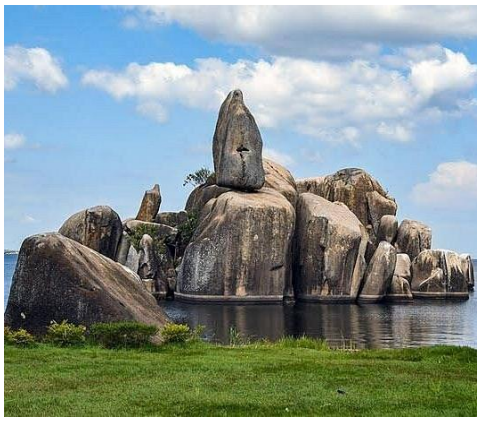
TANZANIA GEOLOGICAL SOCIETY (TGS)

2026 ANNUAL CONFERENCE

BOOK OF ABSTRACTS




MWANZA

12th to 18th of September 2026

Front cover photos

Top Left: *Bismarck Rock - a famous 10-meter-tall granite rising from the waters of Lake Victoria;* ***Top Right:*** *A view of Rubondo Island;* ***Bottom left:*** *Mwanza City centre; and* ***Bottom right:*** *Tilapia fish—the famous symbol of Lake Victoria—is found in statue form at the roundabout between Station Road and Kenyatta Road.*

Message to Participants of the TGS 2026 Conference

Our distinguished participants, colleagues, and guests,

It is with great pleasure that we welcome each of you to the Tanzania Geological Society (TGS) 2026 Annual Conference. We are delighted to host you in the vibrant city of Mwanza, Tanzania, from 12 to 18 September 2026.

Mwanza, located on the southern shores of Lake Victoria, is one of Tanzania's important urban, commercial, and cultural centres. The city is renowned for its distinctive granite landscapes, islands, and scenic setting along the shores of Africa's largest lake. Mwanza provides a fitting venue for a conference that brings together geoscientists, industry professionals, researchers, policymakers, students, and other stakeholders to discuss the contribution of geosciences to Tanzania's development.

The Lake Victoria region has long been associated with mineral exploration, mining, agriculture, fisheries, water resources, energy, and rapidly expanding urban development. Mwanza therefore offers an appropriate setting for examining the connections between geological resources, industrial growth, environmental stewardship, energy security, and resilient development.

Beyond its economic and scientific significance, Mwanza is surrounded by remarkable geological and natural features. Its characteristic granite outcrops and inselbergs provide a striking expression of the region's geological heritage, while the vast waters of Lake Victoria provide an important setting for understanding water resources, ecosystems, communities, and regional development. The wider area also provides opportunities to appreciate the interaction between geology, natural resources, biodiversity, culture, and tourism.

The conference programme will also provide opportunities for participants to explore selected attractions and geological and natural-resource settings through the planned excursions to the Geita Mining Province, Burigi-Chato National Park and Magufuli's Mausoleum, and Mwanza City.

We are honoured to have you join us for what promises to be an inspiring and engaging conference, bringing together experts, practitioners, researchers, innovators, students, and other stakeholders from across Tanzania and beyond. The conference will provide a platform for sharing knowledge, exchanging experiences, strengthening professional networks, and developing collaborations that can contribute to Tanzania's sustainable development.

This year's theme, "Geosciences solutions for industrial growth, energy security, energy transition, and resilient development in Tanzania," calls upon us to reflect on how geoscience knowledge, technologies, and innovations can support national development while addressing emerging challenges in energy, climate resilience, natural-resource management, and community safety.

The conference will feature six sub-themes addressing critical areas of geoscience and sustainable development: Minerals for Industrial and Socio-Economic Growth; Water, Energy, and Clean Cooking Solutions; Climate Insights for Energy Transition and Resilience; Fossil Fuels and the Future of Energy in Tanzania; Geohazards, Community Development, and Community Safety; and Geothermal Resources for Sustainable Development in Tanzania.

The organizing committee has prepared a programme designed to facilitate the presentation and exchange of scientific and technical knowledge. We invite participants to contribute through oral and poster presentations aligned

with the main theme and sub-themes. We encourage all participants to engage actively in the discussions, share experiences and innovations, and establish collaborations that will advance the role of geosciences in Tanzania's industrial and socio-economic transformation.

As we gather in Mwanza, we are reminded that geosciences extend far beyond the study of rocks and geological processes. They provide essential knowledge for understanding and managing the mineral, water, energy, and environmental resources upon which societies depend. Let this conference strengthen our collective commitment to applying geosciences solutions to promote industrial growth, enhance energy security, support the energy transition, protect communities, and build a more resilient Tanzania.

We are sincerely grateful to all TGS members, partners, sponsors, institutions, companies, and volunteers whose continued support contributes to the success of this important professional gathering. Thank you for being part of the TGS 2026 Annual Conference. We look forward for a productive, memorable, and rewarding conference experience as we collectively explore geoscience solutions for industrial growth, energy security, energy transition, and resilient development in Tanzania.

Conference Organising Committee

Tanzania Geological Society (TGS)

Conference Organising Committee

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Conference secretariat	Prof. Elisante Mshiu Dr. Emmanuel Kazimoto Dr. Rachel Sabuni Mr. Ebeneza Mollel Dr. Sara Emanuel Dr. Emily Kiswaka
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Barrick's | Twiga Minerals Corporation

https://www.barrick.com

Twiga Minerals Corporation is the joint venture company between Barrick Mining Corporation and the government of Tanzania. Crowned as Tanzania's top dividend contributor at the Dividend Day 2026, this partnership has secured a steady increase in its contributions from Sh53.5 billion in the 2021/2022 financial year to Sh221.9 billion in the last financial year.

Twiga's footprint goes beyond its direct fiscal contributions to transformative initiatives through programs in education, health, water and infrastructure. One such is the landmark Future Forward Education Programme. As of 2025, Barrick sourced approximately 90% of its procurement needs from Tanzanian companies, the majority of which are indigenous enterprises. The company's workforce is composed of over 96% Tanzanian citizens, with 49% originating from communities surrounding the mine. The Twiga partnership has established a foundation for sustained value creation through shared ownership, local empowerment, and a commitment to responsible development. It now stands as a sustainable model for mineral development in Tanzania.

The Tanzania Geological Society recognizes Twiga Minerals Corporation (Twiga Barrick) as one of its crucial stakeholders and a longstanding and reliable supporter of TGS.

BARRICK

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https://www.geitamine.com/

Geita Gold Mining Limited (GGML) is one of Tanzania's leading gold producers and a wholly owned subsidiary of AngloGold Ashanti, a global gold mining company. For 25 years, GGML has combined geological excellence, safe and disciplined mining, and long-term partnership to create value from Tanzania's rich mineral endowment.

Responsible stewardship is central to how GGML operates. The mine applies rigorous water and environmental management, progressive rehabilitation, and biodiversity protection, while its connection to Tanzania's national electricity grid is expected to reduce diesel use for power generation by about 80% and lower carbon emissions by at least 50,000 tonnes of CO_2.

Beyond the orebody, GGML invests in people and shared prosperity, working with government and communities to strengthen education, healthcare, water infrastructure, local enterprise and livelihoods. GGML's recent recognition as Overall Most Compliant Taxpayer and Outstanding Tax Contributor for the 2024/2025 financial year highlights a sustained track record of its direct contribution to Tanzania's economy.

The Tanzania Geological Society acknowledges and appreciates GGML's distinguished contribution in supporting TGS activities.

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STAMICO

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

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, to increase the mineral sector's contribution to the national economy and create employment opportunities for Tanzanians.

STAMICO stands as the Tanzania's vehicle for local economic empowerment, industrialization, and sustainable development. Through revenue contribution to national revenue through royalties, taxes and dividends to local content prioritizing sourcing services and its equipment and supplies from 100% owned Tanzania companies, providing direct and indirect employment to.

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 Silver Sponsor

Tanzania Petroleum Development Corporation

https://www.tpdc.co.tz/

Tanzania Petroleum Development Corporation (TPDC) is the National Oil Company of Tanzania, mandated by the Petroleum Act of 2015 to undertake Tanzania's commercial aspects of petroleum operations. These operations span upstream, midstream, and downstream and include the Government's participating interests in petroleum and natural gas agreements.

TPDC continues to strengthen national energy security through key upstream activities, including strategic exploration projects in Mnazi Bay North, Eyasi Wembere, West Songo Songo, and Lindi-Mtwara. Across the downstream sector, the Corporation is actively managing natural gas infrastructure and expanding distribution networks across Lindi, Mtwara, Pwani, and Dar es Salaam. This includes expanding access to Compressed Natural Gas (CNG) to power industrial growth, transportation, and the residential sector.

Realizing these ambitions relies on advanced geoscience solutions, high-quality subsurface data, and innovative technologies that improve success rates and resource recovery. TPDC actively partners with geoscientists, academic institutions, technology providers, and industry peers to strengthen subsurface understanding, transfer technology, and build local technical capabilities. The Tanzania Geological Society acknowledges TPDC's sustained contribution through its consistent participation and support of TGS Annual Conferences.

Our Silver Sponsor

PRD RIGS TANZANIA LIMITED

https://www.prdrigs.com/

PRD Rigs Tanzania Limited is a drilling rigs and support company serving the mining, geological exploration, water-well, and energy sectors in Tanzania and across East Africa. It offers an extensive range of drilling rigs and equipment to meet diverse drilling requirements and working conditions across the Region.

Beyond the supply of drilling rigs, a dedicated service and support center in Mwanza delivers maintenance, repairs, rig overhauls, operator training, spare parts, and field technical assistance. The facility also maintains stock of RC and diamond core drilling accessories, spare parts, drilling fluids, survey tools, and consumables, ensuring customers experience minimal downtime.

The company is dedicated to enabling drilling contractors, mining enterprises, exploration teams, and industry professionals to enhance drilling performance, operate efficiently, and maintain project momentum. As part of PRD Rigs India, a manufacturer of drilling rigs and mining equipment with more than 50 years of industry experience, PRD Rigs Tanzania Limited stands as a reliable business partner.

The Tanzania Geological Society recognizes PRD Rigs Tanzania Limited's vital contribution to the TGS 2026 Annual Conference and looks forward to many years of partnership.

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Recognition of the Outstanding Tanzanian Geoscientist

Prof. Shukrani Elisha Manya

A token of appreciation is extended to our esteemed senior TGS member, Prof. Shukrani Elisha Manya, whose unwavering dedication has greatly enriched both the association and the geosciences field at large.

Prof. Shukrani Elisha Manya is a Professor of Geology at the Department of Geosciences, School of Mines and Geosciences, University of Dar es Salaam, Tanzania, where he has served as a Senior Lecturer, Researcher and Academic Leader since 2001. He previously held key academic leadership positions, including Head of the Department of Geology (2012–2015) and Director of Research and Publications at the University of Dar es Salaam (2015–2018).

In 2018, he was appointed by the President of the United Republic of Tanzania as Commissioner for Minerals in the Ministry of Minerals and concurrently served as Acting Executive Secretary of the Mining Commission (January–June 2018). He was subsequently appointed the Executive Secretary of the Mining Commission, a position he held from June

2018 to December 2020. In 2020, he was appointed a Nominated Member of Parliament (2020–2025) and Deputy Minister for Minerals, serving in that capacity until 2022.

As the founding Executive Secretary of the Mining Commission, Prof. Manya played a central role in the initial set-up, organization and operationalization of the institution, ensuring its effective presence across all regions of Tanzania mainland. He was also instrumental in establishing mineral markets nationwide by developing robust, transparent trading systems, including the provision of modern mineral testing equipment and kits, an initiative that has become one of the success stories in transforming the small-scale mining sector in Tanzania. During his tenure at the Mining Commission, he promoted the integration of the mining sector with the financial sector by equipping the staff of the prominent banks in Tanzania with the knowledge required to finance mining ventures both small and large scale mining. Drawing on his understanding of global mineral market dynamics, he championed the establishment of the national gold and gemstone reserve by advising the government to buy the exceptionally large Tanzanite crystals recovered from the Mirerani mines in 2020.

Prof. Manya's research focuses on the geochemistry of gold-bearing terranes in Tanzania. He published widely in peer-reviewed journals and is the author and co-author of several scholarly works, including the Explanatory Notes for the Minerogenic Map of Tanzania. He also serves as an editor and reviewer and is a member of editorial boards of international scientific journals. Prof. Manya continues to mentor young Earth scientists through teaching and the supervision of both undergraduate and postgraduate research students.

He has held several national leadership and advisory roles, including Chairman and Board Member of the Geological Survey of Tanzania (GST), Member of the Ministerial Advisory Board of the former Ministry of Energy and Minerals, Member of the Board Committee of the Tanzania Petroleum Development Corporation (TPDC), and Council Member of Mbeya University of Science and Technology (MUST).

Recognition of the Outstanding Geoscientist

Mr. Hope Yisi Mofor Njakoi

A token of appreciation is extended to our esteemed TGS member, Mr. Hope Yisi Mofor Njakoi, whose dedication and commitment have contributed to the growth of the Tanzania Geological Society (TGS) and the advancement of geoscience in Tanzania.

Mr. Hope Yisi Mofor Njakoi is a geologist and postgraduate student at the Department of Geosciences, School of Mines and Geosciences, University of Dar es Salaam. He holds a BSc in Geology from the University of Dar es Salaam, completed in 2024, and is currently pursuing an MSc focused on the evolution, geological characteristics and resource potential of an Archean greenstone belt.

Following his graduation, Mr. Njakoi dedicated significant time and effort to serving the Tanzania Geological Society and supporting its day-to-day activities and continued growth. Through his engagement with TGS and TGS Extractive Industry Solutions Limited (TEIS Ltd), he gained valuable experience in geological reconnaissance and exploration, including field

activities within the Tanzania Archaean Craton and the Mozambique Belt. His involvement also provided opportunities to contribute to professional development initiatives through conferences, workshops and short courses, including training related to geophysical techniques in mineral exploration.

Mr. Njakoi's emerging research interests include the formation and growth of greenstone belts and other crustal blocks, the composition and evolution of the Earth's mantle, and the geological processes controlling mineral systems from the crustal to lithospheric and mantle scales. Through his continued service to TGS, engagement with TEIS, and developing contribution to geological research and exploration, he represents a promising new generation of geoscientists committed to advancing the geosciences profession in Tanzania.

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Conference Programme

DAY 1 & 2 (12-09-2026 to 13-09-2026)

TIME	PLACE / ACTIVITY
FRIDAY, 11th SEPTEMBER 2026 – ARRIVAL IN GEITA	
All day	Arrival of participants in Geita Town and preparation for the excursion
SATURDAY, 12th SEPTEMBER 2026 – GEITA → CHATO → RUBONDO ISLAND	
07:30 - 08:00	Participants assemble at Geita Bus Stand and board minibuses for the excursion
08:00 - 09:00	Drive to the small-scale mining site at Geita
09:00 - 11:00	Small-Scale Mining Experience: Discussion on mining practices and sharing of the company's success story
11:00 - 13:30	Drive to Dr. J. P. Magufuli Mausoleum, Chato
13:30 - 15:30	Visit to Dr. J. P. Magufuli Mausoleum & Museum
15:30 - 16:30	Drive to Muganza Ferry Terminal
16:30 - 17:30	Ferry transfer from Muganza to Rubondo Island National Park
17:30 - 18:00	Transfer to the Rubondo Island National Park campsite
18:00 - 18:30	Campsite check-in, tent arrangements, and other logistics
18:30 - 20:00	Dinner
20:00 - 00:00	Evening Social: BBQ, bonfire, music, networking and bar
00:00	End of the day's joint programme / Overnight at Rubondo Island
SUNDAY, 13th SEPTEMBER 2026 – RUBONDO ISLAND → MWANZA	
06:30 - 08:00	Early morning activities: Sports and morning stretch
08:00 - 09:00	Breakfast
09:00 - 13:00	Rubondo Experience: Games, safari drive, sport fishing and camp activities
13:00 - 14:00	Lunch and departure preparations
14:00 - 14:30	Transfer to Rubondo Ferry Terminal
14:30 - 15:30	Ferry transfer from Rubondo Island to Muganza Ferry
15:30 - 20:30	Drive from Muganza to Mwanza City
20:30	Final announcements and official conclusion of the excursion

DAY 3 (14-09-2026) OPENING CEREMONY & CONFERENCE

Time	Activity	
07:30 - 08:30	Arrival and Registration	
08:30 - 09:30	Breakfast, Exhibition and Poster Session	
09:30 - 10:00	Tour with the Guest of Honour	
10:00 - 10:15	TGS General Secretary: Introducing participants	
10:15 - 10:30	TGS President: Welcome remarks and welcoming the Guest of Honour	
10:30 - 11:30	Guest of Honour	
11:30 - 12:00	Photo Session	
12:00 - 13:00	**LUNCH BREAK**	
TGS ANNUAL GENERAL MEETING		
Time	**Activity**	**Responsible**
13:00 - 13:30	Opening	Chairperson
13:30 - 13:45	Minutes and Matters Arising from TGS 2025 AGM	TGS General Secretary
13:45 - 14:10	Presentation and Deliberation of TGS Strategic and Annual Implementation Plans	TGS General Secretary
14:10 - 14:25	Constitution Amendment	TGS Deputy General Secretary
14:25 - 15:05	Presentation and Deliberation on TGS 2025 Activities, TGS Journal & Financial Report	TGS ExCOM
15:05 - 15:20	TGS Extractive Industry Solutions Limited (TEIS LTD)	TGS President
15:20 - 15:35	Remarks	TGS Advisory Board Chairperson
15:35 - 15:50	AOB	All
15:50 - 16:00	Closing	TGS Vice President
16:00 - 16:30	**HEALTH BREAK**	
16:30 - 16:45	Recap, Announcements & End of Session	
19:30 - onwards	**Ice-breaking Cocktail Party - All**	

DAY 4 (15-09-2026) CONFERENCE

Time	Presenter	Title
07:30 - 08:30	Arrival, Registration and Breakfast	
08:30 - 09:00	Shukrani Manya	Mining Dynamics in Tanzania: Insights from the 2017 Mining Reforms and Beyond
09:00 - 09:15	Gerald Chuwa	Enhancing Geoscientists' Contribution in the Exploration and Mining Sector of Tanzania
09:15 - 09:30	Kabete, Joas M	Scale-based Solid Geological Mapping for new gold discoveries from the Precambrian Shield of Tanzania
09:30 - 10:15	Bentley Systems' Seequent	Gold Exploration Deposit: From Modelling to Estimation, Using Leapfrog Geo
10:15 - 12:15	**Panel Discussion:** Fossil Fuels and the Future of Energy in Tanzania **Convenor:** Dr Ernest Mulaya - Moderator **Panellists:** Dr Kenneth Lupogo (TGDC) Erick Kivera (TPDC) Ebarhat Dilliwa (PURA) Neema Shayo (Energy Finance, Policy and Market Development Specialist) Representative from EWURA	
12:15 - 13:15	**LUNCH BREAK**	
13:15 - 14:15	**POSTER SESSION**	
Time	**Presenter**	**Title**
14:15 - 14:30	Ebahart Dilliwa	Natural Gas as Tanzania's Transition Fuel: The Strategic Role of Geoscientists in Unlocking Sustainable Energy and Economic Development
14:30 - 14:45	Simon Nkenyeli	Fossil Fuels for the Future of Energy in Tanzania: Balancing Energy Security, Sustainable Resource Management, and The Net Zero Transition
14:45 - 15:00	Faustine Matiku	Assessment of Geological CO_2 Storage Potential in The Songo Songo Gas Field, Tanzania
15:00 - 15:15	Johanes Kakoki	Biostratigraphy and Palynological Assessment of the Early Jurassic- Early Cretaceous Sediments in the Mandawa Basin, Tanzania: Implications for Depositional Environment and Hydrocarbon Exploration
15:15 - 15:30	**HEALTH BREAK**	
15:30 - 15:45	Innocent Mvamba	Microfossil Constraints on the Age, Paleoenvironment and Source Rock Potential of the Eyasi-Wembere Basin, Tanzania
15:45 - 16:00	Fabiani Alexzanda	Application of Machine Learning for Natural Gas Production Forecast: A Case Study of the Songo Songo Gas Field
16:00 - 16:15	Edilitruda Malisa	Fault Systems in the Upper Slope Region of the Southern Offshore Tanzania Basin
16:15 - 16:30	Saidi Chamba	Advancing Tanzania’s Natural Gas Supply: Achievements of the 2026 Mnazi Bay Drilling Campaign
16:30 - 16:45	Recap, Announcements & End of Session	
16:45 - 17:00	**EVENING TEA**	

DAY 5 (16-09-2026) CONFERENCE & CLOSING CEREMONY

TIME	PRESENTER	TITLE
07:30 - 08:30	Arrival, Registration and Breakfast	
08:30 - 08:45	Emmanuel Kazimoto	Origin and Age of the Polymetallic (Au-Cu-Pb) Mineralisation in the Mesoproterozoic Mpanda Mineral Field of the Paleoproterozoic Ubendian Belt, SW Tanzania
08:45 - 09:00	Mayigi Makolobela	Geochemistry And U-Pb Zircon Geochronology of Igurubi Granitoids, Nzega Greenstone Belt, Northern Tanzania: Implications for Crustal Growth and Timing of Gold Mineralization
09:00 - 09:15	Adelina Shilula	A Geoscience Data Architecture and an Artisanal-Mining-Trained Prospectivity Engine for Tanzania: Transferring the European Union Model to the Lake Victoria Goldfield
09:15 - 09:30	Ernest Mulaya	The Future of Critical Minerals in the Deep Sea: Sharing a Common Heritage of Mankind
09:30 - 10:00	Karpinsky Russian Geological Institute	From Basic Competences to International Cooperation
10:00 - 10:15	**HEALTH BREAK**	
10:15 - 12:15	**Panel discussion**: Minerals for Industrial and Socio-Economic Growth **Convenor**: Louisa Katolila (GST) **Panellists:** Dr. Gerald Chuwa (UDSM) Eric Kalondwa (GGM) Chone Malembo (RMO, Mining Commission) Manyama Makweba (Strataedge Resources Limited)	
12:15 - 13:15	**LUNCH BREAK**	
13:15 - 13:30	Johnson Lwilla	Hybrid Pathways for Silica Scaling Mitigation: Comparative Review of Nanoparticle and Reactor Technologies in High-Temperature Geothermal Fluids
13:30 - 13:45	Lucas Tumbu	Ranking Geothermal Sites: A Review of the Northern Tanzania Divergent Zone (Ntdz) and the East African Rift System for Assessment of Additional Geothermal Sites in Tanzania
13:45 - 14:00	Paul Mambosasa	Evaluating the Potential for Lithium Recovery from Geothermal Fluids in Tanzania: A Case Study of Selected Rift Valley Prospects
14:00 - 14:15	Epiphania Mtabazi	Lithosphere-Scale 3D Conductive Thermal Modelling of the Coastal Basin of Tanzania: Implications for Geothermal Resources
14:15 - 14:30	**HEALTH BREAK**	
14:30 - 14:45	Emmanuel Makuliga	Assessment of Surface Temperature and Carbon Dioxide Anomalies for Geothermal Exploration in the Ngozi Geothermal Field, Tanzania
14:45 - 15:00	Tumaini Dang'a	Coal-To-Liquid (CTL) Technology as a Sustainable Alternative for Tanzania's Future Energy Supply
15:00 - 15:15	Dickson Kakuru	Hydrothermal Alteration Mineralogy of the Polymetallic Veins at the Mpanda Mineral Field, Western Tanzania
15:15 - 15:30	Joel Faustine	Mineralogy of the Ngualla Carbonatite and its REE-Enriched Supergene Profile, SW Tanzania
15:30 - 16:00	**HEALTH BREAK**	

CLOSING, TGS 2026 ANNUAL CONFERENCE	
16:00 - 16:10	TGS Vice President: Welcoming Remarks
16:10 - 16:25	TGS President: Speech and Welcome to the Guest of Honour
16:25 - 16:55	Guest of Honour
16:55 - 17:10	Photo Session
17:10 - 17:30	**HEALTH BREAK**

DAY 6 & 7 (17,18-09-2026) POST-CONFERENCE WORKSHOP

TIME	SESSION	ACTIVITY
THURSDAY, 17th SEPTEMBER 2026 – GEOLOGICAL MODELLING WORKSHOP WITH SEEQUENT		
07:30 - 08:00	Arrival and setup	
08:00 - 10:00	Geological Modelling Using Leapfrog Geo: From sedimentary units to intrusion ore body	**Workshop Introduction** (+ Licensing and Data Sharing)
10:00 - 11:00		**Leapfrog Geo Fundamentals** - Drill Hole Data Import, Statistics and Quality Control
11:00 - 12:00		**Geological Modelling** - Sedimentary Units and Intrusions
12:00 - 13:00		**LUNCH BREAK**
13:00 - 15:00		**Leapfrog Geo Advanced** - Gold-bearing Intrusion Advanced Modelling
15:00 - 17:00		**Advanced Modelling Techniques Using DRIVER** (A machine learning algorithm to run 3D anisotropy calculations)
17:00	End of day	
FRIDAY, 18th SEPTEMBER 2026 – GEOLOGICAL MODELLING WORKSHOP WITH SEEQUENT		
07:30 - 08:00	Arrival and setup	
08:00 - 10:00	Gold Resource Estimation Using Leapfrog Edge	**Leapfrog Edge** - Exploratory Data Analysis, Compositing, and Domaining
10:00 - 12:00		**Leapfrog Edge + DRIVER** - Variography, Capping, and Kriging Methods
12:00 - 13:00		**LUNCH BREAK**
13:00 - 15:00		**BlockModel** - Estimation and Validation Methods
15:00 - 16:00		**Resource Classification** - Calculation on report with the BlockModel
16:00 - 17:00		**Q&A Session**
17:00	End of day and Workshop	

POSTER PRESENTATIONS

Presenter	Poster Title
Sakila Benezeth	Geological controls on gold mineralization: a case study of Mlimani Target - Shanta Gold Mine
Mustafa Ngumbi	Mineralogy and Geochemistry of Gemstone-Bearing Marble at the Mahenge-Epanko Area, Southeastern Tanzania
Julius Evodius	Remote Sensing Aided Hydrothermal Alterations in Geothermal Systems: A Case Study of Kisaki Geothermal Area
Kelvin Kusaja	Origin of Ultramafic Rocks Associated with the Mesoproterozoic Ngualla Carbonatite Complex, Southwestern Tanzania
Sosthenes Mndeme	Application of Satellite Images in Prospecting of Areas with Potential for Lithium Deposits at Hombolo, Dodoma
Godson Goodluck & Dativa Kato	Integrated Remote Sensing and GIS-Based Groundwater Potential Zones Mapping Around the Kabanga Nickel Mine Area
Samwel Atinda	Unlocking Tanzania's Gold Potential: The Role of Modern Exploration Technologies and Sustainable Industrial and Socio-Economic Growth
Mapolu Mayanga & Evelyne Emmanuel	The Sustainable Geometallurgical Solution: Enhancing Gold Recovery and Economic Value from Low-Grade Ores at Ushirombo–Kelezia, Geita, Tanzania
Irimina Dominicka	Geophysical Characterization of Subsurface Conditions for Safe Infrastructure Development: A Case Study of UDSM-Main Campus
Joseph Rwekunda	Integrated Ground Water Exploration for Climate-Resilient Water Security in Crystalline Basement Terrains of Tanzania
Honester Mkuwa	Integrated Geophysical Approach for Ground Instability Assessment and Community Safety: A Case Study in Dar Es Salaam, Tanzania
Godliver Kahoza	Transforming Mine Waste into Carbon Sinks: Geochemical Evaluation of Tanzania Carbonatite Tailings for Permanent Carbon Storage and Eco-Cement Synthesis
Zulekha Haruna	Hydrostratigraphic Conceptual Model and Aquifer Geometry of the Gokona Underground Gold Deposit, North Mara Gold Mine, Tanzania
Raya Amiri	Geospatial Modelling for Urban Disaster Risk Reduction: A Case Study of Jangwani, Tanzania
Jane Butindi	ERT-Insight 3D: An Interactive Python Framework for Pseudo-3D Electrical Resistivity Visualization in Sustainable Mineral Exploration

Presenter	Poster Title
Veronica Kwandikwa	Assessment of Coal Quality in Relation to Coal Seams in Tanzania
Peter Mkumbe	A Review of the Geological Controls on the Uranium Mineralization in the Mkuju River Project, Namtumbo District, Southern Tanzania
Donald Makubo	Structural Controls and Geochemical Characterization of the Seka Gold Deposit, Musoma-Mara Region, Tanzania: Implications for Sustainable Resource Expansion and Socio-Economic Growth in Tanzania
Penina James	Investigation of Earthquake Vulnerability in the Haneti Area, Dodoma Region
Abdulrahim Salum	Structural and Volcanic Controls on Geothermal Potential in the Rungwe Volcanic Province, Tanzania: An Integrated Remote Sensing and GIS Approach
Lucas Nyamonge	Reducing Drilling Risks Through Geological, GIS, and Geophysical Approaches in Groundwater Exploration in Sengerema District Within the Lake Victoria Basin
Pamela Massawe	Hydrogeophysical Assessment of Groundwater Potential Sites for Borehole Drilling: A Case Study of Bukokwa Village, Buchosa District, Tanzania
Denis Wilfred Moshia, Peter Charles Magembe	Delineation of Subsurface Structures Controlling Ni–Cu Mineralization, Ruangwa, Se Tanzania

ABSTRACTS

MINING DYNAMICS IN TANZANIA: INSIGHTS FROM THE 2017 MINING REFORMS AND BEYOND

Shukrani Elisha Manya

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Mining Dynamics in Tanzania: Insights from the 2017 Mining Reforms and beyond offers a comprehensive analysis of the critical factors shaping the mining industry in Tanzania. The book begins with a comprehensive presentation of the diverse geology of the country that covers an entire world-wide known chrono-stratigraphy that ranges from Archaean through Proterozoic to Quartenary with the only hiatus coming in Early- to Meso-Paleozoic. It underscores the fact that the country's abundant mineral resources, including gold, diamond, copper, niobium, REE, coal, uranium, gypsum, kaolin, limestone, HMS, gemstones and the exclusive Tanzanite, are attributed to its rich and diverse geology.

By exploring the policy and legal framework governing the mining sector, this book unveils the challenges the country faced during the implementation of the mineral policy prior to 2017 and the factors that led to the 2017 mining reforms. The highlights of the reforms are presented in a way that provides the reader with an understanding of the opportunities available in the mining sector, success stories resulting from the reforms as well as the challenges coming as a result of the suggested reforms. Of all the positive outcomes from the 2017 mining reforms, few are more significant than the

establishment of mineral markets for artisanal and small-scale miners, the introduction of local content and Corporate Social Responsibility (CSR) policies, increased government revenue and the establishment of the National Gold and Gem Reserve. Should these measures be efficiently implemented, they are likely to play a significant role in accelerating sustainable growth of the mining sector, benefiting the local communities as well as the country's economy. On the flip side of the 2017 Mining Reforms, the cancellation of the retention licenses as part of the reforms resulted in disputes between the license owners and the Government. The retention license owners pursued legal action by filing disputes with the International Centre for Settlement of Investment Disputes (ICSID). Subsequently, the Government of Tanzania had to pursue an out-of-court settlement to compensate the mining companies which had the retention licenses; a lesson to be learnt in future mining agreements and ventures.

Moreover, this book goes beyond retrospective analysis to present a forward-looking perspective on the future outlook of mining in Tanzania. In order to ensure the future successful exploitation of mineral resources, the book offers valuable recommendations including the government to strengthen its institutions dealing with the mining sector (GST, STAMICO and the Mining Commission) and adopt a 'triple-helix' partnership involving industry, academia, and government, where mining companies, universities, and the Ministry of Minerals and its institutions jointly drive research, innovation, workforce training for sustainable mineral resource development. Furthermore, emphasis should be placed on further exploration to include industrial minerals, REE, Ni, Nb and He; commence the delayed mining projects such as the Vanadium Titanomagnetite Liganga project, support the

mineral beneficiation and marketing strategy by underscoring the fact that Tanzanite is exclusively found in Tanzania and its marketing and sales needs a peculiar strategy. By emphasizing mineral beneficiation in Tanzania, we can effectively synergize the nation's abundant mineral resources with its industrial development agenda. Such an approach will not only create wealth but also generate employment opportunities, which consequently contribute to the overall economic growth and prosperity of the country. The example given here is that of soon commencement of REE, graphite and nickel mining in Tanzania which should provide an opportunity for establishing electric vehicle battery manufacturing industries through attracting the technology in Tanzania rather than exporting these minerals as raw materials for industries abroad.

In order to attain a highly formalized small scale mining sub-sector, the effective oversight and continued maintenance of the established mineral markets is critical to successful development of small scale mining in the foreseeable future as well as abolishing mining practices without licenses. Continued training and offering legal support as well as facilitating accessibility to credit either through subsidy or low rated bank loans are crucial. Support in legal aspects of mining would enable the artisanal and small scale miners to avoid unnecessary conflicts that might ensue due to poor knowledge of how to negotiate the profits proceeding from the Joint-Venture arrangements. Such a support would safeguard miners from inadvertently relinquishing or losing control of their mineral rights and mining tenements through unfavourable contractual arrangements, an issue that has increasingly been reported in recent years.

Like the great nations of the world, Tanzania should maintain and aggressively pursue to beef up its national gold reserve thereby strengthening monetary stability and enhancing the country's financial security and economic growth.

BIOSTRATIGRAPHY AND PALYNOLOGICAL ASSESSMENT OF THE EARLY JURASSIC- EARLY CRETACEOUS SEDIMENTS IN THE MANDAWA BASIN, TANZANIA: IMPLICATIONS FOR DEPOSITIONAL ENVIRONMENT AND HYDROCARBON EXPLORATION

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Thirty-three (33) cutting sediment samples from well X (150-3040 m) in the Mandawa Basin were analyzed palynologically to establish biostratigraphy, depositional environments, kerogen types, and organic maturation. Standard palynological processing recovered predominantly terrestrial palynomorphs (spores and pollen) with fair to good preservation, low-to-medium diversity and abundance; few marine dinoflagellate cysts were identified. Biostratigraphic assemblages indicate an age range from Early Jurassic to Early Cretaceous. Facies interpretations based on assemblage composition and palynomorph associations suggest dominantly shallow marine depositional settings including fluvial and deltaic systems in a nearshore basin, evidenced by low dinocyst diversity dominated by peridinoids and few gonyaulocoids. Organic matter characterization suggested type III kerogen due to the dominance of plant debris (phytoclasts and sporomorphs) implying a gas-prone source potential, while spore colour index (SCI) determinations inferred maturity levels from mature to over mature source rock. These

results refine the palaeoenvironmental and stratigraphic framework of the Mandawa Basin and provide critical data for hydrocarbon exploration.

MICROFOSSIL CONSTRAINTS ON THE AGE, PALEOENVIRONMENT AND SOURCE ROCK POTENTIAL OF THE EYASI-WEMBERE BASIN, TANZANIA

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The timing and processes governing organic matter accumulation in East African Rift lakes remain poorly constrained due to limited subsurface data. We present the first integrated microfossil-based study for the Eyasi Wembere Basin (EWB). Core samples from three stratigraphic boreholes drilled in the basin are here utilized. Palynological, palynofacies, ostracods and sedimentological analyses are used to determine the age, Paleoenvironment and source-rock potential of the basin fill. Based on palynomorph species: Laevigatosporites ovatus and Triorites minor and ostracodes species: Cytherissa lacustris and Ilyocypris bradyi, the age of the studied material ranges from Pliocene to Holocene. From sedimentological and micropaleontological evidence, studied sediments were deposited within a shallow lacustrine system marked by spatial variations in water depth and hydrological conditions; with periodic fluvial input into the basin. Palynofacies analysis shows organic matter dominated by amorphous organic matter and freshwater algae (Botryococcus), indicating oil-prone kerogen types I and II. Spore-colour observations for the studied material indicate a marginally mature source rock. Thus, the basin, represents a potentially

promising but underexplored segment of the East African Rift System, where deeper drilling and additional subsurface investigations are required to fully evaluate its petroleum system potential.

ENHANCING GEOSCIENTISTS' CONTRIBUTION IN THE EXPLORATION AND MINING SECTOR OF TANZANIA

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Tanzania's mining sector contributes approximately 10% to national GDP and positions the country among Africa's leading mineral producers, yet Tanzanian geoscientists-the professionals' best equipped to interpret the nation's geological endowment-remain largely peripheral to the value creation phase of the sector. This presentation examines the organisational, educational, and financial challenges that have relegated geoscientists to roles as data collectors and technical interpreters for foreign-capital entities, while proposing a transformative pathway toward meaningful repositioning.

The current situation presents a paradox: mineral wealth is expanding, small-to-medium scale Tanzanian-owned operations are proliferating, and technological advances in artificial intelligence and remote sensing are making exploration more accessible. However, most geoscientists are trained primarily as data collectors, lacking foundational interpretation skills, financial literacy, and business acumen. Experienced field geologists are retiring, while younger professionals increasingly rely on computer-based tools without the contextual understanding that underpins robust geological interpretation. Profitable mineral ventures remain dominated by foreign-capital-enabled entities, reducing geoscientists to bystanders in the very boom they understand most intimately.

We argue that three interrelated transformations are essential. First, tertiary education must pivot from training data collectors to cultivating "systems thinkers" capable of integrating structural geology, geochemistry, geophysics, and economic considerations within predictive exploration frameworks. Second, geoscientists must acquire foundational financial acumen, risk assessment capabilities, and project management skills to transition from bystanders to active participants in mineral development. Third, the profession must embrace artificial intelligence and machine learning technologies not as replacements for geological expertise, but as powerful tools for data integration, uncertainty reduction, and target ranking.

Drawing on recent sectoral reviews, emerging academia-industry partnerships, and policy initiatives including the Mineral Research Fund, we demonstrate that repositioning is both necessary and achievable. The future geoscientist in Tanzania must own data, interpret with confidence, communicate effectively with diverse stakeholders, and possess the business acumen to risk investment in projects they understand better than anyone else. This is not merely a professional aspiration but an economic imperative if Tanzania is to maximise benefits from its mineral wealth. We conclude with actionable recommendations for educational institutions, professional bodies, government agencies, and industry partners to collaboratively build a sector where Tanzanian geoscientists lead, innovate, and create lasting value.

SCALE-BASED SOLID GEOLOGICAL MAPPING FOR NEW GOLD DISCOVERIES FROM THE PRECAMBRIAN SHIELD OF TANZANIA

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As gold exploration in exposed granitoid-greenstone belts approaches maturity, looking for alternative exploration targets in under- to un-explored belts is of critical importance. That is, looking for new discoveries from: 1) an over 50% of Neoarchean granitoid-greenstone belts covered by in situ and transported regolith in the Lake Victoria Region; 2) Neoarchaean granitoid-greenstone belts covered by Mesoproterozoic thrust belts in the Kibaran Belt of NW Tanzania; 3) Neoarchean granitoid-greenstone belts covered by unmetamorphosed platformal Neoproterozoic sedimentary rocks and Tertiary volcanic rocks in the Eastern Lake Victoria Superterrane; 4) Paleoproterozoic igneous-sedimentary metamorphic rocks covered by unmetamorphosed platformal Neoproterozoic sedimentary rocks and regolith in the Eastern Ubendian Superterrane; 5) Isolated slices of Neoarchean Mazoka Greenstone and Mafulungu Metamorphic Belts in the >3.6 Ga gneissic-granulites of the Central Tanzania Region; and 6) Tectonothermal reworked Neoarchaean to early Neoproterozoic orogenic gold systems in the in the Southern East African Orogen of Tanzania (Figure 1).

Targeting prospective belts from such crustal blocks requires a clear understanding of distinctive geologic-tectonic environments, such as: 1) protolithic igneous-and clastic-marine sedimentary metamorphic belts; 2) craton-to superterrane-scale geometrical orientation and sequencing of

lithostructures, such as upright and horizontal fold types, shear and fault zone systems); 3) domain-scale lithologic, deformation, metamorphic grade, including chemical reactivity and competency contrast; 4) depositional-site host rock geology marked by chemical reactivity, permeability and impermeability and 5) gold deposit/prospects and respective production from specific corridors, camp and/or district. This data, in conjunction with detailed mapping of the bedrock lithostructural controls of the primary gold mineralization documented from a myriad of subcrops and underground mines developed by small-scale mining communities, add value to the gold camp during the targeting exercise.

The growing evidence for the formation of giant orogenic gold deposits during a specific period of rapid lithospheric growth suggests that these deposits are controlled by lithospheric-scale structures and hydrothermal plumbing systems. In that model, depositional traps are proximal to linear, alternately spaced misaligned geometries of structurally failed reactive rocks juxtaposed or overlain by relatively impermeable sedimentary sequences or extensive thrust sheets of impermeable rocks. Therefore, craton- to superterrane-scale hydrothermal plumbing systems are necessary to scavenge and transport gold from potential source regions to favourable depositional sites. Although debated, fluids are from descending oceanic crust, metamorphic devolatilization, and degassing, whereas gold is from the lithospheric mantle, accretionary prisms of ophiolites, fore-deep sedimentary sequences, and back-arc basins. In that context, solid or seamless geological mapping is critical in discriminating contiguous superterranes, terranes, and domains, with some of the lower-order structures constituting suture zones

along which these crustal blocks were amalgamated. Some of the lower-order structures acted as fluid conduits from lower to mid-and upper crustal levels.

Crustal blocks which make up the Precambrian Shield of Tanzania (Figure 2) are outlined based on the qualitative interpretation of remotely sensed imagery in terms of surface geological data. Remotely sensed images include Land/Radar among other satellite imagery, and magnetic, radiometric, electromagnetic, and gravity data, among other geophysical data. Geological data comprise 1:100,000 and 1:125,000-scale Quarter-Degree-Sheet (QDS), and detailed geological data from specific QDS at 1:50,000, detailed mapping by exploration and mining companies as well as research institutions. As it stands, merging of the individual Quarter-Degree-Sheet (QDS) geological maps, especially where mapped by different geologists at different times, produces obvious mismatches in lithostructural continuity. Merging of those QDS maps will produce a map lacking an integrated geological and metallogenic framework based on the tectono-stratigraphic domains and terranes, like the seamless geological maps of the Yilgarn Craton, Western Australia (Figure 3) and the Superior Cratons, Canada.

LITHOSPHERE SCALE 3D CONDUCTIVE THERMAL MODELING OF THE COASTAL BASIN OF TANZANIA: IMPLICATIONS FOR GEOTHERMAL RESOURCES

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The lithospheric thermal structure of the Coastal Basin of Tanzania remains poorly constrained despite its importance for geothermal resource assessments and petroleum system evaluation. This study developed the first three-dimensional lithosphere-scale conductive thermal model of the basin to characterize the regional subsurface temperature distribution and identify prospective geothermal targets for further exploration. The model integrates lithospheric geometry and thermal properties and was validated using bottom-hole temperature data. The modelled thermal regime exhibits spatial variation across the basin. Temperatures exceeding 200 °C are found at shallower depth of < 5 km, along with elevated geothermal gradients and heat flow above 38 °C km^{-1} and 83 mW m^{-2} respectively, occur predominantly in the western part of the basin. These thermal anomalies result from the combined effects of lithospheric thinning, associated with the ongoing East African rift, basement uplift, sedimentary insulation, and deep fluid circulation. In contrast, the eastern basin exhibits a relatively cooler thermal regime, probably associated with a thick lithosphere. The 150 °C isotherm occurs within economically drillable depths of ~ 3.0–4.4 km, indicating favourable conditions for medium to high temperature geothermal resources in the west and low to medium temperature resources in the east. Comparison with borehole temperatures data shows a good agreement, with localized misfits

confined to areas affected by convective heat transfer. The study identifies the western part of the Coastal Basin as a previously unrecognized priority target for geothermal exploration. The resulting thermal model provides a regional framework for geothermal exploration and valuable thermal constraints for basin and petroleum system modelling.

THE FUTURE OF CRITICAL MINERALS IN THE DEEP SEA: SHARING A COMMON HERITAGE OF MANKIND

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The global transition towards low-carbon technologies has significantly increased the demand for critical minerals, including cobalt, nickel, copper, platinum and rare earth elements (REEs), which are indispensable for green-tech evolution such as electric vehicles, renewable energy systems, high-efficiency motors, and electronics. The deep seabed, also known as ‘‘the area’’ represents one of the world's largest untapped mineral potential occurring within distinct geological scenery such as cobalt-rich ferromanganese crusts, polymetallic manganese nodules, seafloor massive sulphides and rare earth element-rich deep-sea muds. As terrestrial resources become increasingly constrained, these deep-sea deposits are attracting a growing international interest for future mineral supply.

Currently, technologically advanced nations, including Japan, China, the United States, Russia, German, UK etc, together with multinational exploration contractors, dominate deep-sea mineral exploration under licences administered by the International Seabed Authority (ISA) in accordance with the United Nations Convention on the Law of the Sea (UNCLOS). While mineral resources located beyond national jurisdiction are legally recognised as the Common Heritage of Mankind, concerns remain regarding equitable access, technological disparities, environmental stewardship, and the fair distribution of future economic benefits.

Here we examine the current global status of seabed mineral exploration, highlight the geological occurrence and resource potential of deep-sea critical minerals. Particular attention is given to the prospectivity of Tanzania's jurisdiction in the Indian Ocean which presents a future opportunity for scientific investigation and resource assessment.

EVALUATING THE POTENTIAL FOR LITHIUM RECOVERY FROM GEOTHERMAL FLUIDS IN TANZANIA: A CASE STUDY OF SELECTED RIFT VALLEY PROSPECTS

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The increasing global demand for lithium, driven by its essential role in energy storage technologies, has intensified the search for sustainable and alternative resources beyond conventional mining. Geothermal fluids represent a promising source due to their continuous circulation in high-temperature reservoirs, where water-rock interactions facilitate lithium mobilization into solution. This study evaluates the potential for lithium recovery from geothermal systems in Tanzania, focusing on key prospects within the East African Rift System, including Kiejo-Mbaka, Songwe, Manyara, Eyasi, and Lake Natron. The methodology involves the analysis of surface geothermal fluid samples combined with geological and hydrothermal system characterization to assess lithium occurrence and distribution. Measured lithium concentrations from surface manifestations indicate values of 1.03 ppm (Kiejo-Mbaka), 1.04 ppm (Songwe), 0.54 ppm (Manyara), 0.45 ppm (Eyasi), and 2.84 ppm (Lake Natron).

The results show that lithium is present across all studied geothermal systems, with Lake Natron exhibiting the highest concentration, likely due to its alkaline hydrothermal environment and strong tectono-magmatic influence. The observed variations in lithium concentration are interpreted to reflect differences in reservoir temperature, fluid-rock interaction intensity,

and geological setting. Although the concentrations are relatively low compared to conventional brine deposits, the continuous flow and reinjection of geothermal fluids provide a sustainable mechanism for resource replenishment.

The study concludes that Tanzania's geothermal systems, particularly Lake Natron, hold promising potential for lithium recovery. Integrating lithium extraction into geothermal operations could enhance project viability while contributing to the supply of critical minerals. Further work is recommended to conduct subsurface fluid analysis and to develop efficient and selective extraction technologies, particularly direct lithium extraction methods suitable for geothermal conditions.

NATURAL GAS AS TANZANIA'S TRANSITION FUEL: THE STRATEGIC ROLE OF GEOSCIENTISTS IN UNLOCKING SUSTAINABLE ENERGY AND ECONOMIC DEVELOPMENT

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As the global energy landscape pivots toward lower-carbon systems, Tanzania faces a critical opportunity to define the strategic role of its abundant natural gas resources. With reserves exceeding 57 trillion cubic feet (Tcf), current negotiations for the Tanzania Liquefied Natural Gas (LNG) Project, and upcoming offshore and onshore licensing rounds, the nation is well-positioned to leverage its petroleum assets to drive industrialization, bolster energy security, and foster regional economic growth, all while advancing a responsible energy transition.

This paper argues that Tanzania’s energy trajectory should not be framed as a binary choice between fossil fuels and renewables, but as a strategic integration of both. Natural gas serves as a critical transition fuel, offering a lower-carbon alternative to coal and heavy fuel oil. It is essential for reliable power generation, industrial feedstock for petrochemicals and fertilizer production, clean cooking solutions, transportation fuel via compressed natural gas (CNG), and as a foundation for future technologies like blue hydrogen and carbon capture and storage (CCS).

The paper highlights the expanding role of modern geologists, who must now transcend conventional exploration to integrate environmental, commercial, and digital competencies across the petroleum value chain. From basin evaluation and risk assessment to field development planning and carbon

storage characterization, professionals are increasingly leveraging artificial intelligence, machine learning, and advanced seismic imaging to enhance exploration efficiency.

Framed around Tanzania's forthcoming licensing round, this submission examines how high-quality geological data, transparent resource evaluation, and robust petroleum systems analysis can significantly enhance investor confidence and exploration success. Furthermore, the paper emphasizes the integration of environmental, social, and governance (ESG) principles into exploration and development to ensure responsible resource management aligned with national climate objectives.

The paper concludes that as Tanzania advances the development of its petroleum resources and implements its long-term development agenda under Vision 2050, geoscientists will be central to identifying, evaluating, and sustainably managing the nation's subsurface resources. By integrating sound geosciences with innovation, legal and regulatory awareness, commercial understanding, and environmental stewardship, geologists can unlock the full value of Tanzania's petroleum resources while attracting investment, enhancing energy security, supporting value addition and industrialization, and promoting sustainable economic growth. The paper emphasizes that future geoscientists must be interdisciplinary professionals capable of bridging science, law, policy, and business to contribute effectively to Tanzania's transition towards a resilient, inclusive, and sustainable energy future.

FOSSIL FUELS FOR THE FUTURE OF ENERGY IN TANZANIA: BALANCING ENERGY SECURITY, SUSTAINABLE RESOURCE MANAGEMENT, AND THE NET ZERO TRANSITION

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Tanzania's growing economy and increasing energy demand require a pragmatic and inclusive energy strategy that balances energy security, affordability, and environmental sustainability. While renewable energy sources are expected to play an expanding role in the national energy mix, fossil fuels, particularly natural gas, remain a strategic component of Tanzania's energy transition. The country's substantial natural gas resources present a pivotal opportunity to support industrialization, electricity generation, fertilizer production, and regional energy trade while facilitating a gradual transition toward a lower-carbon economy.

This paper examines the evolving role of fossil fuels within Tanzania's long-term energy landscape, emphasizing the importance of responsible upstream petroleum exploration and production in supporting sustainable socio-economic development. It analyzes how advances in exploration technologies, improved reservoir management, methane emission reductions, and strengthened environmental safeguards can reduce the carbon intensity of petroleum operations while maintaining energy reliability and economic competitiveness. Furthermore, the paper explores the complementary role of natural gas in integrating intermittent renewable energy sources and enabling a resilient national energy system.

The paper also highlights the critical contribution of the Petroleum Upstream Regulatory Authority (PURA) in promoting sustainable petroleum resource management through effective licensing, regulatory oversight, environmental compliance monitoring, and enforcement of international best practices across upstream petroleum operations. By ensuring that upstream activities are conducted safely and efficiently, PURA aligns the development of Tanzania's petroleum resources with national climate commitments and global decarbonization goals.

Ultimately, the paper argues that achieving net zero should not necessitate the premature abandonment of domestic fossil fuels; rather, it requires their optimized, environmentally responsible utilization alongside accelerated deployment of renewable energies, carbon mitigation technologies, and robust regulatory frameworks. This balanced approach positions Tanzania to simultaneously achieve energy security, economic growth, and climate resilience.

ASSESSMENT OF GEOLOGICAL CO_2 STORAGE POTENTIAL IN THE SONGO SONGO GAS FIELD, TANZANIA

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Carbon Capture and Storage (CCS) is a key technology for mitigating greenhouse gas emissions while maintaining energy security during the global transition to low-carbon systems. This study evaluates the geological suitability and theoretical carbon dioxide (CO_2) storage capacity of the Songo Songo Gas Field, Tanzania's principal producing natural gas field, using the Peng–Robinson Equation of State (PR-EOS) and Static Volumetric Modelling (SVM). Based on preliminary equation of state calculations, the densities of CO_2 beyond the critical point were determined to be 373 kg/m³ and 619 kg/m³ for the Upper Songo Songo (USS) and Lower Songo Songo (LSS) reservoirs, respectively. These values were then used in a static volumetric storage model to calculate theoretical storage capacities across a sensitivity range of efficiency factors (E) from 60% to 80%. A straightforward deterministic approach was used, and the results indicated a total field capacity of 55.66 Mt CO_2 at E = 60%, increasing to 74.21 Mt CO_2 at E = 80%. On the other hand, Monte Carlo simulations provided a probabilistic distribution of storage potential, yielding a mean total capacity of 64.92 Mt CO_2 and a P50 (median) estimate of 64.40 Mt CO_2. The aforesaid results demonstrate that the Songo Songo Gas Field has substantial potential for secure, long-term geological CO_2 storage. This study provides a

technical baseline for the development of Carbon Capture and Storage (CCS) strategies in Tanzania and contributes to the broader assessment of geological CO_2 storage opportunities across the East African region.

HYDROTHERMAL ALTERATION MINERALOGY OF THE POLYMETALLIC VEINS AT THE MPANDA MINERAL FIELD, WESTERN TANZANIA

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The Mpanda Mineral Field (MMF) in Western Tanzania is known for its copper (Cu), gold (Au), and lead (Pb) mineralization. This study focuses on characterizing the hydrothermal alteration mineralogy of MMF veins using field descriptions, drill core logging, and Short Wavelength Infrared Spectrometry (SWIR). The host rocks to the MMF veins are mainly granitic gneisses, mafic amphibolites, and argillaceous metasediments. Adjacent to veins, these rocks are extremely bleached and fine-grained, with the thickness of the halo ranging between a few cm in smaller veins and a few meters in large veins.

SWIR analysis of host rocks and altered sections from eight boreholes from Kapanda and D-Reef identified ten minerals: chlorite, white mica, epidote, riebeckite, hornblende, biotite, phlogopite, ankerite, and siderite. Chlorite is the most abundant and occurs in mafic-rich host rock with absorption wavelengths between 2249 – 2255 nm (FeOH) and 2322 – 2354 nm (MgOH). In altered mafic rocks, chlorite absorption wavelengths varied between 2248 – 2256 nm (FeOH) and 2329 – 2343 nm (MgOH), suggesting an increase in Mg content in chlorite. White mica was identified in granitic and metapelites, and it is mainly muscovitic in composition with a low and

narrow range of AlOH absorption wavelength (2197.88–2200.83 nm). In altered sections of these units, AlOH absorption wavelength increases to 2199.81 –2227.35 nm, and the minimum and maximum values of mica crystallinity ranged between 0 and 0.7, signifying less to moderately muscovitic to phengitic composition. Epidote was detected in distal alteration zones and has 2251–2255.68 nm. Carbonates (calcite and siderite) are restricted only within and proximal to the veins and have 2339.69 – 2347.06 nm. Uniquely, ankerite was detected only in breccia zones

Hydrothermal alteration in the Mpanda Mineral Field (MMF) was influenced by acidic to near neutral pH, temperatures ranging from 350°C–500°C, indicating mesozonal mineralization under greenschist facies conditions. These mineralogical variations provide critical insights into the alteration environment and serve as valuable exploration indicators for the MMF and similar geological settings.

ORIGIN AND AGE OF THE POLYMETALLIC (Au-Cu-Pb) MINERALISATION IN THE MESOPROTEROZOIC MPANDA MINERAL FIELD OF THE PALEOPROTEROZOIC UBENDIAN BELT, SW TANZANIA

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Our geochemical-mineralogical study investigates the genesis of polymetallic (Au-Cu-Pb) vein deposits in the Mesoproterozoic Mpanda Mineral Field (MMF), hosted by the Archean–Paleoproterozoic Katuma Block of the Ubendian Belt, Tanzania. The granulite-facies host rocks are pervasively overprinted by greenschist-facies hydrothermal alteration extending tens of metres from the veins. The veins exhibit open-space-filling textures and comprise quartz, K-feldspar, siderite, barite, galena, pyrite, and chalcopyrite, with Au associated with pyrite and chalcopyrite. Lead isotopes of primary sulphides indicate a thorogenic, upper-crustal source, while C–O isotopes of siderite are consistent with metamorphic and/or magmatic fluids. Siderite–quartz isotope fractionation indicates hydrothermal temperatures of 390–500 °C. Hydrothermally recrystallised monazite dates the alteration at ca. 1170 Ma, contemporaneous with high-grade Kibaran metamorphism in the adjacent Wakole Block. We propose that metamorphic dehydration during Kibaran crustal thickening generated fluids that ascended through the

Katuma Block and precipitated the polymetallic veins, mainly along reactivated Paleoproterozoic SSE–NNW and E–W fault zones at ca. 1170 Ma. The MMF veins therefore record hydrothermal mineralisation associated with the Kibaran orogenic event and its accompanying metamorphic fluid generation.

HYBRID PATHWAYS FOR SILICA SCALING MITIGATION: COMPARATIVE REVIEW OF NANOPARTICLE AND REACTOR TECHNOLOGIES IN HIGH TEMPERATURE GEOTHERMAL FLUIDS

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Silica scaling is a persistent challenge in high-enthalpy geothermal power plants, caused by supersaturation of monosilicic acid during brine cooling and depressurization, which reduces efficiency and raises maintenance costs. The purpose of this review is to evaluate conventional reactor–retention tank systems alongside emerging nanoparticle-based silica capture technologies. Methodologically, the study synthesizes reported case studies from geothermal fields such as Olkaria in Kenya and Hellisheiði in Iceland and other related current literatures, comparing mechanisms, kinetics, thermodynamics, and reactor design implications. Results indicate that conventional systems, while reliable and scalable, suffer from slow kinetics, large reactor volumes, and high capital costs, whereas nanoparticle approaches including nano seeding, surface-functionalized inhibitors, and reactive scavengers achieve silica capture efficiencies of 85–95% under controlled conditions, enabling rapid nucleation and recovery of high-purity silica nanomaterials though field deployment remains limited. Therefore, the proposed hybrid reactor concept that integrates nanoparticle-assisted nucleation with seeded particle growth, offering higher removal rates,

reduced residence times, smaller reactor sizes, and efficient solid–liquid separation, with future work directed toward field validation, techno economic analysis, and system integration to accelerate industrial adoption.

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 drilling, surface geological mapping, geochemistry, and geophysical surveys. 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 a 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. Hydrothermal alteration mineral signals 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 inactive geothermal systems. This study suggests that combining SRTMDEM and Landsat 8OLI/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.

GEOLOGICAL CONTROLS ON GOLD MINERALIZATION: A CASE STUDY OF MLIMANI TARGET- SHANTA GOLD MINE

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The Mlimani Target, located within the Lupa Goldfield of south-western Tanzania, forms part of the highly prospective New Luika Gold Mine (NLGM), which hosts significant orogenic gold mineralization associated with the Paleoproterozoic Ubendian Belt. Gold mineralization within the target area is controlled by a combination of structural, lithological, and hydrothermal factors that collectively influence the localization and concentration of auriferous fluids. Regional and local-scale shear zones, fault systems, and fracture networks acted as primary conduits for hydrothermal fluid flow, resulting in the development of mineralized quartz veins and vein-hosted sulphide assemblages. The mineralization is predominantly associated with brittle-ductile deformation zones and mylonitic shear fabrics that facilitated repeated fluid migration and gold deposition.

Lithological controls are reflected by the preferential occurrence of gold within altered granitoids, mafic intrusive rocks, and structurally favorable contacts characterized by competency contrasts. Hydrothermal alteration, including silicification, sericitization, chloritization, and sulphidation, is closely associated with mineralized zones and serves as a valuable exploration vector. Detailed geological mapping and structural analysis at the Mlimani Target indicate that high-grade mineralization is concentrated within zones of intense shearing, quartz veining, and sulphide enrichment, particularly where multiple structural orientations intersect. These geological

features demonstrate the strong relationship between deformation processes and gold precipitation.

This study highlights the importance of integrating geological mapping, structural interpretation, and alteration studies to define the key controls on mineralization and improve exploration targeting within the New Luika Gold Mine. The findings contribute to a better understanding of the geological framework governing gold mineralization in the Lupa Goldfield and provide valuable guidance for future resource expansion and exploration programs within the Mlimani Target and adjacent prospects.

FAULT SYSTEMS IN THE UPPER SLOPE REGION OF THE SOUTHERN OFFSHORE TANZANIA BASIN

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Fault mapping and characterization are necessary for successful hydrocarbon exploration, production, and geological storage of carbon dioxide. In the upper slope region of the southern offshore Tanzanian Basin, relatively few studies have focused on fault analysis to improve understanding of their vertical and lateral distributions, factors known to control sedimentation and affect drilling and production operations. In frontier settings, detailed lateral and vertical fault distributions often remain constrained. This study focused on analysing the lateral and vertical distribution of fault systems in this region by utilising different seismic attributes to enhance resolution of structural discontinuities to allow detailed mapping of fault networks. The attributes used include chaos, variance, and ant-tracking, with ant-tracking providing the best fault-mapping results in the study area.

Results indicate that fault density increases in the upper stratigraphic interval. Furthermore, most fault systems in the study area exhibit a NNE-SSW fault trend. Manual interpretation of seismic sections using Petrel software shows that the area is predominantly affected by normal faults. Additionally, a negative fault flower structure was identified, suggesting that the basin evolution was also influenced by shearing. Seismic sections further revealed widespread occurrence of channel features within the younger stratigraphic units, including the Miocene-Holocene interval.

Considering the relevance of fault networks in the petroleum industry, this study provides a benchmark for future regional research, including the use of machine learning, in fault mapping. Further studies in the area should also focus on detailing the influence of different fault systems on prospect distribution.

ADVANCING TANZANIA'S NATURAL GAS SUPPLY: ACHIEVEMENTS OF THE 2026 MNAZI BAY DRILLING CAMPAIGN

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In 2026, Tanzania commenced the implementation of the 2050 National Development Vision which among other goals, targets a 70 GW power generation capacity. Achieving this requires the rapid exploitation of existing energy sources alongside the exploration of new generation opportunities. Consequently, Tanzania's petroleum upstream sub-sector is accelerating initiatives to unlock petroleum reserves and sustainably develop resources, particularly within the Ruvuma and Eyasi Wembere Basins. Key national efforts include expanded exploration and development operations, such as 2D and 3D seismic data acquisition in the Eyasi Wembere and Lindi-Mtwara Blocks to enhance geological imaging of subsurface features, drilling in the Mnazi Bay gas and Ntorya gas fields and commercialization efforts of the offshore discovered natural gas resources. In this context, this presentation highlights the impact of the 2026 Mnazi Bay drilling campaign on national energy supply. This campaign contributes to a sustainable global energy transition, clean energy initiatives in the country, and achieving the 2050 National Vision.

The 2026 Mnazi Bay drilling campaign marks a milestone in the upstream sector. The campaign involves three wells: MB-5, MS-2, and Kasa-1X. To date, the successful drilling and completion of the MB-5 and MS-2 wells

have increased the Mnazi Bay field production capacity from 100 MMscfd, produced from the five existing wells, to 160 MMscfd. Furthermore, the successful completion of the Kasa-1X exploration well is expected to increase this volume even further. This significant increase confirms the promising nature of the Mnazi Bay reservoirs and highlights the potential for exploiting untapped resources, thereby justifying an expanded role for geoscience in exploration across the Ruvuma Basin. The output from the two new infill wells has raised Tanzania's total natural gas production capacity to approximately 230 MMscfd, contributing to energy security and a sustainable energy mix.

DELINEATION OF SUBSURFACE STRUCTURES CONTROLLING Ni–Cu MINERALIZATION, RUANGWA, SE TANZANIA

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The growing global demand for critical minerals required in clean energy technologies and industrial development has increased the need for efficient exploration methods that can support sustainable resource discovery. Nickel (Ni) and copper (Cu) are among the strategic minerals essential for battery manufacturing, electric vehicles, power transmission systems, and renewable energy infrastructure. This study investigates the subsurface structural controls of Ni–Cu mineralization in the Ruangwa area of south-eastern Tanzania to identify prospective mineralized zones and contribute to the sustainable development of Tanzania's mineral resources.

The study integrates geological mapping, geochemical analysis and ground magnetic surveys to delineate structures controlling mineralization. The project area is located within the Mozambique Belt and is characterized by mafic to ultramafic rocks, including garnetiferous pyroxenites, which provide favourable host rocks for Ni–Cu mineralization. Geochemical analyses indicate significant nickel and copper enrichment within the mafic units. Ground magnetic data reveal prominent NW–SE and E–W trending structural features. The integration of these datasets suggests that major fault and shear systems exert strong controls on the emplacement and concentration of Ni–Cu mineralization.

The study demonstrates the effectiveness of integrated geoscientific approaches in reducing exploration risk and improving target generation. The delineated structural corridors represent priority exploration targets for future trenching and drilling programs. By enhancing the discovery and development of critical mineral resources, the findings contribute directly to Tanzania's industrial growth, support the supply of minerals required for the global energy transition, and promote resilient and sustainable resource development.

REDUCING DRILLING RISKS THROUGH GEOLOGICAL, GIS, AND GEOPHYSICAL APPROACHES IN GROUNDWATER EXPLORATION IN SENGEREMA DISTRICT WITHIN THE LAKE VICTORIA BASIN

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Groundwater exploration within the Lake Victoria Basin is frequently constrained by high drilling risks, resulting in low borehole success rates and increased exploration costs. This study aimed to reduce drilling uncertainties in Sengerema District, Tanzania, by integrating geological investigations, Geographic Information Systems (GIS), and geophysical methods to identify and delineate groundwater potential zones.

Geological mapping, remote sensing, and GIS-based spatial analyses were used to generate thematic layers including geology, drainage, lineament density, slope, and land use/land cover. These datasets were integrated with Vertical Electrical Sounding (VES) results to characterize subsurface conditions and identify favorable aquifer zones. A multi-criteria decision analysis approach was employed to produce a groundwater potential map for the entire district. The results revealed that approximately 32% of Sengerema District is characterized by high groundwater potential, 46% by moderate potential, and 22% by low potential. Areas exhibiting high lineament density, favorable lithology, gentle slopes, and low resistivity values were identified as the most suitable for groundwater development. The integrated approach

significantly improves borehole siting accuracy, thereby reducing the risk of unsuccessful drilling and associated economic losses.

This study demonstrates the effectiveness of combining geological, GIS, and geophysical techniques as a cost-effective decision support framework for sustainable groundwater exploration and water resource management in Sengerema District and other regions within the Lake Victoria Basin.

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.

GEOLOGICAL INTERPRETATION OF THE EPANKO GRAPHITE PROJECT AND ITS IMPACT, WITH OTHER MODIFYING FACTORS, ON CONFIDENCE OF INDUSTRIAL MINERAL ORE RESERVES

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Over the course of exploration at the Epanko Graphite Project (Project, Epanko), Morogoro Region of Tanzania, the geological understanding of the deposit has dramatically changed, resulting in the high-resolution interpretation presented in this paper. Commencing with the 125,000-scale Tanzanian Geological Survey QDS map of Ulanga District, the Project now finds itself with a highly detailed deposit-scale geological map and interpretation covering the entire 19km2 of the Project's Special Mining Licence (SML). This evolution is the product of multiple workstreams by Duma TanzGraphite, over recent years, incorporating data from traditional geological field-mapping, exploration drilling and test pitting, as well as desktop interpretation of high-resolution VTEM and magnetic data and aerial imagery.

The resulting interpretation has shown the Project to feature the structurally thickened limb of the Mahenge fold, which results in the Project's SML hosting a 200 m-wide unit of graphitic schist for the entire 5.5 km strike length. This differs from other areas, where the lack of structural thickening

results in multiple thin units of graphitic schist with waste rock between. The impacts of this on project economics are profound, with Epanko featuring sector-leading parameters including tonnes per linear metre and strip ratios. However, geological understanding of the deposit alone cannot define Ore Reserves or project viability, because Modifying Factors, including metallurgy processes, product quality, marketability, must also be assessed, as well as ESG and engineering considerations.

Several minerals listed as critical by Australia, the European Commission and the United States of America are classified under the JORC Code as Industrial Minerals. Their value depends on variable physical specifications that determine possible uses, for example, graphite 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. This paper takes the Epanko Graphite Project in Tanzania as a case study, where the project's favourable geological setting, combined with a strong understanding of the metallurgy, physical properties and marketability of the ore and product, which has been established over the past 13 years, has allowed 82% of its total Ore Reserve to be classified as proved.

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

already in production. Given that reserves dictate project economics, the authors propose that the JORC Code require a minimum Proved threshold for Industrial Minerals.

MINERALOGY AND GEOCHEMISTRY OF GEMSTONE BEARING MARBLE AT THE MAHENGE-EPANKO AREA, SOUTHEASTERN TANZANIA

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The Jongo Pit in the Mahenge-Epanko area of southeastern Tanzania hosts economically important gem-bearing marbles within the Neoproterozoic Mozambique Belt. However, limited knowledge of their mineralogical and geochemical characteristics has reduced exploration efficiency and made it difficult to distinguish mineralized from barren marble during mining operations.

This study assessed the mineralogical assemblages and geochemical characteristics of gem-bearing marble at Ruby International Limited Company. Ten representative rock samples were collected from marble channels. Petrographic analysis was conducted on four thin sections, while six samples were analyzed using X-ray fluorescence (XRF) to determine major oxides and trace elements. The marble is dominated by calcite and dolomite with accessory spinel, clinohumite, pargasite, apatite, phlogopite, and graphite. Spinel-bearing assemblages indicate gemstone mineralization, whereas calcite-dolomite marble represents barren zones. CaO and MgO are the dominant major oxides, while chromium (Cr), supported by Fe, Ti, and Mn, is the principal geochemical indicator of gemstone mineralization.

Integrating petrographic and geochemical analyses provides an effective exploration approach for identifying gem-bearing marble, supporting

sustainable mining, and contributing to industrial growth and socio-economic development in Tanzania.

RANKING GEOTHERMAL SITES: A REVIEW OF THE NORTHERN TANZANIA DIVERGENT ZONE (NTDZ) AND THE EAST AFRICAN RIFT SYSTEM FOR ASSESSMENT OF ADDITIONAL GEOTHERMAL SITES IN TANZANIA

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The Northern Tanzania Divergent Zone (NTDZ) represents a unique early-stage continental rift within the East African Rift System (EARS), characterized by a stark transition from magmatic segments in the north to amagmatic segments in the south. Understanding the deep-seated lithospheric controls is essential for characterizing the geothermal potential in regions where surface manifestations may not fully represent the underlying heat source.

This study provides a comprehensive deskwork evaluation of the NTDZ and entire EARS to identify and rank additional geothermal sites. The primary goal is to integrate regional geophysical datasets-including MT imaging, seismic tomography, and CPD analysis-to develop a robust conceptual model for resource exploration. The assessment synthesizes data from two ~100 km MT profiles (P1 and P2) and 3D inversion models to map subsurface resistivity and thermal structures. Thermal regimes were quantified using CPD estimates and heat flux calculations (79–117 mW/m²) derived from aeromagnetic spectral analysis. Sites were subsequently prioritized using a Conceptual Ranking Framework based on magmatic maturity and thermal weakening.

Investigations reveal that the NTD is controlled by significant variations in mantle composition and partial-melt distribution. The magmatic segments (Natron, Lengai, and Meru) exhibit high geothermal potential, characterized by shallow CPDs (12–16 km), high heat flux, and strong MT conductors interpreted as representing 1–3% partial melt. The amagmatic segments (Manyara and Eyasi) show high to moderate potential; although they lack surface volcanism, deep-seated low-resistivity zones indicate persistent lithospheric metasomatism and thermal anomalies that support rift propagation. Overall, rift segmentation (structural control) is fundamentally governed by lithospheric inheritance and thermo-chemical modification, with seismic swarms localizing in areas of enhanced fluid and melt migration.

The integration of deep geophysical indicators identifies the magmatic northern sector as the highest priority for geothermal development. However, the presence of metasomatized mantle beneath amagmatic segments suggests untapped potential for moderate-enthalpy systems. The study recommends transitioning to detailed field assessment and targeted surface surveys to validate these subsurface models. In addition, the study successfully ranked geothermal potentials in Tanzania based on site-by-site assessment within the entire EARS, with the priority being given to the Rungwe Volcanic Province (RVP), including geothermal sites such as Ngozi, Kiejo-Mbaka and Songwe, which are situated at the triple-triple junction of the EARS, implying enhanced permeability.

COAL-TO-LIQUID (CTL) TECHNOLOGY AS A SUSTAINABLE ALTERNATIVE FOR TANZANIA'S FUTURE ENERGY SUPPLY

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The increasing global demand for transportation fuels and concerns over energy security have renewed interest in Coal-to-Liquid (CTL) technology as an alternative source of liquid fuels. CTL converts coal into synthetic fuels, including diesel, gasoline, and jet fuel, through either direct coal liquefaction or indirect liquefaction involving coal gasification followed by the Fischer-Tropsch synthesis process. Tanzania possesses significant coal resources in the Songwe–Kiwira, Ngaka, and Mchuchuma coalfields, which predominantly contain bituminous and sub bituminous coals suitable for CTL production. These resources present a strategic opportunity to enhance national energy security, reduce dependence on imported petroleum products, and promote value addition to the country's abundant coal reserves.

This work reviews the principles of CTL technology, its major processing routes, economic and environmental challenges, and its potential application in Tanzania. Particular emphasis is placed on the technological requirements for successful CTL implementation, including advanced gasification and Fischer-Tropsch technologies, carbon capture and storage (CCS) systems, reliable water and power infrastructure, and modern process control systems. The study also highlights the critical need to develop skilled human resources in chemical engineering, process engineering, mining, geology, environmental management, and plant operation to support the design,

construction, operation, and maintenance of CTL facilities. Furthermore, investment in research and development, technology transfer, and collaboration between government, universities, and industry is essential for building local technical capacity.

APPLICATION OF MACHINE LEARNING FOR NATURAL GAS PRODUCTION FORECAST: A CASE STUDY OF THE SONGO SONGO GAS FIELD

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This study involves the application of machine learning (ML) techniques to forecast natural gas production at the Songo songo gas field in Tanzania, which currently relies on traditional methods. These methods often involve simplifying assumptions, are time-consuming, and costly. This study, therefore, applied machine learning techniques to forecast natural gas production using historical production data from wells SS10 and SS11, aiming to improve the accuracy and efficiency of production forecasts, which utilize historical production data. The study employs the Extreme Gradient Boosting (XGBoost) model for Well SS11 and the Random Forest Regressor for Well SS10 to develop predictive models for estimating natural gas production.

Methodologies used to achieve the objective of this study involved important steps, including Python library 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 predictions from the test set in the data partition. Important performance evaluation metrics (R^2, MAE, MSE) were evaluated to assess models' performance from the actual dataset and the predicted values.

Model performance was evaluated using the coefficient of determination (R^2), mean absolute error (MAE), and mean squared error (MSE), while testing dataset, the XGBoost model achieved an R^2 of 0.930 with an MSE of 0.001 (mmscf/day) ^{2}and an MAE of 0.015 MMscf/day. In comparison, the Random Forest model achieved an R^2 of 0.825, an MSE of 0.011 $(mmscf/day)^2$, and an MAE of 0.066 MMscf/day.

The study concludes that machine learning-based approaches, particularly XGBoost and Random Forest, provide reliable and accurate tools for natural gas production estimation. These models offer practical value for enhancing forecasting accuracy, supporting reservoir performance evaluation, and improving operational decision-making within the Songo songo Gas Field and similar gas reservoirs.

MINERALOGY OF THE NGUALLA CARBONATITE AND ITS REE-ENRICHED SUPERGENE PROFILE, SW TANZANIA

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The Ngualla carbonatite deposit of southwestern Tanzania is a weathered carbonatite deposit hosted within the Paleoproterozoic Ubendian basement. The deposit is characterised by a ~150 m-thick, REE-enriched, weathered profile preserved above circular-shaped calcite and dolomite carbonatite rocks. This work details the preliminary mineralogical pattern of the Ngualla carbonatite and its weathered profile. The integrated optical petrographic microscopy and X-ray diffraction (XRD) analyses of fresh carbonatite rocks indicate three main types of carbonatites: (i) calcite carbonatite, (ii) dolomite carbonatite, and (iii) talc dolomite carbonatite. The calcite carbonatites comprise calcite, phlogopite, magnetite, and sodic-calcic amphiboles (riebeckite and arfvedsonite). The dolomite carbonatites, on the other hand, are dominated by ferroan dolomite Ca(Mg, Fe)2CO3 and interstitials of quartz, barite, and REE minerals (mainly synchysite). The weathered profile on top of the dolomite carbonatite is characterised by quartz, barite, goethite, hematite, clay minerals (kaolinite, montmorillonite, illite, and minor chlorite), and REE minerals such as bastnäsite-(Pr, Nd), monazite-(Nd), and cerianite.

The mineralogical pattern indicates that primary REE mineralization is limited to dolomite carbonatites. The occurrence of REE minerals as interstitials within dolomite carbonatites provides evidence that REE

mineralization in Ngualla was originally hydrothermal, having crystallized from Si-Ba-REE-F-enriched and OH-poor fluids. The origin of these fluids is still unknown. In situ prolonged weathering of dolomite carbonatite, likely by acidic groundwater and meteoric water, resulted in carbonate leaching. Clays, Fe oxides, and Fe hydroxides were left behind as weathering products, along with resistant minerals such as quartz and barite. During this weathering process, Pr and Nd from pre-existing minerals were enriched in bastnäsite and monazite, whereas Ce and La migrated into cerianite or adsorbed onto Fe-Mn hydr (oxides). Geological structures played a significant role in channelling and localizing groundwater or meteoric water into the deeper parts of the carbonatite during weathering. The enclosed high-standing and weathering-resistant country rocks that bound the Ngualla carbonatite promoted long-term in-situ preservation of the weathered profile by limiting erosion.

A GEOSCIENCE DATA ARCHITECTURE AND AN ARTISANAL-MINING-TRAINED PROSPECTIVITY ENGINE FOR TANZANIA: TRANSFERRING THE EUROPEAN UNION MODEL TO THE LAKE VICTORIA GOLDFIELD

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For decades, European geoscience data was held by more than 30 national geological surveys in incompatible formats, so that no institution could answer a resource question on a continental scale. The Directive 2007/2/EC (INSPIRE) made interoperability a legal duty without need for new data acquisition. The European Geological Data Infrastructure (EGDI) created a single access point to national and pan-European subsurface data. The Geological Service for Europe project (2022–2027) is converting this into a permanent federated service linking surveys across more than thirty countries. Article 19 of Regulation (EU) 2024/1252 now obliges each Member State to run a national exploration programme and to publish predictive maps. Together these form a mineral intelligence system resting on a single principle: data collected once should be used many times.

A Mining vision of 11% of GDP is achieved, yet the geoscience caused the achievement remains weak. Tanzania holds comparable material but little of the architecture. About 94 per cent of the country is geologically mapped, airborne surveys have been flown over 31 districts, and the Geological Survey of Tanzania maintains a national mineral information system. Surrendered exploration reports, borehole records and hundreds of thousands of artisanal workings sit with different institutions. None of it is readily exchangeable. There is no national data standard, no shared access point, and no duty to publish predictive maps. The distance between Tanzania and Europe is therefore an architecture gap, not a data gap and The Puzzle is no longer a shortage of geoscience; it is division and non-delivery.

This paper proposes a Tanzanian mineral intelligence system built on four instruments: a consortium of data-holding institutions led by GST; a national geoscience data standard gazette under the Mining Act; a portal with open, licensed and restricted access tiers; and a national predictive atlas. It also adds a component Europe lacks. Artisanal workings mark places where miners found gold. Geolocated and graded by confidence, they become training data for prospectivity modelling, a resource Europe simply does not have.
The Approach is tested over the Sukuma land-Geita Greenstone Belt using only existing open data: artisanal working locations compiled from the open survey data and satellite imagery, Copernicus DEM derivatives, Sentinel-2 and ASTER alteration ratios, regional magnetic data, and published geological mapping. Evidence layers are organized under a source–pathway–trap mineral systems framework and combined by random forest classification. Performance will be reported as the proportion of withheld artisanal sites captured within the highest-ranked prospectivity area, alongside ROC-AUC and a per-pixel uncertainty layer. Outputs move in two directions. Institutions and companies receive an interoperable prospectivity layer with documented provenance and uncertainty. Artisanal miners receive targeting sheets through the existing network of mineral market and buying centers. The demonstration indicates that Tanzania's most valuable exploration asset may already sit in its own archives and pit fields, and that the barrier to using it is institutional rather than technical.

Keywords: Mineral intelligence system; geoscience data interoperability; mineral prospectivity mapping; artisanal and small-scale mining; Sukuma land Greenstone Belt.

ASSESSMENT OF SURFACE TEMPERATURE AND CARBON DIOXIDE ANOMALIES FOR GEOTHERMAL EXPLORATION IN THE NGOZI GEOTHERMAL FIELD, TANZANIA

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The Ngozi geothermal field, located within the Rungwe Volcanic Province of south-western Tanzania, is among the geothermal prospects with the potential to support Tanzania's energy transition and sustainable development. Surface geothermal manifestations such as high surface temperatures and carbon dioxide (CO_2) gas give potential indicators of active geothermal systems and play a big role in exploration. This study aimed to assess the spatial distribution of surface temperature and CO_2 anomalies in the Ngozi geothermal area using geospatial interpolation method. The datasets of soil temperature and CO_2 concentrations were collected from selected sampling locations and arranged in Microsoft Excel. The datasets were processed using Surfer software, where the Inverse Distance Weighting (IDW) interpolation method was applied to generate temperature and CO_2 anomaly maps. The resulting maps were interpreted alongside geological information to identify areas with geothermal potential. The analysis identified unique zones characterized by elevated temperature and increased CO_2 concentrations. These anomalous areas are spatially associated with major geological structures and known hydrothermal manifestations, showing active fluid migration pathways and potential geothermal reservoirs. The integration of temperature and CO_2 enhanced potential exploration targets within the area. The findings indicate that integrated surface

temperature and carbon dioxide anomaly mapping gives an effective, cost-effective method for geothermal exploration. This study leads to an understanding of Tanzania's geothermal resources and supports national efforts toward energy security, renewable energy development and sustainable industrial growth.

LOW-COST GEOSPATIAL INTELLIGENCE FOR STRUCTURALLY CONTROLLED GOLD TARGETING IN ARTISANAL AND SMALL-SCALE MINING: A CASE STUDY FROM MATONGO-IKUNGI, SINGIDA REGION, TANZANIA

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Artisanal and small-scale mining (ASM) contributes significantly to Tanzania's gold output and rural livelihoods, yet most operations rely on empirical prospecting with minimal geological guidance, resulting in low discovery rates, wasted capital, and unsafe workings. This study presents GeoSmart, a low-cost geospatial intelligence workflow developed to bring formal exploration methods within reach of ASM operators. The workflow integrates automated lineament extraction from SRTM-derived hill shade and flow-accumulation models, ASTER-based hydrothermal alteration mapping (iron oxide, ferrous minerals, clay, carbonate, and silicification indices), and a structural intersection scoring model that ranks NE×NW fault crossings as potential gold-trap sites. Outputs are delivered through a lightweight web-based platform organised on the quarter-degree sheet registry, allowing operators to view ranked targets, structural trends, and alteration polygons without specialised software. The workflow is being validated at an active small-scale gold operation on PML 0283 in the Matongo-Ikungi area, where field outcomes - both mineralised and barren workings - are systematically logged with GPS positions and stamped against model predictions, enabling quantitative assessment of targeting performance over time. Preliminary results demonstrate that freely available satellite data, open-source tools, and

structured field feedback can meaningfully de-risk ASM prospecting at a fraction of conventional exploration cost. The approach offers a scalable model for ASM formalisation and productivity growth, directly supporting the contribution of mineral resources to Tanzania's industrial and socio-economic development.

ORIGIN OF ULTRAMAFIC ROCKS ASSOCIATED WITH THE MESOPROTEROZOIC NGUALLA CARBONATITE COMPLEX, SOUTHWESTERN TANZANIA

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The Ngualla carbonatite complex, located in southwestern Tanzania, is a Late Mesoproterozoic intrusion (1040 ± 40 Ma) emplaced within the Paleoproterozoic Ubendian Belt. The complex comprises a central magnesiocarbonatite plug enclosed by a large calcite carbonatite body, and surrounded by fenitized country rocks. Associated with the carbonatite units are poorly characterized ultramafic rocks that occur as scattered synmagmatic intrusions and late-stage dikes within the carbonatite complex. Despite a well-established understanding of the carbonatite units and their REE ore genesis and enrichment, the petrological characteristics of these ultramafic rocks and the reasons for their association with the Ngualla carbonatite remain largely unresolved and unexplored.

This study aims to investigate the origin of the Ngualla ultramafic rocks associated with the Ngualla carbonatites. The focus is to address two fundamental questions: (i) what processes were responsible for the formation of the ultramafic rocks, and (ii) how are these ultramafic rocks related to the carbonatite units and REE mineralization at Ngualla? Through an integrated petrological approach, this study will combine detailed fieldwork and drill core logging, mineralogical observations (e.g., optical microscopy, Scanning Electron Microscopy-SEM, Electron Probe Microanalyzer-EPMA), whole-

rock geochemistry (XRF AND ICP-MS), and geochronology of accessory minerals. The outcome of this study will highlight how the ultramafic rocks of Ngualla formed and how they fit into the geological evolution model of the carbonatite. In a broad sense, the study results will contribute to the debated topic of carbonatite-ultramafic rock associations globally and contribute to reconstructing the tectono-magmatic processes that governed Mesoproterozoic alkaline magmatism during the history of the Ubendian Belt.

APPLICATION OF SATELLITE IMAGES IN PROSPECTING OF AREAS WITH POTENTIAL FOR LITHIUM DEPOSITS AT HOMBOLO, DODOMA

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Lithium (Li) is an alkali metal that does not exist in its free form and has properties that make it possible to be applied in several modern industries. Most of the methods used in prospecting for lithium are very costly and time-consuming. To overcome this problem, satellite remote sensing offers an efficient and cost effective way for mineral prospecting. This study evaluated the application of Landsat 8(OLI) satellite imagery (QDS 064) using ENVI and ArcMap software to define lithium-bearing mineralized zones within the Tanzanian craton at Hombolo, Dodoma.

Cloud free Landsat level 1 and level 2 datasets were processed using NDWI masking to remove surface water interference. Three image processing techniques were applied to target lepidolite and spodumene alteration zones with Band ratios (3/5 for spodumene and lepidolite target signatures), RGB Composite Combinations (3-2-11 and 7-3-11), and principal Component Analysis (PCA) on bands 2,3,5 and 8. Spectral outputs demonstrated consistent target signals across all three processing methods. However, Principal Component Analysis proved to be most effective in lithology

targeting while removing soil and vegetation noise. Specifically, the fourth principal component (PC4) identified key mineralized zones through distinct eigenvector loadings showing strong positive reflectance on Band 3(+0.6726) and significant absorption on Band (-0.5931). The resulting light grey pixel anomalies on PC4 maps aligned directly with lithium target signatures. Spatial validation using geological datasets and active mine shapefiles from the Geological Society of Tanzania (GST) confirmed that the high reflectance PC4 anomalies align with documented lithium pegmatite occurrences in Hombolo area.

Applying Landsat 8 spectral analysis successfully mapped potential lithium host rocks at Hombolo, establishing remote sensing as a tool for regional critical mineral prospecting in Tanzania. Identification of prospective deposits supports national efforts to utilize mineral resources. Locating these potential mineral targets will ensure a promising future for national battery storage, technological hardware manufacturing like laptops and smartphones, advancing green energy, and job creation in the mining sector.

INTEGRATED REMOTE SENSING AND GIS-BASED GROUNDWATER POTENTIAL ZONES MAPPING AROUND THE KABANGA NICKEL MINE AREA

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Kabanga Nickel Mine is located within the Eastern African Nickel Belt (EANB), which planned to start production in 2026. Bugarama, a nearby village to the project, depends on domestic water supply which is typically obtained from small tributaries, streams, springs and shallow dug wells. However, due to dewatering operations that will be done for stabilizing the underground mine, the village will be at risk of facing critical water shortage.

This study used remote sensing and the geographical information system to evaluate the groundwater potential zones at Bugarama village. Multiple data such as digital elevation model (DEM), soil data, Rainfall, lithological data and land use-land cover data were used to create influencing parameters like (land use-land cover, slope, soil, lithology, drainage density.

The weight parameters assessment on each influence on groundwater potential was calculated by using the Analytical Hierarchy Process Calculator in Excel, and the consistency ratio obtained was 0.55, which is less than 0.1, meaning it is acceptable. Followed by weighted sum overlaying in QGIS and results show rainfall contribute 13%, lineament density 23%, drainage density 16%, Topographic Wetness Index (TWI) 13%, slope 18%, soil and lithology contribute in small about 6.2% and 4.8% to generate ground water potential map.

The final map shows four classes: High (4%), moderate-High (27%), low-moderate (54%), and low zone (15%) of the village area depending on the influence and availability of water in the study area. These findings were integrated with present boreholes on the area and three dry boreholes shown to be located at low zone and other two (2) best yield boreholes found at moderate-high zone, this study how digital tools like QGIS and remote sensing can be used to add value on water resource monitoring and security especially to societies near mining areas.

UNLOCKING TANZANIA'S GOLD POTENTIAL: THE ROLE OF MODERN EXPLORATION TECHNOLOGIES AN SUSTAINABLE INDUSTRIAL AND SOCIO-ECONOMIC GROWTH

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Gold is one of the most valuable mineral resources contributing significantly to Tanzania's economy through foreign exchange earnings, employment creation, infrastructure development, and government revenue. Tanzania hosts several world-class gold deposits within the Archean Tanzania Craton, particularly in the Lake Victoria Goldfields, making the country one of Africa’s leading gold producers. Despite this considerable mineral wealth, substantial portions of the country remain underexplored due to geological complexity, inadequate exploration data, limited investment in technologies, and challenges associated with sustainable resource development.

Modern mineral exploration technologies have transformed the discovery and evaluation of gold deposits worldwide. Techniques such as high-resolution airborne geophysics, satellite remote sensing, Geographic Information System (GIS), geochemical surveys, three-dimensional geological modelling, machine learning, and advanced drilling methods have significantly improved exploration efficiency while reducing operational costs and environmental impacts. The integration of these technologies allows exploration geologists to identify concealed mineralization that conventional exploration methods may overlook.

This study reviews the contribution of modern exploration technologies to sustainable gold resources development in Tanzania and evaluates their role

in promoting industrial growth and socio-economic transformation. Different areas reviewed with supporting literature for exploration are within Lake Victoria goldfields, Handeni gold belt, Mpanda goldfield, Lupa goldfield, and other prospective regions. Particular attention is given to the integration of geological mapping, structural analysis, geochemistry, geophysics, and remote sensing in improving exploration success rates.

The findings indicate that the integrated exploration approaches significantly enhance the identification of economically viable gold deposits while minimizing exploration risks. Remote sensing techniques provide regional-scale mapping of alteration zones and structural controls associated with mineralization. Airborne magnetic and radiometric surveys improve the delineation of the lithological boundaries, fault systems, and shear zones that host gold mineralization. Geochemical sampling provides valuable pathfinder element signatures that guide detailed exploration, whereas three-dimensional geological modelling improves resource estimation and mine planning.

The study recommends increased investment in high-resolution geological surveys and enhanced digital geological databases, which will lead to an increased quantity of mineral production and enhance the contribution of Tanzania's gold sector to national industrialization and sustainable development. This aligns with the objectives of Tanzania's Development Vision 2050.

THE SUSTAINABLE GEOMETALLURGICAL SOLUTION: ENHANCING GOLD RECOVERY AND ECONOMIC VALUE FROM LOW-GRADE ORES AT USHIROMBO–KELEZIA, GEITA, TANZANIA

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Artisanal and Small-Scale Mining (ASM) in Tanzania is constrained by inefficient recovery methods, heavy reliance on mercury, and the abandonment of vast low-grade saprolitic resources. Field investigations at Ushirombo–Kelezia, Geita, reveal that most miners do not apply basic geochemistry or geological mapping, leaving behind low-grade saprolitic oxide ores that are uneconomical for mercury or gravity-only methods such as Knelson concentrators, yet remain highly valuable if processed correctly.

The Sustainable Geometallurgical Solution introduces a transformative paradigm shift from traditional artisanal practices to a sustainable "Middle-Small Scale" model by integrating precise geological mapping and geochemical analysis with an optimized heap leaching framework. First, low-cost geological mapping and orientation geochemistry are conducted over abandoned artisanal sites to delineate residual low-grade oxide zones and saprolitic layers, recommending safe, supportable open pits instead of risky timber-shaft mining. Second, a small-scale, lined heap leaching system is introduced specifically for low-grade ores averaging about 0.34g/t, comprising a minimally sloped impermeable pad (affordable HDPE), basic

drip irrigation, and a small carbon-in-pulp tank with no expensive pressure tanks or milling or crushing circuits required.

At Ushirambo–Kelezia, this method successfully processed over 70,000 tonnes of saprolitic ore previously rejected by artisanal miners. Gold recovery begins within 2–3 weeks, and the total leach cycle lasts approximately 120 days, ensuring consistent cash flow and high gold capture rates from unprocessed materials left behind by Knelson concentrators.

This "Sustainable" approach transforms artisanal operations into mid-scale small-scale mining, eliminates mercury, protects miner health and the environment, and turns waste into wealth, proving that combining basic geological re-evaluation of abandoned sites with a low-cost, environmentally sound heap leach enables profitable recovery of gold from low-grade ores without mercury.

GEOPHYSICAL CHARACTERIZATION OF SUBSURFACE CONDITIONS FOR SAFE INFRASTRUCTURE DEVELOPMENT: A CASE STUDY OF UDSM-MAIN CAMPUS

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Rapid infrastructure development requires reliable subsurface information to ensure the safety, sustainability, and resilience of engineering structures. Geophysical methods provide a non-invasive and cost-effective means of identifying subsurface conditions before construction, thereby minimizing geotechnical risks that may threaten infrastructure and community safety. This study demonstrates the application of integrated Seismic Refraction and Electrical Resistivity Tomography (ERT) in assessing the suitability of a proposed construction site at the University of Dar es Salaam (UDSM), Tanzania.

Seismic refraction and ERT profiles were acquired to characterize subsurface conditions, identify weak zones, and evaluate the engineering competence of near-surface materials. The integrated interpretation revealed a sequence of loose sandy soils overlying thick, water-saturated clay-rich deposits. Seismic velocity models indicate low compressional wave velocities in the shallow subsurface, increasing gradually with depth due to soil compaction rather than the presence of competent foundation materials. Similarly, the resistivity models are dominated by low-resistivity zones associated with saturated clay,

while localized higher resistivity values correspond to relatively dry sandy materials.

The combined geophysical results indicate that the study area is characterized by weak and compressible subsurface materials that are susceptible to excessive settlement if not adequately considered during foundation design. The absence of shallow competent bearing strata highlights the need for appropriate foundation solutions, including deep foundations for heavy structures and ground improvement where necessary. The study further recommends detailed geotechnical investigations to complement the geophysical findings before construction.

This study demonstrates the critical role of integrated near-surface geophysics in reducing construction-related risks by identifying problematic subsurface conditions at an early stage. The findings emphasize how geophysical investigations contribute to infrastructure resilience, informed engineering decision-making, and community security by preventing structural failures and promoting safer land development. The approach provides a practical example of how geoscience supports sustainable infrastructure development and disaster risk reduction.

INTEGRATED GROUND WATER EXPLORATION FOR CLIMATE-RESILIENT WATER SECURITY IN CRYSTALLINE BASEMENT TERRAINS OF TANZANIA

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Groundwater is the main source of water for many communities in Tanzania, particularly in areas underlain by crystalline basement rocks. However, groundwater occurrence in these terrains is controlled by weathered and fractured rocks, making productive aquifers difficult to locate. This often results in unsuccessful boreholes and unreliable water supply, especially under increasing climate variability. Crystalline basement terrains in Tanzania include the Lake Victoria craton, the Central Tanzania Basement Complex, the Eastern Arc Crystalline Terrains, the southern Highlands Basement Province and Western Rift Marginal Basement Zones. Despite their wide distribution, groundwater development remains challenging because of limited subsurface characterization and dependence on conventional drilling methods. This study presents an integrated groundwater exploration approach using magnetic survey, geological investigations, and Vertical Electrical Sounding (VES) to improve groundwater targeting in crystalline basement terrains. Magnetic data identified fracture-controlled structures, while six VES stations determined aquifer depth, thickness, and resistivity in Lwamgasa Village. The approach revealed relationships between lineaments, weathered or fractured rocks, and groundwater occurrence. VES03 and VES04 showed promising groundwater zones,

demonstrating that integrated geophysical methods improve borehole siting and support sustainable water security in Tanzania.

INTEGRATED GEOPHYSICAL APPROACH FOR GROUND INSTABILITY ASSESSMENT AND COMMUNITY SAFETY: A CASE STUDY IN DAR ES SALAAM, TANZANIA

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Rapid urbanization in Tanzania has increased the demand for infrastructure development, yet many buildings are constructed without adequate subsurface characterization, exposing communities to hazards associated with differential settlement and foundation instability. Such failures threaten public safety, increase maintenance costs, and reduce the resilience of critical infrastructure. This study uses an integrated engineering geophysical approach to identify the causes of the differential settlement failure using Electrical Resistivity Tomography (ERT) and the seismic refraction method.

In doing so, a total of four profiles were acquired around the affected structure to characterize subsurface lithological variations and identify weak foundation materials. The integrated interpretation revealed heterogeneous conditions consisting of weathered sandstones, sandy-clay and clay-rich saturated zones. ERT profiles show low resistivity anomalies (< 5 ohm) corresponding to highly conductive, water-saturated, clayey zones. The seismic velocity ranges (<800m/s) correspond to the presence of weak zones, compressible low bearing capacity materials. The presence of these values demonstrates that the settlement straddles from competent sand units to weak clay units, resulting in uneven differential failure of the settlement.

The study demonstrates that integrating ERT and seismic refraction provides a reliable, rapid, and non-invasive technique for identifying hidden strata before structural failure occurs. The findings emphasize the importance of incorporating engineering geophysics into geotechnical site investigations to support evidence-based foundation design, infrastructure rehabilitation, and land use planning. The study therefore highlights the critical role of applied geophysics in promoting safer and more sustainable infrastructure development in Tanzania, in line with national goals for resilient communities and disaster risk reduction.

TRANSFORMING MINE WASTE INTO CARBON SINKS: GEOCHEMICAL EVALUATION OF TANZANIA CARBONATITE TAILINGS FOR PERMANENT CARBON STORAGE AND ECO-CEMENT SYNTHESIS

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The global transition toward net-zero industrial processes requires scalable, permanent geological carbon storage solutions integrated within localized circular economies. This study presents a practical, data-driven framework for Tanzania. Geological carbon sequestration via mineral carbonation offers a dual solution for industrial carbon dioxide emissions and sustainable mine waste management pathways for alkaline tailings generated from the Panda Hill Carbonatite Niobium Project in south-western Tanzania. Based on Definitive Feasibility Study (DFS) parameters, the project processes Sövite-rich carbonatite ore, producing approximately 2.08 to 2.58 million tonnes per annum (Mtpa) of fine tailings during its full 2.6 Mtpa throughput phase. Geochemical analysis reveals that the primary Sövite lithology contains 60–75% calcite ($CaCO_3$) by volume, yielding high calcium oxide concentrations averaging 32.36% CaO, the primary mining complementary mineral oxides, including iron oxide averaging 14.20% (Fe_2O_3) in primary mining push backs (ranging between 10.15% and 18.40% Fe_2O_3), silica averaging 6.80% (SiO_2) in primary mining push backs (ranging between 4.20% and 9.85% SiO_2), and titanium dioxide averaging 0.95% TiO_2 in primary mining push

backs (ranging between 0.45% and 1.55% TiO_2). While (CaO) drives the primary carbon sequestration reaction by reacting with dissolved CO2 to form permanent calcium carbonate ($CaCO_3$).

Thermodynamically, modelling the accelerated ex-situ carbonation of this waste stream via flue gas injection into specialized reactors. Stoichiometric calculations demonstrate that reacting the 2.08 Mtpa tailings stream permanently locks up to 450,000 tonnes of industrial carbon dioxide (CO_2) annually into thermodynamically stable solid calcite ($CaCO_3$). Economically, the resulting carbonated matrix exhibits significant porosity reduction and accelerated strength development, enabling its commercial valorisation into carbon-negative "eco cement". Furthermore, this sequestration framework is fully aligned with Tanzania's regulatory landscape under the Environmental Management (Control and Management of Carbon Trading) Regulations, 2022 (Government Notice No. 636), establishing a legal mechanism for domestic carbon-credit generation and registration to systematically leverage to transform mining liabilities into commercial assets while fulfilling national climate mitigation mandates.

HYDROSTRATIGRAPHIC CONCEPTUAL MODEL AND AQUIFER GEOMETRY OF THE GOKONA UNDERGROUND GOLD DEPOSIT, NORTH MARA GOLD MINE, TANZANIA

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Groundwater inflow is a persistent operational hazard at the Gokona underground mine in North Mara Gold Mine, Tanzania. At Gokona mine, development in the east decline repeatedly intersects water-bearing fractures and permeable rock units that exceed the capacity of the existing dewatering system. To map aquifer geometry where fractured hard-rock hydraulics supersede lithology, this study developed a 3D hydrostratigraphic conceptual model for the East Gokona deposit (E890 and E920 levels). Collar, survey, geological, and hydrogeological data from 39 diamond drill holes were integrated into Leapfrog Geo alongside ArcMap-based DEM topographic analysis. Correlating water-intercept records with lithological logs enabled the classification of aquifers, aquitards, and aquicludes, while inter-length statistics from 274 validated intercepts quantified unit thickness and spatial continuity.

Crystal tuff was identified as the principal aquifer: it is the most laterally continuous unit in the deposit and hosts the majority of recorded water intercepts, with a mean physical thickness of 23.76 m (median 16.35 m) and a maximum of 170.70 m within a structurally thickened zone, narrowing to less than one meter in tectonically compressed zones. Groundwater

occurrence is shown to be governed jointly by lithology and structure, with shear zones, dyke contacts, and fracture networks providing the principal flow pathways, while gentle surface slopes and seasonal rainfall support recharge. The resulting conceptual model provides the first hydrostratigraphic framework for East Gokona and offers a basis for shifting mine dewatering from a reactive to a predictive, structurally informed approach. To fully benefit from this model, this study recommends several measures to be applied during drilling and mining. These include: planning drill dewatering wells targeting the high-water-bearing zones and structural features identified in the hydrostratigraphic model; utilizing this conceptual model to build a numerical hydrostratigraphic groundwater flow model for long-term dewatering optimization at greater depths; and performing hydrochemical and isotope analyses to define the recharge source and infiltration rate.

ERT-INSIGHT 3D: AN INTERACTIVE PYTHON FRAMEWORK FOR PSEUDO-3D ELECTRICAL RESISTIVITY VISUALIZATION IN SUSTAINABLE MINERAL EXPLORATION

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Electrical Resistivity Tomography (ERT) is widely used in mineral, groundwater, geothermal and engineering investigations to characterize subsurface electrical properties. However, multiline surveys are often interpreted as separate two-dimensional sections, making it difficult to assess the lateral continuity and geometry of anomalies. This study presents ERT-Insight 3D, a Python-based framework that combines multiple inverted 2D ERT profiles into an interactive, topography-aware pseudo-3D resistivity model.

The framework imports spatial coordinates, elevation, depth, and resistivity values from conventional inversion outputs. Survey lines are positioned according to their actual geometry, resistivity values are logarithmically transformed, and interpolation is restricted to the data-supported survey volume. Users can examine vertical sections, horizontal depth slices, resistivity thresholds, and three-dimensional isosurfaces. A confidence layer based on line spacing and distance from measured points distinguishes well-constrained areas from regions strongly influenced by interpolation. A simplified graphical interface allows users to upload data and adjust visualization parameters without advanced programming skills.

ERT-Insight 3D is designed to complement, rather than replace, existing inversion software. It improves the visualization of possible mineralized structures, lithological contacts and alteration zones. Since resistivity interpretation is non-unique, results must be validated using field geology, boreholes, geochemistry or other geophysical methods. By transforming conventional ERT outputs into accessible and uncertainty-aware 3D visualizations, the framework supports improved exploration targeting, digital transformation and efficient use of subsurface data in Tanzania.

GEOSPATIAL MODELING FOR URBAN DISASTER RISK REDUCTION: A CASE STUDY OF JANGWANI, TANZANIA

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Flooding remains a severe geohazard threatening urban communities in Tanzania, especially in low-lying areas such as Jangwani, affecting infrastructure, community safety, and sustainable development. Driven by factors such as rapid urbanization, poor drainage systems, climate variability, and unplanned settlement development. This vulnerability demands precise spatial risk assessments. This study evaluates flood risk and its implications for community development using Geographical Information System (GIS) and remote sensing techniques. Spatial datasets, including Digital Elevation Model (DEM), Landsat 8/9 satellite imagery, rainfall records, drainage networks, and land use information, are analyzed to create a model for hazard zones. The spatial analysis combined core physical parameters such as elevation, slope, vegetation cover, proximity to water channels, and drainage density to generate comprehensive flood susceptibility and risk maps. The resulting mapping isolates highly vulnerable urban zones and clarifies how unplanned development accelerates. This study further proposes targeted mitigation frameworks, including improved drainage planning, land-use regulation, localized early warning systems (GIS flood models and SMS alert system), and community awareness. To enhance resilience and reduce disaster risks. This research contributes to the

application of geosciences solutions in promoting community safety, sustainable urban development, and disaster risk reduction in Tanzania.

ASSESSMENT OF COAL QUALITY IN RELATION TO COAL SEAMS IN TANZANIA

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Coal is a black or brown-black rock that forms from the remains of ancient plants that were buried, compressed, and heated due to the presence of high temperatures and pressure over millions of years. Coal is a fossil fuel and has been widely used as a source of energy. Tanzania hosts several coalfields, including Ruvuma, Mchuchuma, Ngaka, and Songwe-Kiwira. These fields occur along the different formations found within the Karoo basins, which include the Ruhuhu formation and Mchuchuma formation in the southwestern part of Tanzania. The coal quality varies significantly among and within the coal seams due to differences in depositional environments, geological conditions, and the degree of coalification. This project assessed the coal quality in relation to coal seams in Tanzania using the key coal quality parameters, including moisture content, ash content, volatile matter, calorific value, and fixed carbon. The objective was to evaluate the variations in coal properties among seams and determine their potential in energy and power generation. The project provides multidisciplinary knowledge in geology, engineering, and business potential toward Tanzania's development. It involves lithological mapping, laboratory analysis (proximate analysis techniques), and a correlation method between coal quality and coal seams. The results indicated noticeable variations in coal quality between seams, which can be caused by the presence of organic

matter in some seams, where detailed seam characterizations are recommended to enhance resource management and improve efficiency of energy production. The study demonstrates that coal seam characteristics play a significant role in determining coal quality. Understanding seam-to-seam variation is essential for effective mine planning, resource evaluation, coal beneficiation, and suitable energy development.

Coal quality in Tanzania provides valuable information, especially to policymakers, mining companies, and energy stakeholders seeking to optimize the exploitation and utilization of Tanzania’s coal resources.

A REVIEW OF THE GEOLOGICAL CONTROLS ON THE URANIUM MINERALIZATION IN THE MKUU RIVER PROJECT, NAMTUMBO DISTRICT, SOUTHERN TANZANIA

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Uranium is one of the critical minerals that has gained increasing global importance due to its role in nuclear energy generation and the global transition toward low-carbon energy systems. Tanzania hosts significant uranium resources, with the Mkuju River project in Namtumbo district, Ruvuma region, representing one of the country's most important uranium deposits. This study presents a review of the geological controls on uranium mineralization within the Mkuju River project, with emphasis on lithological characteristics, structural settings, and depositional environments that influence uranium occurrence and concentration.

The study was conducted through a comprehensive review of published scientific literature, geological maps, exploration reports, and publicly available data relating to the Mkuju River project. The collected information was analyzed to develop a conceptual understanding of the regional geology, host rock characteristics, structural deformation, sedimentary environments, and mineralization styles associated with uranium deposition.

The review indicates that uranium mineralization in the Mkuju River project is primarily controlled by favourable sandstone host rocks with sufficient porosity and permeability, structural features such as faults and fracture systems that enhance fluid migration, and redox boundaries where oxidizing

uranium-bearing groundwater interacts with reducing conditions; variations in sedimentary facies, groundwater flow dynamics, and permeability contrasts play a significant role in localizing uranium enrichment within the basin.

The study demonstrates that the integration of sedimentology, structural geology, hydrogeology, and geochemistry provides the framework for understanding uranium mineralization and improving exploration targeting in the Mkuju River project. The findings contribute to a broader understanding of uranium prospectivity in southern Tanzania and highlight the importance of geological knowledge in supporting the sustainable development of the country’s critical mineral resources.

STRUCTURAL CONTROLS AND GEOCHEMICAL CHARACTERIZATION OF THE SEKA GOLD DEPOSIT, MUSOMA-MARA REGION, TANZANIA: IMPLICATIONS FOR SUSTAINABLE RESOURCE EXPANSION AND SOCIO-ECONOMIC GROWTH IN TANZANIA

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The Musoma-Mara Greenstone Belt hosts significant potential for structurally controlled gold mineralization, including the Seka deposit that has attracted growing interest because of its geological potential and considerable capacity to support mineral-based industrial development, yet maximizing its contribution to Tanzania's industrialization and socio-economic development requires precise and well-designed geological targeting. This study evaluates the structural controls and geochemical signatures of the Seka gold deposit to meet optimization of resource delineation and promote sustainable mining practices that foster and enhance regional socio-economic growth. Integration of high-resolution airborne magnetic data, lithological and structural field mapping, basically focusing on shear zones and joints, petrographic examination, and systematic core logging with fire assay and inductively coupled plasma mass spectrometry (ICP-MS) geochemistry was conducted.

Gold mineralization at Seka is primarily hosted within quartz-carbonate veins structurally controlled by NNW-trending secondary shear zones cutting through Neo-Archaean meta-basalts. Geochemical profiling reveals a strong

gold-arsenic-antimony (Au-As-Sb) correlation, identifying hydrothermal alteration halos that extend up to 15 meters beyond the main vein systems controlling gold mineralization. These findings define clear quantitative vectoring parameters for deeper, high-grade mineralization zones and thus effectively reduce exploration risks that can implicitly aid in resource expansion and socio-economic growth in Tanzania.

Significant roles played by optimizing resource extraction at Seka deposits include providing local industries with stable mineral feedstock, securing long-term employment, investing in mineral beneficiation, improving infrastructure such as road networks, and boosting or promoting municipal revenue to drive regional socio-economic development, growth, and continuity sustainably. The study recommends increased investment in digital geological databases and high-resolution geological surveys to maximize gold production and enhance industrialization and sustainable development.

INVESTIGATION OF EARTHQUAKE VULNERABILITY IN THE HANETI AREA, DODOMA REGION

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Haneti area is located within Chamwino District, Dodoma Region, in central Tanzania. It is located within the tectonically active East African Rift System (EARS) where the Earth's crust is gradually moving apart, producing faults and associated seismicity. The region has experienced moderate earthquakes, including the Mw 5.5 event of November 2002 that caused structural damage in Dodoma. Haneti lies near tectonically active zones and is an area of rapid settlement growth, where many houses are constructed locally with poor building standards. The main objective of this study was to assess earthquake vulnerability in the Haneti area to support disaster risk reduction, and the specific objectives were to identify lithologies and geological structures associated with earthquakes, determine seismic activity, and develop an earthquake vulnerability map. The study used GIS and remote sensing techniques to integrate datasets including seismic epicentres from 1966-2003, an aeromagnetic map, and a DEM obtained from the Geological Survey of Tanzania GST. Kernel density analysis and weighted overlay analysis were performed in ArcGIS. The results indicate that seismicity is clustered along NE-SW-trending faults; the vulnerability map classifies Haneti into three zones: high vulnerability in the central and eastern parts and moderate vulnerability covering most of the area.

STRUCTURAL AND VOLCANIC CONTROLS ON GEOTHERMAL POTENTIAL IN THE RUNGWE VOLCANIC PROVINCE, TANZANIA: AN INTEGRATED REMOTE SENSING AND GIS APPROACH

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The Rungwe Volcanic Province (RVP), located within the Triple Junction of the East African Rift System in south-western Tanzania, is one of the most promising geothermal regions in Tanzania, characterized by active tectonism, Quaternary volcanism, elevated heat flow, and numerous hydrothermal manifestations. Despite its recognized geothermal potential, the relative influence of tectonic structures and volcanic features on the localization of geothermal systems remains poorly constrained. This study investigates the structural and volcanic controls on geothermal potential within a priority geothermal exploration area of the RVP using an integrated remote sensing and Geographic Information Systems (GIS) approach. To determine land surface temperature, we used 5 years (2020-2024) MODIS land surface temperature and high-resolution Landsat 8/9 thermal data. We used DEM data to extract lineaments in the study region. Both datasets were integrated with Quaternary volcanic centres and thermal springs within the area. This data integration aimed to determine if volcanic centres and lineament density control the occurrence of thermal springs in the region. We found land

surface temperatures ranging from 21 to 28 0C, with values above 30°C distributed following NW-SE, N-S, NE-SW, and E-W. The identified dominant lineament trends are NW-SE, N-S, and E-W, consistent with the known regional trend in the region. Our results reveal strong alignment between Quaternary volcanic centres, lineaments, and the location of thermal springs, suggesting that the geothermal system controls the interplay between volcanic heat source and fracture permeability that facilitates geothermal fluid circulation in the region. The proposed integrated approach of Remote Sensing and GIS framework contributes to better understanding and visualization of the geothermal systems. Furthermore, this integrated approach helps to reduce exploration uncertainties and provides a practical basis for prioritizing future geothermal exploration and drilling targets in volcanic-rift settings.

GEOCHEMISTRY AND U-PB ZIRCON GEOCHRONOLOGY OF IGURUBI GRANITOIDS, NZEGA GREENSTONE BELT, NORTHERN TANZANIA: IMPLICATIONS FOR CRUSTAL GROWTH AND TIMING OF GOLD MINERALIZATION

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The Igurubi gold camp, located within the Nzega Greenstone Belt of northern Tanzania, is hosted within the Nyanzian Supergroup, which consists of Neoarchean volcano-sedimentary rocks that are intruded or flanked by intrusions of different ages. Lacustrine deposits of the Manonga largely obscure the rocks of the Igurubi Gold Camp–Wembere Basin and residual cover, leaving only limited and discontinuous exposures of primary bedrock. Observations along the Mwabomba River and in artisanal mining shafts therefore provide key constraints on the temporal and spatial lithological relationships and structural controls of gold mineralization. Two contrasting granitoid suites occur at Igurubi: trondhjemite with high Al_2O_3 (mean = 15.6) and Na_2O/K_2O (mean = 5.3), low heavy REE, high Sr/Y and La/Yb, TTG like affinity), and potassic granites that exhibit lower Al_2O_3 (mean = 14.8), lower Na_2O/K_2O (mean = 0.9), low concentrations of heavy REE and variable Sr/Y and La/Yb). Both show enrichment in Zr, Th, and Pb, with negative Nb, P, and Ti anomalies in mantle-normalized spidergrams. The

geochemical features of the trondhjemites are interpreted to reflect formation by partial melting of the hydrous basaltic crust within the garnet and amphibole stability fields, most likely at an Archaean convergent margin. The K-granites on the other hand, are interpreted to have formed by anhydrous partial melting of the pre-existing rocks that include TTG and greenstones.

U-Pb zircon ages indicate emplacement of Igurubi trondhjemites at 2902 ± 15 Ma and potassic granite at 2559 ± 12 Ma. The older trondhjemite predate the ~2820 Ma mafic volcanism in the Lake Victoria greenstone belts, providing evidence for the first building blocks of the late Archaean continental crust upon which the greenstone succession accumulated. On the other hand, the 2559 ± 12 Ma reported for potassic granites is consistent with the late pulse of granitic magmatism responsible for the stabilization of the Tanzania Craton. Gold mineralization occurs in quartz veins within sheared and hydrothermally altered potassic granites, with sericite-silica alterations and sulphides, pyrite, and associated chlorite, carbonate, and hematite. The maximum age of gold deposition at the Igurubi gold camp is ~2559 Ma, which is markedly younger than the mineralization ages reported from the Golden Pride Mine (~2680 Ma) and the Buzwagi Mine (~2674 Ma). This age disparity indicates that gold mineralization within the region was not the product of a single event but instead reflects multiple mineralizing episodes. The Igurubi mineralization event, therefore, represents a younger phase of hydrothermal activity, demonstrating that ore formation in the Lake Victoria greenstone belts persisted until at least approximately 2.56 Ga. These results reinforce the interpretation that gold deposition at Igurubi is linked to late orogenic processes superimposed on older crustal architecture.

HYDROGEOPHYSICAL ASSESSMENT OF GROUNDWATER POTENTIAL SITES FOR BOREHOLE DRILLING: A CASE STUDY OF BUKOKWA VILLAGE, BUCHOSA DISTRICT, TANZANIA

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Groundwater plays a critical role in sustaining water supply for domestic use in rural and urban areas, especially where surface water resource is limited or unreliable. This study present hydrogeophysical assessment aimed at delineating groundwater potential zones across Bukokwa Village. The magnetic survey was conducted to identify potential weak zones associated with groundwater occurrence, particularly fractured and faulted zones. This was followed by Vertical Electrical Sounding (VES) surveys using the Schlumberger array configuration to characterize the subsurface lithology, layer thicknesses, and depth to the aquifer. Complementary geophysical data were integrated with geological, geomorphological and hydrological datasets within a Geographic Information System (GIS) and IP2WIN to show the potential sites for drilling. Factors such as lithology, lineament density, slope, drainage pattern and soil characteristics were considered in the analysis to classify areas into high, moderate, and low groundwater potential zones.

The results indicate that areas characterized by a thick sedimentary cover and well-developed fracture networks identified from the magnetic survey have higher groundwater potential, whereas crystalline and low-permeability formations are associated with limited groundwater availability. The six VES

profiles revealed low-resistivity and moderate-to-high conductivity layers in the subsurface, with resistivity values comparable to those measured at existing dug wells. These results suggest the presence of potential aquifer-bearing layers that could be targeted for drilling sustainable groundwater boreholes.

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