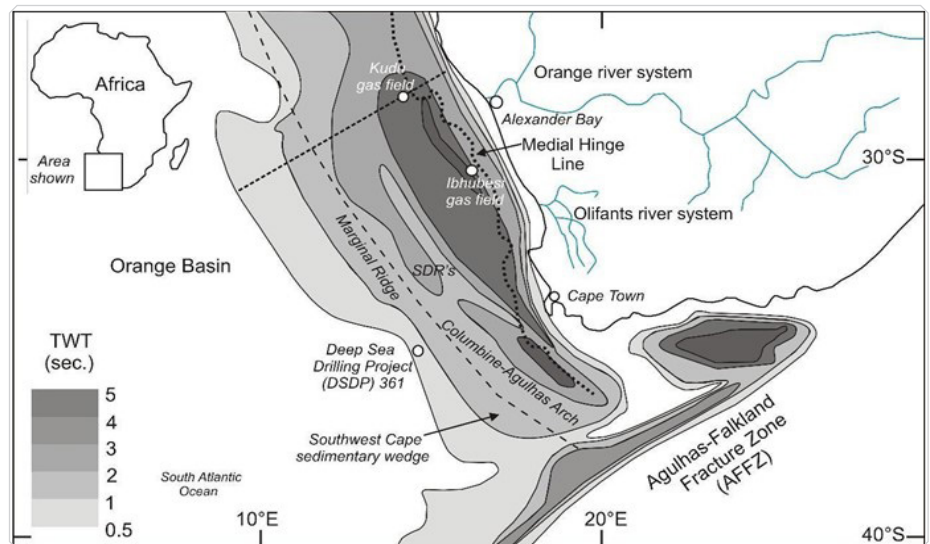
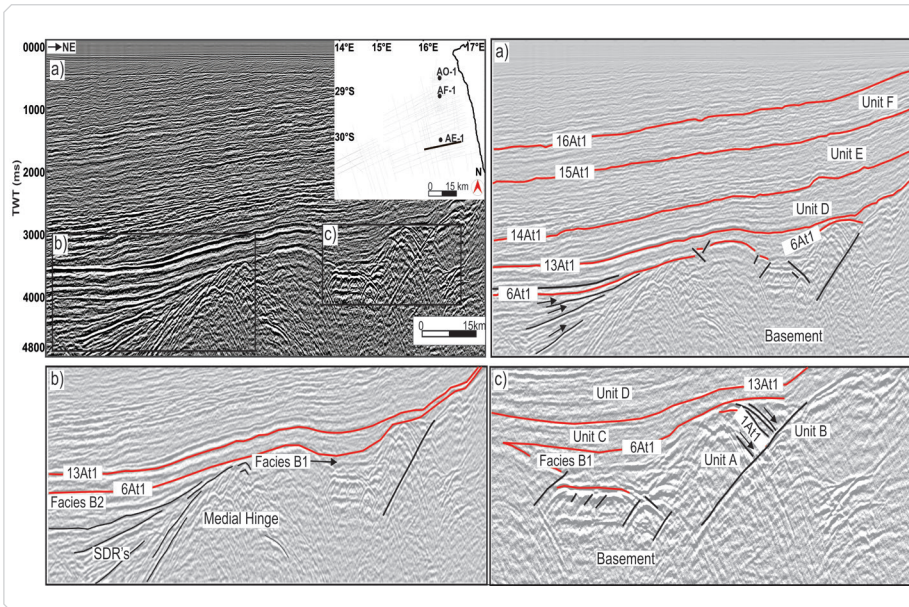


Figure 2: Isopach of the Hauterivian to seafloor drift interval (horizons 6At1 to sea-floor) within the Orange Basin, modified from Jungslager, (1999) and Broad *et al.* (2012). The elongated sedimentary wedge along the margin of the southwest Cape and the western flank of the Columbine-Agulhas Arch, also known as the Southwest Cape sedimentary wedge is shown. Graben and half graben systems are separated from the synrift wedge by a medial hinge. Note the Agulhas-Falkland Fracture Zone (AFFZ) morphotectonic features defining the basin at the south. The Kudu and Ibhubesi gas fields along the Southwest African Coastal Basin are shown.

sequences. Syn-rift deposits are laterally discontinuous, controlled by accommodation space formation within graben systems bound by extensional

faults (Figure 3). This process, involving crustal extension and mechanical subsidence, is typical of rift and failed-rift systems. Volcanism during the rifting



**Figure 3:** a) The syn-rift infill within the graben system of the study area shows onlapping seismic reflectors against basement structures, indicating tectonic control on deposition. b) Unit B, facies B1, is marked by eastward-dipping reflectors that are subparallel to the basement. A medial hinge, formed by a basement high, separates the half-graben infills from an undifferentiated wedge to the west, which features seaward-dipping seismic reflectors (SDRs). c) Unit B overlies the 1A11 seismic reflector, with its reflectors aligned parallel to the fault scarps. The 6A11 seismic reflector truncates the underlying Unit A. Proximally, Unit B thins and terminates against the down-dipping fault. The reflectors within Unit A display a distinct eastward dip.

of the Orange Basin is indicated by the presence of SDRs (seaward dipping reflectors) (Figure 3b), a common feature in passive margin evolution. Each unit (A-F) is separated into seismic facies and associated systems tracts, as defined by Catuneanu *et al.* (2011). Geophysical log signatures and seismic architecture were used to define systems tracts and interpret depositional environments for each facies (Figures 3 and 4).

Seven seismic units (A-G) were delineated within the study area (Figures 3 and 4). This study identified Upper Jurassic and Cretaceous sand-rich deposits. Upper Jurassic and Lower Cretaceous syn-rift sand deposits, associated with grabens and half grabens in the basin's proximal areas, can be correlated with A-J graben deposits. These syn-rift sand deposits include fluvio-deltaic and lacustrine sandstones. Units A and B represent a syn-rift sedimentary succession, while Units C-G were deposited during passive margin formation (Figure 3). Each unit is delineated by high-amplitude, erosional seismic reflectors (Figure 3) and is characterised by multiple seismic facies, each exhibiting distinct seismic architectures. (Figure 3).

This study identified sand-rich sedimentary units within facies that have CO<sub>2</sub> storage potential, with well-defined reservoir-seal pairs based on depth (> 800 m), sedimentology, and seismic

architecture. These include facies A and the basal zone of facies B2 (Unit B), within Units E and F (Figures 3 and 4).

Reservoir 1 identified in Unit A from well A-O1 (Figure 4), consists of sandstones, volcanoclastics, shales, and silts, primarily deposited in a fluvial environment. The unoxidised lacustrine shales in well A-O1 suggest proximal facies within the graben. Units A and B within the graben system show upturning into fault planes, interpreted as mounding that formed fault compartments. Facies B1 is characterised by the upturning of strong reflectors, creating mounded zones that onlap and downlap onto the underlying unit. These features are likely associated with continental to lacustrine sandstones, similar to those found in the A-J graben to the south.

Reservoir 2, a stratigraphic play within Unit E (Figures 3 and 4), is the most laterally extensive potential reservoir zone identified in this study. It consists of Middle Albian to Cenomanian fluvial channel sandstones, which were key target horizons in the Ibhuesi gas/condensate field in the southern Orange Basin, showing favorable reservoir properties and high gas flow rates. During SOEKOR's 1987 testing of the A-K1 well, these sandstones produced 340 barrels of condensate per day. More recently, in December 2021, TotalEnergies and Shell began drilling within the Aptian-Cenomanian successions in deepwater

offshore southern Namibia. TotalEnergies targeted an Albian-age basin floor fan system with the Venus-1 well, while Shell drilled the Graff-1 well, aiming at shallower Late Aptian-Albian sandy turbidite systems on the lower slope.

In the study area, Reservoir 3 identified in Unit F consists of a Turonian-age shelfal sandstone, likely equivalent to the 133t1 or "11" sandstone identified by McMillan (2003) in the Orange, Outeniqua, and Gamtoos basins, with correlatives in the Durban and Zululand basins. Given its excellent reservoir properties and wide lateral extent across the southern African continental shelf, it is a prime target for future CO<sub>2</sub> injection studies.

This study demonstrates that a detailed sedimentological and seismostratigraphic analysis of the northern offshore Orange Basin was conducted using 2D seismic profiles and well log data from three offshore wells. The analysis identified multiple phases of margin growth during the late Mesozoic and Cenozoic, including syn-rift sedimentation, structurally controlled deposition, incipient ramp development, and progradational shelf sedimentation. Additionally, sand-rich deposits, interpreted as Reservoirs 1-3, were identified and correlated with hydrocarbon-bearing sequences across the southwestern African continental shelf.



# South Africa and Nigeria deepen cooperation through bilateral technical working visit in Abuja, Federal Republic of Nigeria - CGS supports the DMPR minister

## INTRODUCTION & BACKGROUND

In a significant step toward strengthening bilateral relations, the Republic of South Africa and the Federal Democratic Republic of Nigeria convened a high-level technical working visit from the 14<sup>th</sup> - 17<sup>th</sup> of April 2025. The technical visit was led by the Minister of Mineral and Petroleum Resources (DMPR), the Honourable Mr Gwede Samson Mantashe. This follows the commitments made during the 11<sup>th</sup> Session of the South Africa-Nigeria Bi-National Commission (BNC) previously held in December 2024. The visit was jointly hosted, by Nigeria's Ministry of Solid Minerals and Steel Development together with the Ministry of Petroleum Resources and Gas.

This meeting sought to bring together senior technical experts and officials from South Africa's Department of Mineral and Petroleum Resources (DMPR) and representatives of the Council for Geoscience (CGS), Sibongiseni Hlatshwayo and Ntsako Mhlarhi, as well as their Nigerian counterparts. The South African delegation led by the Minister of DMPR included Ms Ntokozo Nzimande, the Deputy Director General for Mining and Mineral Policy Development - DMPR; Mr Godfrey Moagi, the Chief Executive Officer of the South African National Company (SANPC); Mr Robert Maake, the Director at the South African National Planning Committee; Mrs Lindi Mminele, the Acting High Commissioner at the South African High Commission in Abuja, Nigeria<sup>1</sup>. The core objective of the engagement was to explore and operationalize areas of cooperation in the fields of mineral resources development, energy (oil and gas) and geoscience research, aligned with the strategic intent of the BNC to promote mutual development through knowledge sharing and technical collaboration.



Figure 1: The Ministerial Steel Development and Solid Minerals Delegation and the Minister of the Department of Minerals and Petroleum Resources (South Africa), signing the action plan agreement.



Figure 2: (left – right) Mr. S Hlatshwayo and Mr. N Mhlarhi (CGS); Lindi Mminele - RSA Acting High Commissioner to Nigeria, Permanent secretary for Ministry of Solid Minerals, Minister of Solid Development, Minister of DMPR, Minister of Solid Minerals, DDG of DMPR – Ms. N Nzimande, Permanent secretary for the Ministry of Steel development, Advisor to the Minister of DMPR – Gwebinkundla “Gwebs” Qonde, and Director of SANPC – Mr R Maake.

<sup>1</sup> Names listed are not to the exclusion of other delegates.



Figure 3: The Government officials from both Nigeria and South Africa, with their respective Ministers of Mineral Resources.

South Africa, with over 150 years of mining experience, boasts a robust institutional capacity in geoscientific research, discussing its advanced capabilities in mineral exploration, mining rehabilitation, core repository management, and environmental monitoring. In contrast, Nigeria, endowed with significant petroleum and gas potential and growing expertise in hydrocarbon exploration, provided invaluable insights into challenging oil and gas sector operations—an area South Africa seeks to further develop.

## DISCUSSIONS AND DELIBERATIONS

In his opening remarks, the DMPR's Minister underscored the significance of African countries working collaboratively to unlock the continent's natural wealth - "This technical exchange reflects our shared commitment to South Africa-Nigeria cooperation and the African Union's Agenda 2063. Our complementary strengths can drive industrialization, energy security, and sustainable development for both our nations."

The South African delegation, through the DMPR's Minister, expressed appreciation for Nigeria's hospitality and reaffirmed the country's (through CGS-DMPR) dedication to strengthening ties in geological mapping, resource

governance, and training of young professionals. The Minister stressed the need for South African companies to be at the forefront of investment in Nigeria for both exploration, infrastructure development, and mining to the completion of Nigeria's critical or focused geoscience mapping and data processing. The minister further emphasized the criticality of trade agreements in crude oil and gas between the two (2) nations through SANPC and the parallel skills transfer through training by CGS and other South African science parastatals which will be key to ensure a mutually beneficial relationship both in the short and medium term.

Key highlights of the working visit included:

1. An agreement on the development of a joint roadmap for collaborative projects, including capacity-building initiatives, exchange programmes, and joint research in both the solid minerals and hydrocarbon sectors.
2. Presentations on South Africa's geoscience mapping and discussion on mineral regulation frameworks, as well as rehabilitation models and resuscitating Nigeria's mining industry
3. Discussions on Nigeria's petroleum exploration successes and lessons

learned, as well as trade in Crude oil and Liquefied Petroleum Gas.

## CONCLUSION

The technical working visit led by the Minister of DMPR, Honourable Gwede Samson Mantashe was successful as four (4) Nigerian ministries were engaged, and all reflected a great desire for cooperation and shared capacity building for both nations.

Both parties reiterated the urgency of translating the Memorandum of Understanding (MoU) into actionable outcomes, identifying funding mechanisms, and setting up a joint technical committee to monitor progress.

The visit concluded with a joint communiqué affirming the importance of geoscientific cooperation in achieving sustainable development goals and the shared vision of advancing Africa's resource-based industrialisation.

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## Attending the Annual Women in Mining Conference

The Annual Women in Mining Conference is dedicated to empowering women across various sectors through thoughtfully organised events. It serves as a platform to highlight the invaluable roles and contributions of women within the industry. Attending the conference is both intellectually stimulating and deeply inspiring for every woman granted the opportunity to participate. It was a day spent alongside trailblazing women who lead with integrity and courage at the forefront in their fields.

Attendees had the opportunity to:

- Gain exclusive insights into the industry
- Enhance their professional skills and advance their careers
- Mentor and inspire the next generation of leaders
- Give insight on the positive strides taken to ensure a safe working environment for women as the mining industry transforms into an inclusive environment

### Conference Proceedings

On Friday, 9 May 2025, a powerhouse group of female scientists gathered at the NH Sandton for the Annual Women in Mining Conference, an event that proved you can, in fact, mix hard hats with high-impact ideas. This year's theme strategically focused on empowering women by highlighting their vital role in driving growth, uplifting others, and redefining career progression as a shared journey, not a solo race to the top. The speakers reminded everyone that real success comes with company (and ideally, good coffee).

The event was chaired by Ms. Charlotte Ramparsad, an experienced speaker, moderator, and CEO of Green Glasses Environmental Communication Consultancy, a 100% women-owned business. Featured speakers included Dr. Urishanie Govender (Chief Sustainability Officer: Harmony Gold), Ms. Keele Letsipa (Group Manager



Figure 1: Women in Mining Conference underway, chaired by Ms. Charlotte Ramparsad.



Figure 2: The CGS's delegates attending the Women in Mining Conference. From left to right: Meses. Vhuwawvhohau Nengovhela, Molebogeng Modiba, Connie Setladi, Sinovuyo Myendeki, Tshildzi Mudau, Matamba Tsanwani, and Tebogoo Makono.

for Safety and Health: Exxaro) and Ms. Bedelia Theussien (HR Executive: Mintek). The speakers delivered inspiring talks on empowering women to embrace leadership roles and create lasting legacies within their organisations.

Key themes included refining one's personal vision, developing subject-matter expertise (because Google can't

do *everything*), and pursuing excellence without burnout. Delegates were urged to lead boldly, stay adaptable, and commit to lifelong learning, even when it means unlearning a few things first.

### Conclusion

Conversations throughout the day highlighted the importance of mentorship

and the ripple effect of empowering others. There was also a healthy dose of reality about workplace culture, with kindness and accessibility framed as essential tools for transformation.

Above all, the conference served as a reminder: women in mining are not just breaking ground, they are rewriting the blueprint. And judging by the energy

in the room, they are doing it with grit, grace, and just the right amount of humor. The CGS ladies who had the privilege to attend this unforgettable event included: Molebogeng Modiba, Connie Setladi, Sinovuyo Myendeki, Matamba Tsanwani, Tebogo Makono, Vhuhwavhohau Nengovhela and Tshildzi Mudau.

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## Field School: Shaping the Future of Geoscience Education at Tshwane University of Technology

On May 12, 2025, the Council for Geoscience's (CGS) Minerals, Energy, Environment, and Groundwater (MEEG) staff members hosted a transformative two-week Field School experience for students at the Tshwane University of Technology (TUT). This initiative aims to foster a deeper understanding of geophysical techniques and their applications in addressing geological challenges.

The structured format of the Field School was designed to accommodate the participants' diverse academic levels. During the first week, the Geophysics staff members were invited to assist a class of third-year students in Hartbeespoort. In the second week, twenty (20) postgraduate students gathered at the abandoned Edendale Lead & Silver Mine (which was in operation from 1890 to 1938) near Mahube Valley, Mamelodi, where geophysical surveys were conducted to map dolerite and the potential locations of the contaminant plumes, respectively.

Under the guidance of Emmanuel Chirenje, Melvin Sethobya, and Kevin Morewane, the Geophysics team, the students were exposed to a hands-on learning experience where theoretical knowledge came to life. The team engaged the students not merely as passive learners but as active participants in the geoscience exploration process. This interactive approach facilitated a unique opportunity for students to connect classroom learning with real-world applications.



Figure 1: Melvin Sethobya (CGS), explaining to the 3<sup>rd</sup> Year TUT students how the electrical resistivity tomography (ERT) is conducted.

The program was thoughtfully curated to introduce various geophysical techniques, including passive (ground magnetic and gravity) and active (reflection and refraction seismic, electric resistivity tomography, and frequency-domain electromagnetics) methods. Each technique was demonstrated, highlighting its significance and potential impact on environmental assessment, resource exploration, and hazard mitigation. The Geophysics team emphasised the importance of scientific investigation and pragmatic observation in the geosciences by showcasing the fundamental principles behind these techniques.

One of the most engaging aspects of the Field School was the opportunity

for field data acquisition. Students were taken outside the traditional classroom setting, allowing them to collect data in real-time and apply their learning in a practical context. Armed with geophysical equipment, students conducted surveys, gathered datasets, and collaborated in small teams to interpret their findings. This hands-on experience was invaluable, as it unveiled the complexities of fieldwork and the collaborative nature of scientific research.

Throughout the program, the team encouraged students to think critically and creatively about the data they collected. Interpreting geophysical datasets requires not only technical acumen but also an understanding of geological contexts. The students

learned to consider the implications of their results for broader environmental and societal challenges, such as water resource management, mineral exploration, and urban planning. By framing these discussions within the context of real-world applications, the Field School enriched students' perspectives on their potential futures in the geosciences.

The collaborative attitude fostered during the Field School extended beyond the students and MEEG members. The program also promoted synergy between academia and industry by inviting professionals from different sectors to share their insights and experiences. Guest speakers, each with unique backgrounds in various facets of geoscience, presented on topics such as environmental impact assessments, sustainable mining practices, and innovative technologies in geophysical research. This exposure allowed students to envision the pathways available to them after graduation and the dynamic roles they could play in their chosen fields.

The success of the Field School was reflected in the enthusiasm and active engagement of the participants. Students expressed a renewed sense of passion for geoscience, inspired by the opportunity to connect with experts in the field and participate in hands-on, experiential learning. Many participants articulated a newfound appreciation for the challenges and responsibilities of being a geoscientist in a world that increasingly relies on sound scientific practices for sustainable development.

Furthermore, the program aimed to instill a sense of advocacy for environmental stewardship among the participants, an essential focus where geoscientists are integral to addressing climate change, natural resource depletion, and sustainable land management. The Field School equipped students with technical skills and the ethical framework to tackle these pressing challenges.

As the two weeks drew to a close, participants reflected on their experiences with a mix of nostalgia and excitement about the future. The lessons



Figure 2: Enthusiastic 3<sup>rd</sup> Year Tshwane University of Technology (TUT) students on the final day of the field school.



Figure 3: Kevin Morewane (CGS) explains and illustrates the acquisition of refraction seismic data and the related principles.



**Figure 4:** Emmanuel Chirenje (CGS) explains how frequency-domain electromagnetics (FDEM) surveys are conducted and general considerations when acquiring data.



**Figure 5:** Eager students acquiring FDEM data on the line of investigation.

learned and skills acquired during this immersive program left a lasting impact on each student's academic journey.

The collaboration between the CGS and Tshwane University of Technology for the Field School exemplifies a meaningful investment in the future of education, especially in geoscience. By

bridging the gap between theoretical understanding and practical application, this initiative is shaping a new generation of geoscientists better equipped to address the critical challenges of our time. As we move forward, such programs are essential in fostering innovation, encouraging collaboration, and enhancing our understanding of

geology, ultimately paving the way for a more sustainable and scientifically informed society.

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## Mineral separation at CGS analytical services: Zircon for geochronology and isotope geochemistry

### INTRODUCTION

An accurate geochronological investigation requires separating zircon or other accessory minerals from large geological samples to measure isotope ratios within individual crystals. Zircon ( $ZrSiO_4$ ) is widely used as an accessory mineral to determine the crystallization age of igneous rocks and to constrain the timing of metamorphic events based on their overgrowth or recrystallized domains. Additionally, detrital zircon crystals provide valuable information about sedimentary provenance.

Zircon is resistant to chemical and physical weathering and accommodates variable concentrations of highly

compatible uranium (U) and thorium (Th). In addition, cerium (Ce), europium (Eu), and titanium (Ti) anomalies in zircon can be an indicator of the oxidation state of the parental magma. As a result, zircon is a very important mineral in U-Th-Pb geochronology and isotope geochemistry. It is widely used to determine the age of rocks by taking advantage of the decay of U and Th into Pb within the zircon crystals. This is achieved by using high-precision analytical instruments, such as TIMS, SIMS, and LA-ICP-MS, generating enormous amounts of geochronological and trace element data from zircon.

The concentration and separation of zircon primarily relies on its unique physical properties, particularly its

extremely high density of 4.6 to 4.7 g/cm<sup>3</sup>. Zircon crystals are heavy but also non-magnetic, which means that they can be easily separated from equally heavy iron-bearing minerals. The mineral separation process involves a sequence of steps designed to isolate zircon crystals from the bulk samples. This process begins with a sample of approximately (five) 5 kilograms and produces less than (one) 1 gram of zircon-bearing heavy mineral concentrate. Through a systematic mineral separation process that includes crushing, milling, sieving, gravitational and magnetic separation, coupled with strict contamination prevention, pure zircon grains are accurately obtained.

## MINERAL SEPARATION PROCESS

### CRUSHING AND MILLING

The mechanized mineral separation process begins with (i) crushing several kilograms of sample (approximately 5 kg) using a jaw crusher, followed by (ii) milling in a roller mill. There are instances where, if the rocks are too large to fit in the jaw crusher, a (ii) hydraulic rock splitter is used to reduce their size. This step allows the microscopic zircon crystals in the rock to be broken loose from the surrounding bulk minerals. The sample is then sieved using a 250  $\mu\text{m}$  screen, and the material smaller than 250  $\mu\text{m}$  is used in the next step.

### THE WILFLEY SHAKING TABLE

Following the crushing and milling process, is the process of pre-concentration of heavy minerals, using a Wilfley shaking table, this is aimed at producing a heavy mineral concentrate, with all accessory minerals in the rock, including zircon. The milled sample (<250  $\mu\text{m}$ ) is washed over a shaking table to separate the mineral grains by density. Firstly, the sample is dropped onto the top-right side of the table, and the mineral grains move down and to the left as the inclined table shakes from side to side and water streams across it. Light minerals get washed off the table and collected into the front trough, while heavy minerals, such as zircon are caught within the rills and grooves of the table and are collected at the far end.

### MAGNETIC SEPARATION

Magnetic separation is a critical step in isolating zircon from other heavier minerals like iron oxides. Following the Wilfley shaking table has provided the heavy mineral concentrate, the magnetic separation process further refines the mineral concentrate by removing iron- and magnesium-rich mineral grains.

Strongly magnetic minerals (magnetite) are removed using a hand (-held) magnet, whilst weakly magnetic minerals are further removed using the Frantz magnetic separator. The Frantz magnetic separator consists of a large magnet with two parallel trackways. The upper,



Figure 1: The various machines used in the mineral separation process: rock splitter (a), jaw crusher (b) and a roller mill (c).

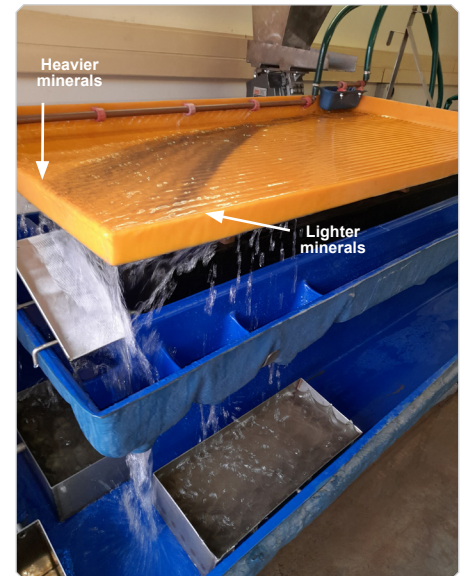


Figure 2: A Wilfley shaking table showing the various collection points for heavy and light minerals.

inside track passes through the magnet, while the lower, outer track sits just outside of the magnet. As the sample goes down the inner track, magnetic minerals attracted to the magnet continue their path, while non-magnetic minerals like zircon fall into the lower outside track. Both magnetic and non-magnetic streams are collected into different cups. The non-magnetic fraction that contains the zircons is taken to the next step to be processed further to isolate zircon grains.

### HEAVY LIQUID SEPARATION

The non-magnetic fraction of the heavy mineral concentrate from the Frantz magnetic separator contains both heavy minerals like zircon and lighter minerals like quartz and feldspar. The heavy zircon crystals are further separated by using a dense liquid in a separatory funnel. Quartz and feldspar float at the top of the liquid, but dense minerals like zircon sink to the bottom. A valve at the bottom of the funnel is opened to allow the dense minerals to be collected and then cleaned. Sodium polytungstate (SPT) is currently used as a heavy liquid with a density of 3.1 g/cc. Diiodomethane (3.3 g/cc) was previously used at CGS as a heavy liquid, but it was stopped due to the risks associated with its toxicity. The density of SPT is reduced by the addition of distilled water. The heavy liquid separation further refines the zircon concentrate by rejecting the lighter

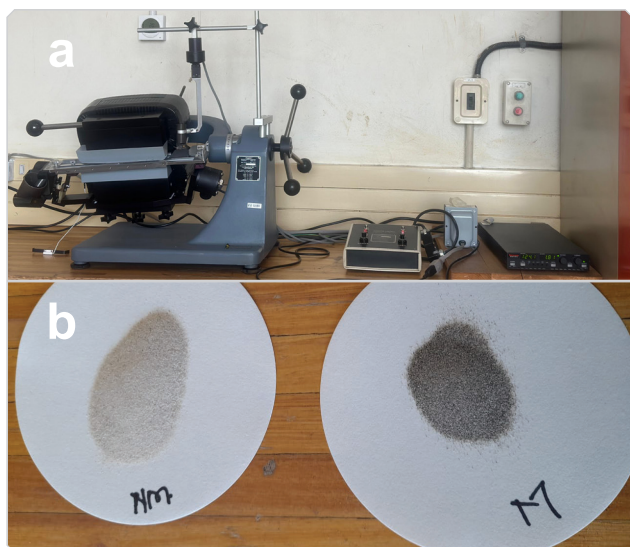


Figure 3: A Frantz magnetic separator (a), NM: non-magnetic and M: magnetic fraction (b).

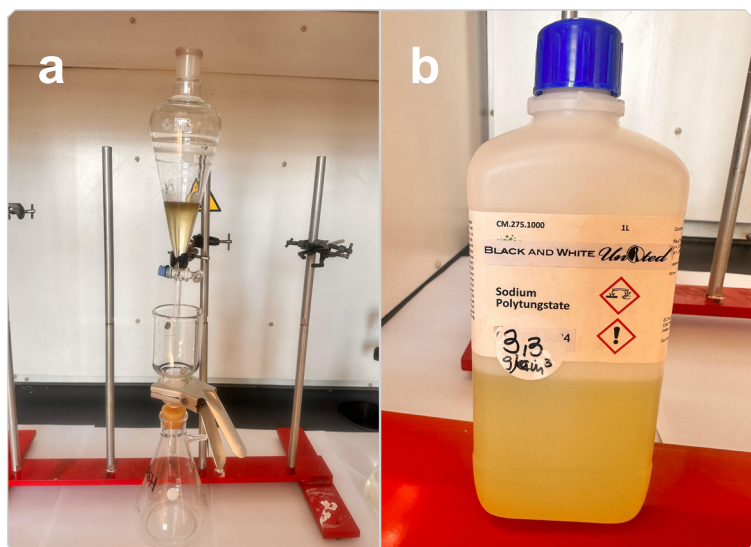


Figure 4: A heavy liquid separation funnel (a) alongside a sodium polytungstate solution (b).

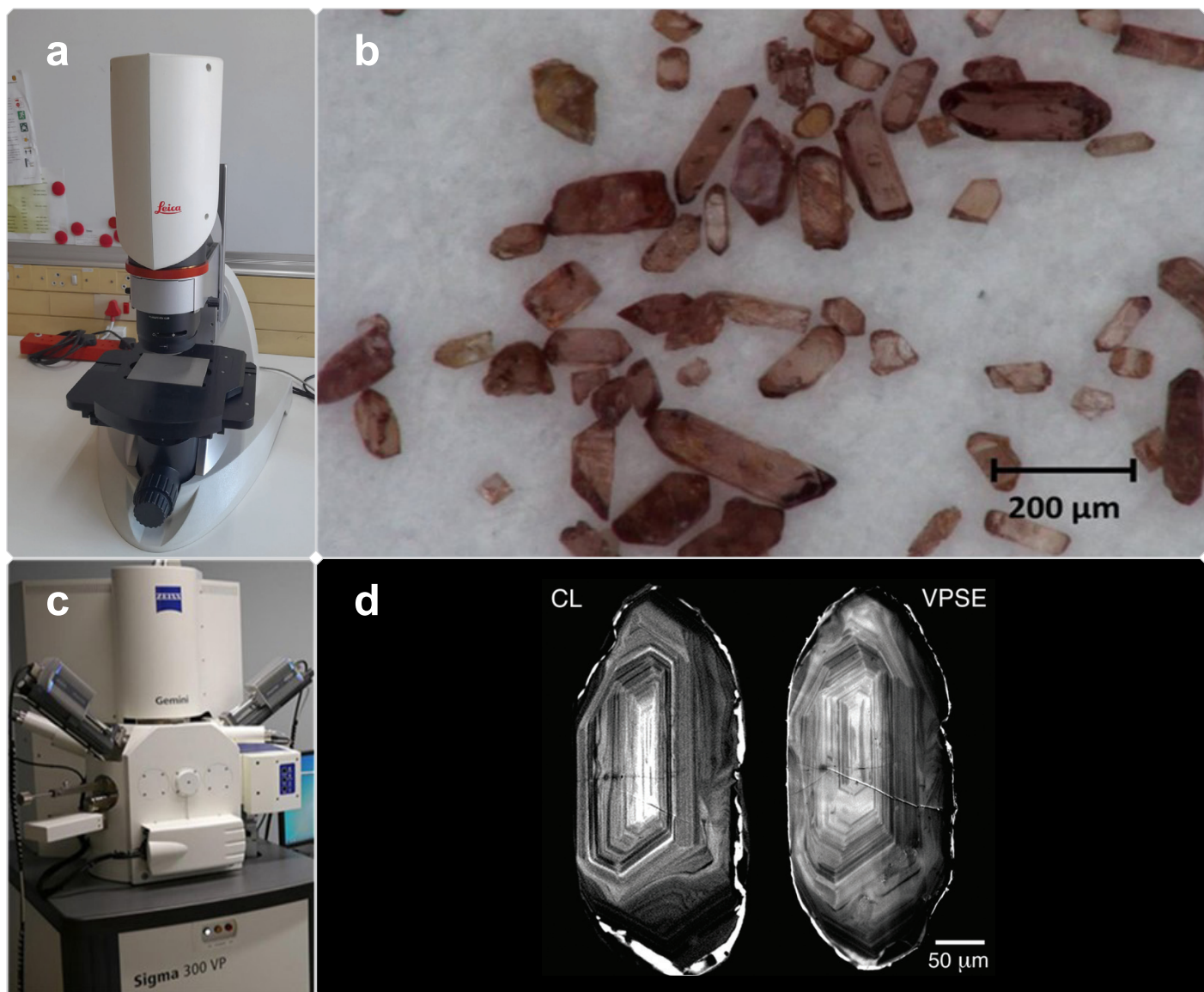



Figure 5: Leica stereo microscope (a), stereo microscope images of zircon crystals (b), Zeiss Sigma 300 variable pressure SEM (c) and CL and variable pressure SE image showing growth patterns similar to tree rings (d).



minerals that were still present in the non-magnetic heavy mineral concentrate.

### **ZIRCON PICKING AND IMAGING**

The final step is to pick zircons under a stereo microscope and image the crystals using different techniques. Zircon grains are examined for internal structures, growth zoning, and the presence of tiny inclusions. Zircon crystals that contain

multi-growth domains or have local internal deformations within a single grain may not produce geologically meaningful age results if the analyses are conducted on mixed domains. Therefore, it is important to pick suitable crystals for further analysis for geochronology. Scanning electron microscopy (SEM) imaging by cathodoluminescence (CL) detector and secondary electron (SE) detector under variable pressure is done

on the selected zircon grains. This will reveal deformation and internal growth structures within zircon crystals. Zircon grains are finally packaged for analysis in the external laboratory.

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