TANZANIA GEOLOGICAL SOCIETY (TGS)

2025 ANNUAL CONFERENCE

BOOK OF ABSTRACTS




MBEYA

01st to 6th of December 2025

Front cover photos

Top Left: *The Kapologwe Waterfall in Mbeya - a breathtaking attraction in Isuba village, just 15 km from Tukuyu town;* ***Top Right:*** *A view of Mbeya City - one of the important junctions in Mbeya Town;* ***Bottom left:*** *Lake Ngozi, the second largest crater lake in Africa found near Tukuyu, Rungwe District; and* ***Bottom right:*** *Mnara wa Mwenge (Torch of Freedom), stands proudly in the heart of Mbeya, symbolizing the nation's historical struggles and victories.*

Message to Participants of the TGS 2025 Conference

Our distinguished participants, colleagues, and guests, it is with great pleasure that we welcome each of you to the Tanzania Geological Society (TGS) 2025 Annual Conference. We are delighted to host you in the vibrant city of Mbeya.

Mbeya, often referred to as "***the Green City***", '*food basket of Tanzania*', lies in the country's southern highlands, surrounded by majestic mountains, rolling tea estates, and fertile valleys. The city serves as a gateway to the Southern Highlands and is an important economic and agricultural hub for Tanzania and the wider East and Southern African regions.

Founded in the early 20th Century during the gold rush era, Mbeya has evolved from a small mining settlement into one of Tanzania's most dynamic urban centres. Today, it stands as a crossroads for trade, culture, and science, connecting Tanzania with Zambia and Malawi through the historic TAZARA Railway and the Great North Road, respectively.

Beyond its economic significance, Mbeya is blessed with exceptional natural beauty and geodiversity. The region is home to the majestic Mbeya Range, active volcanic mountains, the Loleza and Rungwe volcanoes, and the Mbaka fault escarpments, which collectively reveal a fascinating geological history of rifting and volcanic activity. Nearby attractions such as Lake Ngozi, one of Africa's largest crater lakes, Kitulo Plateau National Park, famously known as the "Garden of God" for its vibrant wildflowers, and the Songwe hot springs, offer visitors a glimpse into the interplay between geology, ecology, and tourism potential.

We are honoured to have you join us for what promises to be another inspiring and engaging conference, bringing together experts, thought leaders, innovators, and young scientists across the geosciences, extractive industries, academia, and policy sectors from Tanzania Mainland, Zanzibar, and abroad.

This year's theme, "**Harnessing Earth Resources for a Sustainable Planet**," calls upon us to reflect deeply on the role of geosciences and engineering in shaping a sustainable future. The discussions will explore how we can balance resource utilization with environmental stewardship, ensuring that the Earth's endowments continue to support both current and future generations.

The conference will feature seven sub-themes that address critical aspects of sustainability and earth resource management: Sustainable Energy Solutions, Sustainable Oil and Gas practice, Technologies in Exploration and Responsible Mining, The Role of Strategic and Critical Minerals in Energy Transition, Transboundary Water Resources and Hydrogeology, Policy and Global Cooperation for Sustainability, and Geoparks and Environments: Guardians of the Earth's Heritage.

The organizing committee has prepared a dynamic agenda featuring high-level keynote addresses, technical sessions, and panel discussions designed to spark dialogue, share knowledge, and foster innovation. We encourage you to participate actively, exchange ideas, and forge new collaborations that will drive forward Tanzania's contribution to global sustainability.

As we gather here in Mbeya, a city where nature, culture, and science meet, we are reminded that geology is not only about studying the Earth but also about sustaining it. Let this conference be a platform for collaboration,

learning, and renewed commitment to using our knowledge and skills to ensure a sustainable and prosperous future.

We are sincerely grateful to all TGS members, our sponsors, and every volunteer whose dedication has made this conference possible. Please feel free to reach out to our organizing team for any assistance or inquiries throughout the event.

Thank you for being part of this experience. We wish you a productive, memorable, and rewarding TGS 2025 Annual Conference here in the Green City of Tanzania, Mbeya.

Conference Organising Committee

Tanzania Geological Society (TGS)

Conference Organising Committee

Subcommittees	Members
Conference secretariat	Dr. Elisante Mshiu Ms. Rosemary Rwebugisa Dr. Emmanuel Kazimoto Mr. Ebeneza Mollel Dr. Sara Emanuel Dr. Emily Kiswaka
Venue, Media, and Excursion Committee	Dr. Mary Moshi Mr. Edmund Josephat Mr. Japhet Fungo Dr. Emily Kiswaka
Editorial Committee	Dr. Emily Kiswaka Dr. Emmanuel Kazimoto Mr. Mofor Njakoi
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Barrick Mining Corporation is a global, sector-leading gold and copper producer dedicated to building the world's most valued gold and copper company through owning and operating the best assets, while remaining firmly committed to delivering strong returns and meaningful benefits to all its stakeholders especially its host countries and communities.

The Government has praised Barrick Mining Corporation for its exceptional tax compliance highlighting the company's US$ 92 Million income tax payment in 2024 as a benchmark for the mining sector. Beyond this significant contribution, Barrick has demonstrated its commitment to supporting host communities through various initiatives.

One such initiative is the Barrick Twiga Future Forward Education Program, now in second phase of a three-phase US$30 million commitment; the program is set to provide classroom space for an additional 45,000 pupils.

Additionally, the Barrick Academy has already trained more than 2,000 foremen, supervisors, and superintendents from across the company's Africa and Middle East region.

The Tanzania Geological Society recognizes Barrick Mining Corporation as a key stakeholder with an unwavering commitment to supporting TGS. .

Our Silver Sponsor

STAMICO

http://www.geitamine.com/en.html

The State Mining Corporation (STAMICO) is a wholly owned government enterprise under the Ministry of Minerals. It was established under the Public Corporation Act Cap 257 through Establishment Order No. 163 of 1972, and later amended in 2014. STAMICO was re-established in 2015 through the Public Corporations (Establishment) (Amendment) Order, 2015, with the aim of increasing the mineral sector's contribution to the national economy and creating employment opportunities for Tanzanians.

STAMICO has played a vital role in supporting small-scale miners by providing field surveys and drilling services. These services have enabled small-scale operators to achieve better results, increase profits, and improve their overall financial outcomes compared to previous years, while also positioning them to access loans from local financial institutions.

Beyond its contributions to the extractive sector, STAMICO also advances environmental conservation efforts through Rafiki Briquettes—an alternative domestic energy source that reduces reliance on charcoal and helps combat deforestation.

The Tanzania Geological Society recognizes STAMICO as a key stakeholder with a strong and consistent commitment to supporting the Society's mission

Our Bronze Sponsor

Geita Gold Mine | AngloGold Ashanti

https://www.stamico.co.tz/

Geita Gold Mining Limited (GGML), one of AngloGold Ashanti's flagship operations, is in northwestern Tanzania in the Lake Victoria Goldfields, Geita Region. As one of the country's largest and most compliant taxpayers, GGML's impact extends well beyond its economic contribution. The company actively supports initiatives that expand access to clean water, create employment opportunities, and strengthen education.

GGML is widely recognized in the mining sector for its commitment to developing local talent, promoting diversity and inclusion, and implementing a comprehensive approach to talent management. Its long-standing investment in capacity building includes an internship programme that has supported over 300 graduates from various institutions, more than 50% of whom have been retained, alongside field student placements and the Female Future Tanzania initiative, among others.

The Tanzania Geological Society acknowledges and appreciates GGML's distinguished contribution as a dependable and long-standing stakeholder in supporting TGS activities.

ANGLOGOLDASHANTI

GEITA GOLD MINE
TANZANIA

Recognition of the Outstanding Tanzanian Geoscientist

Dr. Joas Muganyizi Kabete

A token of appreciation is extended to our esteemed senior TGS member, Dr. Joas Muganyizi Kabete, whose unwavering dedication has greatly enriched both the association and the geosciences field at large.

Dr. Kabete is a Tanzanian geologist with BSc, MSc and PhD degrees and over 34 years' experience in gold, nickel and base-metal exploration. He has worked with STAMICO, Placer Dome, BHP, AngloGold Ashanti and MIL Mining. His PhD work advanced gold exploration in Tanzania, leading to discoveries such as the Magambazi deposit. Dr. Kabete founded Mazoka Resources, delivers training for geoscientists and institutions, and serves on boards while managing major gold projects in Tanzania and the DRC.

Dr. Kabete's contributions span academic research, mineral exploration, TGS leadership, and the representation of the geoscientific community's interests across both the private and public sectors. He has mentored, and continues to mentor, a significant number of geoscientists throughout their professional development.

Editorial Team

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Conference Programme

DAY 1 & 2 (01-12-2025 to 02-12-2025)

Pre-conference Excursion Programme at RVP

SUNDAY 30.11.2025	
Time	**Place/Activity**
06:00 - 00:00	Participants arriving in Mbeya
MONDAY 01.12.2025	
Time	Place/Activity
07:30 - 08:00	Participants gather at the Royal Tughimbe Hotel to board mini-buses for excursion trip
08:00 - 09:00	Drive to and hiking at the Ngozi Crater Lake
09:00 - 11:00	Discussion: Geology of Rungwe Volcanic Province and Crater Lake Hydro Geochemistry
11:00 - 12:00	Drive to TGDC Ngozi drilling site
12:00 - 13:30	Discussion: Geology of Ngozi and its potentiality for production
13:30 - 14:30	Lunch Break at Kiwira
14:30 - 15:30	Drive to God's Natural Bridge
15:30 - 16:30	Discussion: God's Natural Bridge formation
16:30 - 17:30	Drive to Matema Beach
17:30	Announcement and Adjournment

TUESDAY 02.12.2025	
Time	**Place/Activity**
07:30 - 09:00	Gathering and breakfast at Matema Beach
09:00 - 11:30	Lake Nyasa Activities: Fish watching, swimming and beach football
11:30 - 12:30	Drive to Kyela town
12:30 - 13:30	Lunch break at Kyela
13:30 - 14:00	Drive to Kasumulu One Stop Border
14:00 - 15:00	Visiting Kasumulu One Stop Border
15:00 - 15:30	Drive to Kiwira Coal Mine
15:30 - 18:00	Discussion: Coal formation (Karoo), mining cycle - production
18:00 - 19:00	Drive to Mbeya town
19:00	Announcement and adjournment

DAY 6 (06-12-2025)

Post-conference Excursion Programme at Songwe

SATURDAY 06.12.2025	
Time	**Place/Activity**
07:30 - 08:00	Participants gather at the Royal Tughimbe Hotel to board mini-buses for an excursion trip
08:00 - 09:00	Drive to the Mbeya Cement
09:00 - 11:00	Discussion: Geosciences and its integration within cement industry activities
11:00 - 12:00	Drive to Travertine Quarry Site
12:00 - 13:30	Discussion: Formation of travertine and its economic importance
13:30 - 14:30	Lunch Break at Nzonwe
14:30 - 15:30	Drive to Mbozi Meteorite
15:30 - 16:30	Discussion: Mbozi meteorite and folklore
16:30 - 17:30	Drive to Songwe Majimoto
17:30 - 18:30	Discussion: Maji moto Songwe Geothermal System
18:30 - 19:30	Camping at Songwe Majimoto
19:30 - 23:59	Dinner/BBQ, music, Bar, and night swimming
00:00	A goodbye echoing from the heart of the swimming pool

DAY 3 (03-12-2025) OPENING CEREMONY & CONFERENCE

Time	**Activity**	
07:30 - 08:30	Arrival and Registration	
08:30 - 09:30	Refreshments, Exhibition and Poster Session	
09:30 - 10:00	Tour with the Guest of Honour	
10:00 - 10:15	TGS President: Speech and welcome note	
10:15 - 10:45	Regional Commissioner: Speech and welcome the Guest of Honour	
10:45 - 11:45	Guest of Honour	
11:45 - 12:00	Photo Session	
12:00 - 13:00	**LUNCH BREAK**	
Time	**Presenter**	**Title**
13:00 - 13:30	Mr Ismail Diwani	Keynote Speech from Mamba Minerals Corporation Ltd
13:30 - 14:00	Dr. Mary Stith	Keynote Speech from PULA Group
14:00 - 14:15	Gerald Chuwa	Bridging the Technical Gap in Gold Mining for Maximum Value Addition in Tanzania: Roadmap from Small-Scale Artisanal to Enterprise-Centred Approach
14:15 - 15:30	**PANEL DISCUSSION ON TECHNOLOGIES IN EXPLORATION AND RESPONSIBLE MINING**	
15:30 - 15:40	**Q&A – All**	
15:40 - 16:00	**HEALTH BREAK**	
16:00 - 16:15	Mary Moshi	Beyond the Obvious: Exploring for unconventional rare earth resources of Tanzania
16:15 - 16:30	Ernest Mulaya	'Lost Riches Beneath Our Feet': Structural controls on mineralisation from missed targets to model-driven discoveries
16:30 - 16:45	Rongino Ebil	Magmatic History and Petrogenesis of the Host Rocks within the New Luika Gold Mine and its Surrounding Prospects, Lupa Gold Field, South-western Tanzania
16:45 - 17:00	Emmanuel Kazimoto	Geochemistry and U-Pb Geochronology of the Neoproterozoic Aluminous A-type granite in the South-western Tanzania: Implications for the Tonian geodynamic evolution of Southern Africa
17:00 - 17:15	Stanley Shitindi	Critical Minerals as the Backbone of the Energy Transition Challenges and Strategic Role of the Geological Survey of Tanzania (GST) for Sustainable Energy Transition
17:15 - 17:30	Joas Kabete	An Apparently Poorly Endowed Undewa-Ilangali Gold Province: A proxy to discoveries in the under-explored belts situated in the Central Tanzania Region, Archean Tanzania Craton
17:30 - 17:40	All	Q&A
17:40 - 17:55	Recap, Announcements & End of Session	
19:30 - onwards	**Ice-breaking Cocktail Party - All**	

DAY 4 (04-12-2025) CONFERENCE

Time	Presenter	Title
07:30 - 08:30	**Arrival, Registration and Breakfast**	
08:30 - 08:45	Obeid Lemna	Mapping Geology from Aeromagnetic Data: Implications for mineral exploration and geodynamic setting
08:45 - 09:00	Adelina Shilula	Not Every Chalcophile Needs the IP Method: Is it a concern for copper?
09:00 - 09:15	Rachel Sabuni	Technological Innovations in the Exploration of Cobalt-Rich Ferromanganese Crusts in the Pacific Ocean: Advancing responsible seabed mining
09:15 - 09:30	Yedidia Mgema	Bridging the Gap: Integrating iimplicit and mmachine learning modelling in mineral resource estimation
09:30 - 09:45	Daniel Mwakitalu	Machine Learning Technique in Mineral Exploration
09:45 - 10:00	George Kato	Geosciences and Sustainable Development in Tanzania
10:00 - 10:15	Agness Gidna	UNESCO Global Geoparks and Geotourism as Drivers for Sustainable Development in Africa: A case study of Ngorongoro Lengai UGG, Tanzania
10:15 - 10:45	**POSTER SESSION**	
10:45 - 12:15	**PANEL DISCUSSION ON GEOPARKS AND ENVIRONMENTS: GUARDIANS OF THE EARTH'S HERITAGE**	
12:15 - 12:30	**Q&A – All**	
12:30 - 13:30	**LUNCH BREAK**	

DAY 4 - SESSION I **Science-Driven Approaches to Improve Resource Governance and Technical Performance in Mining and Water Management**		
Time	**Presenter**	**Title**
13:30 - 13:45	Petro Ligwa	Integrating Actual Measurement and Artificial Modelling in Monitoring Blast Movement and their Impact on Minimising Ore Dilution/Losses in Open Pit Mining
13:45 - 14:00	Kagusi Kagusi	Modelling Groundwater Resources of the Stampriet Transboundary Aquifer System (STAS)
14:00 - 14:15	Mwanamkuu Mwanyika	Transboundary Water Management in Tanzania: Exploring benefits and challenges
14:15 - 14:30	Filbeta Magidanga	Tanzania Bureau of Standards and The Quality Infrastructure in The Mining Sector
14:30 - 14:45	William Kalinga	GST State-of-the-Art Laboratory Services
14:45 - 15:00	Q&A	
15:00 - 15:15	**HEALTH BREAK**	

DAY 4 - SESSION II Provenance, Depositional Systems, and Petroleum/Helium Prospectivity Across Tanzania's Mesozoic–Cenozoic Basins.		
Time	**Presenter**	**Title**
13:30 - 13:45	Charles Kasanzu	Geochemical Characterisation of the Cenomanian–Campanian Red Sandstone Group of the Rukwa Basin, SW Tanzania: Implications for provenance, paleoclimate and paleo-redox conditions
13:45 - 14:00	Joyna Kabohola	Facies Analysis and Depositional Environments of the Lower Karoo-equivalent Beds in the Tanga Basin, Northern Coastal Tanzania
14:00 - 14:15	Cassy Mtelela	Potential Reservoir Units for Helium Accumulation across the Cretaceous to Quaternary Stratigraphy of Rukwa Rift Basin, Southwestern Tanzania
14:15 - 14:30	Aneth Lyaka	Assessment of Hydrocarbon Potential in the Mandawa Basin
14:30 - 14:45	Antipass Tarimo	Source Rock Evaluation and 1D Basin Modelling in the Ruvuma Basin, Southeast Tanzania
14:45 - 15:00	All	Q&A
15:00 - 15:15	**HEALTH BREAK**	

DAY 4 – MAIN VENUE	
15:15- 16:45	**PANEL DISCUSSION ON TRANSBOUNDARY WATER RESOURCES AND HYDROGEOLOGY**
16:45 - 16:50	**Recap, Announcements & End of Day 4**

DAY 5 (05-12-2025) ***CONFERENCE & CLOSING CEREMONY***

Time	**Presenter**	**Title**
08:00 - 08:30	Arrival & Poster Session	
08:30 - 08:45	Epiphania Mtabazi	Geothermal Resource Assessment of the Rift Basins of the East Africa Rift System in SW Tanzania
08:45 - 09:00	Martha Nnko	Estimation of Subsurface Temperature Distribution of Songwe Geothermal Field by Numerical Methods
09:00 - 09:15	Berliner Bujulu	System Design for Minimisation of Gasoline Vapour Emissions from Storage Tanks: A Case Study of TIPER, Tanzania
09:15 - 09:30	Karimu Nasibu	Reservoir Management Via Physics-Informed Hybrid AI: Dual target (2D) forecasting using PG-RDI blending index and ensemble fusion
09:30 - 09:45	Denis Moshi	Application of the Magnetotelluric Method in Assessing Subsurface Resistivity Variations within the Geothermal Reservoir at the Kiejo - Mbaka Prospect
09:45 - 10:00	Saidi Chamba	Upcoming Mnazi Bay and Ntorya Drilling: Strengthening Tanzania's natural gas supply
10:00 - 10:15	All	Q&A
10:15 - 10:30	HEALTH BREAK	
10:30 - 12:00	**PANEL DISCUSSION ON SUSTAINABLE ENERGY SOLUTIONS AND OIL AND GAS PRACTICE**	
12:00 - 12:15	Q&A	
CLOSING, TGS 2024 ANNUAL CONFERENCE		
12:15 - 12:20	TGS Vice President, TGS: Welcoming Remarks	
12:20 - 12:45	TGS President: Speech and Welcome Guest of Honour	
12:45 - 13:45	Guest of Honour	
13:45 - 13:55	Photo Session	
13:55 - 14:55	**LUNCH BREAK**	

TGS ANNUAL MEETING		
Time	**Activity**	**Responsible**
14:55 - 15:00	Opening	TGS President
15:00 - 17:00	Reporting on TGS 2024/2025 Activities, TGS Journal & Financial Report (Auditor's report)	TGS General Secretary, Treasurer and Editor
17:00 - 17:20	TGS Extractive Industry Solutions (TEIS)	TGS President
17:20 - 18:00	New TGS Leadership	All
18: 00 - 18:10	Remarks	TGS Advisory Board Chairperson
18:00 - 18:20	Closing	TGS Vice President
19:30 - Onwards	**CONFERENCE DINNER**	

POSTER PRESENTATIONS

Presenter	Poster Title
Daniel Reuben	Natural Gas and Liquids Production Forecasting Using Machine Learning: A Case Study at Field 'Z', Tanzania
Obed Charles	Sustainable Energy Solutions in Tanzania
Safiness Bonny	Assessment of the Performance and Cost Analysis of Compressed Natural Gas in a Domestic Liquefied Petroleum Gas Cook Stove
Sakila Benezeth	The Application of Heavy Mineral Sands: Case Study of Fungoni, Dar Es Salaam, Tanzania
Innocent Mvamba	Late Cretaceous Palynological Dynamics Based on Quantitative Analysis of Palynomorphs and Its Implications for Hydrocarbon Potential
Amani Berre	Population Distribution Around Geothermal Areas in Tanzania: Insights from the 2022 Census
Julius Evodius	Remote Sensing Aided Hydrothermal Alterations in Geothermal Systems: A Case Study of Kisaki Geothermal Area
Calvin Goodluck	Machine Learning Based Mapping of Hydrothermal Alteration Zones for Gold Prospecting: A Case Study of Ushirombo, Tanzania
Ronald Machumu	How Sustainable Energy Solutions Will Promote Sustainable Economic Growth and Development in Tanzania
James Phaustine	Investing in the Future: Catalysing Beneficiation of Tanzania's Critical Minerals Through Strategic Knowledge and Value Chain Development
Kaspary Ngonyani	Turning Stones into Gold: Harnessing Basalt Rocks for the Development of High-Performance Basalt Fibre Products in Tanzania
Rahma Mussa	Unlocking Geo-Heritage Potential: Integrating the Role of Geo-education Towards Sustainable Conservation of the UNESCO Global Geoparks in Tanzania
Happiness Munthali	Unlocking Geothermal Energy for Sustainable Development in Tanzania: Lessons from Kenya

Presenter	Poster Title
Godfrey Dunia	Geological Characterisation of the Kiejo-Mbaka Geothermal Prospect, Tanzania: Implications for Geothermal Potential
Jane Buttindi	Sustainable Geophysical Exploration of Critical Minerals in Tanzania: Bridging Discovery and Environmental Responsibility
Roman Kabonge	Integrating the Role of Advanced Technologies for Sustainable Mineral Exploration and Gold Production in Tanzania
Alen Mwiru	Geological Assessment of Wingayongo Deltaic Region: Structural Indicators and Hydrocarbon Potential
Pamela Massawe	Hydrogeophysical Assessment of Groundwater Potential Along the Lake Victoria Basin, Tanzania: A Case Study from Meatu, Simiyu
Ishengoma Erasmus	Structural and Geological Insights from Aeromagnetic Data, Northern Tanzania
Salumu Salumu	Transforming Artisanal Mining of Saprolitic Low-grade Gold Ores through Heap Leaching: A Geometallurgical Case Study of the Ushirombo-Kelezia Area, Geita Region, Tanzania
Lukelo Matimbwi	Carbon Emission Reduction in Tanzania: Carbon Capture and Storage (CCS)
Raya Amiri	Application of Modern Geospatial Technologies for Sustainable Mining Practices in Tanzania: A Case Study of Kelezia-Ushirimbo, Geita
Godson Godluck	Geophysical and Remote Sensing Techniques Integration for Mapping Uranium Mineralisation and its Implications for Sustainable Energy Transition: A Case Study of Mpanda, Tanzania

ABSTRACTS

BRIDGING THE TECHNICAL GAP IN GOLD MINING FOR MAXIMUM VALUE ADDITION IN TANZANIA: ROADMAP FROM SMALL-SCALE ARTISANAL TO ENTERPRISE-CENTRED APPROACH

Gerald Chuwa

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The leap from small-scale to medium-scale gold mining represents the most critical and challenging transformation in a mine's life. Small-scale operations are centred on a mindset of "high-grading", selectively chasing visible gold with rudimentary tools, an approach which has led to loss of value due to low gold recoveries. Tied to small-scale miners' mindset, is the lack of key technical capabilities emanating from a fundamental divide in philosophy between intuitive and unguided digging, to well explored and engineered extraction of ore.

Bridging this gap is key to unlocking immense trapped economic value for individuals and enterprises in Tanzania. Here, a practical framework built on four transformative pillars is presented. The first pillar focuses on replacing geological guesswork with data-driven knowledge, demonstrating how systematic exploration including drilling and basic block modelling can reveal a deposit's true potential, turning wasted rock into a quantifiable asset. Second, the shift from dangerous, ad-hoc pits to planned mining is outlined; where simple bench designs and grade control protocols improve safety, efficiency, and ore consistency. The third pillar tackles the core of

profitability from properly designed and managed processing. A clear pathway from inefficient sluices and hazardous mercury extraction techniques should give way to advanced gravity concentration and cyanidation. This pillar has demonstrated leaps in gold recovery rates from 50% to over 90%, turning tailings and low-grade ore into a new revenue stream. Finally, the fourth pillar addresses the enterprising and business side of mining through informed formalization, financial discipline and environmental stewardship, which are non-negotiable for attracting capital and ensuring longevity.

These proposed pillars provide an actionable and phased road-map to guide local operators through the essentials of proposed transition. By building this bridge, risky informal ventures can be transformed into safe, profitable, and sustainable enterprises that fully harness their resource potential, becoming the cornerstones of Tanzania’s economic development.

GEOCHEMISTRY AND U-PB GEOCHRONOLOGY OF THE NEOPROTEROZOIC ALUMINOUS A-TYPE GRANITE IN THE SOUTH-WESTERN TANZANIA: IMPLICATIONS TO THE TONIAN GEODYNAMIC EVOLUTION OF SOUTHERN AFRICA

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This study presents new insights on the Litembo Granite, a 30 km wide pluton located south of the Ubendian Belt in the southern Tanzania, East Africa. Whole-rock geochemistry, U-Pb zircon geochronology, and the Rb-Sr isotope system were used to determine its geochemical composition, age, and origin, contributing to regional geological and geodynamic context. The granite is metaluminous to peraluminous, ferroan, and calc-alkalic with high concentrations of Sr, Rb, Ba, High Field Strength Elements (HFSE; e.g., Zr, Y, Nb, and Ta), and high Ga/Al ratios. The total Rare Earth Element (REE) concentrations of the granite range from 335 to 693 ppm, showing fractionated REE patterns in the chondrite-normalized spider diagram ($(La/Yb)_{CN}$ = 9.40–27.1) and a negative Eu anomaly (Eu/Eu*; mean = 0.87). Primitive mantle-normalized spidegrams reveal negative patterns for Ti, Sr, P, Y, and Cs, along with enrichment in Large Ion Lithophile Elements (LILE; e.g. Rb and Ba). Geochemical features of the rock are akin to anorogenic (A-type) granites, implying formation of Litembo granite from a

deep source melts, involving plagioclase, garnet, and amphibole and/or complex differentiation processes, under extensional tectonics. An initial $^{87}Sr/^{86}Sr$ ratio (~0.7113) suggests evolved crustal origins, with a Rb – Sr imprecise age of about 658 ± 20 Ma. Laser ablation ICP-MS U-Pb zircon dating yields crystallization ages of 737.1 ± 2.9 Ma and 730.1 ± 3.0 Ma, indicating emplacement between 730 and 740 Ma, followed thermal diffusion of Rb and Sr in the rock at about 660 Ma. These ages and compositional features align with the Tonian intraplate (alkaline and carbonatite) magmatism in southern Africa and support for a thermal event linked to Rodinia's breakup, preceding development of the Mozambique Belt.

‘LOST RICHES BENEATH OUR FEET’: STRUCTURAL CONTROLS ON MINERALIZATION FROM MISSED TARGETS TO MODEL-DRIVEN DISCOVERIES

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Global occurrences of economical mineral resources such as gold, copper, tanzanite etc. are largely controlled by geological structures such as boudinage, fractures, veins, folds, faults, shear zones and crustal-scale architecture. Alternatively, a combination of all these structures may form geological patterns/geometries which define a 3D - mineralisation trend. Besides the success story of frequent mineral discovery found in structures such as folds, veins etc. a significant portion of global mineral targets ends in exploration failures. Notable success cases include, the occurrence of tanzanite specifically within boudinage in graphite-bearing gneisses along tight folds, an occurrence that was effectively ‘blind’ during the early stages of exploration until the structural model was understood and keep refining to the present day. Among many other geological reasons, the failure cases may result from poor delineation of ore zones due to misinterpretation, dearth of relevant field data, inadequate understanding of structural framework and application of key principles. This oversight has resulted in missed exploration targets, underestimation of mineral potential, and premature cessation of otherwise viable targets.

Here various failure and success cases related to structural geology are demonstrated whereby a robust advanced structural analysis workflow has

been deployed— analyze 3D orientation (stereonet analysis), strain mapping, kinematic prediction, geometric and evolution modeling. Such understanding aims to optimize mineral exploration targets and improve resource development, i.e. unraveling the structural controls and provide valuable insights into geometrical extent of mineralisation. The findings advocate for a paradigm shift in exploration strategy at all levels from junior explorers to giant miners. An exploration that prioritises structural geology as a core competency rather than a supporting tool towards achieving more sustainable, cost-effective, and scientifically robust exploration outcomes hence overturning the previous “no-go” interpretations.

TECHNOLOGICAL INNOVATIONS IN THE EXPLORATION OF COBALT-RICH FERROMANGANESE CRUSTS IN THE PACIFIC OCEAN: ADVANCING RESPONSIBLE SEABED MINING

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The global demand for critical minerals such as cobalt, nickel, and rare earth elements is rapidly increasing in support of the transition toward clean energy. Among the promising marine sources of these strategic metals are cobalt-rich ferromanganese crusts (CRCs) found on seamounts, ridges and plateaus across the Pacific Ocean. In response to this demand, Japan has taken a leading role in advancing deep-sea mineral exploration through the use of cutting-edge technologies and sustainable practices. This study presents findings and experiences from the 2025 International Seabed Authority - Japan Organization for Metal and Energy Security (ISA–JOGMEC) at-sea training program conducted in the Pacific Ocean, which integrated Japanese marine exploration technologies with environmentally responsible practices. Field investigations were conducted aboard the research vessel Hakurei across Takuyo in Exclusive Economic Zone (EEZ) and Areas Beyond National Jurisdiction (ABNJ) seamounts using cutting-edge geophysical and geological tools. Technologies such as the Multi-Beam Echo Sounder (MBES) and Expendable Bathythermograph (XBT) were used for seabed mapping and site selection. The Benthic Multicoring System-C (BMS-C) and Remotely Operating Vehicle was used for drilling and precise core sampling. Magnetometer and X-ray Fluorescence (XRF) coupled with

geological logging on board were done to characterise the cores in terms of crust morphology, texture, and metal content. Complementary training modules on Volcanogenic Massive Sulphides demonstrated Japan's strong emphasis on sustainable seabed exploration and mining. The findings highlight the technological innovation and environmental responsibility needed for Tanzania, presenting the importance of international collaboration and the application of advanced exploration technologies to ensure that seabed mineral development proceeds within the framework of scientific integrity, environmental protection, and equitable benefit sharing.

CRITICAL MINERALS AS THE BACKBONE OF THE ENERGY TRANSITION: CHALLENGES AND STRATEGIC ROLE OF THE GEOLOGICAL SURVEY OF TANZANIA (GST) FOR SUSTAINABLE ENERGY TRANSITION

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Transitioning from fossil fuels to low-carbon energy systems presents a major materials challenge. Technologies such as solar panels, wind turbines, batteries, and EVs require specialized minerals. These minerals, often referred to as critical minerals, are essential for enabling decarbonisation. Secure supply, responsible sourcing, and strategic management of these resources are therefore vital. Critical minerals commonly required by the energy transition include lithium, cobalt, nickel, copper, rare earth elements (REE), graphite, manganese, vanadium, and certain platinum-group elements. Each has a distinct role: lithium, graphite and nickel are key components in different lithium-ion battery chemistries; cobalt and manganese for stabilizing battery performance; copper for electricity generation and transmission (conductors, motors, cabling); nickel and vanadium in advanced battery and grid scale storage concepts; and REE in permanent magnets critical for wind turbines and electric motors. The combination of high demand growth, geographic concentration of supply, high-tech industries and strategic importance for national energy security has elevated these commodities to “critical” status in many countries’ policy frameworks.

Availability of critical minerals is very challenging due to supply chain vulnerability, technical and geological complexity, environmental and social concerns, infrastructure and financing gaps, value-chain bottlenecks. To realize the potential of critical minerals for Tanzania's sustainable development, GST should prioritize open geoscience, targeted surveys in promising terranes, and coordinated capacity building; publicly available, high-quality data will significantly reduce exploration costs and encourage responsible investors. Critical minerals serve as the backbone of the global energy transition. The Geological Survey of Tanzania stands at the forefront of this endeavour, guiding the nation through strategic exploration, responsible resource management, and technological innovation. By aligning mineral development with renewable energy goals, Tanzania can ensure a resilient, inclusive, and sustainable pathway toward a cleaner energy future.

BEYOND THE OBVIOUS: EXPLORING FOR UNCONVENTIONAL RARE EARTH RESOURCES OF TANZANIA

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The current global demand for Rare Earth Elements (REEs), is driven by the green energy transition and high-technology industries. In these industries, REE are heavily utilized in manufacturing of heat resistant permanent magnets (NdFeB and SmCo magnets), commonly employed in hybrid and electric vehicles, wind turbines, data storage drives, medical devices, and aerospace. This has amplified the demand of mid rare earth elements (MREE) and heavy rare earth elements (HREE) over the light rare earth elements (LREE), and made deposits enriched in these commodities highly sought.

Tanzania is endowed with alkaline carbonatite intrusions, some of which host world-class REE deposits. However, primary carbonatites and alkaline sources are dominated by LREE (La, Ce, Pr), and rarely are they enriched with the valuable MREE and HREE. This discussion aims to shade light into the unconventional REE sources in Tanzania, and their potential for MREE and HREE. The discussion highlights advantages and challenges of these unconventional targets and how they impact the environment and mining value chain in our country. The goal is to fuel exploration of these unconventional resources sustainably and therefore emplacing Tanzania in a profitable and competitive niche in the global mineral market.

MAPPING GEOLOGY FROM AEROMAGNETIC DATA: IMPLICATION FOR MINERAL EXPLORATION AND GEODYNAMIC SETTING

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Geophysical data (e.g., gravity, magnetic, radiometric, and electromagnetic) have been successfully used worldwide to map concealed geological structures important for mineral exploration and the geodynamic setting of a particular region. This study reviews the use of aeromagnetic data to gain insight into the litho-structural architecture relevant to mineral exploration and geodynamic settings.

Enhancement of aeromagnetic data using various mathematical transformations/filters enables mapping of different types of geological structures like faults, folds, shear zones, and magmatic intrusions. Mathematical transformation filters such as vertical and tilt derivatives, analytical signal, total horizontal derivative, together with methods that are used to deduce the depth to magnetic basement such as the Source Parameter Imaging (SPI™), Tilt-depth Method and Euler Deconvolution not only facilitate the mapping of magnetic sources and their depth extent but also help in understanding the structural framework of the study area, and identify potential zones of mineralisation and hydrocarbons.

Generating magnetic lineament maps showing geological structures, intrusions, and hydrothermal alteration zones plays a critical role in identifying basement structures, which act as conduits transporting mineralised fluids during magmatic or hydrothermal processes. Hence, it is

important to understand the spatial relationship/distribution of these structures with ore deposits.

GEOTHERMAL RESOURCE ASSESSMENT OF RIFT BASINS OF THE EAST AFRICA RIFT SYSTEM IN SW TANZANIA

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In this study, the geothermal resource potential of southwestern Tanzania is assessed by integrating a 3D model of the upper crust, constructed from seismic, geological, and gravity data, with the updated thermal model constrained by deep crustal and basin properties. Utilizing an advanced quantitative techno-economic assessment method from the LEAP_RE Geothermal Atlas 4 Africa, the analysis evaluates the potential for direct heat utilization, cooling, and power production. The findings indicate significant geothermal potential, with direct heating capacities of up to 45 MW. Regarding the potential for geothermal cooling, the RVP offers more than 9 MW. The electricity generation potential is modest, with most basins indicating less than 2 MW, except for the RVP, which can reach up to 8 MW. The estimated levelized cost of energy (LCOE) for direct heating and chilling are notably lower, especially in the RVP, with heating costs mostly under 5 $ct/kWh. Conversely, LCOE for electricity generation is higher, ranging from 25 to 30 $ct/kWh in Rukwa, under 5 $ct/kWh in Songwe, and 10 to 15 $ct/kWh in RVP. These findings indicate that direct heating and chilling have the highest potential and are cost-effective in most RVP and

Songwe Basin areas. In contrast, electricity generation is the best option in the RVP, particularly in the Kyela, Isuba Mateba, and Tukuyu regions.

THE IMPORTANCE OF PROVEN MATERIAL IN INDUSTRIAL MINERAL ORE RESERVES: A CASE STUDY OF THE EPANKO GRAPHITE PROJECT, TANZANIA

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Several of the minerals featured on critical minerals lists published by Australia, the European Commission and the United States of America happen to be what the JORC Code regards as industrial minerals. Industrial minerals are those whose variable physical specification dictates its potential uses and thus its value. With graphite, much of the value lies with its flake size, which helps establish its suitability for different applications, for example, as a refractory (large flake) or battery anode (fine flake) material. The importance of physical specifications in industrial minerals can determine whether a deposit is economically viable, hence the requirement to consider these, along with other modifying factors whilst classifying an ore reserve.

Given the reliance on an ore reserve when determining the economics of a project, the authors of this paper consider that, for industrial minerals a minimum portion of reserves must be proven and as such defined within the JORC Code. This would help prevent companies which hold industrial mineral deposits, with unfavourable physical specifications for the minerals, from misleading investors into the viability of a project. This becomes of

greater significance when considering the elevated level of importance that Modifying Factors are anticipated to have in the forthcoming update to the JORC Code.

This paper takes the Epanko Graphite Project in Tanzania as a case study, where 82% of its total ore reserve is classified as proven, partially dictated by the strong understanding of the metallurgy, physical properties and marketability of the ore and product, which has been established over the past 12 years.

Analysis was completed on 19 major, publicly listed graphite deposits, of which 15 had declared a reserve. Results of which demonstrate significant variation amongst peers. At 82%, Epanko is the only deposit globally with a proven proportion of reserve greater than 75%, and one of only two greater than 50%. Of the 15 deposits with reserves, five contained 0% proven, and therefore all material classified as probable, with one of these deposits already in production.

UPCOMING MNAZI BAY AND NTORYA DRILLING: STRENGTHENING TANZANIA'S NATURAL GAS SUPPLY

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Tanzania has experienced notable growth in power generation driven among others by hydro and natural gas. Prior to the commissioning of the Julius Nyerere Hydropower Project, natural gas was the main contributor in the energy mix. Currently the country's energy mix stands at 61.45% water, 36.65% natural gas, and 1.9% other sources. Power generation remains the largest user at 85.41% of the total produced natural gas. However, the natural gas demand continues to rise internally across industries, CNG vehicles, households, institutions and the regional markets. Furthermore, in line with the National Development Vision 2050, targeting an economy with 70 GW capacity of power generation, Tanzania aims to explore its potential and sustainably exploit existing petroleum resources, including in established fields such as in Mnazi Bay and Ntorya. This study evaluates the expected contribution of the upcoming drilling activities in Mnazi Bay and Ntorya gas fields to the national energy supply.

The forthcoming drilling operations will be among the most extensive since Ndovu's 2017 drilling campaigns for Ntorya-1 and Ntorya-2 wells in the Ruvuma Block and Equinor's 2018 drilling operations for Pilipili-1 wells in Block 2. Maurel and Prom (M&P) Exploration Production Tanzania Limited, the operator of Mnazi Bay Block, is preparing to launch a drilling campaign for three (3) wells in December, 2025 aimed at enhancing production and

extending the field's output capacity. Similarly, ARA Petroleum Tanzania Limited, the operator of the Ntorya gas field, is preparing to drill the Chikumbi-1 exploration well in 2026. Upon successful drilling and testing of wells at Mnazi Bay and Ntorya, and bringing them on stream, the wells are expected to incrementally contribute up to 200 mmscfd of natural gas production.

These drilling initiatives are strategically aligned with Tanzania’s goals to increase domestic natural gas supply through the National Natural Gas Infrastructure. The increase of natural gas production is expected to directly support the national grid and drive industrial growth, as well as campaigns that reflect Tanzania’s broader commitment to leveraging natural gas as a transitional fuel in its shift toward a more sustainable and diversified energy mix.

POTENTIAL RESERVOIR UNITS FOR HELIUM ACCUMULATION ACROSS THE CRETACEOUS TO QUATERNARY STRATIGRAPHY OF RUKWA RIFT BASIN, SOUTHWESTERN TANZANIA

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The Rukwa Rift Basin has recently witnessed increased exploration activity for Helium, leading to the discovery of Helium levels up to 10.6% in gas samples from natural gas seeps. While exploration is ongoing to identify potential targets and estimate reserves, little is known about reservoir units across the rift stratigraphy. The basin is characterized by three mega depositional units: the Karoo Supergroup, the Red Sandstone Group (RSG), and the Lake Beds Group (LBG). This study compiled existing data based on our recent publications on what is currently known regarding the reservoir and seal properties of Cretaceous to Quaternary stratigraphic units comprising the aforementioned RSG and LBG strata within the basin. In addition, we have conducted a battery of new petrographic, geochemical, and geochronological analyses to fill in key gaps and address a series of focused questions centered around the characterization of reservoir and seal properties in the rift basin. For the RSG, the results reveal that there is a very good opportunity for stacked pay that takes advantage of good reservoirs at the top of the Cretaceous Galula Formation and in the mid-upper Utengule Formation, both of which are capped by thick, nearly pure smectite bentonite

intervals that are likely the best seal units in the basin. For the LBG, the results indicate that tuffaceous siltstone and sandstone units have very high porosity and permeability and are expected to represent excellent reservoirs. Siliciclastic-dominated sandstones have far lower porosities and permeability. Seal potential in the Upper Lake Beds is uncertain, and we suggest that the best seal units are likely the siliciclastic-dominated fine-grained facies that developed and expanded during the volcanic periods in the basin. The identification of these potential reservoir and seal units across the Rukwa Rift Basin stratigraphy will most likely support a more focused exploration strategy for Helium accumulation in the Rukwa Rift Basin.

FACIES ANALYSIS AND DEPOSITIONAL ENVIRONMENTS OF THE LOWER KAROO-EQUIVALENT BEDS IN THE TANGA BASIN, NORTHERN COASTAL TANZANIA

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Detailed field mapping along with sedimentological descriptions has been used to characterise the Umba deposit in the Tanga Basin, in northern Tanzania, providing a better understanding of characteristic facies, facies associations, and depositional environments. Facies, facies associations and the depositional environments through which these deposits were laid down have been poorly understood. Fifteen sedimentary facies and seven facies associations (FA1-FA7) have been identified. They include thick, poorly bedded diamictite (FA1); thick, massive, homogeneous diamictite (FA2); dropstone-bearing, lenticular, ripped to laminated sandstone (FA3); lenticular to sub-horizontal sandstone (FA4); horizontally stratified wavy sandstone (FA5); tabular beds of sandstone, siltstone, and mudstone (FA6) and carbonate deposit (FA7). Based on the sedimentological features and regional correlation to the Ruhuhu basin of Tanzania and the Dwyka Group of the South African Karoo Basin, the identified sediments are interpreted to have been deposited mainly in low relief and extensive peneplain glaciofluvial-lacustrine settings with subordinate subglacial till (FA1 and FA2), proglacial braided river channels (FA3), and delta front environments. The delta front environment is characterised by a distributary channel (FA4), a subaqueous levee (FA5), a distal bar (FA6), and an overbank deposit

(FA7). This study provides new insights into the deposition of the Lower Karoo-equivalent rocks, both at the local and regional levels.

GEOCHEMICAL CHARACTERISATION OF THE CENOMANIAN–CAMPANIAN RED SANDSTONE GROUP OF THE RUKWA BASIN, SW TANZANIA: IMPLICATIONS FOR PROVENANCE, PALEOCLIMATE AND PALEO-REDOX CONDITIONS

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Major, trace, and rare earth element (REE) compositions were carried out for the Red Sandstone Group of the Rukwa Basin, SW Tanzania in order to assess the nature of the source rocks, paleo-weathering intensities, paleoclimate and paleo-redox conditions. This research is the first of its kind in the basin and it is expected to broaden the database of the Red Sandstone Group whose previous investigations hinged on sedimentology. In interpreting the obtained trace element data, it was assumed that elemental ratios such as La/Sc, Th/Sc, Cr/Th, Th/Co, La/Co and REE in the detrital silicate fraction of the samples behaved as a closed system during weathering, transportation and eventual deposition in the basin. Shales from all the Red Sandstone Group show similar patterns in the primitive mantle normalized diagrams. However, notable depletions characterize the Ba and Sr abundances, while Rb and Th contents are significantly elevated relative to adjacent elements. The shales are characterized by enrichments of the light rare earth element [$(La/Yb)_{CN}$ range 8.18–27.761; average = 13.699; CN stands for chondrite normalized] and relatively flat heavy rare earth element (HREE; $(Gb/Yb)_{CN}$ = range 1.115–2.958; average = 1.723) coupled with negative Eu anomalies (Eu* average = 0.76). Such features are similar to

those of the Post-Archean Australian Shale (PAAS). Overall, this points to a felsic Upper Crust Continental protolith for the Red Sandstone Group rocks. Furthermore, the trace element ratios of La/Sc, Th/Sc, Y/Ni, Cr/Th, and Th/Co indicate a more felsic source than that for the Upper Crust Compositions and PAAS. Discriminant diagrams of Co/Th versus (vs) La/Sc and Cr/V vs Y/Ni enabled to make inferences of source rocks to be the meta-anorthosites of the Ubendian Belt and Cratonic granites around and to the NE of the basin. The calculated Chemical Indices of Alteration (CIA) indicate mainly intermediate magnitudes, suggesting sporadic variations of climates. Considerations on Al/Na and CIA values point to prevalent warm-humid climates during the deposition of the Red Sandstone Group rocks. On the other hand, V/(V + Ni), V/Cr, Ni/Co, and calculated Mn* values (Mn* = log [(Mnsample/Mnshales)/(Fesample/Feshales)]); redox proxy parameters demonstrate an overall well oxygenated/oxic environment when the sediments were deposited in the Rukwa Basin during the geologic past. Integrated geochemical proxies are essential to improve our understanding of geological surface processes in the natural environment and can be used to constrain their effect from other factors controlling sediment composition.

UNESCO GLOBAL GEOPARKS AND GEOTOURISM AS DRIVERS FOR SUSTAINABLE DEVELOPMENT IN AFRICA: A CASE STUDY OF NGORONGORO LENGAI UGGp, TANZANIA

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The UNESCO Global Geopark is the most recent UNESCO site designation. UNESCO's work with geoparks began in 2001. On 17 November 2015, the UNESCO Global Geopark label was ratified by the 195 Member States during the 38th General Conference of the Organization. At present, there are 229 UNESCO Global Geoparks in 50 countries; only 2 are from Africa, irrespective of Africa's spectacular and diverse geological heritages of international significance. In 2018, Tanzania through the Ngorongoro Conservation Area Authority, received the UNESCO Global Geopark status "Ngorongoro-Lengai UNESCO Global Geopark" as the first geopark in the country and in Africa south of the Sahara. Despite the fact that Tanzania is endowed with diverse geological sites of all ages and contexts with high international significance the concept of geopark is not well known. This contribution aims to highlight the key factors for the low number of UNESCO Global Geoparks in Africa, including Tanzania and raising awareness about the importance of geopark and geotourism and their significance in promoting geological heritage protection, while enhancing local sustainable development.

The experience showed that working in collaboration with the community can be mutually beneficial and rewarding. The benefits include opportunities

to empower the community to conserve and protect geosites that are associated with their own beliefs and other sacred meanings at geopark territory and to exchange more effective preservation strategies, information about local technologies, as well as the sustainable use of the geoheritage sites.

MODELLING GROUNDWATER RESOURCES OF THE STAMPRIET TRANSBOUNDARY AQUIFER SYSTEM (STAS)

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Stampriet Transboundary Aquifer System (STAS) is a large sedimentary basin with an area of 157,366 km2 located in Southern Africa. The STAS covers three countries: Namibia, Botswana, and South Africa. The basin has a semi-arid climate and is characterised by low rainfall, high potential evapotranspiration, and a thick unsaturated zone, mainly composed of Kalahari sand. The STAS has three main aquifers, including Kalahari, Auob, and Nossob, which are all important for providing water for social, economic, and environmental use. The presence of large trees and tall grasses in the STAS, as well as the invasion of new tree species such as Prosopis glandulosa, mostly located along the river valleys, has a negative impact on groundwater resources. These vegetation species affect the groundwater recharge in the STAS by intercepting rainfall, hence reducing infiltration. Moreover, the presence of large trees affects the net recharge of the STAS through direct uptake of groundwater by a system of deep roots. This research, novel in its application, aimed to quantify rainfall interception loss in the STAS area, and the spatiotemporal net recharge and groundwater resources, applying an integrated hydrological model (IHM).

The spatio-temporal variability of the rainfall interception loss in the STAS area was carried out by applying the Revised Gash Model (RGM) with the help of in situ and remote sensing data. The MODFLOW 6 numerical code was used to develop the IHM using the ModelMuse graphical user interface.

The daily effective precipitation and effective potential evapotranspiration were estimated with the help of rainfall interception loss and used as driving force inputs of the model. The IHM was calibrated in transient mode within the period of 4 hydrological years (2003-2006) under the daily stress period, whereby piezometric heads observations were used as calibration state variables. From the IHM, the daily and annual spatio-temporal variability of water fluxes in the STAS for the period of 4 years (hydrological years) was quantified.

In proportion to STAS rainfall, the mean-annual rainfall interception loss in the STAS was 4.84% of the mean-annual average precipitation (269.96 mm). The water balance (WB) of the STAS for the whole period of simulation and for each year was developed. The evapotranspiration from the unsaturated zone and the groundwater evapotranspiration are the most influential components of the WB. Groundwater evapotranspiration was the main output of the saturated zone and mainly occurred along the river valley as a result of large trees' groundwater pumping from the aquifers. The gross recharge of the STAS was small, hence the net recharge was mostly controlled by groundwater evapotranspiration. In the simulated years, the STAS net recharge was consistently negative, ranging from -26.04 mm year-1 during the driest year 2003 with rainfall of 181.57 mm year-1, to -15.09 mm year-1 during the wettest year 2006 with rainfall of 383.59 mm year-1. The consistently negative net recharge makes the STAS unsustainable.

TRANSBOUNDARY WATER MANAGEMENT IN TANZANIA: EXPLORING BENEFITS AND CHALLENGES

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According to the United Nations (UN Water 2019), there are more than 286 internationally shared watercourses in the world that connect more than one country, and more than 145 countries have water sources that cross their borders. Management of transboundary water resources is paramount to ensure shared use of watershed resources and to eliminate conflicts and disputes. For instance, between 1948 and 2015, there has been approximately 37 registered conflicts and disputes in the use of transboundary waters worldwide. Therefore, in order to strengthen the shared use of watershed resources and eliminate conflicts and disputes, a total of 295 worldwide Cooperation Agreements on the management, use and development of transboundary water resources have been negotiated and signed between the countries globally. Tanzania is the only country in Africa with multiple watersheds shared with other countries. Approximately 43.3 per cent of the country's water resources are transboundary. Therefore, the topic of how the country manages transboundary water resources is an important area of policy debate. This paper extends the discourse by elaborating further on the benefits and challenges encountered so far.

BRIDGING THE GAP: INTEGRATING IMPLICIT AND MACHINE LEARNING MODELLING IN MINERAL RESOURCE ESTIMATION

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Recent advances in geoscientific data acquisition and computational modelling have led to debate on the role of machine learning (ML) in geological interpretation. Specifically, whether ML can replace traditional implicit modelling or complement it to improve subsurface understanding. Implicit modelling remains a robust method for constructing 3D geological frameworks. It converts sparse datasets, including drillholes and field mapping, into continuous surfaces guided by structural, stratigraphic, and domain knowledge. Its primary strength is interpretability and geologically coherent outcomes. Machine learning offers data-driven capabilities to identify complex, nonlinear patterns across diverse datasets such as geochemistry, geophysics, and remote sensing. However, unconstrained ML models may lack geological plausibility, producing results that are difficult to interpret or validate. This study proposes a hybrid approach, combining ML with implicit modelling. ML enhances efficiency by automating lithological classification, domain identification, and predictive interpolation, while implicit modelling maintains geological control and ensures structural consistency. The integration of domain knowledge with computational intelligence enables faster, more objective, and geologically consistent interpretations. This approach reduces uncertainty, improves decision-making, and supports effective mineral exploration and resource evaluation.

MAGMATIC HISTORY AND PETROGENESIS OF THE HOST ROCKS WITHIN THE NEW LUIKA GOLD MINE AND ITS SURROUNDING PROSPECTS, LUPA GOLD FIELD, SOUTH-WESTERN TANZANIA

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We investigated host rocks of the New Luika Gold Mine and Mbangala prospects (Luika area) in the Lupa terrane of South-western Tanzania to constrain their petrology, geochemistry, and age, and relate them to the terrane's evolution. The Luika area is dominated by three main magmatic units: gabbro, potassic granite, and granodiorite, which are intruded by pegmatites, aplites and doleritic dikes. The potassic granite is the oldest unit in the area ($^{207}Pb/^{206}Pb$ zircon age of 2078 ± 23 Ma), and occur as weakly metamorphosed, unfoliated units, high in SiO_2, with fractionated REE patterns and negative Eu anomalies. The granite was intruded by gabbro at 2041±14 Ma (apatite U-Pb age). The gabbro consists of pyroxenes, amphiboles, and plagioclase, and exhibit high Mg number (Mg# = 70), weak positive Eu anomaly (Eu/Eu* mean = 1.07), a slightly fractionated REE patterns (La/Yb_{CN} 2.07 – 7.49) and depletion in HFSE (Nb, Zr, Hf), Pb, and P relative to chondrite. The granodiorite emplacement occurred at 1959 ± 17 Ma ($^{207}Pb/^{206}Pb$ zircon age), and its crystallisation was followed by the intrusion of pegmatites at 1923 ± 17 Ma. Collectively, the Luika magmatic

rocks record two main Paleoproterozoic magmatic events at 2070 - 2040 Ma and 1960 - 1920 Ma, within a continental arc environment. These results are consistent with other studies that portray the Lupa terrane as an active continental margin during the Paleoproterozoic Ubendian orogeny. Our results further extend the onset of Paleoproterozoic magmatism in the Lupa terrane by 110 Ma earlier than previously recognised, consistent with the broader tectono-magmatic history of the Ubendian Belt.

APPLICATION OF THE MAGNETOTELLURIC METHOD IN ASSESSING SUBSURFACE RESISTIVITY VARIATIONS WITHIN THE GEOTHERMAL RESERVOIR AT THE KIEJOMBAKA PROSPECT

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The Kiejombaka geothermal prospect in Tanzania is located in the Rungwe volcanic province, close to the Rukwa, Usangu, and Karonga triple junction, on the eastern edge of the late Miocene Karonga rift basin. The Mbaka Fault, which dips SW and trends NW, limits the uplifted and outcropping block of Precambrian gneiss basement that characterizes the Kiejombaka area to the southwest direction.

The magnetotelluric (MT) method is passive surface measurement of the Earth's natural electric field and magnetic field in orthogonal directions. This study employs the use of the MT method to assess the subsurface resistivity changes in geothermal reservoirs at Kiejombaka prospect. The results obtained include the 2D resistivity model that shows the lateral and horizontal resistivity changes due to the complex subsurface with distinct geologic units of the area.

A combined 2D resistivity model together with geological study of the Kiejombaka geothermal prospect reveals a potential high-temperature geothermal system with important surface and subsurface indicators like hot springs, hydrothermal alteration with clay caps rocks, faults which provide a

clear and reliable guide for deeper reservoir targeting, lowering project risk and acceleration to the successful harvesting of geothermal energy.

This study has shown how advanced geophysical techniques can help identify and harness clean, renewable geothermal energy resources. This contributes to sustainable energy solutions to reduce reliance on fossil fuels, and promotes responsible exploration of Africa’s rich geological potential.

SYSTEM DESIGN FOR MINIMISATION OF GASOLINE VAPOUR EMISSIONS FROM STORAGE TANKS: A CASE STUDY OF TIPER, TANZANIA

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This study was focused on the system design for minimization of gasoline vapor emission from storage tanks of TIPER, Tanzania, to the atmosphere. The gasoline stored at TIPER was characterised by analysing physical parameters such as density, viscosity and vapour pressure, which were utilised for estimating evaporation rate. Other parameters, such as working losses and temperature, were estimated in sizing the adsorber. The system that was designed consisted of a storage tank, a globe valve, and an adsorber. The capacity of the fixed storage tank S4, which was 17000 m³, was used as a basis. A water jacket was designed to cool the storage tank to 25℃. SuperPro Designer version 10 was used to imitate the system by injecting gasoline at various temperatures. The globe valve size was 2 inches. This valve was utilised to regulate the inlet vapour pressure of the packed bed adsorber. The adsorber was used to trap hydrocarbon vapours. The performance of the adsorber to trap hydrocarbons was 97.77% at an adsorption rate of 38.925 m^3/month. If the companies that store gasoline use the designed adsorber, it may simplify compliance with local (TBS) and international (ISO) emission standards.

NATURAL GAS AND LIQUIDS PRODUCTION FORECASTING USING MACHINE LEARNING: A CASE STUDY AT FIELD 'Z', TANZANIA

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This study involves application of machine learning (ML) techniques to enhance natural gas field production forecasting at field 'Z' in Tanzania, which currently operates with software that relies on conventional techniques (MBAL). Moreover, many other petroleum fields employ the use of conventional methods such as decline curve analysis and reservoir simulation in running production forecasting. These traditional methods embedded in software often involve simplifying assumptions, are time-consuming and costly. By contrast, ML offers the advantage of learning directly from data, potentially uncovering complex patterns that traditional methods might miss, require less cost (CAPEX and OPEX) and require less time.

This data-driven approach aims to improve the accuracy and efficiency of production forecasts, which utilize historical production data, reservoir characteristics and operational parameters from five (5) producing wells to train artificial neural network (ANN) and support vector machine (SVM) models for gas production prediction and produced liquids prediction respectively.

Methodologies used to achieve the objective of this project involved important steps including python libraries calling, data importation,

exploratory data analysis (EDA), normalization of the data, feature engineering, data partition to train and test sets, ML algorithms calling, training and validating and eventually making prediction data partition. Important performance evaluation metrics (i.e. R2, MAE, MSE and RMSE) were evaluated to assess models' performance from the actual dataset and the predicted values.

Models' performance results (both ANN and SVM) in terms of R2 were in range of about 85 to 98%, while exceptionally R2 for one well showed a less value of 61% due to less data compared to other wells and the whole field. The MAE, MSE and RMSE showed values less than 0.1791, 0.046 and 0.2144 respectively for all 5 wells gas prediction and liquids production.

Generally, from the models' performance evaluation metrics, both models were reliable as they showed greater accuracy in prediction (R2) when compared to the actual datasets. It was highly advised to employ these models in the fields resource forecasting and optimization. It was also recommended to compare these models with the conventional models to see which method works better than the other, which is the future plan of this work.

RESERVOIR MANAGEMENT VIA PHYSICS-INFORMED HYBRID AI: DUAL TARGET (2D) FORECASTING USING PG-RDI BLENDING INDEX AND ENSEMBLE FUSION

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This study presents a physics-balanced hybrid modelling approach for estimation of reservoir fluids (gas and condensate) production to bridge the gap between field operations and the changing technology environment in the oil and gas sector. The method embeds artificial intelligence algorithms XGBoost and Random Forest into a dual mixing structure controlled by a covariance based α index, which echoes the intrinsic pressure gradient and reservoir drive mechanisms. This physics-informed hybrid architecture adaptively balances linear ensemble predictions and nonlinear interactions, enabling accurate prediction in dynamic reservoir systems. Historical field data were pre-processed to correct inconsistencies, and feature extraction of production indices relevant to both upstream flow and subsurface conditions was conducted.

The model training pipeline was based on a forward validating modular framework, with performance metrics (RMSE, MAE, R^2) attesting to strong predictive reliability. Real operations testing yielded estimates that matched plant output measurements closely, attesting to the framework's deployment readiness and field credibility. A feedback loop pattern was instanced outside the main flow, invoked only when performance criteria were unmet. The adaptive routine residual error analysis, α logic refresh, and Optuna hyperparameter tuning facilitated retrials without full pipeline reset,

mimicking SCADA-driven field control systems and reducing computational burden. The system's capacity to blend model logic and physical domain knowledge reflects a core paradigm shift in predictive engineering where double and single blending mechanisms provide resilient forecasting through condensate-rich formations.

The outcomes confirm that physics-based AI has the potential to revolutionize production estimation workflows. Recommendations for future research include the application of the framework to multi-phase reservoir systems, the inclusion of real-time telemetry integration, and integrating it with downstream logistics software for intelligent fuel distribution. This research is a move toward practical digitalisation of the oil and gas sector, in which machine learning is harmonized with the reality of engineering to support sustainable energy operation.

NOT EVERY CHARCOPHILE NEEDS THE IP METHOD: IS IT A CONCERN FOR COPPER?

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In the midst of curiosity, to position Tanzania's Madini vision 2030 with the global demand for green energy and critical minerals, copper has been among the critical base metals prospected. Literature reports 'Dodoma-Handeni-Morogoro-Iringa-Mbeya' area as the most copper bearing geological setting, with some parts of Kabanga area included. This area is characterized by a complex geology that includes the Mozambique Belt, the Ubendian-Usagaran Belt, and part of the Archean Tanzania Craton. Despite the common flow of methodologies used for delineating hydrothermal alteration zones, which are ought to bear both disseminated and massive/porphyry copper ore deposits, there is still a failure to correlate geophysical magnetic and IP signatures with the geological formations.

Unfortunately, geophysical signatures of copper are dependent on host rock properties, ore minerals, nature of occurrence, deformation, triggers of fluid flow, and type of mineralisation controls/traps such as rock, vein, dyke, faults or folds. Among the ten (10) global classifications of copper deposits, Tanzania is particularly known for sediment-hosted, vein/structurally controlled, and shallow supergene/oxide types of copper mineralisation, as observed in Mpwapwa. This type differs from porphyry, massive, and disseminated types, which are well studied in terms of prospecting and can be more easily detected by concise integration of geology, magnetic, and IP

signatures. This is due to the strong surface polarization response employed by the IP method for both massive and disseminated sulphide. Tanzania's copper-bearing setting consists of a mixture of amphibolite facies, granitic gneisses, marbles, quartzites, schists, kyanite and graphite-bearing gneisses. Moving away from the Archean Tanzanian Craton, the grade of metamorphism increases, with granulite and marbles becoming more; conversely, moving toward the craton, the metamorphic grade decreases, and quartzites and amphibolites become more prominent. The deposits are usually small, structurally controlled, masked and hosted in metasedimentary units making it difficult for IP method to give clear anomaly/zone of ore deposits.

In this study, preliminary technical-exploration framework is utilized, which increases the efficiency of target generation by greater percentage. Host rock prospectivity through different tactics like buffering, magnetic structural index-scoring, and electromagnetic methods are showcased to discriminate potential copper deposits, with clear understanding on its nature, trend and continuity before further feasibility studies. The successful result is the implication to good utilization of geo-skills and cost minimization approach.

MACHINE LEARNING TECHNIQUE IN MINERAL EXPLORATION

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For a long time, mineral exploration has been conducted using different techniques such as geochemical and geophysical methods including magnetic and IP surveys. In addition to the geochemical and geophysical methods, machine learning techniques are very essential in interpreting the data from the current methods, and this helps in getting more confidence in the exploration field. The machine learning algorithms can automatically identify complex patterns, optimize target area selection, and predict mineral resource potential. This presentation proposes the adoption of machine learning (ML) techniques to enhance mineral exploration and prospect targeting for small-scale miners. Drawing on recent local studies- such as the gold prospecting mapping in central Tanzania using ensemble models, this work illustrates how ML based models can help identify promising zones for further exploration. Similarly, lithology classification using measurement while-drilling data hyperspectral imaging for ore/waste discrimination demonstrates potential for reducing exploration costs and improving targeting precision. Small-scale miners could benefit from ML tools by: (i) gathering affordable input data (e.g. geological maps, soil geochemistry, remote sensing data, field surveys data); (ii) selecting and training suitable ML models; and (iii) validating and interpreting results into field decision making. Implementation of ML-augment exploration could reduce wasted effort, lower environmental

impact, increase yield, and ultimately improve incomes and sustainability for small-scale in Tanzania.

TANZANIA BUREAU OF STANDARDS AND THE QUALITY INFRASTRUCTURE IN THE MINING SECTOR

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Tanzania Bureau of Standards (TBS) is the national standards body established by the government of Tanzania as part of the efforts to strengthen the support infrastructures for industry and commerce sectors within the country. The Bureau was established by Parliamentary Act No. 3 of 1975 and in 2009; it was repealed and replaced by the Standards Act No. 2 of 2009.

TBS is mandated to undertake all measures related to quality control of different products and to promote standardization working under the Ministry of industry and trade. To accomplish these goals, the bureau is mandated to implement the quality infrastructure by developing, approving and promoting Tanzanian standards (TZS), testing and certifying products for quality and safety, inspecting imported and locally manufactured goods for compliance, metrology services (calibration), quality assurance, training and awareness for industries and SMEs. Specifically in the mining sector, the bureau through its Mining section has developed about 235 standards related to the energy and mining sectors. The testing capabilities in these areas have also been established. The Tanzania Bureau of Standards (TBS) invites all stakeholders to participate in the development of the national standards and make use of the available quality infrastructures for sustainability in services and goods in the mining industry as well.

ASSESSMENT OF HYDROCARBON POTENTIAL IN THE MANDAWA BASIN

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The Mandawa Basin, located along the coastal region of Tanzania, is a geologically significant sedimentary basin with a history spanning from the Permian to the Tertiary periods. It comprises a thick sequence of both marine and non-marine sediments, including shales, sandstone, limestone, and evaporites. This study aims to evaluate the petroleum potential of the basin. The study specifically seeks to identify key petroleum system elements such as source rocks, reservoir rocks, traps and seals, as well as infer the geological processes critical to hydrocarbon generation, migration, and accumulation.

Structurally, the Mandawa basin is segmented into three zones: North, Central and South delineated by the Matandu and Mbwemkuru faults. Sedimentation began during the Triassic, as indicated by palynological data from the Mbuo and Nondwa formations. These units represent alluvial to lacustrine environments and contain organic-rich shales with hydrocarbon potential. Tectonic subsidence during the Late Triassic to Jurassic led to the accumulation of evaporites in the central parts of the basin, while paleo-highs remained exposed. A Middle Jurassic marine transgression deposited the Mtumbei and Mbaro formations, followed by extensive clastic input of the Kihuluhulu Formation of the Mavuji Group in the Late Jurassic to Early Cretaceous. From the Aptian to Paleogene, continued subsidence promoted

shelf marine deposition, culminating in the Nangurukuru, Kivinje, Masoko and Pande formations of the Kilwa Group.

In July 2025, PURA conducted field work on rock exposures along roadcuts, rivers/stream cuts, around hills, and through superficial soils. The field investigations across the basin revealed a diverse stratigraphic sequence comprising Neoproterozoic high-grade, coarse-grained quartz-feldspathic gneiss basement rocks displaying compositional banding, overlain by fossiliferous limestones and mudstones containing coral, belemnite, and ammonite fossils. Sandstone units were also observed, with medium to coarse grain size, moderate to well sorting, and planar and trough cross-bedding. Features such as amalgamated beds, mud clasts, and voids indicate dynamic depositional environments. Additionally, gypsum units with grey to dark coloration were observed, suggesting the presence of organic matter, bitumen, or hydrocarbon staining - valuable geochemical indicators of potential hydrocarbon systems.

The Mandawa Basin presents a promising petroleum system, shaped by its prolonged depositional history, tectonic evolution, and stratigraphic diversity. Field observations confirm the presence of key petroleum system elements, including organic-rich mudstone at Nondwa, which presents a strong candidate for potential source rocks; fossiliferous limestones and sandstones of the Mtumbei Formation as reservoirs; and evaporites and mudstones widely distributed in the central part of the basin acting as effective seals. Structural features such as faults and folds provide potential traps, while sedimentary and facies evidence support hydrocarbon generation and migration. This paper highlights findings that indicate the Mandawa Basin’s strong hydrocarbon potential. However, geochemical analysis of the

source rocks is required to determine their maturity and hydrocarbon expulsion potential.

SOURCE ROCK EVALUATION AND 1D BASIN MODELLING IN THE RUVUMA BASIN, SOUTHEAST TANZANIA

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Source rock evaluation and basin modelling play an important role in understanding hydrocarbon potential in any sedimentary basin. Currently, there is limited research focusing on source potential in the sediments of Ruvuma Basin; most studies rely on a few samples. As a result, the variability in organic matter types and quality with respect to basin evolution has not been well constrained. In an effort to better understand the source rock potential in the Ruvuma Basin, this study was carried out using geochemical analysis of cutting samples (n=48) along with 1D Basin Modeling performed by PetroMod (Version 2012) across stratigraphy in Lukuledi well -1 including Karoo and Mtumbei formations. Geochemical analyses reveal that both organic matter content and quality vary across stratigraphy. The organic richness in the sediments of the Mtumbei Formation fluctuates from 0.05 wt% to 0.14 wt%, with an average of 0.08 wt%. In the sediments of the Karoo Formation, TOC values fluctuate along stratigraphy as follows: in the upper part, TOC values range from 0.23 wt% to 2.79 wt%, with an average of 0.85 wt%; in the middle part, they range from 0.23 wt% to 7.53 wt%, with an average of 2.35 wt%; and in the lower part, they range from 0.4 wt% to 78.74 wt%, with an average of 24.08 wt%. This variability indicates varying hydrocarbon generating capabilities. The organic matter is exclusively made of kerogen types II and III, which has been subjected to a wide range of thermal alterations ranging from immature

to post mature (oil to gas prone). The burial history curve reveals that the sediments of Ruvuma Basin have undergone different tectonic phases, accompanied by seven major episodes of deposition, uplifting and erosion events from 293 Ma until recent times. The thermal maturity model agrees with rock pyrolysis data interpretation (Tmax, Vr%), both providing insight into the thermal evolution of the basin.

INTEGRATING ACTUAL MEASUREMENT AND ARTIFICIAL MODELLING IN MONITORING BLAST MOVEMENT AND THEIR IMPACT ON MINIMISING ORE DILUTION/LOSSES IN OPEN PIT MINING

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Blasting is the first stage of comminution in the mining process. It is carried out to reduce the size of rock and make material easier to transport, separate and process. In open pit mines, this invariably involves huge amounts of explosive energy which causes rock materials to be displaced from their original position. This movement is detrimental to the accurate delineation of the predefined ore and waste zones and could lead to ore loss and dilution if not accounted for.

At Geita Gold Mine, several stages of monitoring blast movement have been employed, this ranges from direct measurements such as the use of visual markers like pre-blast installed poly-pipes which are then located post blasting giving the displacement of material, and the ore/waste boundaries are adjusted accordingly. This method was prone to poor recovery as well as inability to measure displacement at depth. Blast movement monitors (BMM) manufactured and distributed by Blast Monitoring Technology (BMT) currently provide the most accurate method of blast-induced rock movement despite the cost of data acquisition and vector limitations.

In recent years, indirect determination of blast movement has been introduced using software and complicated simulation algorithms. This

method utilizes pre- and post- blast survey topographies, in-situ grade control model, blasting parameters and measured vectors to simulate using machine-learning approach producing post blast muck pile model. In this presentation, the importance of integrating indirect blast movement measurement models with direct measurement in minimizing ore loss/dilution is discussed.

GEOSCIENCES AND SUSTAINABLE DEVELOPMENT IN TANZANIA

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The United Nations has for years been putting benchmarks for its member countries to follow so as to ensure there is development to the nations and their people. In 2012, the United Nations in its conference on Sustainable Development in Rio de Janeiro put forward a proposal of sustainable development goals for the world replacing Millennium Development Goals that served a smaller scope (UNDP). The Sustainable Development Goals came in to bring solutions to various challenges in the areas of environment, economy and politics. There are 17 Sustainable Development Goals. Nearly every development sector is touched by one or more of the goals. Geosciences being the science that deals with Earth is also among those sectors. I will focus on five United Nations Sustainable Development Goals, namely; - No Poverty (SDG 1), Zero Hunger (SDG 2), Quality Education (SDG 4), Decent Work and Economic Growth (SDG 8) and Industry, and Innovation and Infrastructure (SDG 9). These goals have to a certain extent been attained by the contribution of Geosciences in the country. With proper management of natural resources, we can beat poverty, evict hunger, ensure quality education for our people, create decent work and good economic growth, and boost industry, innovation and infrastructure. We need to revamp our approach by transforming our governance structures, prioritizing patriotism, and eliminating wasteful government spending.

GST STATE-OF-THE-ART LABORATORY SERVICES

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The Geological Survey of Tanzania (GST) traces its origins to the Geological Survey Department (GSD), established in 1925 under British colonial administration with its headquarters in Dodoma. Initially focused on geological mapping and mineral exploration, the department maintained its core mandate through colonial and post-independence periods. In 2005, GST was reconstituted as a government agency to improve efficiency and attract investment in the mineral sector. Subsequent legal reforms, particularly the 2017 amendments to the Mining Act, transformed GST into a national institution with an expanded mandate, reinforcing its role in generating geoscientific data to support sustainable mineral resource development in Tanzania.

Established in 1926 as part of the Geological Survey Department (GSD), the predecessor of today's Geological Survey of Tanzania (GST), the GST Laboratory was initially created to support geological mapping, mineral identification, and geochemical analysis for early exploration activities in Tanganyika. Over the years, it has evolved into one of Tanzania's leading geoscientific facilities, offering comprehensive services in geochemistry, mineralogy, petrology, mineral processing, geotechnical analysis, and environmental monitoring, all supported by an ISO/IEC 17025-compliant Quality Assurance System. The laboratory's capabilities include chemical assays for major, trace, base, and precious elements, water and soil testing, and specialized petrophysics measurements such as magnetic susceptibility,

density, and conductivity. Equipped with modern instruments and robust data management systems, GST laboratories continue to provide high-quality analytical services that guide mineral discoveries, inform policy, support scientific research, and meet the needs of commercial clients, maintaining their historic role as a trusted source of geoscientific data for Tanzania's sustainable development.

Building on this legacy, GST is currently developing a state-of-the-art Geoscientific Laboratories at Kizota, Dodoma, and zonal laboratories in Chunya and Geita, which will house modern staff offices and advanced sections in geochemistry (AAS, XRF, SEM, ICP), petrology and mineralogy, geotechnical testing, metallurgy and mineral processing, environmental management, and sample preparation, while incorporating artificial intelligence to enhance efficiency and data interpretation. Strategically, GST plans to prioritize critical and strategic minerals to align with Tanzania's development goals and global demand, reinforcing its role as a hub for scientific research, industry services, and sustainable resource management.

Moreover, GST has grown from its early beginnings in 1925 into a modern institution providing accredited geoscientific services that support exploration, research, and sustainable mineral development. With the upcoming state-of-the art Geoscientific Laboratory at Kizota, Dodoma, GST is poised to expand its capabilities in geochemistry, petrology, mineralogy, geotechnics, metallurgy, environmental management, and critical mineral analysis, while integrating advanced technologies such as artificial intelligence. GST warmly welcomes all clients and partners— including small-scale miners, medium- and large-scale mining companies, researchers, contractor companies, and other related stakeholders — to collaborate and

make full use of its laboratory services in advancing geosciences and supporting Tanzania’s socio-economic growth.

AN APPARENTLY POORLY ENDOWED UNDEWA-ILANGALI GOLD PROVINCE: A PROXY TO NEW DISCOVERIES IN THE UNDER-EXPLORED BELTS SITUATED IN THE CENTRAL TANZANIA REGION, ARCHEAN TANZANIA CRATON

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The lack of new discoveries of large to giant gold deposits in the recent past has prompted some to suggest that Tanzania is mature or approaching maturity in terms of exploration. New tectonic-metallogenic subdivisions proposed in the recent past are used to demonstrate the potential existence of high-ranking belts prospective for large gold deposits in the Central Tanzania Region in the Archean Tanzania. The architecture of the craton is defined by first-order shear zones and faults bounding networks of anastomosing NW-SE to WNW-ESE-trending lithostructures, among which host to significant gold deposits.

At orogen scale, the Central Tanzania Region is comparable to the gold-hosting Southwest, Southern Cross and Murchison Gold Provinces in the Yilgarn Craton, Western Australia. In those provinces low-proportions of isolated juvenile granite-greenstone belts are confined by extensive ortho and paragneiss belts, in domains that are host to relatively large orogenic gold deposits, including Boddington, albeit a deformed porphyry Cu-Au system, Marvel Loch and Mount Magnet. Given similarities in geologic-geometric settings between these and greenstone belts in the Central Tanzania Region, potential exists for hosting significant orogenic gold systems in the Dodoma Basement Superterrane, Central Tanzania Region. In this superterrane, the

Undewa-Ilangali Terrane comprises greenschist-amphibolite facies, Mafulungu Metamorphic Belt, and Mazoka Greenstone Belt, which are host to significant small-scale orogenic gold systems, among others.

In the Mafulungu District, gold is hosted by shear-laminated veins with intra-foliated epidote, actinolite-tremolite and chlorite altered country rocks. Quartz veins of up to 50cm are restricted in relatively thin zones of shear-foliated dolerite schist and quartz-diorite gneisses. The primary gold-hosting lithostructures are restricted in mafic volcanic rocks, dolerite sills and quartz-diorite gneisses, bounded by the ~3.60 Ga fuchsite quartzite and diorite gneiss to the north and biotite-quartzo-feldspathic gneiss and syn- to late-kinematic biotite-granitoids to the south. Selected channel and grab rock samples from artisanal pits returned between 99 g/t Au over 3 cm vein quartz, 2.39 g/t Au across 2.2 m wide zone and 64 g/t Au from a 3.75 m wide shear-foliated mafic volcanic rock. These gold-in rocks gold assays are coincident with a 60-200 ppb Au in soil anomalies, and the best drill-intercepts of 7.2 m @ 13.44 g/t Au and 2.4 m @ 11.61 g/t Au, with a resource of 10t Au defined by Shanta Mining in 2006.

In the Mazoka Gold District strongly deformed basaltic to andesitic flows overlain by rhyolite and undifferentiated volcano-sedimentary rocks, pelitic-sedimentary rocks and BIFs, contain interleaves of shear-foliated zones, gossan and sulfidic chert. These greenstones are concordantly juxtaposed against felsic to ultramafic intrusive rocks and crosscut by NE-SW-trending cross-faults and felsic dykes. Mazoka Gold District comprises at least three major gold-hosting lithostructures, including: 1) shear-foliated to strongly mylonitic zones, with impregnations of quartz veins and stringers with over 10-15% disseminated/fracture-filling pyrite and arsenopyrite. Rock chip

samples from this shear zone returned 10g/t Au, whilst a shear-foliated and irregularly fractured laminated quartz veins/stringers in quartz diorite returned 1.95g/t Au; 2) impregnations of quartz stringers in shear-foliated biotite quartzo-feldspathic rock with >2.44 g/t Au; and 3) silicified and chlorite-altered shear zones with disseminated and fracture filling pyrite and pyrrhotite in porphyritic andesite hosting between 0.5 and 1g/t Au. These results overlap with a 50 to 500-m wide of 80-375-ppb Au in soil anomalies exposed intermittently for at least 9 km along strike.

ESTIMATION OF SUBSURFACE TEMPERATURE DISTRIBUTION OF SONGWE GEOTHERMAL FIELD BY NUMERICAL METHODS

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Subsurface temperature is the main parameter in sedimentary basins for geothermal energy prospection. In geothermal exploration and development, numerical modelling is essential to understand both regional and reservoir-scale processes. A numerical model is built simulating subsurface thermal processes in the Songwe Basin. In this approach, we assume exclusively conductive heat transfer, neglecting the role of fluids, an approach which is normally used to provide initial temperature distribution assessment in the subsurface, especially in the unexploited fields with neither well nor seismic data.

The study presents a reconstructed geological model with a deep structure, a realistic geometry that is essential for thermal modelling. In thermal modelling, we first simulate different 2D thermal models in order to get a preliminary understanding of temperature profiles over the subsurface and identify thermal anomalies in the area. We then simulate a 3D thermal model to observe the temperature distribution over the whole volume. That way, we observe variations in temperature distribution along the fault strike and

related to the position of sedimentary bodies. We also performed a sensitivity study to account for the uncertainty of selected thermal parameters, which are thermal conductivity and heat flow.

LATE CRETACEOUS PALYNOLOGICAL DYNAMICS BASED ON QUANTITATIVE ANALYSIS OF PALYNOMORPHS AND IT'S IMPLICATIONS FOR HYDROCARBON POTENTIAL

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A quantitative analysis of the palynomorphs from the TDP Core samples sites 21 and 24 from Lindi Region, Southern Costal of Tanzania, was conducted to describe the temporal changes in palynomorphs in rocks in order to identify factors that cause the palynological changes of palynomorphs from selected core samples. Palynofacies analysis was also undertaken to analyse the trend of depositional environments. The Late Cretaceous sediments that are found in Southern Coastal Tanzania are rich in palynological and palaeobotanical remains. The selected core samples yielded abundant well preserved marine and terrestrial palynomorphs with very few barren samples. One hundred and twelve species were identified and systematically described. These include 35 species of dinoflagellate assigned to 22 genera, 49 pollen grains of both gymnosperm and angiosperm accommodated in 31 genera, and 28 species of spores were placed in 21 genera. In addition, a single species of Chlorophycophyten algae, two species of Prasinophyta algae, Foraminifera test linings, and various fungal fruitifications were observed. The palynomorph assemblages were used in a palynostratigraphic age assignment based on comparisons with previously developed biozones for the Late Cretaceous of Gondwana. Further on palynological analysis of sediments was found to be rich in a mixture of the palynofloral remains of ferns, conifers, dinocysts and fungal fruitifications.

The TDP site 21 assemblages are dominated by low abundances of both terrestrial and marine polymorphs. In contrast, the TDP site 24 assemblages are dominated by far spores and contain an abundance of pollen and dinoflagellate cysts, including megaspores and microspores, as well as a high proportion of Angiosperm pollen. The species from recovered fossils and sporomorph vary according to lithology. For example, the species Cyathidites minor were mostly abundant in siltstones. There are many factors contributing to the temporal changes in the vegetation and palynomorph composition during the Late Cretaceous period, and some of them includes long-term depositional changes, whereby the temporal changes in pollen/spores and dinoflagellates cysts fossil were due to shifts in deposition and vegetation over time. The depositional environment is controlled by the surrounding parent vegetation, which in turn influences the number of pollen/spores and plant fossils in the area. This study indicates that the variation in sporomorphs is related to lithological changes within the rock layers; for example, the claystone beds were found to contain a higher number of plant sporomorphs than the siltstones. In conclusion, the Late Cretaceous palynological dynamics in the study area, based on the quantitative analysis of palynomorphs, indicate differences in sporomorph composition resulting from changes in depositional environments, potential climate variations, and other ecological factors. Palynofacies analysis was also carried out and used to reconstruct the palaeoenvironment, revealing deltaic or shallow-marine to open-marine depositional settings. The thermal maturation of the palynomorphs indicates that the sediments are marginally mature and capable of generating gas, but not at commercially viable levels.

POPULATION DISTRIBUTION AROUND GEOTHERMAL AREAS IN TANZANIA: INSIGHTS FROM THE 2022 CENSUS

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Understanding the population distribution around geothermal prospects is essential for assessing both potential beneficiaries and those who may be affected by development. In this study, geothermal areas were identified from existing publications and matched with ward-level data from the 2022 Population and Housing Census. Results show that 7.4% of Tanzanians, equivalent to about 4.6 million people, live in 306 wards surrounding 76 known geothermal manifestation areas. These wards form both continuous clusters and isolated pockets. The analysis highlights wards with the highest population densities as well as those with the largest overall populations. Findings underscore the importance of incorporating population distribution into geothermal planning particularly for direct-use applications such as grain drying, fisheries, edible oil and fruit processing, and geothermal spa resorts to maximize community and economic benefits. This approach represents the first national-level attempt to link census data with geothermal development planning in Tanzania.

ASSESSMENT OF THE PERFORMANCE AND COST ANALYSIS OF COMPRESSED NATURAL GAS IN DOMESTIC LIQUEFIED PETROLEUM GAS COOK STOVE

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Tanzania is making serious attempts at expanding access to clean cooking fuels, supported by stronger environmental policies that promote the utilization of Liquefied Petroleum Gas (LPG) in the country. Nevertheless, the nation's huge natural gas (NG) deposits offer an opportunity to introduce Compressed Natural Gas (CNG) as a cheaper and cleaner fuel. There is little research despite such possibilities on the performance of four-stroke CNG in cook stoves designed for LPG, i.e., their efficiency, emissions, and overall fitness.

This study examines the performance of an LPG cook stove with both LPG and CNG fuels. The LPG cook stove was not modified but the pressure was reduced to enable it to function properly with CNG, and its performance was evaluated through Water Boiling Tests (WBT) and Controlled Cooking Tests (CCT). Thermal efficiency was correlated with fuel used, calorific value, temperature difference, cooking time, and ambient conditions, whereas CO, CO_2, and NO_x emissions were measured. Cost-benefit analysis was also used to determine the economic implications of using LPG and CNG in an identical stove system.

It can be observed that CNG is a highly feasible alternative clean cooking fuel. While CNG usage (0.392 kg) was slightly higher than that of LPG (0.38 kg), it offered faster cooking times and reduced overall emissions. Higher CO levels were noted, but improper combustion and ventilation was addressed. Economically, CAPEX for CNG was 592.95% higher than that of LPG, yet OPEX was 60.55% lower, and thus there is tremendous long-term value. Overall, CNG has both economic and environmental advantages that make it sensible for its potential role in developing Tanzania's cleaner cooking initiatives.

MACHINE LEARNING BASED MAPPING OF HYDROTHERMAL ALTERATION ZONES FOR GOLD PROSPECTING: A CASE STUDY OF USHIROMBO, TANZANIA

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Geological prospecting methods, which rely on field observations and rock sample analysis, are inefficient for continuous spatial mapping of geological features such as alteration zones. Machine learning has transformed mineral exploration by turning vast geological datasets into actionable insights. In this study, machine learning techniques were used on Landsat 8 data to delineate hydrothermal alteration zones in Ushirombo, Tanzania. Spectral signatures related to iron oxides, clays, and carbonates were extracted and processed to highlight alteration anomalies linked to gold mineralisation. Support Vector Machine (SVM) and K-Nearest Neighbor (KNN) classifiers were applied to classify alteration patterns and evaluate their performances in discriminating against key mineralogical zones. Results indicate that both algorithms successfully identified hydrothermal alteration halos, with SVM providing higher classification accuracy and better noise reduction compared to KNN. The results demonstrate the potential of integrating remote sensing and machine learning techniques to enhance the efficiency and precision of geological prospectivity, particularly in discerning subtle alterations indicative of gold mineralisation.

HOW SUSTAINABLE ENERGY SOLUTIONS WILL PROMOTE SUSTAINABLE ECONOMIC GROWTH AND DEVELOPMENT IN TANZANIA

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Sustainable energy solutions, like solar mini-grids and micro-hydro projects, are vital for tackling the energy crisis in Tanzania and preventing conflicts that arise from energy scarcity. By shifting away from a heavy reliance on centralized hydropower and imported fuels, these smaller, decentralized systems will provide a more reliable and fair power supply to different regions. Some benefits of this approach include, easing of tensions over resource distribution and strengthening the nation's energy security over time, making the country less vulnerable to droughts and fluctuations in global fuel prices. On top of that, embracing these sustainable energy practices will spark significant economic growth with reliable electricity. Key sectors such as processing and manufacturing industries can thrive, leading to job creation and business development. This not only keeps money flowing within the local economy but also helps to reduce energy costs, boosting profits and stable incomes for the people. Additionally, the construction and upkeep of renewable energy infrastructure will create new local value chains and investment opportunities, further enhancing community development with less pollution caused to the environment. This poster aims to explore in detail the significance of using sustainable energy

solutions for fostering sustainable economic growth and technological development and to how we can adapt to these practices in Tanzania.

INVESTING IN THE FUTURE: CATALYSING BENEFICIATION OF TANZANIA'S CRITICAL MINERALS THROUGH STRATEGIC KNOWLEDGE AND VALUE CHAIN DEVELOPMENT

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The global energy transition to clean energy technologies has exponentially increased the demand for Strategic and Critical Minerals (SCMs) with their demand expected to double by 2040 as stated by the IEA (2025). Examples of these minerals include graphite, nickel, lithium and Rare Earth Elements (REEs), which are vital components in clean energy technologies like lithium-batteries and wind turbines. Tanzania is endowed with globally significant deposits, including the 5th largest graphite reserves with approximately 18 million tons as reported by USGS (2023), and substantial nickel and lithium prospects, positioning it a key player in this market. However, the national objective, as outlined in Tanzania's nascent critical minerals strategy, is to move beyond mere extraction and ensure maximum beneficiation or local value addition to achieve sustainable and inclusive economic growth, as the mineral resources foundational statement and later on the critical minerals' enforcement.

This paper argues that the realized future beneficiation from strategic minerals depends on a strategic investment approach to ensure a sustainable exploitation of the resources, strengthening human capital and deepening the local value chain. Drawing on existing geological and governmental policy

data, the abstract highlights the current trajectory of SCM exploration and project development in Tanzania (e.g., advanced graphite projects in Lindi and Morogoro, nickel in Kagera). A gap in the specialized skills required for the processing of the critical mineral resources into final products such as battery precursor and cathode manufacturing has been identified.

To address this, the project proposes actionable strategies: 1) Curriculum Reorientation: Integrating advanced technologies in mineral processing and value addition into universities and vocational training programs to align with industry needs, ensuring a continuous supply of knowledgeable and skilled local graduates. 2) Student-Industry Nexus: Establishing mandatory industry internships supported by Public-Private Partnerships to transform theoretical knowledge into practical. 3) Targeted Value Chain Investment: Advocating for policy and incentives that prioritize and de-risk investments in local processing infrastructures over raw export, thereby creating demand for the newly-skilled workforce and capturing higher value.

In conclusion, as the critical minerals boom gains momentum, Tanzania has a unique, time sensitive opportunity. The paper emphasizes that sustained investment in the knowledge gain of its students and a deliberate shift towards local value addition are non-negotiable prerequisites to ensure that the wealth from the energy transition translates into long-term, self-sustaining industrial development and equitable beneficiation for the nation by the coming decades.

UNLOCKING GEO-HERITAGE POTENTIAL: INTEGRATING THE ROLE OF GEO-EDUCATION TOWARDS SUSTAINABLE CONSERVATION OF THE UNESCO GLOBAL GEOPARKS IN TANZANIA

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Tanzania is endowed with globally significant geological sites that hold scientific, cultural, and economic value, yet many remain underutilized and vulnerable. The Ngorongoro-Lengai UNESCO Global Geopark illustrates this potential, featuring Ol Doinyo Lengai- the world's only active carbonatite volcano shifting dunes, prehistoric footprints, and fossil-rich layers. Other sites such as Tendaguru fossil beds, Olduvai Gorge, Mt. Meru, Amboni Caves, Mbozi Meteorite, and Lake Natron also contribute to biodiversity, heritage, tourism, and research. However, threats from encroachment, climate change, and population growth strain ecological and cultural capacity, while restricted zones crucial for biodiversity and fossil preservation face limited research access. A key challenge is low geo-education among tourists and residents, who often overlook deeper geological significance. Although internationally recognized, the Geopark is underrated due to lack of accessible, structured geo-information, which limits sustainable use and conservation.

Addressing these issues requires a multi-layered framework. Community-driven geo-education programs can train local "Geo-ambassadors", fostering stewardship and authentic interpretation. Digital documentation, including

open-access databases, 3D models, and indigenous knowledge archives, would enhance accessibility. Integrated land-use planning and increased government support under the National Sustainable Tourism Strategy are essential for site protection. Capacity building through curriculum integration, research incentives, and partnerships with international geopark networks can strengthen knowledge and conservation. Promoting geo-branded products such as volcanic soaps, fossil replicas, and cultural crafts can also diversify local livelihoods while reducing unsustainable land use. These measures can safeguard Tanzania's geo-heritage, advance sustainable tourism, and ensure communities benefit from their unique geological legacy.

UNLOCKING GEOTHERMAL ENERGY FOR SUSTAINABLE DEVELOPMENT IN TANZANIA: LESSONS FROM KENYA

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In the global drive toward sustainable energy systems; the transition to renewable energy sources is crucial both for climate resilience and for meeting growing energy demands in developing countries like Tanzania. This work proposes that geothermal energy, a stable, baseload, and clean power source, is a promising sustainable energy solution that can significantly transform Tanzania's energy landscape. Tanzania's position within the East African Rift Valley provides it with an estimated 5,000+ MWe of potential geothermal resources, presenting a critical opportunity to diversify its energy mix and reduce reliance on climate-vulnerable hydropower and costly fossil fuels. Tanzania has identified over 50 potential geothermal sites across 16 regions. The development efforts are currently focused on a handful of priority areas, primarily in the South-western and northern volcanic provinces. Kenya remains Africa’s geothermal powerhouse, successfully leveraging its rift valley resources to achieve a total installed capacity of approximately more than 779 MWe placing it among the world’s top ten geothermal producers. Tanzania can learn many useful lessons from Kenya’s experience in geothermal development.

To understand a complex connection of the two countries’ geothermal landscape and potential replication lessons, a systematic review has been

conducted to compare the geothermal resource potential, geothermal exploration and development efforts and initiatives as well as research and innovation in Tanzania and Kenya. Kenya has an estimated potential of 7000-10,000Mwe, and it has currently been able to install more than 900 Mwe of geothermal power in their electricity generation profile making them the top geothermal power producer in Africa and in the world. Kenya's achievements stem from consistent investment in exploration and development, strong institutional support, and well-designed policies. With an estimated potential of 5000 Mwe, Tanzania can follow a similar path by increasing investment in geothermal exploration and development, especially in key areas such as those in the northern and southern volcanic provinces. Establishing clear policies and regulations that encourage private investment, similar to Kenya's model, would also help accelerate progress. In addition, Tanzania should focus on building local capacity by training more experts in geothermal science and engineering and by forming partnerships with Kenyan institutions that already have experience in this field. Regional cooperation between the two countries can also promote knowledge sharing and reduce exploration risks. By adopting these approaches, Tanzania can replicate Kenya's success and build a strong and sustainable geothermal energy sector. Key potential areas in Tanzania are currently under systematic phases of geothermal exploration and development.

GEOLOGICAL CHARACTERIZATION OF THE KIEJO-MBAKA GEOTHERMAL PROSPECT, TANZANIA: IMPLICATION FOR GEOTHERMAL POTENTIAL

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The Kiejo-Mbaka geothermal prospect, located in the Rungwe Volcanic Province within Tanzania's East African Rift System, is a promising site for geothermal energy development. This study evaluates the influence of surface and subsurface geological features on the geothermal potential of the area. Through detailed geological mapping and core logging of wells KMB-01 and KMB-03, the research identifies key lithological units (basalt, vesicular basalt, pegmatitic dike), structural features (faults, fractures, veinlets), and hydrothermal alterations (chloritization, carbonate alteration). Results reveal a high-enthalpy geothermal system driven by an active magmatic heat source, evidenced by young volcanic activity and pegmatitic dikes intruding basaltic units. Chloritization in cored sections indicates high reservoir temperatures, challenging prior assumptions of a low-to-medium temperature system. Surface manifestations, including hot springs and travertine deposits, further confirm active fluid circulation. These findings highlight the prospect's viability for sustainable geothermal energy development, with permeable structures facilitating fluid flow and a heat source supporting high temperature reservoirs. By enhancing understanding of the geological characterization, this research supports efficient resource

assessment and risk mitigation for future geothermal development in Kiejo-Mbaka.

SUSTAINABLE GEOPHYSICAL EXPLORATION OF CRITICAL MINERALS IN TANZANIA: BRIDGING DISCOVERY AND ENVIRONMENTAL RESPONSIBILITY

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The global shift toward renewable energy has increased demand for critical minerals such as lithium, graphite, and rare earth elements. Tanzania hosts significant deposits of these resources within the East African Rift and cratonic terrains. However, most exploration efforts have focused primarily on economic discovery, with limited assessment of environmental sustainability. This study addresses that gap by demonstrating how modern geophysical surveys can reduce the environmental footprint of mineral exploration while maintaining technical accuracy and cost efficiency. Airborne magnetic and radiometric surveys are utilized as non-invasive, wide-area mapping tools to identify prospective lithologies and structures without ground disturbance. These datasets are complemented by targeted gravity surveys and induced polarization (IP) surveys that provide subsurface details with minimal surface disturbance compared to traditional trenching or extensive drilling. The integrated analysis using Geophysics software like Oasis montaj and Surfer software which enable precise target delineation, thereby reducing unnecessary drillholes, carbon emissions, and ecological impact. By linking geophysical data integration with sustainable exploration outcomes, this study proposes a new workflow that aligns resource discovery

with Tanzania’s green growth and environmental management policies. The results aim to demonstrate that responsible geophysical exploration can play a direct role in supporting the global energy transition through low-impact mineral resource development.

TURNING STONES INTO GOLD: HARNESSING BASALT ROCKS FOR DEVELOPMENT OF HIGH-PERFORMANCE BASALT FIBRE PRODUCTS IN TANZANIA

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Basalt is a fine-grained volcanic rock formed from the rapid cooling of mafic lava, containing mafic minerals such as olivine, pyroxene, and plagioclase. Tanzania is rich in basalt deposits, particularly along the East African Rift and within some of the ancient greenstone belts, such as Musoma-Mara and Sukumaland regions in the northern part of the country. The project aims to develop high-performance basalt fibre products in East African countries by converting abundant basalt rock into cost-effective, durable, and sustainable reinforcement materials for the construction, transportation, aerospace, and energy industries. It strives to addresses import dependency, limited awareness, and infrastructure challenges through local production, advanced processing and market expansion.

The project integrates multidisciplinary expertise in geology, engineering and business development. It involves geological mapping, geophysical surveys, and mineralogical analysis to locate and quantify basalt reserves. This is followed by development and quarrying to extract the basalt rocks using advanced mining methods. The processing stage converts the basalt into continuous filament through high-temperature melting and extraction. Finally, marketing and distribution efforts aim to establish local and international supply chains and create awareness among industries.

Various geological studies confirm that Tanzania possesses extensive basalt deposits associated with tectonic and volcanic activity along the East African Rift and some parts of northern Tanzania in ancient greenstone belts. Mineralogical analysis reveals favorable composition of olivine, pyroxene, and plagioclase, supporting the suitability of these rocks for fiberization.

Basalt fibre offers several advantages over steel and carbon fibres, including corrosion resistance, high tensile strength and light weight making it ideal for the structures exposed to harsh environments. It is also cost-effective and environmentally friendly compared to carbon fibre. Moreover, basalt fibre provides thermal stability, chemical resistance and can be fully recyclable.

The project emphasizes the opportunity for import substitution, industrial diversification and environmental innovation. With coordinated support from government, academia, and private stakeholders, Tanzania can leverage its geological wealth to become a regional leader in sustainable composite materials. This initiative holds significance not only for advancing materials science and geotechnical innovation, but also for contributing to Tanzania's economic growth, infrastructure development, and alignment with global sustainability goals. It exemplifies how interdisciplinary collaboration across geology, engineering, and business can unlock the latent value of Earth resources for transformative industrial impact.

The study demonstrates how the production of basalt fibre products in Tanzania can reduce the importation and use of steel and carbon fibres, thereby supporting the country's economic growth, strengthening infrastructure development, and advancing alignment with global sustainability goals.

INTEGRATING THE ROLE OF ADVANCED TECHNOLOGIES FOR SUSTAINABLE MINERAL EXPLORATION AND GOLD PRODUCTION IN TANZANIA

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Mineral exploration is rapidly evolving with the adoption of spatial technologies that improve efficiency, sustainability, accuracy, and environmental responsibility. This is evidenced in the use of geospatial and processing technologies such as remote sensing, geographic information systems (GIS), drone mapping, and geophysical surveys with responsible gold production techniques such as thiosulfate leaching, bioleaching, and sensor-based ore sorting. These technologies enhance mineral exploration and promote responsible mining practices in Tanzania. Mining activities in Tanzania face challenges such as inaccurate targeting of mineral deposits, environmental degradation, ineffective identification of mineral deposits, inefficient data handling, and the use of harmful chemicals during mining activities. The methods to be used include data collection, preprocessing, and spatial analysis. To address these challenges and promote effective, responsible mining in Tanzania, this study focuses on geologically significant areas such as gold production zones. It utilizes satellite imagery, geophysical measurements, and spatial analysis in ArcMap, combined with subsurface geophysical data and drone-based high-resolution mapping. Together, these methods enable precise identification of mineralized zones

and environmentally sensitive areas. Moreover, through analytical techniques such as spatial overlay and buffering, the study supports the generation of thematic maps that enable informed decision-making in exploration and sustainable mining. In addition, focusing on responsible gold extraction in Tanzania, the use of Thiosulfate Leaching technology provides a cyanide-free alternative that minimizes toxic waste. Complementary approaches such as bioleaching, which employs bacteria to extract gold from sulfide ores with minimal chemical input, and sensor-based ore sorting, which reduces processing waste and improves efficiency, further enhance environmentally responsible mining practices. These technologies can be effectively applied in Tanzanian mineral zones such as Geita and Bulyanhulu for sensor sorting and blockchain traceability in large-scale gold mines. Mwanza and Shinyanga for drone and remote sensing surveys for small-scale miners, and Chunya and Mpanda for testing thiosulfate leaching in alluvial and oxide gold deposits. By combining advanced exploration tools with sustainable extraction methods, this approach supports responsible mining practices in Tanzania. Therefore, the integration of geospatial, aerial, and geophysical technologies offers a robust framework for achieving both effective mineral development and environmental stewardship.

SUSTAINABLE ENERGY SOLUTIONS IN TANZANIA

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Tanzania's demand for energy is growing rapidly as the population and economy expand, yet a large percentage of the population still lacks access to reliable electricity. To achieve sustainable development, the country must embrace clean and renewable energy sources that reduce poverty, protect the environment, and ensure long-term energy security. Currently, Tanzania depends heavily on hydropower, natural gas, and biomass. Hydropower remains a key source of electricity, but it is highly vulnerable to droughts. Natural gas is growing in importance, while biomass such as firewood and charcoal continues to dominate in rural households, contributing to deforestation and health risks. These challenges are made worse by limited grid coverage and high costs of fossil fuel–based energy. Sustainable energy solutions offer a pathway forward. Solar power has immense potential due to high solar radiation across the country and is already improving rural electrification through off-grid systems. Wind energy is promising in regions such as Singida and Makambako, while geothermal potential in Mbeya and Songwe could provide stable and renewable baseload power. Small-scale hydropower projects are helping villages generate their own electricity, and biogas technology offers clean alternatives for cooking and energy, reducing reliance on wood and charcoal. Government policies and institutions such as the National Energy Policy and the Rural Energy Agency support renewable energy investments, with partnerships from the private sector and NGOs

playing an important role. Expanding sustainable energy will reduce dependency on imported fuels, cut greenhouse gas emissions, create jobs, and provide affordable power to under-served communities. Tanzania has the resources and opportunities to build a cleaner, more reliable, and inclusive energy system. By combining solar, wind, geothermal, hydropower, and biogas, and strengthening collaboration between government, private sector, and local communities, the nation can secure a sustainable energy future.

REMOTE SENSING AIDED HYDROTHERMAL ALTERATIONS IN GEOTHERMAL SYSTEMS: A CASE STUDY OF KISAKI GEOTHERMAL AREA

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Exploration for geothermal energy has historically depended on costly and logistically challenging techniques like surface geological mapping, geochemistry, and geophysical surveys, and drilling. As technology advances, exploration programs are increasingly incorporating contemporary remote sensing techniques to reduce expenses and speed up the preliminary study phase. Hydrothermal alteration zones with direct effect from fluid conducting geological structures and recharge areas are important parameters associated with geothermal systems. Located in the Geothermal Eastern Zone of the Rufiji Basin, the Kisaki Geothermal Prospect has been impacted by the tectonic deformation of the East African Rift System. SRTM DEM and Landsat 8 OLI/TIRS data were used in this study as a remote sensing technique to map these important hydrothermal alterations. A possible recharging zone of Kisaki hot spring was found in the north-west highlands of the Kisaki watershed by hydrological study of the DEM data. Additionally, prominent NE–SW and NW–SE trending lineaments were identified in the Geothermal Eastern Zone of Tanzania by DEM analysis, which aligns with the region's tectonic tendencies. Signals for hydrothermal alteration minerals were enhanced by processing techniques including band-ratio, Principal Component Analysis (PCA), unsupervised classification, as

well as clumping and sieving. The results showed that the mapped lineaments seem to govern the hydrothermal alteration zones, and that there is a strong correlation between these structures and the existence of hot springs at Kisaki. The alteration patterns found are in line with mineral assemblages that are formed in active geothermal systems. This study suggests that combining SRTM DEM and Landsat 8 OLI/TIRS data can be useful in identifying and defining potential geothermal resources. More research, including field geological mapping and geophysical surveys, is advised to confirm these findings and enhance the overall goal of this work.

THE APPLICATION OF HEAVY MINERAL SANDS: CASE STUDY OF FUNGONI, DAR ES SALAAM, TANZANIA

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Heavy mineral sands represent a significant resource with diverse industrial applications, and the Fungoni deposit in Dar es Salaam offers an important case study in Tanzania. The sands are enriched with valuable minerals such as ilmenite, rutile, zircon, and garnet, which have wide-ranging uses in various sectors. Ilmenite and rutile provide titanium feedstock for pigment production and titanium metal, zircon is essential in ceramics, refractories, and nuclear applications, while garnet serves as an abrasive in industrial processes. Monazite, though minor, is a potential source of rare earth elements critical for advanced technologies. The Fungoni deposit demonstrates not only the potential for contributing to Tanzania's industrial growth through mineral beneficiation and export but also highlights the need for sustainable exploitation to balance economic benefits with environmental stewardship. This case underscores the strategic importance of heavy mineral sands in supporting infrastructure, technology, and industrial development at both national and global levels.

SOCIETAL PERCEPTIONS OF GEMSTONE MINING IN TAITA TAVETA COUNTY, KENYA: PRIORITISING GEMSTONES OVER INDUSTRIAL MINERALS

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Gemstone mining in Taita Taveta County, Kenya, occupies a paradoxical position within the broader extractive sector. While the county is endowed with a diverse range of industrial minerals, societal perceptions overwhelmingly privilege gemstones as symbols of wealth, status, and economic opportunity. This study interrogates the socio-cultural, economic, and environmental dimensions underpinning such prioritization. The goal is to provide a nuanced understanding of community attitudes towards mining. The area, located along the Mozambique Belt, is rich in precious rubies, sapphires, tourmalines, tsavorites and industrial minerals such as Iron, graphite and manganese. Drawing on qualitative interviews, stakeholder narratives, and secondary data, the research reveals that gemstones are valorized not only for their market allure but also for their cultural embeddedness in notions of prosperity and identity. In contrast, industrial minerals are often perceived as less glamorous, despite their strategic role in infrastructure and industrialization. This imbalance shapes local livelihood strategies, community expectations, and policy discourse, thereby influencing governance and sustainable resource management. The study was carried out in the field by visiting and interviewing approximately 150

artisanal and small-scale miners (ASMs) who were actively involved in gemstone mining, 50 locals and 3 key landlords. The respondents were asked to indicate their knowledge and understanding of the ASM sector and how it relates to their day-to-day lives and socio-economic activities. Some of the areas of interest to this study were mining experience, education level, conflicts over land use, access to utilities, contribution to household income and impacts of mining on tourism. This paper discusses the analysis of data collected and makes recommendations. Most of the respondents interviewed had worked as miners for a period ranging from 1 year to 25 years, while locals lived in the region for their entire lifetime. Mining enabled the surrounding communities to meet their day-to-day needs but not accumulate wealth. Mining companies such as Rockland Kenya LTD and Equator Gemstone Mines support local community projects.

The paper argues that addressing these perceptual asymmetries is essential for equitable mineral policy, community benefit-sharing, and the alignment of resource governance with national development goals.

GEOLOGICAL ASSESSMENT OF WINGAYONGO DELTAIC REGION: STRUCTURAL INDICATORS AND HYDROCARBON POTENTIAL

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The Wingayongo area, located within a deltaic sedimentary setting, exhibits promising geological features that could support hydrocarbon exploration. This study focused on mapping and characterizing structural and subsurface indicators relevant to oil and gas potential. Field work included systematic documentation the geometric attitudes of structures, which revealed the presence of significant shear zones and fault systems - key structural elements for hydrocarbon entrapment. Notably, a borehole drilled to a depth of 750 meters did not yield any oil or seepage observed at the surface, suggesting possible hydrocarbon migration or dissipation. Despite the absence of a confirmed reservoir rock, the geological environment remains favourable. The deltaic nature of the basin suggests inter-bedded sandstone and shale sequence, which, under further investigation, could reveal reservoir-cap rock pairs. The presence of oil seepage combined with active deformation structures such as faults and shears indicates potential pathways and traps for hydrocarbon accumulation. Current findings suggest that Wingayongo remains under-explored with hydrocarbon potential yet to be fully realized. Ongoing discoveries and evidence of seepage call for more advanced exploration techniques, including geochemical profiling and

seismic surveys. Unlocking the petroleum potential of this area could contribute significantly to local and national development. Aligning with the broader goal of harnessing geosciences for Africa's growth, this study thus provides a baseline understanding of the region's structural framework and lays the foundation for targeted hydrocarbon exploration in Wingayongo and similar deltaic settings across Africa. In recognition of the uncertain hydrocarbon yields, this study also explores alternative development pathways. Groundwater resource assessment emerges as a priority and geo energy as well. Simultaneously, the presence of active faults and shear zones warrants environmental monitoring and geohazard risk mapping to support safe land use and disaster preparedness.

HYDROGEOPHYSICAL ASSESSMENT OF GROUNDWATER POTENTIAL ALONG THE LAKE VICTORIA BASIN, TANZANIA: A CASE STUDY FROM MEATU, SIMIYU

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Groundwater represents a critical resource for domestic, agricultural, and industrial purposes, particularly in regions experiencing seasonal variability and increasing demand. In the Lake Victoria Basin, Tanzania, specifically in Meatu district, the sustainable management of groundwater requires a comprehensive understanding of subsurface hydrogeological conditions. This study presents a hydrogeophysical assessment aimed at delineating groundwater potential zones across the basin.

Vertical Electrical Sounding (VES) surveys were conducted to characterise subsurface lithology, aquifer thickness, and depth to the water table. Complementary geophysical data were integrated with geological, geomorphological, and hydrological datasets within a Geographic Information System (GIS) framework to produce groundwater potential maps. Factors such as lithology, lineament density, slope, drainage patterns, and soil characteristics were considered in the analysis to classify areas into high, moderate, and low groundwater potential zones.

The results indicate that aquifer development is predominantly controlled by structural features and the spatial distribution of unconsolidated sediments. Zones exhibiting thick sedimentary cover and well-developed fracture networks correlate with higher groundwater potential, whereas crystalline and low-permeability formations show limited groundwater availability. The

study demonstrates that the integration of hydrogeophysical methods with GIS-based spatial analysis offers a robust and cost-effective approach for groundwater resource evaluation and management. The findings provide essential guidance for sustainable water resource planning and policy formulation in the Lake Victoria Basin.

STRUCTURAL AND GEOLOGICAL INSIGHTS FROM AEROMAGNETIC DATA, NORTHERN TANZANIA

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This study investigates the structural and geological features of a section of the Tanzanian Craton in north central Tanzania using low-resolution aeromagnetic data. The study area, covering approximately 12,100 km² (110 km × 110 km), lies between 3°00′S to 4°00′S and 33°00′E to 34°00′E. It includes parts of Mwanza, Simiyu, Shinyanga, and northern Tabora regions. This region is within the eastern Lake Victoria Goldfields, part of the Archean Tanzanian Craton, known for its granite greenstone terranes and shear zones. The project aimed to derive structural and geological insights from legacy aeromagnetic data to map subsurface features and evaluate mineral potential.

Aeromagnetic data collected between 1976 and 1980 were processed using several geophysical techniques. Reduction to the Pole (RTP) was applied to the centre magnetic anomalies over their sources. Residual magnetic fields were extracted by removing regional trends. Upward continuation enhanced deeper features, while CET Porphyry Analysis helped identify circular magnetic patterns. Edge detection methods, including horizontal and TILT derivatives, mapped structural trends. Source Parameter Imaging (SPI) and Euler Deconvolution provided depth estimates and source geometries. A Digital Elevation Model (DEM) supported interpretation of surface geology.

The results revealed dominant north-to-south trending dykes, northeast-to-southwest dykes and faults, and intersecting structural lineaments. Depth estimates to magnetic sources range from 127 m to over 6 km. Granitic and volcanic rocks dominate the northeastern highlands, while alluvial sands, mbuga clay, calcareous lacustrine deposits, and cemented gravels cover the southeastern and western lowlands. High magnetic circular anomalies align with known mineral sites such as the Williamson Diamond Mine.

These findings show that even low-resolution aeromagnetic data provide meaningful insights into subsurface geology and mineral potential. The study recommends follow-up ground surveys, geochemical sampling, and 3D modelling to refine these results and guide future exploration.

TRANSFORMING ARTISANAL MINING OF SAPROLITIC LOW-GRADE GOLD ORES THROUGH HEAP LEACHING: A GEOMETALLURGICAL CASE STUDY OF THE USHIROMBO-KELEZIA AREA, GEITA REGION, TANZANIA

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The economic extraction of low-grade gold ores remains one of the key challenges in modern mineral development, particularly within the Lake Victoria Goldfields of northwestern Tanzania. The Ushirombo-Kelezia Project, a historically artisanal mining area within Archean greenstone belts predominantly composed of the three main lithological units - metasediments, rocks of the Nyanzian system, and granite intrusions - features structurally controlled auriferous mineralisation.

Despite confirmed gold mineralisation through geochemical surveys and assay data, much of the ore is subeconomic under conventional processing methods due to its low grade. Heap leaching presents a strategic alternative, as it requires lower investment and allows for efficient extraction from ores with minimal or no size reduction. The method involves stacking crushed or run-of-mine ore into engineered heaps, followed by irrigation with cyanide-based lixiviants that dissolve gold, which is later recovered through carbon adsorption and electrowinning techniques. This method is particularly well-suited to the Ushirombo-Kelezia mineralisation in saprolitic deposits. Despite its advantages, the process necessitates strict environmental controls due to its reliance on cyanide. This study emphasises the importance of integrating

cyanide detoxification measures and designing secure containment systems to prevent environmental contamination through the use of impermeable lined heap pads, especially considering the ecological sensitivity of the nearby water sources.

In conclusion, this research highlights the potential of heap leaching as a sustainable and cost-effective method for processing low-grade ores in the Lake Victoria Goldfields. The approach aligns geological understanding with metallurgical and environmental innovation, offering a scalable solution that could transform formerly artisanal mining areas into productive, industrial-scale operations. The outcomes provide a reference framework for evaluating similar deposits across the Lake Victoria Goldfields.

CARBON EMISSION REDUCTION IN TANZANIA: CARBON CAPTURE AND STORAGE (CCS)

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Carbon emissions in Tanzania have shown a consistent upward trend, rising from approximately 39,000 kt CO_2e in 1990 to 89,000 kt CO_2e in 2020, primarily driven by human activities such as agriculture, cement production, deforestation, and fossil fuel combustion. As the nation seeks sustainable pathways to mitigate its greenhouse gas footprint, Carbon Capture and Storage (CCS) emerges as a viable technological solution. Drawing inspiration from global best practices—particularly the Sleipner gas field in Norway, which has successfully implemented offshore CCS since 1996—this presentation explores the feasibility of deploying CCS in Tanzania, especially by repurposing abandoned deep wells for secure CO_2 sequestration. Case studies such as Heidelberg Materials' cement plant in Brevik, Norway, demonstrate practical CCS integration in energy-intensive industries through carbon capture, use of alternative fuels, and substitution of clinker with supplementary materials like fly ash. For Tanzania, strategic recommendations include enforcing emission reduction policies favouring the implementation of CCS and assessing the viability of CCS with respect to source markets, subsurface potential, and requirements of transporting, processing and injection infrastructure.

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