TANZANIA GEOLOGICAL SOCIETY (TGS)

2023 ANNUAL CONFERENCE

BOOK OF ABSTRACTS




UNGUJA

07th to 11th of November 2023

Front cover photos:

Top Left: *Traditional sailing vessels of the Indian Ocean (Zanzibar) – one of the symbols characteristic of Zanzibar;* ***Top Right:*** *A view of Stone Town with Sultan's Palace, Zanzibar;* ***Bottom left:*** *A view of Stone Town; and* ***Bottom right:*** *Seaweed farming, Zanzibar.*

Message to Participants of the TGS 2023 Conference

Dear Conference participants,

We are greatly honoured to invite you to this year's TGS Conference in Zanzibar. The TGS Conference Organising Committee is particularly happy to be your host in Unguja Island, the main Island of Zanzibar. Zanzibar is a captivating tourist destination in Africa, renowned for its stunning beaches and vibrant culture. The archipelago boasts some of the world's most beautiful beaches, making it an ideal spot for relaxation and water activities such as diving and snorkelling. Zanzibar's rich history, including Portuguese influence in the 16th century, is reflected in its historical sites like the House of Wonders, Turkish baths, and the Portuguese fort. Additionally, the spice farms on the island offer a unique opportunity to learn about the cultivation and use of various spices that have been a part of Zanzibar's heritage for centuries.

This year's conference boasts a multidisciplinary group of stakeholders spanning industry executives, geoscientists, engineers, technicians, state actors, researchers, and academicians, from Tanzania mainland, Zanzibar, and abroad. We anticipate the conference to have a profound professional impact on all our stakeholders, from the rich scientific presentations, discussions fora, and exhibitions, all aimed at contributing immensely to the growth of the geosciences industry.

We look forward to an intriguing and sensational TGS 2023 Annual Conference under the theme 'Accelerating Blue Economy from Geosciences Perspective'. The conference will offer platforms for discussions on several crucial geoscientific issues along the conference sub-themes, i.e., Tanzania's Mining Sector Expansion from Gold to Strategic Minerals; Geotechnical

Application in Petroleum Mining and Construction; Contribution of Water to the National Economy; Sustainable Coastal and Marine Tourism; Deep Sea Resources, Exploration and Development in Tanzania; Green Energy Potentials, Development and Technologies.

With the shift in the mineral intensity of the global economy set to increase exponentially over the coming decades, coupled with the depleting terrestrial resources and the tremendous social environmental costs of land-based mining, there has been renewed but stronger-than-ever interest globally in deep sea mining. As a maritime country with a significant block of the seabed within our national jurisdiction, we must therefore leverage this endowment to position ourselves as an important contributor in the region to the development of green technologies.

As we strive to bolster our blue agenda, aimed at the sustainable use of our ocean resources for economic growth, improved livelihoods, and jobs while preserving the health of its ecosystem, marine and coastal tourism presents tremendous opportunities here. Coastal tourism is still a sleeping giant despite the good progress and development in Tanzania's tourism sector. In this year’s conference, it is expedient we not only stimulate discussions, thoughts, and ideas that will bring about the awakening of this sector over the coming years but we move further to generate concrete action steps for each stakeholder.

Touching the expansion of the Tanzania mining sector from gold to strategic minerals that are essential for the promotion of green energy transition and development, we have witnessed a series of major mining contracts signed by our nation over the last few years. This development has featured the entry of mid-tier players focused on the exploration and mining of critical minerals, a major step, following the reforms of the mining sector and

improvements in investment policy across the country. To continue, over the past few months, discussions have intensified regarding how Tanzania, which hosts significant deposits of critical minerals, can leverage this strategic position, to take advantage of the global clean energy transition. Therefore, with all stakeholders well represented, we must now face this pressing issue head-on and strive to maximize the contribution of our critical mineral wealth to the nation's economy. In the same light, The East African Rift System, previously tagged at our last conference as a hidden energy gem for sub-Saharan electricity production, is estimated in Tanzania to have the potential to generate more than 5,000 megawatts of electricity. This potential stands to play a vital role in supporting our move from overreliance on fragile hydropower toward becoming drought-resilient in our energy sector.

Finally, the Tanzania Geological Society is grateful to all TGS members and every volunteer whose efforts make this conference a success. Special thanks to our sponsors and partners for their generosity and enthusiastic support: Barrick Gold Corporation, State Mining Corporation, Geita Gold Mine Limited, Tanzania Petroleum Development Corporation, Geofields Tanzania Limited, Petroleum Upstream Regulatory Authority, Mwamba Mining, National Microfinance Bank, Mining Commission, Ministry of Water Energy and Minerals Zanzibar, Ministry of Blue Economy Zanzibar, Zanzibar Petroleum Development Company, Zanzibar Petroleum Regulatory Authority, Ministry of Water, Ministry of Energy, Ministry of Minerals, Tembo Nickel, and Azurite Management and Consultancy. The Conference Organising Committee is hugely indebted for your continued support.

Conference Organising Committee

Tanzania Geological Society (TGS)

Conference Organising Committee

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Conference Organising Committee

Sub-Committees	Members
TGS Students Chapter	Ms. Jessica Kiritta Ms. Tola Hadija Ms. Janeth Kimario

Ms. Jessica Kiritta

Our Gold Sponsor

Barrick Gold Corporation

https://www.barrick.com

Barrick is a sector-leading gold and copper producer. Operating on 4 continents and in 19 countries, its portfolio spans the world's most prolific gold and copper districts and is focused on high-margin, long-life assets. It operates two mines in Tanzania, in North Mara and Bulyanhulu.

Barrick's two mines in Tanzania, North Mara, and Bulyanhulu, boosted their combined output to 547,000 ounces in 2022, achieving another step toward their potential Tier One status in the group's asset portfolio as a combined complex. Last year North Mara was officially recognized as Tanzania's largest taxpayer and Bulyanhulu was awarded the Best Compliant Employer prize by the National Social Security Fund. North Mara and Bulyanhulu also received the first and second runner-up recognition awards, respectively, for the Export of Minerals and the generation of foreign currency.

Since the take-over in 2019, Barrick has pumped $2.4 billion into the Tanzanian economy. Last year it paid $303 million in taxes, royalties, levies, dividends shareholder loan repayments, and, $476 million to local suppliers. As the mines have grown they have continued to prioritize local employment. Their workforce is already 96% Tanzanian, with 45% of new hires drawn from the surrounding communities. Through their community development committees, the mines have invested more than $10 million in projects to improve healthcare, education, access to potable water, and road infrastructure.

BARRICK

Our Silver Sponsor
STAMICO

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

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

What STAMICO does – (1) Facilitating the transformation of the Artisanal and Small-Scale Mining sub-sector in the country, (2) Offering commercial Drilling services, Geological, Mining, Mineral Processing, and Environmental consultancies, (3) Engaging in refining, grading, producing, cutting, processing, buying and selling of minerals, (4) Carrying mineral exploration and development, and (5) Developing and Operating Mines Projects.

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Geita Gold Mine | Anglogold Ashanti

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

Geita Gold Mining Limited (GGML or Geita mine), one of AngloGold Ashanti's flagship mines, is located in North-Western Tanzania in the Lake Victoria goldfields in Geita region, about 120km from Mwanza City and 4km west of the township of Geita. It is one of Tanzania's largest and most compliant taxpayers as well as a generous contributor to local investments, visible in its about $5 million invested in community projects. Anglo-Ashanti also boasts a total recordable injury frequency rate of 0.00 per million hours worked and zero reportable environmental incidents.

It has been in operation as a large-scale mine for over two decades although mining has taken place in the area since the 1930s. The Geita gold deposit is currently mined as a multiple open-pit and underground operation. As of 31 December 2020, the Mineral Resource is at 7.92 million ounces. Approximately 1,555m of capital development was completed for the Star & Comet, Nyankanga, and Geita hill underground sections, to access new areas for stope mining and further exploration in 2021. Open-pit mining at Nyastandsa and Geita Hill continued with Geita Hill reaching the end of its economic life and Nyankanga completed in September 2020. In April 2021, GGML started open pit mining activities at Nyamulilima (2.4km from Star & Comet) with expectations of producing one million ounces in the next six years.

Our Silver Sponsor

Tanzania Petroleum Development Corporation

https://tpdc.co.tz/

Tanzania Petroleum Development Corporation (TPDC) is the National Oil Company of Tanzania, wholly owned by the Government of Tanzania, with all its shares held by the Treasury Registrar. TPDC was established through the Government Notice No.140 of 30th May 1969 under the Public Corporations Act No.17 of 1969 as amended.

The Petroleum Act, 2015 has given the TPDC mandate to undertake Tanzania's commercial aspects of petroleum operations in the upstream, midstream, and downstream and participating interests of the Government in the petroleum and natural gas agreements. TPDC has exclusive rights over the natural gas midstream and downstream value chain.

For effectively carrying out specific petroleum operations as stated in the Petroleum Act 2015, TPDC formed two subsidiary companies; Gas Supply Company Limited (GASCO), responsible for operations and maintenance of the National Natural Gas Infrastructure (NNGI) and TANOIL Investments Limited, which undertake oil trading business. TPDC and its subsidiaries have a combined workforce of over 350 people.

Our Silver Sponsor

National Environmental Management Council

https://www.nemc.or.tz/

The National Environment Management Council (NEMC) came into being in 1983 when the Government of Tanzania enacted the National Environment Management Act No. 19 of 1983. NEMC was established with a broad mandate in response to the national need for such an institution to oversee environmental management issues and also implement the resolutions of the Stockholm Conference (1972), which called upon all nations to establish and strengthen national environmental Councils to advise governments and the international community on environmental issues.

With its vision to be a world-class environmental management authority that ensures a clean, safe, and healthy environment for people in Tanzania. Committed to promoting environmental management in Tanzania through coordination, facilitation, awareness raising, enforcement, assessment, monitoring and research, NEMC offers an exceptional array of services namely Environmental Inspection, Expert Registration, Environmental Research Coordination, Environmental Education, Enforcement Sanctions, and Compliance Monitoring.

Our Silver Sponsor

Mwamba Mining

https://mwambamining.com/

Mwamba Mining is a gold mining company dedicated to the acquisition, development, and operation of late-stage resource properties in Tanzania. Mwamba is committed to the empowerment of artisanal gold mining communities and endeavors to sustainably develop ASGM in its areas of operation. The majority of ASGMs rely on toxic and inefficient mercury as a fast and cheap alternative to capital-intensive modern processing technologies. Mwamba eliminates mercury in ASGM communities near its mine developments by purchasing their ore. This intervention leads to a 400% increase in the productivity of participating miners by doubling gold recovery and eliminating hazardous mercury-processing-related labor. Mwamba is a member of the UNEP's global mercury partnership and a private sector advisor to the GEF-funded and UNEP-led PlanetGOLD Program.

Our Silver Sponsor

Petroleum Upstream Regulatory Authority

https://www.pura.go.tz

The Petroleum Upstream Regulatory Authority (PURA), is the regulatory authority established under Section 11 of the Petroleum Act, 2015 (Act No. 21 of 2015) with the mandate to regulate and monitor petroleum upstream operations and LNG activities in Mainland Tanzania and provide advisory services to the Government and the Minister responsible for petroleum affairs.

The mandate is underpinned by several Policy and legal instruments including the National Energy Policy, 2015; the Petroleum Act, 2015; the Oil and Gas Revenue Management Act, 2015 and the Tanzania Extractive Industries (Transparency and Accountability) Act, 2015. The Oil and Gas Revenue Management Act of 2015 requires PURA to carry out or cause to be carried out costs and revenues audit of the petroleum operations. The Extractive Industry (Transparency and Accountability) Act, of 2015 also requires PURA to observe transparency and accountability in its undertakings. PURA mandates are further derived from the National Energy Policy, 2015 which gives guidance on the establishment of an upstream regulator to effectively and efficiently manage petroleum upstream operations.

Our Silver Sponsor

Geofields Tanzania Limited

https://www.geofields.co.tz

Founded in 2008, Geofields is a multidisciplinary strategic service provider company for the exploration and mining industry. Geofields is Tanzania's leading exploration and mining service company, with an integrated and comprehensive service portfolio of drilling services, ground exploration survey works, exploration and mining equipment supply, and mining ventures.

With more than 50 years of combined local and international experience from the team of geologists and drillers. GTL has established itself as one of the successful mining industry services and consultancy providers in Tanzania through its brand name “GTL”, and focuses on helping its broad spectrum of clients spanning small to large-scale mining companies, State institutions, and parastatals, engineering firms, and private players in the industry.

Our Bronze Sponsor

NMB

https://www.nmbbank.co.tz/

NMB Bank Plc. (“NMB”) is a full-service commercial bank incorporated in the United Republic of Tanzania. NMB boasts over 4 million customers and over 3,400 staff and is well-represented across the country with 226 branches, over 9,000 Agents (Wakala), and more than 700 ATMs.

Through its 3 main business divisions: Retail, Wholesale, and Treasury, NMB provides a suite of financial services and products of exceptional quality to retail customers, farmers, SMEs, Corporations, Institutions, and the Government, proven by its figures.

NMB Bank also numbers among the few financial institution pioneers committed to contributing to the development of the Earth Resources Sector and actively supporting state efforts to increase productivity in the mining sector, visible in its implementation of several strategies aimed at empowering miners such as the Lake Zone Mining Club and creating a special allocation to provide loans for miners.

Recognition of the Outstanding Tanzanian Geoscientist

Prof. Abdulkarim Mruma

A token of appreciation is extended to our senior active TGS member and the former TGS president (2010 – 2022), Prof Abdulkarim Mruma for his dedication to serving for more than a decade the geoscientific community and the Tanzania Geological Society in the capacity of the TGS President. Under his leadership and guidance, the Society saw immense growth and contributed greatly to the geoscientific community. Apart from his contribution to the TGS, Prof Mruma has taught and mentored several geologists in the country and beyond and has served well in important institutions on geoscientific matters in the country. In addition, he still pays his TGS membership fees, participates actively in TGS day-to-day matters, whenever he gets a chance, and volunteers for TGS activities. The Tanzania Geological Society Executive Committee would like to thank Prof Abdulkarim Mruma for his commitment and dedication to serving TGS.

Recognition of the Outstanding Tanzanian Geoscientist

Prof. Evelyne Mbede

A token of appreciation is extended to our senior active TGS member, the first female geologist in the country, Prof. Evelyne Mbede for her dedication to the geoscientific community and the TGS. Prof. Mbede has been a mentor to several geologists in the country let alone students she has taught. She sits on important boards of companies and institutions in the country, instrumental in providing direction to these state institutions. As the first female geologist and the only female professor of geology in Tanzania, she has set an example and has been active in teaching, supervising, and mentoring the next generation of geoscientists. Prof. Mbede is also an active member of the TGS, readily availing herself to various capacities in TGS events. The Tanzania Geological Society Executive Committee would like to sincerely thank the Professor for her commitment to the TGS.

Editorial Team

Dr. Emily B. Kiswaka
Department of Petroleum Science and Engineering,
University of Dar es Salaam.

Dr. Emmanuel O. Kazimoto
Department of Geosciences,
University of Dar es Salaam.

Mr. Mofor Njakoi
Tanzania Geological Society Extractive Industry Solutions Limited,
Dar es Salaam.

TGS 2023 Conference Abstract Titles

Contents and Abstract Titles **page**

Conference Programme

DAY 1 & 2 (07-11-2023 to 08-11-2023)

EXCURSION

Monday 06.11.2023	
Time	**Place/ Activity**
06:00 - 00:00	Arriving in Unguja (Excursion participants)
Tuesday 07.11.2023	
Time	**Place/ Activity**
08:00 - 08:30	Gathering at Forodhani garden
08:30 - 09:15	Driving to spice farm
09:15 - 10:45	Visiting the spice farm and a discussion on the geology of Zanzibar
10:45 - 11:30	Driving from Spice farm to Forodhani
11:30 - 12:15	Cruising from Forodhani to Prison Island
12:15 - 14:15	Touring around the Prison Island
14:15 - 15:00	Cruising from Prison Island to Nakupenda sandbank
15:00 - 16:30	Health Break and Refreshments / exploring the Nakupenda sandbank
16:30 - 17:30	Cruising from Nakupenda sandbank to Forodhani
17:30 - 19:30	Stone town tour
19:30 - 21:30	Dinner and exploring the Forodhani night market
21:30	End of day 1
Wednesday 08.11.2023	
Time	**Place/ Activity**
08:30	Gathering at Forodhani garden
08:30 - 09:15	Drive to Safari Blue Cruise
09:15 – 16:15	Touring around Safari Blue Cruise
16:15 - 17:00	Drive back to town
17:00	End of excursion

DAY 3 (09-11-2023) ***OPENING CEREMONY & CONFERENCE***

Time	**Activity**	
07:30 - 08:30	Arrival, Registration	
08:30 - 09:30	Refreshments, Exhibition & Poster Session	
09:30 - 10:00	Tour with Guest of Honour	
10:00 - 10:15	TGS President: Speech, and to welcome Regional Commissioner	
10:15 - 10:35	Regional Commissioner: Speech and to welcome Minister for Water and Energy	
10:35 - 11:00	The Minister for Water and Energy: Speech, and welcome Guest of Honour	
11:00 - 12:00	Guest of Honour	
12:00 - 12:30	Photo session	
12:30 - 13:30	LUNCH BREAK	
Time	**Presenter**	**Title**
13:30 - 14:00	Hon. Abdulsamad Abdulrahim Director, Ocean Business Partners	**Keynote speech** on the importance of professional and industry-specific conferences for investment in Earth Resources: A focus on Blue Economy
14:00 - 14:30	Prof. Evelyne Mbede, UDSM	**Keynote speech** on A Comparative Analysis of the Helium and the Hydrocarbon System of the Rukwa Rift Basin, SW Tanzania
PANEL DISCUSSION ON GREEN ENERGY POTENTIALS, DEVELOPMENT AND TECHNOLOGIES		
14:30 – 16:00 Convenor: **Representative - ZPDC**	Representative - Ministry of Water, Energy and Minerals – Zanzibar	
	Representative - Ministry of Energy	
	Representative - ZPRA	
	Representative - PURA	
	Representatives - TGDC	
16:00 - 16:30	HEALTH BREAK	
16:30 - 16:45	Ezra Kavana	Potential, advancements, and technology associated with green energy, with a focus on energy efficiency project approvals, permits, and regulatory compliance requirements
16:45 - 17:00	Johanes Kakoki	Palynology: A powerful tool in oil and gas exploration and production, a key element of the blue economy in Tanzania
17:00 - 17:15	William A. Kalinga	Geological hazards and risk assessment in coastal regions for sustainable blue economy
17:15 - 17:30	Ernest Mulaya	The global scramble for 'Gold' Hydrogen, Helium and Lithium: Tanzania on a cusp of becoming a giant supplier?
17:30 - 17:45	Japhet Nasson Fungo	Unveiling the Hidden Dangers of Geological Disasters in Tanzania: Threats, Preparedness, and a Vision for Tomorrow
17:45 - 18:00	Lucas Tumbu	Understanding the role of geophysics in geothermal exploration and its relevance to geology and geochemistry
18:00 - 18:15	Desmond Risso	Blue Hydrogen: A Necessary Address to the Net Zero Emissions Initiatives in Tanzania
18:15 - 18:25	End of Session & Announcements	
19:00 - onwards	**Icebreaking Cocktail Party**	

DAY 4 (10-11-2023) ***CONFERENCE***

Time	Presenter	Title
08:00 - 08:40	Arrival, Registration & Poster Session	
08:40 – 09:10	**Representative**, Ministry of Blue Economy and Fisheries	**Keynote speech** on Blue Economy in Zanzibar
09:10 - 09:25	Rose Sallema Mtui	Blue Economy investment activities and effects on local communities: A Case of Mtwara Coastal area, Tanzania
09:25 - 09:40	Morris F. Hiji	Upgrading the Tanzania's lithium ore to meet the minimum requirements for exportation
09:40 - 09:55	Jeremiah Mosingo	Assessment on upgrading graphite from Ruangwa graphite ore by froth flotation
09:55 - 10:10	Duke N. Nyangena	Seafloor spreading kinematics at the Afar triple junction
10:10 - 10:25	Shaidu N. Shaban	The deep basin and underlying basement structure of the Lake Tanganyika rift
10:25 - 10:55	HEALTH BREAK	
10:55 - 11:10	William A. Kalinga	Geo-economic implications of Tanzania mining sector expansion from gold to strategic mineral resources
11:10 -11:25	Alex Rutagwelela	Geology and Geochronology of the Carbonatites in Southwestern Tanzania: Focusing on the Nb-Ta and REE deposits
11:25 -11:40	Gerald L. Chuwa	Geochemistry and U-Pb Zircon Geochronology of S-type Granites in the Karagwe Ankolean Belt, Northwestern Tanzania: Implications for Rare-Metals Mineralisation
11:40 - 11:55	Mary Charles Moshi	Petrological, geochemical and mineralogical characteristics of Wigu Hill Carbonatite, Uluguru Mountains, Tanzania: Insights into carbonatite evolution and REE mineralization
11:55 -12:10	Japhet Nasson Fungo	Petrographic features of the Sangu-Ikola Carbonatites Southwestern Tanzania
12:10 - 12:25	Benjamin C. Safi	The Nature and Characteristics of Select Handeni Gold Occurrences: Constraining Au-occurrences in the Neoproterozoic Mozambique Belt
12:25 - 12:40	Kabete, Joas M.	Potential discovery of > 1 Moz Au deposits from Mkurumu-Magamba Province in the Southern East African Orogen of Tanzania: a product of frontier exploration and basic research initiatives
12:40 - 13:40	LUNCH BREAK	
PANEL DISCUSSION ON TANZANIA MINING SECTOR, EXPANSION FROM GOLD TO STRATEGIC MINERALS		
13:40 - 15:00 Convenor: Representative – Eng. Kimogele	Representative – Geological Survey of Tanzania	
	Representative – Mining Commission	
	Representative – Chamber of Mines	

Time	Presenter	Title
Joseph Shigongo (APEX Resources)	Bartholomew Mkinga – PENSENA Metals	
15:00 - 15:15	Duke N. Nyangena	Reconstruction of continental rifting and kinematics for the evolution of sedimentary basins in the Afar region
15:15 - 15:30	Venance E. Mboya	Timing of the Cenozoic magmatic intrusions in the offshore Tanga Basin, Tanzania: correlation to age equivalent deposits in the Eyasi-Wembere Basin and their implications for petroleum potential
15:30 - 15:45	Charles H. Kasanzu	Topographic maturation of Tanzania basement terrains – Review of thermochronological data.
15:45 - 16:00	Ibrahim Mfungo	Geotechnical and geochemical characterization of building minerals and rocks in the Coastal Basin and Mozambique belt, eastern Tanzania; implication on the supply chain of quality building materials for construction
16:00 - 16:20	HEALTH BREAK	
PANEL DISCUSSION ON GEOTECHNICAL APPLICATIONS IN PETROLEUM, MINING AND CONSTRUCTION		
16:20 - 17:50 Convenor: Representative -	Representative – ZPDC	
	Representative - Ministry of Water	
	Representatives – Karume Institute of Science and Technology (KIST)	
	Representatives – TPDC	
17:50 - 18:05	Denis S. Nkwabi	Application of High-Resolution Geoelectrical, Geomagnetic, and Ground Penetrating Radar (GPR) methods in geotechnical investigations
18:05 - 18:20	Juma N. Kubingwa	Integrated geospatial and geophysical approaches for mapping groundwater potential in the semi-arid Bukombe district, Tanzania
18:20 - 18:35	Daniel Edward	Removal of arsenic in a sand filter coupled with zero-valent iron
18:35 - 18:45	**Announcements & End of day 4**	

DAY 5 (11-11-2023) ***CONFERENCE & CLOSING CEREMONY***

Time	Presenter	Title
08:00 - 08:30	Arrival & Poster Session	
08:30 - 09:00	John Mataro, The Mining Commission	**Keynote speech** on Deep Sea Resources, exploration and development in Tanzania.
09:00 - 09:15	Innocent Mvamba	TPDC laboratory services
09:15 - 09:30	Faustine Matiku	Tanzania Petroleum Potential: the 5th Bidding Round and Multiclient arrangement
09:30 - 09:45	Venance E. Mboya	Geology of Eyasi-Wembere Basin, Potential for Petroleum Exploration in Tanzania
09:45 - 10:00	Ernest Selestin	Spatial distribution of petroleum system elements in the Pangani rift basin of north-eastern Tanzania based on interpretation of gravity and magnetic datasets
10:00 - 10:15	John W. Gama	Sedimentary evolution and source rock potential of Lower Jurassic successions in the Mandawa Basin, SE Tanzania
10:15 - 10:35	HEALTH BREAK	
PANEL DISCUSSION ON DEEP-SEA RESOURCES, EXPLORATION, AND DEVELOPMENT IN TANZANIA		
10:35 - 12:10 Convenor: Representative – Ministry of Water, Energy and Minerals Zanzibar	Representative - Ministry of Water, Energy and Minerals – Zanzibar	
	Representative - Ministry of Minerals	
	Representatives – TPDC	
	Representatives – ZPDC	
	Representatives – PURA	
CLOSING, TGS 2023 ANNUAL CONFERENCE		
12:10 - 12:15	TGS Vice President, TGS: Welcoming remarks	
12:15 - 12:45	TGS President: Speech, and welcome Guest of Honour	
12:45 - 13:45	Guest of Honour	
13:45 - 13:55	Photo session	
13:55 - 14:50	LUNCH BREAK	
TGS ANNUAL MEETING		
Time	**Activity**	**Responsible**
14:50 - 15:20	Opening	TGS President
15:20 - 17:50	Reporting on TGS 2022/2023 Activities, TGS Journal & Financial Report (Auditor's report)	TGS General Secretary, Treasurer and Editor
17:50 - 18:00	TGS Extractive Industry Solutions (TEIS)	TGS President
18:00 - 18:50	Election	All
18: 50 - 19:10	Closing	TGS Vice President
19:30 - onwards	**CONFERENCE DINNER**	

POSTER PRESENTATIONS

Presenter	Poster title
Rachel Sabuni	Geophysical Analysis of the Tanga Basin, Northern Coastal Tanzania, Based on Gravity, Aeromagnetic and 2D Seismic Data: Implication for Petroleum Prospectivity
Benatus Mvile	Petroleum Systems and Hydrocarbon Potential of the Ruvuma Basin, Tanzania
Daniel C Reuben	Environmental carbon footprints capture machines: technologies to capture and utilize dangerous carbon to make useful energy fuels, economic geology, and enhanced oil recovery
Loveness Damian Chilumba	A sustainable path to a greener future
Mussa Kimweri	The value of water to the National Economy: How water is linked to the national economy, approaches to cover the existing gap between water resources and the national economy together with benefits from the outcome
Ronald Machumu	Unconventional hydrocarbon resources in Tanzania
Hobokela Mwakajumba	Geothermal exploration methods development in the context of artificial intelligence revolution: A case of Tanzania geothermal prospects
Jessica Kirita	Underpinning the alteration proxies for gold mineralization at Buckreef gold deposit in the Rwamagaza gold camp, Sukumaland greenstone belt

POTENTIAL, ADVANCEMENTS, AND TECHNOLOGY ASSOCIATED WITH GREEN ENERGY, WITH A FOCUS ON ENERGY EFFICIENCY PROJECT APPROVALS, PERMITS, AND REGULATORY COMPLIANCE REQUIREMENTS

Ezra Kavana
East Africa Crude Oil Pipeline, EACOP Ltd (Tanzania and Uganda)
*ezrakavana2@gmail.com

The potential of green energy is vast, encompassing solar, wind, hydroelectric, geothermal, and biomass sources. These renewable resources provide considerable benefits, such as reduced greenhouse gas emissions, energy security, and long-term sustainability. Taking use of this potential necessitates a thorough understanding of the many technologies involved.

Green energy technology development has accelerated in recent years. Solar photovoltaic (PV) systems have become more efficient and cost-effective, making them a popular alternative for household and commercial applications. Wind turbines, both onshore and offshore, have also evolved in size and production capacity, providing a competitive alternative to traditional fossil fuel-based power generation.

Hydroelectric power is a prominent force in the green energy sector, with large-scale projects producing steady and reliable electricity. Furthermore, geothermal energy uses the heat of the Earth to generate power, providing consistent energy production in geologically active areas. Biomass technologies, which use organic materials such as agricultural waste and forest residues, also contribute to green energy generation.

Despite their enormous potential and technological developments, green energy project development is subject to a variety of approvals, permits, and regulatory compliance requirements. These restrictions are intended to safeguard the environment, promote public safety, and assure compliance

with energy standards. Assessing the environmental impact of projects, holding community consultations, and adhering to regulations regarding zoning and land-use restrictions are all part of the permitting process.

Furthermore, compliance with regulations is critical for the successful execution of green energy projects. Local, regional, and national authorities impose emissions regulations, renewable portfolio targets, and other legal obligations on developers. Compliance with these regulations promotes a responsible and long-term strategy for green energy deployment.

Finally, green energy promises a promising path toward a more sustainable and environmentally responsible future. Exploiting the potential of renewable sources and utilizing innovative technologies will propel the green energy sector forward. However, getting authorizations and complying with regulatory frameworks, supporting responsible growth, and guaranteeing a cleaner and greener energy landscape are all critical to attaining successful project outcomes.

PALYNOLOGY: A POWERFUL TOOL IN OIL AND GAS EXPLORATION AND PRODUCTION, A KEY ELEMENT OF THE BLUE ECONOMY IN TANZANIA

Johanes Kakoki
Tanzania Petroleum Development Corporation (TPDC), Directorate of Exploration, Production & Development, P. O. Box 2774, Dar es Salaam.
* jkakoki@tpdc.co.tz

Tanzania's blue economy includes oil and gas exploration and production linked to a substantial offshore, shallow continental shelf, and along the coastline gas discoveries. Organic-walled microfossils have been widely used to ascertain geological age, depositional environment, thermal maturity, and correlation of rock strata to ensure successful exploration and production of oil and gas. These microfossils include dinoflagellates, acritarchs, pollen, and spores; have been studied to establish chronostratigraphy, depositional environments, thermal maturity, and correlation of bio events in the shallow continental shelf of southern Tanzania. Thirty rock-cutting samples from boreholes X and Y retrieved from the study area were palynologically processed and studied. In well X, Wanaea fimbriata, Wanaea clathrata, and Gonyaulocysta jurassica have been found to represent the earliest interval, whereas Homotryblium tenuispinosum represented the newest Messinian portion of the stratigraphy. In well Y, Coronifera oceanica and Glaphyrocysta semitecta were found to represent the oldest Hauterivian section and the youngest Rupelian horizon, respectively. Results also show that the oxygen levels varied from oxic, dysoxic, and anoxic, while the depositional habitats spanned from the proximal shelf to the deep basin. Type III and IV gas-prone kerogen predominated in the majority of the studied samples. The presence of Apectodinium homomorphum was a marker of a

hot environment, Pediastrum sp. indicated a freshwater input, and plant pollen indicated a terrestrial effect. The abundance of fungal spores and hyphae also indicated a humid climate. Thermal maturity ranged from mature to over-mature. Six bio-events were present in both wells and their correlation indicated varying rates of sedimentation at some intervals and breaks in sedimentation at other intervals. These fluctuations were caused by differences in the amount of accommodation space that was created within the basin as a result of shifting sea levels and tectonic uplift and subsidence.

GEOLOGICAL HAZARDS AND RISK ASSESSMENT IN COASTAL REGIONS FOR SUSTAINABLE BLUE ECONOMY

William A. Kalinga*
Geological Survey of Tanzania, P. O. Box 903, Dodoma, Tanzania.
*kalingawilliam@hotmail.com

Coastal regions are vital for the development of the blue economies, which rely on marine resources for economic growth. They play a great role in supporting a sustainable blue economy (SBE), as they offer abundant resources and various economic activities. However, these regions are also prone to a wide range of geological hazards that can pose significant risks to both the human population and the environment. This study presents an overview of comprehensive geological implications aimed at understanding and mitigating geological hazards in coastal areas, assessing their associated risks, and proposing strategies to foster SBE. These hazards encompass coastal erosion, subsidence, landslides, tsunamis, and the impacts of sea-level rise due to climate change. The study employs a comprehensive methodology, which utilizes advanced geological mapping, geological survey data, and satellite imagery to identify vulnerable areas and characterize the geological processes driving these hazards as well as a multidisciplinary approach such as integrating geological, geophysical, and remote sensing techniques to assess various geological hazards faced by coastal regions. Furthermore, the research incorporates risk assessment methodologies to quantify the potential consequences of geological hazards on coastal communities and economic activities associated with the blue economy. This involves the development of vulnerability models that consider both physical and socio-economic factors, such as population density, infrastructure, and economic value. The results and findings reveal

the need for proactive planning and mitigation measures to ensure the sustainability of blue economy strategies in coastal regions specifically Zanzibar. To enhance the resilience of coastal regions and promote sustainable development, the study also investigates and proposes various mitigation and adaptation strategies. The study also emphasizes the importance of effective early warning systems and emergency preparedness measures to reduce the risks associated with sudden geological events, such as tsunamis and landslides. It explores the integration of real-time monitoring technologies and community engagement to ensure timely response and evacuation. Ultimately, this scientific study contributes to the advancement of knowledge on geological hazards in coastal regions and their implications for SBE development. It provides valuable insights for policymakers, urban planners, and coastal communities, guiding them in making informed decisions to protect coastal environments and support the long-term sustainability of the blue economy. The findings underscore the necessity of a holistic approach that combines geological expertise, risk assessment, and strategic planning to address geological hazards in coastal regions and foster a prosperous and resilient blue economy.

BLUE ECONOMY INVESTMENT ACTIVITIES AND EFFECTS ON LOCAL COMMUNITIES: A CASE OF MTWARA COASTAL AREA, TANZANIA

Rose Sallema Mtui [1, *] and Isaacs Moenieba[1]

[1]The Institute for Poverty, Land and Agrarian Studies (PLAAS), University of the Western Cape (UWC), South Africa

[*] nrsallema@yahoo.com

Geological activities that involve oil and gas exploration and extraction have been growing over the years. The discovery of oil and gas has also brought other investors, and therefore, high expectations for economic growth and hope for a promising future for local communities. However, in some marine protected areas, Blue Economy (BE) investments have been a major setback to fishing communities' livelihoods that calls for a balance between development projects and peoples' livelihood sustainability. Examples are drawn from coastal states like Niger, Ghana, and Mexico where resource endowments have been a source of livelihood deterioration. This paper focused on identifying types of BE investments in the study area and assessing the effect on community livelihoods. The study employed both qualitative and quantitative methods comprising key informant interviews and focus group discussions administered to different officials in the study area. Results indicate a higher number of investments in oil and gas, a condition that should take precedence for other investments to advance. At the study area where the marine park is also operational, communities are facing significant challenges that include loss of settlement, settlement relocation, cases of imprisonment, fines, confiscation of gears, and burning of gears; an increase in investment activities contributes to the escalation of these tensions and conflicts. These challenges and especially the loss of

settlement for communities that have to relocate, means that they are losing their cultural and ancestral land, hence the loss of their identity and livelihood. On this basis, this paper argues that BE investment activities have the potential to disrupt surrounding communities' livelihoods in both positive ways for some and negatively for the majority who do not benefit directly from these investments.

UNVEILING THE HIDDEN DANGERS OF GEOLOGICAL DISASTERS IN TANZANIA: THREATS, PREPAREDNESS, AND A VISION FOR TOMORROW

Japhet Nasson Fungo*, William Andrew Mremi, Edista Alex Abdallah

Department of Geosciences, P.O. Box 35052, University of Dar es Salaam, Tanzania

*fungo.japhet@udsm.ac.tz/ japhetnfungo@gmail.com

Tanzania, renowned for its geological diversity, is a land of both natural beauty and inherent risks. The nation grapples with diverse geological hazards, including earthquakes, rock falls, beach erosion, landslides, volcanic eruptions, and flooding, all of which pose substantial threats to human lives and critical infrastructures. As Tanzania's population grows, accompanied by increased urbanization, the need for robust geological disaster prevention, monitoring, and emergency response systems becomes more pressing. This comprehensive study thoroughly examines the current status of geological disaster management in Tanzania. It encompasses exploring existing threats, identifying less visible yet imminent dangers, and proposing strategic interventions to enhance the nation's resilience against geological disasters. Importantly, this endeavor emphasizes the importance of collaboration among all stakeholders.

UNDERSTANDING THE ROLE OF GEOPHYSICS IN GEOTHERMAL EXPLORATION AND ITS RELEVANCE TO GEOLOGY AND GEOCHEMISTRY

Lucas Tumbu*, and Albano Mahecha
Tanzania Geothermal Development Company Limited
P.O. BOX 14081, Dar es Salaam
* lucas.tumbu@tgdc.go.tz

This paper is aimed at creating awareness of the techniques applied in geological, geochemistry, and geophysics exploration of geothermal resources. An understanding of geological processes and the nature of geothermal systems, whether related to magmatic activity or extensional faulting, is needed for successful geothermal exploration and development campaigns. The analysis of tectonic regimes involving divergent, convergent, and transfer boundaries of plate tectonics is necessary. Geochemical studies are needed for the identification of fluid flow patterns and the origin and nature of geothermal fluids. This is accomplished through the application of techniques like soil gas surveys, water surveys, and analysis of gas constituents within the given sample. The geophysical investigation of geothermal resources is accomplished by using techniques for identifying geophysical parameters such as temperature, porosity, permeability, salinity, pressure, seismicity, density, and magnetic susceptibility. Geophysical exploration is vital and plays a big role in the identification of drilling targets and reservoir geometry (shape, size, and depth).

On the other hand, geothermal exploration is a multidisciplinary aspect involving the integration of geological, geochemical, hydrological, and geophysical data sets to build up a geothermal conceptual model. The model ends up locating the drilling site for resource confirmation. The resource confirmation is done through three (3) exploration wells of either

Temperature Gradient Holes (TGH) or **Slim Holes**, followed by three (3) to six (6) **Appraisal Wells** for further confirmations of the resources. Once the resource is deemed to be present; **Production Wells, Re-injection Wells, Make-up Wells, and Work-over Wells** are drilled whenever necessary. For a successful well, integration of **3G's** (**Geology**, **Geochemistry,** and **Geophysics**) should have delivered reliable information that altogether matches within a reasonable scientific level of confidence.

BLUE HYDROGEN: A NECESSARY ADDRESS TO THE NET ZERO EMISSIONS INITIATIVES IN TANZANIA

Desmond Risso
Petroleum Upstream Regulatory Authority, P. O. Box 11439, Dar es Salaam.
desmond.risso@pura.go.tz

Tanzania is among the signatories of the Paris Agreement of 2015 which calls for increased efforts in climate change mitigation and adaptation. The agreement has resulted in a heightened requirement for substantial reductions in greenhouse gas emissions across the spectrum, including the petroleum industry, guided by the overarching goal of achieving net zero emissions by 2050. The prominence of the net-zero emission agenda has significantly influenced strategies in the exploration and development of new petroleum resources on a global scale. Among others, natural gas, due to its significantly lower CO_2 emissions, has been recognized as a transitional energy source.

The petroleum industry has conceived several reorganizations to attain a business model that is more sustainable, environmentally friendlier, potential for financing its development projects, and is profitable to the parties. Technology is central to the changes in the industry. Production of hydrogen from methane/natural gas coupled with carbon capture use and storage is rapidly adopted and projected to rise.

Tanzania, given its significant volume of natural gas discovered so far and the proportion of untapped volume therein, has the potential to develop a blue hydrogen economy. This paper sheds light on opportunities concerning the potential of blue hydrogen production in Tanzania and challenges that require attentive attention to warrant the potential is realized.

SEAFLOOR SPREADING KINEMATICS AT THE AFAR TRIPLE JUNCTION

Duke N. Nyangena*, Athanas S. Macheyeki, Seetharamaiah Jagarlamudi

Department of Geology, College of Earth Sciences and Engineering, the University of Dodoma, P. O. Box 259, Dodoma, Tanzania

* nyangenaduke74@gmail.com

Seafloor spreading is a fundamental process in plate tectonics, and understanding its kinematics at the Afar Triple Junction has been a subject of great interest for Geoscientists. Previous studies have focused mainly on the geological history of the western Aden region and the evolution of the Aden-Owen Carlsberg ridge, leading to a limited understanding of the comprehensive seafloor spreading rates at the Afar Triple Junction. This research aimed to estimate these rates by integrating multiple data sources into the Gplates Software, ensuring the validity of the investigations by referencing the geomagnetic reversal time scale and drawing conclusions from previous studies. Two synthetic anomaly profiles are generated across the Aden Ridge using actual field data and compared to validate the spreading rates. Orientation analyses of seafloor materials are conducted using newly modeled magnetic anomaly profiles, while the age of the oceanic crust is determined from the seafloor age grid. Based on the magnetic anomaly data integrated into this study, we observe a dominant E-W orientation of seafloor spreading widths, indicating the progression of seafloor spreading and the formation of new oceanic crust as one moves away from the Aden Ridge center. As the process of seafloor spreading advances, progressively older rocks are encountered, preserving the record of the Earth's magnetic field orientation at the time of their formation, leading to positive magnetic anomalies. The estimated seafloor spreading rates using

magnetic anomaly data from 16 Ma to the present range from 12.29 mm/yr to 20.12 mm/yr. These established slip rates suggest that the region is slowly transitioning from continental lithosphere to oceanic crust at an average rate of 15.75 mm/yr. This propagation process is attributed to the rotation of two rigid plates, Arabia and Somalia, around a relatively stationary pole located to the northwest of the propagating ridge. The study reveals that seafloor spreading is more pronounced towards the African continent, covering approximately 170.67 km, compared to the Arabian side, which covers 138.03 km. The calculated rates show approximately 10.67 mm/yr to the eastern side and 8.67 mm/yr to the western side, indicating faster separation and crust formation on the eastern side, while the western side experiences a slightly slower rate. Furthermore, the calculated azimuths and slip rates indicate an average pole relative motion between the Somalian and Arabian plates at 10.5469 N 35.1857 E, with an average angular rotation of 0.5353°/Ma. The results obtained are consistent with previous field observations by other researchers.

THE DEEP BASIN AND UNDERLYING BASEMENT STRUCTURE OF THE LAKE TANGANYIKA RIFT

Shaidu N. Shaban[1, 2, *], Folarin Kolawole[3], Christopher A. Scholz[1]
[1]Department of Earth and Environmental Sciences, Syracuse University, Syracuse, NY, USA,
[2]Tanzania Petroleum Development Corporation, DSM, Dar es Salaam, Tanzania,
[3]Department of Earth and Environmental Sciences, Columbia University, Newark, NY, USA
[*]snuru@tpdc.co.tz

The oldest structures in a rift basin define incipient rift architecture and modulate the patterns of landscape evolution, sedimentation, and associated hazards in subsequent phases of rift development. However, critical early-rift processes remain poorly understood due to deep burial beneath younger, thick syn-rift sequences and limited resolution of seismic imaging. In the Tanganyika Rift, East Africa, we augment existing 2-dimensional (2-D) seismic reflection data with newly acquired aeromagnetic and Full Tensor Gradiometry (FTG) data to investigate the deep basin and underlying basement structure. Seismically-constrained 2.75-dimensional forward modeling of the aeromagnetic and (FTG) data reveals: 1) an anomalously high-density (2.35-2.45 g/cc) deep-seated, fault-bounded wedge-shaped sedimentary unit that directly overlies the pre-rift basement, likely of Mesozoic rift (Karoo) origin; 2) a ~4 km-wide sub-vertical low-density (2.71 g/cc) structure within the 3.2 g/cc basements, interpreted to be an inherited basement shear zone, 3) significant intra-basin early-rift fault co-located with the modeled shear zone margins, defining a persistent intra-basin 'high', and 4) a shallow intra-sedimentary zone of comparatively dense material (~2.2 g/cc), interpreted to be a younger axial channel complex confined between the intra-basin 'high' and border fault. These results provide insight into the

earliest basin architecture of the Tanganyika Rift, controlled by inherited basement structure, and provide evidence of their persistent influence on the subsequent basin evolution.

THE GLOBAL SCRAMBLE FOR 'GOLD' HYDROGEN, HELIUM AND LITHIUM: TANZANIA ON A CUSP OF BECOMING A GIANT SUPPLIER?

Ernest Mulaya[1, 2], Jon Gluyas[2], Ken McCaffrey[2], Chris Ballentine[3], Tom Phillips[2, 4],

[1]School of Mines and Geosciences, University of Dar es Salaam, P.O. Box 35052, Dar es Salaam, Tanzania.

[2]Department of Earth Sciences, Durham University, Durham, UK, DH1 3LE.

[3]Department of Earth Sciences, University of Oxford, Oxford, UK, OX1 3AN.

[4]His Majesty's Revenue & Customs (HMRC), UK

* ernestmulaya@gmail.com

Helium (He), hydrogen (H), and Lithium (Li) have received immense interest in recent years, primarily due to their exponentially rising demand and skyrocketing prices. These three consecutive elements on a periodic table are critical inputs into emerging clean technologies from the electronic industry, electric vehicles (batteries) renewable energy systems, and many others that rely on these elements. Despite these important applications, some without substitutability, the global supply especially helium has been dwindling year after year putting the world community under the pressure of scarcity to look for further discoveries. Unlocking these resources is critical to keeping abreast of the current global societal demand and also towards supporting the green energy revolution.

Here we present why and how the Rukwa Rift case in Tanzania suits the prerequisites for helium gas alongside 'gold' hydrogen and possible lithium potential in a similar geological setting. Motivation is based on the recent gas composition data from the Rukwa Rift which indicate high radiogenic helium

content up to ~ 10%, Nitrogen up to ~96% which are far above the economic threshold evidently documented in thermal springs and briny waters.

Integrated approaches of geological, geochemical, and structural evidence are deployed using softwares in a loop of artificial intelligence (AI) models. The evolution and timing of structural patterns are demonstrated in space and time within two structural domains: Domains A (north) and B (south) separated by the Saza Shear Zone (SSZ) which controls the oblique divergent effects of the Rukwa Rift. These structures control the distribution and accumulation potential i.e., trap geometry and reservoir quality evolution in space and time. Modelling suggests significant insights into the timescale of helium production, release, and a possible time-window of helium accumulation surge triggered by heat flow anomaly in the rift. These findings provide comprehensive geological aspects as important feedstock into techno- and socio-economic analyses towards commercially viable resources.

UPGRADING THE TANZANIA'S LITHIUM ORE TO MEET THE MINIMUM REQUIREMENTS FOR EXPORTATION

Morris F. Hiji[1*], Jeremiah Mosingo[1], and S. Jackson[2]

[1]Department of Mining and Mineral Processing Engineering, College of Earth Sciences and Engineering, University of Dodoma, P. O. Box 259, Dodoma, Tanzania.

[2]Geological Survey of Tanzania, P. O. Box 903, Dodoma, Tanzania.

[*]morris.frankh@gmail.com

Lithium is among the critical minerals found in Tanzania along the Morogoro, Katavi, and Dodoma regions. This strategic mineral is in high demand worldwide because it is utilized in the production of electric vehicle batteries and cell phones, both of which are high-tech industries. Despite being present in Tanzania, it is of low grade and does not meet the standards for export. The goal of this study is to improve this potential resource to the minimum standard of 5.7% lithium oxide that is acceptable on the global market. To attain this goal, strategic sampling procedures were used of which, a 20 kg sample of lithium was collected from Hombolo-Dodoma, and prepared by crushing and pulverizing to different size fractions. The prepared sample was divided into subsamples used for elemental analysis and the flotation test works. The experimental setup was designed using the central composite design, with controlled variables being particle size and collector concentration. The analysis of variance (ANOVA) was utilized to assess the relationship between the experimental factors and model response. The results revealed that the lithium from Hombolo can be upgraded to 15.26% Lithium oxide, hence meeting the required grade. Furthermore, the optimal experimental conditions, -0.106mm particle size and 0.2 ml NaOL collector yielded optimum recovery of 92% Lithium oxide. In light of the potential benefits of lithium in advancing industrialization and enhancing Tanzania's

blue economy, this study strongly recommends the use of froth flotation technology to upgrade the lithium ore (spodumene) from Hombolo-Dodoma.

GEO-ECONOMIC IMPLICATIONS OF TANZANIA MINING SECTOR EXPANSION FROM GOLD TO STRATEGIC MINERAL RESOURCES

William A. Kalinga*
Geological Survey of Tanzania, P. O. Box 903, Dodoma, Tanzania.
*kalingawilliam@hotmail.com

This study investigates the geo-economic implications of the expansion of Tanzania's mining sector from gold to strategic mineral resources. Tanzania as a resource-rich country has embarked on an ambitious journey to diversify its mineral extraction efforts. The transition entails not only exploring and exploiting new mineral resources but also involves significant shifts in foreign investment, international trade, environmental sustainability, and socio-economic development. The study offers a comprehensive analysis of these geo-economic implications, providing insights into potential benefits and challenges associated with Tanzania's mining sector expansion. The mining sector in Tanzania has undergone a significant transformation over recent years, shifting its focus from traditional gold extraction to the exploration and exploitation of strategic mineral resources. This research endeavors to comprehensively analyze the geo-economic implications of Tanzania's strategic pivot in its mining sector, exploring the multifaceted dimensions of this transition. Tanzania, endowed with a rich geological landscape, has historically relied heavily on gold mining as a primary revenue generator. However, recognizing the global demand for strategic minerals crucial to advanced industries such as electronics, renewable energy, and aerospace, the country has embarked on an ambitious journey to diversify its mining portfolio. This shift necessitates a holistic examination of the geological, economic, and geopolitical dynamics intertwined with the

expansion into strategic mineral resources. The research will employ a multi-disciplinary approach, integrating geological surveys and mineralogical assessments to identify and quantify the strategic mineral deposits within Tanzanian territory. These minerals may include but are not limited to rare earth elements, lithium, tantalum, and graphite, which are crucial for emerging technologies. Detailed geological mapping, mineralogical analyses, and remote sensing techniques will be employed to provide an accurate characterization of the deposits' size, quality, and distribution. Furthermore, the economic implications of this transition will be examined through the lens of macroeconomics, trade, and investment. The research will assess the potential impact on Tanzania's GDP, balance of trade, foreign direct investment, and job creation. Additionally, the study will analyze the international market dynamics, considering the demand for strategic minerals, price volatility, and competition with other global suppliers. A significant aspect of this research involves an in-depth examination of the geopolitical ramifications of Tanzania's strategic mineral exploration. The study will scrutinize the nation's engagement with international stakeholders, including diplomatic and trade relations, as well as the potential for geopolitical competition in the region due to the growing importance of these minerals in global supply chains. Moreover, environmental and social dimensions will not be overlooked. The research will address the environmental sustainability of strategic mineral extraction, including the potential ecological impacts and mitigation strategies. Additionally, the social implications, such as community displacement, labor rights, and local development, will be assessed to ensure the responsible and equitable exploitation of these resources. In conclusion, this research will provide a comprehensive understanding of the geo-economic implications associated

with Tanzania's transition from gold mining to the exploration and extraction of strategic mineral resources. By integrating geological, economic, and geopolitical perspectives, it aims to offer valuable insights for policymakers, investors, and international stakeholders interested in the sustainable development of Tanzania's mining sector and the broader implications for global resource supply chains.

PETROGRAPHIC FEATURES OF THE SANGU-IKOLA CARBONATITES SOUTHWESTERN TANZANIA

Japhet Nasson Fungo*, Nelson Boniface, Elisante Elisaimon Mshiu

Department of Geosciences, P.O. Box 35052, University of Dar es Salaam, Tanzania

*fungo.japhet@udsm.ac.tz/ japhetnfungo@gmail.com

Carbonatites are unique igneous rocks rich in carbonate minerals calcite and dolomite. These rocks are reported to host large deposits of rare earth elements (REEs). The REEs have become increasingly crucial in high-tech industries, such as the manufacturing of batteries for electric vehicles, renewable energy (wind turbines), aerospace applications, and telecommunication (smartphones). Subsequently, the economic potential of carbonatites as a source of REE has gained significant attention in recent years. However, despite the economic significance and the presence of carbonatites in Tanzania, there is limited geologic information on known carbonatite deposits in the country. This study aimed to investigate the geology and geochemistry of Sangu-Ikola carbonatite to add more understanding to their REE potential in Tanzania. However, for the purpose of this communication, we present preliminary results on the petrographic features of the Sangu-Ikola Carbonatites deposits.

Petrographic analysis has revealed Sangu-Ikola carbonatite composed of calcite and dolomite as major phases, with minor phases of quartz, apatite, ±pyrochlore, ±magnetite, ±hematite, ±sulphides, and ±biotite. The presence of large swans of microstructures is suggested to signify multiple deformation events. Geochemical results showed elevated light Rare Earth Elements also indicate Sangu-Ikola carbonatite is calciocarbonatite and

magnesiocarbonatite with less ferrocarbonatite. Spectra collected by Analytical Spectra Device (ASD) have also revealed the presence of calcite, dolomite, ankerite, siderite, montmorillonite, kaolinite, chlorite and hornblende in the Sangu-Ikola carbonatites.

GEOLOGY AND GEOCHRONOLOGY OF THE CARBONATITES IN SOUTHWESTERN TANZANIA: FOCUSING ON THE NB-TA AND REE DEPOSITS

Alex Rutagwelela[1, 2, *], Nelson Boniface[1], ElisanteMshiu[1] and Francisco Apen[3]

1 Department of Geosciences, School of Mine and Geosciences, University of Dar-es-salaam

2State Mining Corporation, Mirembe Road, Hazina Plot No.173, Block W, BOX 981, Dodoma

3Department of Earth Science Webb Hall, University of California, Santa Barbara CA 93106

* acyprian2003@yahoo.co.uk

Carbonatites normally undergo various magmatic-hydrothermal processes during their evolution that are important for the enrichment of rare earth elements (REE), Niobium (Nb), and Tantalum (Ta). This study aimed to increase the understanding of the carbonatite deposits in SW Tanzania (Nachendazwaya, Panda Hill, and Ngualla) by investigating their geological setup through geology, geochemistry, and dating to unravel the source and nature of the carbonatite magmas, REE, and Nb-Ta mineralization. Field geological observations show that the Ngualla, Panda Hill, and Nachendazwaya carbonatites are located within the Palaeoproterozoic Ubendian belt. The three deposits are hosted within the amphibolitic gneiss, which is fenitized at the contact with the carbonatite. Other rocks within these deposits include ultramafic rocks, sövites, dolomitic dykes, and pyroclastics in the case of the Panda hill deposit. Unlike the Ngualla and Panda Hill deposits which are circular, the Nachendazwaya deposit shows a northwest trend similar to the Ubendian belt suggesting a metamorphic event after its emplacement. U-Pb geochronology study indicates three episodes of rifting and magmatic events are related to the studied carbonatite; at around 1280 ± 36.3 Ma, between 1184.1 ± 17.2 Ma – 1081.6 ± 44.7 Ma and

metamorphic reworking between 693.5 ± 14.3 Ma – 662 ± 12.6 Ma. Petrographic observations combined with geochemical data suggest that these deposits exhibit features that are typical of magmatic, magmatic-hydrothermal, and post-magmatic processes through their evolution. The presence of magnetite in these deposits implies the slow cooling of magma whereby the partial melting of the magma is indicated by high Ba values and depletion of compatible elements Hf, Zr and K. These suggests that the deposits' magma was derived from the mantle by a very low degree partial melting followed by magmatic differentiation. The studied carbonatites host LREE, Nb-Ta mineralization from both magma source and mineralization enriched from fractional crystallization of the carbonatitic magma and are hereby, therefore, classified as LREE, Nb-Ta deposits.

GEOCHEMISTRY AND U-PB ZIRCON GEOCHRONOLOGY OF S-TYPE GRANITES IN THE KARAGWE ANKOLEAN BELT, NORTHWESTERN TANZANIA: IMPLICATIONS FOR RARE-METALS MINERALISATION

Gerald L. Chuwa [a*], Charles H. Kasanzu [a], Francisco E. Apen [b], Emmanuel O. Kazimoto [a]

a Department of Geosciences, School of Mines and Geosciences, the University of Dar-es-Salaam, P.O. Box 35052, Dar es Salaam, Tanzania.

b Department of Earth Science, University of California, Santa Barbara, CA 93106-9630.

* gerald7chuwa@gmail.com

The Mesoproterozoic Karagwe Ankolean Belt in the Central Eastern Africa region hosts suites of granites that intruded supracrustal rocks and are associated with Sn-W mineralization. In northwestern Tanzania, the granites are S-type, peraluminous and calc-alkalic to alkalic-calcic in composition. Geochemical analyses of the granites reveal the following concentrations: SiO_2 (71 - 77 wt.%), Al_2O_3 (11 - 15 wt.%), K_2O (3 - 7 wt.%), MgO (0.06 - 0.86 wt.%), TiO_2 (0.07 - 0.36 wt.%) and Fe_2O_{3T} (0.71 - 2.40 wt.%). The SiO_2 contents correlate negatively with MgO, CaO and K_2O and positively correlate with Nb, Ta, Zr, Sr, Ba, Hf, Th and the REE (Eu, Ce and Sm). Primitive mantle normalized spider plots show elevated LILE against depletions in Ba, Nb, Ti and La, suggesting inherited arc-magmatic signatures from the protolith. Chondrite-normalized REE spider plots show elevated LREE and relatively flat MREE and HREE as indicated by $(La/Yb)_{cn}$ = 2 – 9 and negative Eu* anomalies (0.05 - 0.24). Modelling of nearby Uha group sedimentary rocks partial melts supports fractional crystallization and upper crustal contamination for generation of the KAB granites. Trace elemental ratios of Y/Nb, Nb/Ta, Zr/Hf and P_20_5 suggest the granites are weakly mineralized to barren in Sn-W.

The U-Pb zircon ages point to two successive and overlapping periods: from 1418 ± 15 Ma to 1395 ± 6 Ma (mean = 1406 Ma) and from 1385 ± 8 Ma to 1376 ± 11 Ma (mean = 1381 Ma). Inheritance U-Pb dates of xenocryst zircons comprise early to late Paleoproterozoic ages ranging from 2376 ± 30 Ma, 2000 ± 27 Ma to 1901 ± 39 Ma, and from 1795 ± 7 Ma to 1738 ±7 Ma, implying the participation of the Paleoproterozoic sedimentary rocks in the petrogenesis of the granites. A zircon rim overgrowth age of 1015 ± 26 Ma is interpreted to date a metamorphic/anatexis event that coincided with the c.1000 Ma amalgamation of the supercontinent Rodinia and the emplacement of Sn - W enriched granites. The ages of S-type granite magmatism (1418 - 1376 Ma) obtained from this study are restricted to the Mesoproterozoic within the widespread bimodal magmatism event c.1375 Ma.

PETROLOGICAL, GEOCHEMICAL AND MINERALOGICAL CHARACTERISTICS OF WIGU HILL CARBONATITE, ULUGURU MOUNTAINS, TANZANIA: INSIGHTS INTO CARBONATITE EVOLUTION AND REE MINERALIZATION

Mary Charles Moshi [a b, *], Yasushi Watanabe [a], Nelson Boniface [b], Tatsuki Tsujimori [c d], Carmela Tupaz [a], Daisuke Araoka [e], Aoki Shogo [a], Elisante E. Mshiu [b]

a Mineral Resources and Tectonics Group, Graduate School of International Resource Sciences, Akita University, Akita 010-8502, Japan.

b School of Mines and Geosciences, University of Dar es Salaam, P.O. Box 35052 Dar es Salaam, Tanzania.

c Department of Earth Science, Tohoku University, Aoba, Sendai 980-8578, Japan

d Center for Northeast Asian Studies, Tohoku University, Aoba, Sendai 980-8576, Japan

e Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Ibaraki 305-8567, Japan

* marylinc64@gmail.com

Wigu Hill Carbonatite (WHC), located south of Uluguru Mountain, is amongst the REE-endowed carbonatites in Tanzania. First discovered in 1956, the deposit has recently become an economic focus due to the rising demand for REE in the global market. This work presents the first detailed petro-geochemical and mineralogical characteristics of the Wigu Hill. In the field, WHC stands as a complex of mineralogically and texturally distinct suites of low-radiation magnesiocarbonatite, enveloped by a sodic fenite. Its evolution tracks a polygenetic path that began with the emplacement of large fine-grained apatite magnesiocarbonatite, and successively breccia carbonatite and locally micaceous magnesiocarbonatite. They are distinct for their simple mineralogy, high P_2O_5, elevated Nb, and low LREE (<0.5 wt%).

These earlier carbonatites are crosscut by REE-rich magnesiocarbonatite and ferrocarbonatite dikes that host fine to pegmatitic, well-preserved hexagonal pseudomorphs after burbankite.

Shortly after emplacement, alteration of primary burbankite was attained through evolving carbothermal fluids (CO_2-rich fluids), resulting in pseudomorph color disparity, mineralogical differences, and variation of REE enrichment within REE-bearing dikes. Two major carbothermal phases may have occurred, with the earliest evidenced in dikes with yellow pseudomorphs where primary burbankite was replaced by an assemblage of synchysite(Ce)-barite-Ca-strontianite-calcite-quartz-fluorite. These dikes are geochemically featured by low P_2O_5 and high LREE concentrations of up to ~8wt%. and high $(La/Ce)_N$ - $(La/Nd)_N$ in synchysite. Continuous interaction of the dikes with residual fluids sustained locally, leading to the replacement of synchysite(Ce) to bastnasite(Ce) and astronomical LREE concentration of up to ~12 wt%.

The second carbothermal phase is pronounced in the northern part of Wigu. In there, evolved PO42-bearing late-stage fluids interacted with burbankite creating greenish- and rose-pink pseudomorphs typified by assemblage of synchysite(Ce)-barite-Ca-strontianite-quartz-monazite-apatite-florencite-goyazite. Characteristically, these dikes are high in P_2O^5, elevated MREE, and low synchysite $(La/Ce)_N$ - $(La/Nd)_N$ ratios. Textural and geochemical data indicate main REE mineralization phase in WHC occurred during the end of the magmatic phase, but pervasive reworking by carbothermal fluids created such outstanding enrichment.

THE NATURE AND CHARACTERISTICS OF SELECT HANDENI GOLD OCCURRENCES: CONSTRAINING AU-OCCURRENCES IN THE NEOPROTEROZOIC MOZAMBIQUE BELT

Benjamin C. Safi and Gerald L. Chuwa

The Handeni geological province in eastern Tanzania is located in the Mozambique Belt and borders the Tanzania Craton to the west. The Mozambique Belt is a predominant N-S-aligned Neoproterozoic belt comprised of high-grade metamorphic rocks. In recent years, several gold occurrences and deposits have been discovered in Handeni, including the ~ 1.5 Moz Magambazi deposit, ~0.75 Moz Kwandege-Negero occurrences, and the ~0.5 Moz Manga occurrences. These active gold occurrences and deposits are hosted in granulite to amphibolite facies metamorphic rocks inferred to have formed from precursors ranging from mafic-ultramafic to felsic volcanics and sedimentary rocks. In most workings in Handeni, gold mineralization is confined to garnet-amphibolite horizons within quartzofeldspathic biotite gneisses and in quartz veins emplaced along shear zones between lithological contacts.

Gold deposits in high-grade metamorphic terrains have sparked controversy regarding their origin and characteristics, with three leading prevailing schools. The first proposed the formation of these deposits during prograde metamorphism synchronous with peak metamorphic conditions, whereas the second attributes retrograde metamorphism to gold mineralization. The third school suggests deposits were formed during pre-peak metamorphism in greenschist-lower amphibolite conditions and were subsequently overprinted by high-grade metamorphic events**.** There are limited detailed exploration and genetic studies of these gold occurrences in Handeni. The timing of gold mineralization with respect to peak high-grade metamorphism and

retrogression within shear zones is still equivocal and debated among geologists.

The nature and environment of mineralization and the lack of macroscopic hydrothermal alteration features require further investigation to develop genetic and exploration models to assist in earth resources evaluation strategies. We present features of gold mineralization in the Kwandege, Manga, and Magambazi occurrences, highlighting the pre-peak metamorphic origin of gold mineralization and some possible mineralization associated with retrogressive regimes post-peak metamorphism. More focused studies are required to develop robust exploration models for these pre-peak gold mineralization types along the entire East African Orogeny and the Mozambique belt in particular, cognize of their elusive and complex nature compared to traditional Greenschist-Amphibolite facies hosted gold deposits.

RECONSTRUCTION OF CONTINENTAL RIFTING AND KINEMATICS FOR THE EVOLUTION OF SEDIMENTARY BASINS IN THE AFAR REGION

Duke N. Nyangena [1, *], Athanas S. Macheyeki [1], Seetharamaiah Jagarlamudi [1]

[1] Department of Geology, College of Earth Sciences and Engineering, the University of Dodoma, P. O. Box 259, Dodoma, Tanzania,

[*] nyangenaduke74@gmail.com

The Afar region, situated in the northeastern part of Ethiopia, is a significant area within the East African Rift System (EARS). It marks the incipient boundary of the Nubia, Arabia, and Somalia plates and is associated with continental breakup and rift formation. The Main Ethiopian Rift, a crucial component of the EARS, connects to the Afar triple junction and has been subject to extensional deformation since the late Oligocene-early Miocene periods. This tectonic activity has shaped the evolution of sedimentary basins in the region, offering valuable insights into crustal dynamics and potential hydrocarbon reservoirs, making it an essential area for geological exploration. Continental rifting can either be episodic or continuous and establishment of the timing and dynamics of rifting is a challenging task, particularly for the East African Rift System. Despite numerous studies on rift evolution, a consensus on the exact age of rifting initiation remains elusive, leading to conflicting age estimates in the literature. Some researchers propose a broad range of initiation ages from 30 Ma to 15 Ma, while others suggest a timeframe of 25 Ma to 10 Ma. Additionally, older ages, like around 35 Ma for the Gulf of Aden, further add complexity to understanding the region's geological history. This study presents a review focused on establishing the timing of initial continental rifting and trajectory patterns of the Arabian and Somalian plates over the past 65 Ma. Gplates

algorithms were employed to process finite rotations and geological data for the boundaries of the Somalian and Arabian plates, with Euler rotations of both plates while maintaining the Nubian plate as a fixed reference frame. Results revealed that rifting between the Arabian and Somalian plates initiated 19 Ma. Subsequently, both plates drifted apart in different velocities and directions. The Arabian plate initially underwent counterclockwise rotation towards the northeast direction by approximately 40˚ from 19 Ma to around 13 Ma. Between 12 Ma and 10 Ma, the plate rotated further to the north-northeast with a rotation of 2˚ and decelerated in velocity. From 9 Ma to 5 Ma, the Arabian plate underwent a north-northwestward drift, accelerating at a rate of 3.7875 * 10-7 mm/yr^2, which persisted until the Present. In contrast, the Somalian plate started moving south-southeast from 19 Ma to 14 Ma, and from 13 Ma to 7 Ma, it changed direction towards the southeast with an approximately 17˚ rotation. At around 6 Ma, the plate began rotating counterclockwise towards the east. The first major rifting event for the Somalian plate occurred between approximately 19 Ma and 15 Ma, followed by deceleration from 13 Ma to 11 Ma. The second major rifting event occurred between 10 Ma and 2 Ma. Currently, the estimated velocity magnitude of the Somalian plate is approximately 6.142 mm/yr, and for the Arabian plate, it is 12.131 cm/yr. The Arabian plate exhibited a maximum velocity magnitude approximately three times faster than the Somalian plate. Over the past 19 Ma, the Somalian plate travelled slightly over 100 kilometers, while the Arabian plate covered around 200 kilometers, indicating differential plate motions during the rifting process. Furthermore, both plates experienced two periods of maximum velocities; at approximately 13 Ma and 6 Ma for the Arabian plate, and at approximately 15 Ma and 3 Ma for the Somalian plate, providing evidence of major rifting

events. The complex tectonics in the Afar region have played a crucial role in the formation and evolution of sedimentary basins. Studying the relationships between tectonics and basins allowed us to be able to refine the timing and understand the geological evolution of the region. The tectonic forces, including the convergence and divergence of plates, have influenced the subsidence and uplift of the region, leading to the development of grabens and horsts within the sedimentary basins. These geological processes have provided valuable insights into the tectonics of the Afar region and have contributed to a better understanding of its geological history, providing a framework for exploring potential hydrocarbon resources and other geological phenomena in the area.

TIMING OF THE CENOZOIC MAGMATIC INTRUSIONS IN THE OFFSHORE TANGA BASIN, TANZANIA: CORRELATION TO AGE EQUIVALENT DEPOSITS IN THE EYASI-WEMBERE BASIN AND THEIR IMPLICATIONS FOR PETROLEUM POTENTIAL

B. N. Mvile1, E. B. Kiswaka2, O.O. Osinowo3, E. E. Mshiu2, Venance. E. Mboya4, *

1Department of Physics, College of Natural and Mathematical Sciences, University of Dodoma, Postal Office Box 259, Dodoma, Tanzania

2School of Mines and Geosciences, University of Dar es Salaam, Postal Office Box 35052, Dar es Salaam, Tanzania

3Department of Geology, University of Ibadan, Ibadan 200284, Nigeria

4Tanzania Petroleum Development Corporation (TPDC), P. O. Box 2774, Dar es Salaam

*Corresponding author: vemanuel@tpdc.co.tz

The offshore Tanga Basin of North-Eastern Tanzania contains Cenozoic sedimentary successions that have been poorly studied. The basin development was due to an interplay of multiple factors including periods of active fault movement linked to the East African Rift system (EARs) which influenced the Cenozoic development of the offshore Tanga Basin.

The EARs recorded several discrete tectonic episodes that were associated with magmatic activities and massive volcanism. However, there is no report on the possible presence of magmatic intrusions indicative of magmatic activities and volcanism in the history of the Tanga Basin. Timing of occurrence and distribution of magmatic intrusions are among the key components needed to

evaluate the petroleum potential of the basin. A detailed 2D qualitative seismic interpretation, coupled with core logging data and analysis of elemental proxies, has been employed to evaluate the petroleum potential of the Cenozoic successions of the offshore Tanga Basin considering the presence and timing of occurrence of the magmatic intrusions.

These used data and the associated interpretation techniques have not been used before to meet similar objectives. Both core logging and elemental proxies are newly collected information used in this study. Results suggest that the Tanga Basin has been variedly intruded by magmatic sills and dikes. Seismic well tie and correlation to age-equivalent deposits across the onshore successions in the Eyasi-Wembere Basin (EWB) revealed that the volcanic events occurred during tectonic episodes that influenced the development of the East African Rift basins. Seismic interpretation also suggests that these tectonic episodes occurred possibly during the Miocene, Pleistocene and Holocene periods when magmatic intrusions are believed to have promoted source rock maturation and facilitated the formation of structural elements for petroleum preservation.

TOPOGRAPHIC MATURATION OF TANZANIA BASEMENT TERRAINS – REVIEW OF THERMOCHRONOLOGICAL DATA

Charles H. Kasanzu
Department of Geosciences, University of Dar es Salaam, P.O. Box 35052, Dar es Salaam, Tanzania.
kcharls16@yahoo.com

Compilation of low-temperature thermochronological data from Tanzanian various terrains indicate apatite fission track and alpha-corrected apatite (U–Th)/He ages ranging from 317 ± 33 to 103 ± 21 Ma and from 433 ± 24 to 154 ± 20 Ma, respectively. Thermal models derived from the data in tandem as well as modelling of basement denudation and the sedimentary record, indicate that first order topography of Tanzania developed due to exhumation mainly during Mesozoic times (Carboniferous – Cretaceous to Neogene). The topographic gain was succeeded by erosion and depositional loading associated with the sedimentation in the Karoo basins south of the country. A review of the data suggests that the eastern and western Rift arms had a similar denudation history and were probably at a similar topographic level before the late Cretaceous break-up in the realm of Gondwana evolution. This event led to the development of the present topography. Additionally, volcanism in the region had a minor and localized influence on the landscape of some parts of the region.

REMOVAL OF ARSENIC IN A SAND FILTER COUPLED WITH ZERO-VALENT IRON

Daniel Edward[1, *], Petro Karungamye[1, 2], Grite Nelso[1], Juma Selemani[1], Karoli N. Njau[1]

[1]School of Materials, Energy, Water, and Environmental Sciences, Nelson Mandela African Institution of Science and Technology, P.O Box 447, Arusha, Tanzania,

[2]Department of Chemistry, The University of Dodoma (UDOM), P.O Box 338, Dodoma, Tanzania

[*]edwardd@nm-aist.ac.tz

Arsenic (As) in wastewater has negative effects on the environment and human health, hence As containing wastes must be handled properly. Given the accessibility of metallic iron, studies investigating into the potential application of zerovalent iron in the removal of arsenic are promising. In this study, the performance of sand filters blended with several kinds of zero-valent iron (Fe^0), such as iron wool, iron fillings, and iron nails, were compared. These materials were combined in a sand filter column, and the efficiency was calculated using the As concentrations in the influent and effluent samples. Experiments were carried out to compare performance as a function of Fe^0 dose and contact time. The outcome of this investigation showed that sand filters containing iron wool had a better removal efficiency of arsenic removal than iron filings and iron nails. The results in all columns showed that as dosage was increased, the removal efficiency of arsenic increased significantly. In the case of contact time, the results revealed that arsenic can effectively be removed from water in the first 48 hours. The early adsorption response is quick in all columns but gets slower as time goes on. The highest removal efficiency was 99.6% and the lowest removal efficiency was 82.7%.

GEOTECHNICAL AND GEOCHEMICAL CHARACTERIZATION OF BUILDING MINERALS AND ROCKS IN THE COASTAL BASIN AND MOZAMBIQUE BELT, EASTERN TANZANIA; IMPLICATION ON THE SUPPLY CHAIN OF QUALITY BUILDING MATERIALS FOR CONSTRUCTION

Ibrahim Mfungo[1, 2, *], Mary Mahenge[1,2], Frank Macha[1,2], Sixbert Switbert[1,2], William Kidala[1,2], Muyo Machaule[1,2], Upendo Kilumbi[1,2], Nachindala Mohamed[1,2], Shabani Juma[1,2], Ramadhani Mashina[1,2], Clara Makoi[1,2], Fasida Kwisola[1,2], Yohana Lusega[3], Rachel Maganga[3], Hassan Jumanne[4] and Dr. Elisante Mshiu[1]

[1]Department of Geosciences, School of Mines and Geosciences (SoMG), University of Dar es Salaam, P.O. Box 35052, Dar es Salaam, Tanzania

[2]TGF Company Limited, Tabata Kimanga, Dar es Salaam Tanzania

[3]Department of Transportation and Geotechnical Engineering, College of Engineering and Technology (CoET) University of Dar es salaam, P. O. Box 35052, Dar es salaam

[4]Department of Structural and Construction Engineering, College of Engineering and Technology (CoET), University of Dar es Salaam, P. O. Box 35052, Dar es Salaam, Tanzania.

* tgftanzania@yahoo.com

Building minerals and rocks, otherwise known as aggregates, are integral to construction and engineering works. A lack of understanding about the right quality of these materials in Tanzania has led to potentially hazardous construction practices. This study aimed to analyze crushed rocks and sand from parts of the Coastal Basin and Mozambique Belt to identify suitable aggregates for construction purposes and create awareness about the importance of using quality building materials. Using geotechnical and geochemical methods, the aggregates were analyzed against reference standards TBS-TZS 53:1980, similar to BS882:1952 and ASTM. Results revealed that Amphibolite gneisses produced strong aggregates due to their low porosity and strong crushing strength. However, variations in quality were observed between samples from different areas. Jurassic Limestones,

Neogene Limestones, and Marbles, on the other hand mostly produced low-quality aggregates, with few strong and durable ones. Most sand samples did not meet standards for specific construction activities. As such, it is necessary to regularly test aggregates to ensure their suitability for specific jobs and maintain their quality. The study also highlights environmental concerns related to aggregate exploitation activities, such as stripped overburden, and the creation of pits and ponds. Ultimately, the knowledge gained from this study will assist in selecting suitable aggregates for quality and durable infrastructures and promote the importance of using safe and sustainable building materials.

APPLICATION OF HIGH-RESOLUTION GEOELECTRICAL, GEOMAGNETIC, AND GROUND PENETRATING RADAR (GPR) METHODS IN GEOTECHNICAL INVESTIGATIONS

Denis S. Nkwabi
Directorate of Exploration and Drilling, State Mining Corporation (STAMICO), Dar es Salaam
denis.nkwabi@stamico.co.tz

The geophysical method is one of the most powerful geoscientific techniques for the investigation of subsurface geology applied since the 19th Century. The technique has been applied in mineral explorations, investigation of water resources, exploration of hydrocarbons, geotechnical studies, etc. This work was focused on geotechnical investigation of near-surface conditions using High-Resolution Geoelectrical, Geomagnetic, and Ground Penetrating Radar (GPR) methods. The aim was to use the mentioned geophysical approaches to understand the subsurface geology (*ground physical properties*) and to advise the University Management accordingly before the construction of students' facilities.

The SYSCAL, a geoelectric measuring instrument, was used for the simultaneous measurement of resistivity and changeability as the important input parameters in this analysis. The deep geophysical measurements were not necessary to achieve the focus of this study. However, the measurement resolution was very important. Therefore, an electrode separation of 1 meter was planned to acquire measurements through equally spaced survey lines and a cross-cutting profile survey line. The recorded data were downloaded and processed by using Prosys II software and the 2D inversion was performed with the RES2DINV. The magnetic measurements were

performed with the GSM-19 Overhauser magnetometer. In addition to that, subsurface investigation was also conducted using a ground penetrating radar (MALA) using a 500 MHz frequency electromagnetic wave antenna.

Based on magnetic methods, the magnetic bodies such as buried gas and water pipes were identified and differentiated from non-magnetic bodies. However, using the geoelectric method it was possible to investigate the depth of the causative body based on differences in chargeability and electric resistivities. In addition to that, a very fine GPR with a 500 MHz frequency electromagnetic wave antenna was a powerful tool to identify very near objects based on the reflection properties of the electromagnetic waves interpreted on the radiogram.

INTEGRATED GEOSPATIAL AND GEOPHYSICAL APPROACHES FOR MAPPING GROUNDWATER POTENTIAL IN THE SEMI-ARID BUKOMBE DISTRICT, TANZANIA

Juma N. Kubingwa [1, 2, *], Edikafubeni E. Makoba [2] and Kassim Ramadhani Mussa[2]

1Lake Tanganyika Basin Water Board, Kahama P.O. Box 471, Tanzania
2Department of Geography and Environmental Studies, Sokoine University of Agriculture, Morogoro P.O. Box 3038, Tanzania

* kubingwa@yahoo.com

The rapid growth of civil societies coupled with population influx due to the artisanal mining industry in the Bukombe district (BD) has triggered a high demand for water resources. The daily consumption of water resources in the district surpasses the supply from available surface water sources. Thus, the situation has raised the demand for groundwater resources as an alternative. Despite the importance of groundwater resources, no current studies have spatially assessed groundwater potential to locate optimal points for borehole development. This study intended to investigate and map the groundwater potential areas (GWPAs) in the semi-arid BD using remote sensing (RS), the geographic information system (GIS), and the analytic hierarchy process (AHP) to help local communities access clean and safe water. Rainfall, geology, slope, drainage density, land use/land cover, and lineament density were prepared to delineate the map of GWPAs. The map was categorized into poor (0.21%), moderate good (51.39%), good (45.70%) and very good (2.70%). Finally, the GWPA map was validated using Vertical Electrical Sounding (VES), 2-D sections, and a drilled borehole. The validation results confirmed that the applied approach provides significant results that can help in planning the sustainable utilization of groundwater resources.

TPDC LABORATORY SERVICES

Innocent Mvamba*, Adam Sajilo
Tanzania Petroleum Development Corporation, P.O. Box 2774, Dar-es-Salaam
* imvamba@tpdc.co.tz

Tanzania Petroleum Development Corporation (TPDC) Laboratory was established in 1988 through Norwegian Agency for Development Cooperation (NORAD) funds. It is operated in accordance with good oilfield industry practices. The Laboratory provides services to the Corporation and other clients while constantly adapting to new technologies for the delivery of quality services. Currently, the Laboratory is in the certification process for the International Standard Organization (ISO).

Since its establishment, the Laboratory has offered various analytical services to different International Oil Companies, neighboring Countries and Research Institutions in collaboration with various local and International Universities.

TPDC Laboratory offers a range of analytical services from an outcrop scale, single well, data analyses, and interpretations. Currently, the Laboratory comprises four sections namely Geochemistry, Micropaleontology, Palynology, and Petrology. The services provided include Total Organic Carbon (TOC) analysis and pyrolysis, relative age determination, paleoenvironmental settings, thermal maturity, and petrographic analysis.

TPDC invites all stakeholders in the industry, Research institutions, various entities, and individuals to use our Laboratory facilities and services.

TANZANIA PETROLEUM POTENTIAL: THE 5TH BIDDING ROUND AND MULTICLIENT ARRANGEMENT

Faustine Matiku*, Paul Matumbi
The Petroleum Upstream Regulatory Authority (PURA), P.O Box 11439
* faustine.matiku@pura.go.tz

The Government of the Republic of Tanzania, through the Ministry of Energy and the Petroleum Upstream Regulatory Authority (PURA), intends to invite Oil and gas Companies for the onshore and offshore competitive bidding round to explore oil and gas. This will be the fifth licensing round in Tanzania. In this Fifth Licensing Round, companies will be invited to apply for Production Sharing Agreements (PSAs) electronically or manually. For a company to apply for a certain block(s), data available for such a particular block becomes paramount.

PURA as an Upstream Regulatory Authority is mandated to store and provide data for licensing purposes. PURA will host all data for the licensing round that will be accessible in the Data Room at its offices in Dar es Salaam and some in multi-client companies to be acquired and announced soon. All general information about the Fifth Licensing Round and the availability of technical data shall be available on the PURA website (http://www.pura.go.tz).

PURA has grouped the blocks into five separate defined sedimentary basins including the Ruvu Basin; the Dar es Salaam Platform; the Rufiji Trough; the Mandawa Basin; the Ruvuma Basin; and the Offshore-deep water Basins. In total 95,323 (40,534 offshore and 54,788 onshore) sq. km of the acreage will be made available for licensing rounds throughout the territory of Tanzania. Areas that adjoin each other may be linked and combined into a single application.

Applicants interested in participating in the licensing round will only apply for the whole of the defined area and present a work program that evaluates the block(s). Further details on the blocks on offer in the fifth licensing round will be provided on the aforesaid PURA website. With assistance from an international multi-client geophysical company, PURA shall compile a comprehensive technical database, using all the released technical data. These data shall be available for licensing by companies applying in the Tanzania Fifth License Round.

This paper will provide more detail about the technical data available and will highlight petroleum potentials to blocks in support of applications.

GEOLOGY OF EYASI WEMBERE BASIN, POTENTIAL FOR PETROLEUM EXPLORATION IN TANZANIA

Venance E. L. Mboya
Tanzania Petroleum Development Corporation (TPDC), Dar es Salaam
vemanuel@tpdc.co.tz

Eyasi-Wembere (EW) Block is an inland Miocene basin in the northeastern part of Tanzania, along the eastern arm of the East African Rift System (EARS). The Block covers an area of about 19,197 square kilometers including the Eastern North sub-basins Natron, Manyara, and Engaruka sub-basins. The current study is concentrated on the Western South of the block with an area coverage of about 10,630 Sqkm which is composed of three sub-basins, namely, Eyasi, Wembere, and Manonga sub-basins. The aim is to highlight the geology of these sub-basins based on geophysical and geological studies to be able to understand their petroleum potential.

The geophysical (AGG) and geological studies undertaken in the basin have indicated some elements of petroleum potentiality. These elements have aided the construction of a basin model allowing establishment of the tectonic setting and stratigraphy of the sedimentary packages in the basin. Three sedimentary formations are noted; they include the Pliocene Clastic Formation, Pleistocene Volcaniclastic Formation, and the Holocene sediment flats formation.

SPATIAL DISTRIBUTION OF PETROLEUM SYSTEM ELEMENTS IN THE PANGANI RIFT BASIN OF NORTH-EASTERN TANZANIA BASED ON INTERPRETATION OF GRAVITY AND MAGNETIC DATASETS

Ernest Selestin*[1], Emily Barnabas Kiswaka[1], Obeid Saitabau Lemna[1], and Elisante Elisaimon Mshiu[1]

[1]School of Mines and Geosciences, University of Dar es Salaam, P.O. Box 35052, Dar es Salaam, Tanzania.

* ernestmziray24@gmail.com

There are limited studies on the occurrence and spatial distribution of petroleum system elements in the Pangani Rift Basin (PRB) of northeastern Tanzania. The elements include magmatic intrusions, sediment thickness, and faults and fold structures. This study aimed to assess the petroleum potential of the PRB based on the distributions of these elements. To meet the focus of this work, the interpretation of gravity and magnetic datasets was employed. Results show that the basin contains thin and thick sedimentary covers ranging from 0.25 to 2.5 km, respectively. Thick sedimentary successions are found in the northern and southern parts of the basin; the central part contains thin sedimentary cover. Overall, sedimentary fills are thickening westward, toward the NNW-SSE trending master fault. Other mapped faults have the N-S and NNE-SSW trends. Results of magnetic data interpretation also show that igneous intrusions are present in the PRB and they have produced several fold structures; that are dominantly increasing toward the northern part of the basin. The locations of these intrusions conform to locations of different faults suggesting tectonic influence in magmatism. The mapped and estimated features (faults, igneous intrusions,

and sediment thickness) indicate the possible presence of petroleum accumulations in the PRB.

SEDIMENTARY EVOLUTION AND SOURCE ROCK POTENTIAL OF LOWER JURASSIC SUCCESSIONS IN THE MANDAWA BASIN, SE TANZANIA

John Gama[1, 2*], Lorenz Schwark [1, 3]

1 Department of Organic and Isotope Geochemistry, Institute of Geosciences, University of Kiel, Germany

2School of Mines and Geosciences (SoMG), University of Dar es salaam, P.O. Box 35052, Dar es Salaam, Tanzania

3WA-OIGC, School of Earth and Planetary Sciences, Curtin University, Perth, Australia

* johngama71@yahoo.com

Lower Jurassic successions that form syn-rift sedimentary packages in the Mandawa Basin preserve a complete stratigraphy that records tectonic processes related to the break-up of Gondwana as well as evidence of an extension of the Neothethys Sea (Somali Ocean) into the East African Margin prior to the opening of the Indian Ocean and thus is considered to be important in Tanzania's geological history. Previous exploration activities have indicated the presence of a working petroleum system in the subsurface, with key elements such as source rocks, reservoirs, and seals present in both syn-rift and post-rift sedimentary packages. Syn-rift sedimentary packages have received little attention compared with post-rift sequences that are outcropping and have good biostratigraphic control. An understanding of the sedimentary facies evolution and depositional conditions of syn-rift sedimentary packages is important in assessing the petroleum potential of Lower Jurassic successions in the Mandawa Basin. In this study, an integrated geochemical approach, which includes bulk organic matter analysis (CNS, TOC), stable isotope analysis of organic matter ($\delta^{13}C_{org}$), and programmed pyrolysis analysis, was employed to determine the variation in

organic matter types and quality with respect to lithofacies evolution in the Mandawa Basin during Early Jurassic times. In addition to geochemical data, Spectral Gamma Ray logs (Th, U, K) and sediment lithotype data (carbonates, salts, and clastics) were integrated in the study to improve an interpretation and to reconstruct the basin-fill of the Lower Jurassic successions in the Mandawa Basin. Variations in depositional settings for the eastern, western and northern, southern central parts of the basin during the Early Jurassic have been revealed by this study. These variations may be attributed to changes in subsidence, eustatic rise in sea level, and local climate. Southern central parts of the basin, which were subsidized at a relatively higher rate, exhibited more reduced conditions as opposed to shallow, more oxic depositional settings prevailing in the eastern and western flanks. These conditions switched to less oxic depositional settings during Toarcian times when restricted marine conditions were established. In addition to these findings, the relationship between sediment input (carbonates, clastics, and organic matter) during the Early Jurassic was also illustrated, this providing insights into factors regulating the distribution of organic matter within the Mandawa Basin. The data obtained from the investigation of outcrops and well data in Lower Jurassic sediments show variability in TOC and source rock potential. TOC, kerogen yield (S2) and hydrogen index (HI) are generally low, and organic matter is composed mainly of type III (gas prone) to IV (inert) kerogens with lesser admixture of type II-III kerogen (oil-gas prone), which have been deeply buried (>2000m) and undergone a wider range of thermal diagenesis, from early to over mature stage. This suggests that source intervals found within the sediments of Lower Jurassic successions have poor to fair source rock potential, and

only few intervals have been locally enriched due to periodic marine ingression that persisted since the Pliensbachian period.

Furthermore, this study revealed that the source rock potential (S2, HI) varies spatially in the basin, the highest source potential has been observed in the southwestern and northwestern parts, suggesting that these areas were more favourable for the deposition and preservation of organic matter. Low source rock potential observed in the eastern and western flanks, would indicate degraded organic matter and significant terrestrial influx from the emerging lands in these parts. Changes in depositional conditions in an evolving rift basin, driven by changes in relative subsidence, eustatic sea level change and sediment influx are the proposed mechanisms for the organic matter distribution and source rock enrichment during Early Jurassic times in the Mandawa Basin. Organic matter was poorly preserved when high sediment flux exceeds the subsidence rate, generally in the eastern and western but also southern part. Whenever there was a high subsidence rate coupled with an eustatic rise in sea level and lower sediment supply, the productivity and preservation of organic matter in deep lakes to restricted marginal marine conditions were enhanced.

A COMPARATIVE ANALYSIS OF THE HELIUM AND THE HYDROCARBON SYSTEM OF THE RUKWA RIFT BASIN, SW TANZANIA

Ernest Mulaya[1], Emily Barnabas Kiswaka[1], Rachel Sabuni[1, 3], Meshack Kagya[1], Cassy Mtelela[2] and Evelyne Mbede[1, *]

1School of Mines and Geosciences; Department of Petroleum Science and Engineering; University of Dar es Salaam, P.O. Box 35131 Dar es Salam, Tanzania

2School of Mines and Geosciences; Department of Geosciences; University of Dar es Salaam, P.O. Box 35052 Dar es Salam, Tanzania

3Institute of Marine Science, University of Dar es Salaam, P.O. Box 668, Zanzibar

* embede@gmail.com

Although helium is often co-produced together with petroleum, it is clearly known that their sources are quite different where the earlier is derived from mineral decay (inorganic source) and the latter from decay of organic matter. A source of helium and its occurrence depends on rocks rich in Uranium (U) and Thorium (Th) minerals. Recent research and publications have shown that both helium and petroleum share a similar geophysical and geological exploration strategy that yields information about both plays and prospects. The case of the Rukwa Basin in the Tanzanian section of the East African Rift has proven thermal springs containing high-nitrogen gas seeps and helium up to 10%. The question of whether the basin's history supports the co-existence of such high concentration of helium with petroleum in one trap remains untested/unsuccessful. This helium concentration is far above the minimum economic threshold of 0.3% required for a conventional helium gas field. Currently, all helium in the world is co-produced with hydrocarbon from oil fields in countries such as Algeria and Qatar with concentration typically below 0.1%. This means that should a global demand for liquefied

natural gas (LNG) and petrochemical products decline then extraction and sale of helium from this source would not remain economical.

Despite the discoveries of hydrocarbons in similar, co-evolved Albertine Graben (Uganda) and Lokichar Basin (Turkana Rift) of northern Kenya, the hydrocarbon exploration in the Rukwa Rift remains unsuccessful. However, recent research activity in the RRB indicated presence of hydrocarbon play elements alongside unprecedented tips of numerous oil seeps at various locations. Here we report newly discovered oil seeps in the Rukwa Rift Basin, analyzed using Gas chromatography mass spectrometry (GC-MS). The play elements for both helium and petroleum systems are then compared to inform on their potential occurrences within the stratigraphic sequences of the Rukwa Basin.

The analysis reveals regular patterns, which indicate the occurrence of hydrocarbons i.e., hydrocarbon distribution is predominantly odd to even-numbered with a high abundance of alkane compounds. This is the first direct indication of a working petroleum system in the basin. The discovery of these oil seeps coupled with the findings from the earlier works, promotes further interest in future work and the acquisition of more datasets in the search for petroleum and helium resources in the rift.

PETROLEUM SYSTEMS AND HYDROCARBON POTENTIAL OF THE RUVUMA BASIN, TANZANIA

Rachel A. Sabuni *
School of Mines and Geosciences, P.O. Box 35052, University of Dar es Salaam, Tanzania
*kajolshahid@gmail.com

Ruvuma Basin is widely recognized across the world for large gas field discoveries, which indicate the presence of gas-prone sources. However, little is known about the basin's source rock's hydrocarbon generation potential including the distribution of significant petroleum systems. Inferences are often drawn from Permo-Triassic and Jurassic source rocks in Mandawa Basin, Tanzania, and Morondava Basin, Madagascar. As a result, knowledge of the basin's potential source rocks is not known. To constrain possible source beds including petroleum systems, this study thoroughly reviewed previous literature coupled with rock eval pyrolysis and vitrinite reflectance analysis on rock cuttings (n = 19) from the Ruvuma Basin's Permo-Triassic, Jurassic, and Cretaceous shales of Lukuledi-1 well.

The findings indicate variable petroleum systems with different generation potentialities in the Permo-Triassic, Jurassic, Cretaceous, and Cenozoic intervals. The Permo-Triassic plays sourced hydrocarbons from the matured Permo-Triassic shales of kerogen type II and I, with a Total Organic Carbon (TOC) average of 40 %wt, Hydrogen index (HI) average of 286.5 mg HC/g TOC, vitrinite reflectance (Ro%) average of 0.81 with Tmax average of 436 ◦C capable of oil generation. The Jurassic play systems are charged from matured Jurassic kerogen type III and mixed type II/III shales with TOC~ 4 %wt, HI~54.25 mg HC/g TOC, Ro% ~0.6 and Tmax ~444 ◦C capable of gas generation. Cretaceous and the Cenozoic play systems, sourced hydrocarbon

from deeper sources because their source rocks are thermally immature with kerogen type III, having TOC ~0.6 %wt, HI ~53.6 mg HC/g TOC, Ro% ~0.3 and Tmax <420 ◦C capable of gas generation.

These results indicate that the Cenozoic play system incorporates hydrocarbons from diverse sources/reservoirs, making it a potential exploration target for future discoveries. These findings necessitate more research to determine migratory patterns, which will result in new ground-breaking discoveries in the basin.

NORTHERN COASTAL TANZANIA, BASED ON GRAVITY, AEROMAGNETIC AND 2D SEISMIC DATA: IMPLICATION FOR PETROLEUM PROSPECTIVITY

Benatus Norbert Mvile[1, *], Emily Barnabas Kiswaka[2], Olawale Olakunle Osinowo[3], Mussa Mathew Nalogwa[4], Elisante Elisaimon Mshiu[2], and Obeid Saitabau Lemna[2]

[1]Department of Physics, College of Natural and Mathematical Sciences, University of Dodoma, P. O. Box 259, Dodoma, Tanzania

[2]School of Mines and Geosciences, University of Dar es Salaam, P. O. Box 35052, Dar es Salaam, Tanzania

[3]Department of Geology, University of Ibadan, Ibadan 200284, Nigeria

[4] Tanzania Petroleum Development Corporation, P. O. Box 2774, Dar es Salaam, Tanzania

* benimvile98@gmail.com

2D satellite Gravity modeling constrained by a 2D seismic profile allowed geophysical mapping of five Cretaceous-Holocene sedimentary units in the Tanga basin. The mapping of these units was based on density differences between intervals constrained by horizons from seismic interpretation. Chronologically, these units are the Lower Cretaceous and older, Upper Cretaceous-Paleocene, Eocene-Oligocene, Miocene-Pliocene, and the Quaternary intervals. Depth estimates based on Werner solutions derived from Bouguer gravity anomaly show that these units contain thick sedimentary successions with potential source and reservoir rocks for petroleum generation and accommodation, respectively. A combination of aeromagnetic and gravity data revealed the possible presence of magmatic intrusions in the study area. Structural mapping revealed the presence of at least four sub-basins in the study area. These sub-basins are bounded by major faults and dissected by several other minor faults which reach the sea bottom. The bounding faults for these sub-basins controlled the sedimentary

development of the Tanga Basin. The revealed sub-basins have several structural lows interpreted as potential areas where source rocks may be present.

ENVIRONMENTAL CARBON FOOTPRINTS CAPTURE MACHINES: TECHNOLOGIES TO CAPTURE AND UTILIZE DANGEROUS CARBON TO MAKE USEFUL ENERGY FUELS, ECONOMIC GEOLOGY AND ENHANCED OIL RECOVERY

Daniel C Reuben, Calvin Goodluck, Abduel Mfangavo, Gerald Ibabwe, Atukuzwe Kitaluka

Department of Geosciences, School of Mines and Geosciences, the University of Dar-es-Salaam, P.O. Box 35052, Dar es Salaam, Tanzania.

* reubendaniel2099@gmail.com

Carbon dioxide pollution has been a challenge and one of the major issues discussed in our current world. According to the Intergovernmental Panel on Climate Change (IPCC), more than 10 giga-tones of CO_2 need to be removed from our atmosphere annually to ensure the global temperature rises by only 2 ^{0}C by 2050. Among the sources of this CO_2 are industry emissions including power plants, geothermal plants, and local goods industries. These pollutions affect our ecosystem by affecting air and water sources. The carbon emissions lead to global warming and CO_2 dissolution forms acidic water bodies leading to the deaths of living organisms. The little public attention on this main greenhouse gas enhances the unwanted changes in ocean acidity following atmospheric increases in CO_2. The effects are already impacting commercial fish and shellfish populations. Existing literature points out that atmospheric levels of CO_2 have increased by about 40% since the Industrial Revolution. This follows the extensive burning of fossil fuels in power plants, transportation facilities, and Industries' emissions. The oceans absorb one-third of that CO_2, which results in acidification from the formation of carbonic acid. The aim of this project is

the designation of a small-scale engineering carbon capture machine that will direct air capture the CO_2 based on chemical analysis and reactions of hydrated lime $Ca(OH)_2$ within a closed unit. This unit will be humidified to maintain the efficiency of the reaction with the help of a bubbling mechanism and the fan blower to keep the unit at the required humidity level and air intake. The project is also aimed at foreseeing the designation of systems that will show the utilization of the large-scale captured CO_2 for economic uses. This will be done through converting the captured carbon to CO_2 mineralization technology, metallurgical and cement industries (raw material) exports for Enhanced Oil Recovery and energy fuel production. The methodology that is used in this prototype is the mass and mole measurements of the input and the output material in the unit. The mass of the filler paper is initially measured before the mass of the hydrated lime $Ca(OH)_2$ is added. The mass of the filler paper is denoted as M_1, while the mass of which is 10g will be added and denoted as M_2. When the process is started by allowing air to enter the unit, CO_2 will be captured and thus there will be an increase in mass that will be measured in a mass balance. The new mass will be denoted as M_3 and therefore the difference of mass will be known essentially to calculate the amount of CO_2 captured and that $CaCO_3$ formed by mole ratio relationships. The proposed equation for the unit reaction is $Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$. Another important methodology used in showcasing the importance of this project is on-site capture and storage of CO_2 by bypassing the CO_2 captured from the exit stream in power plants and Tanzania industries. Instead of letting the harmful gases pollute the air, we have designated a system to abstract the exit/flue compositions and CO_2 and mix them with either sea or freshwater underwater and store them underground for many years or used for carbon mineralization. With

this project, the CO_2 uses such as in metallurgical and cement industries, oil and gas application, and energy fuel production will be shown. The findings for the preliminary experiments done on the small-scale carbon capture machine was between 0.7 to 1.2 gram of CO_2 captured depending on the level of humidification within a unit per 25 minutes. This finding shows that if a large system is to be designed, then the amount of humidity should be between 25% and 75%. It has also been found that the direct on-site capture of CO_2 is not costly compared to direct air capture by the machine. The calculated cost of installing the fans and the whole device is too big compared to the on-site capture; even in the actual designing of the prototype system, the direct air capture was too expensive than the on-site carbon capture. We hope that this project will help to reduce the amount of carbon dioxide that is in the atmosphere and also through that target, also it will create opportunities for local people through carbon capture businesses. There are several cements, material processing, and metallurgical industries in Tanzania that need carbon dioxide as raw materials in making cement, plasterboard, and advanced materials, therefore it is easier for the government and its people to look at the problems caused by carbon dioxide and change these problems into the useful opportunities.

A SUSTAINABLE PATH TO A GREENER FUTURE

Loveness Damian Chilumba
University of Dar es Salaam, School of Mines and Geosciences, Department of Geoscience,
P. O. BOX 35052, Dar es Salaam
chilumbalovenessdamian@gmail.com

Green energy sources often referred to as renewable energy sources have minimal impact on the environment and are replenished naturally. These sources, such as solar and wind energies, play a critical role in reducing greenhouse gas emissions and mitigating climate change while achieving more sustainable energy sources. Transitioning from fossil fuels to renewable sources is a key step in the pursuit of a cleaner and greener energy future. Research and innovation are vital in developing new and more efficient green energy technologies. Current energy sources contaminate the environment and will cause additional costs related to community health and ecosystem damage. This calls for the need to replace fossil fuels with clean energy.

Lithium, cobalt, nickel, copper, rare earth minerals, and other metals are critical to building clean energy infrastructures (generators, batteries, electronics) but their current supply is in shortage. There is a shortage of newly discovered deposits of critical minerals which slows down the sustainable energy transition. The technology for building high-tech products ranging from electric trains and cars, wind turbines, solar panels, and battery storage industry is $450bn. The rare earth minerals increase the efficiency and performance of wind turbines for generating electricity. Unfortunately, their occurrence in nature is rare, and finding them is an extremely challenging geological problem.

It is crucial to supply the necessary materials to build renewable energy infrastructure and help the world transition to clean energy. The success rate of rare metals exploration through edge technologies must be increased substantially to be able to eliminate the environmental impact. Therefore, fast-tracking rare mineral exploration efficiently should be given a high preference to provide critical minerals for energy transition.

THE VALUE OF WATER TO THE NATIONAL ECONOMY: HOW WATER IS LINKED TO THE NATIONAL ECONOMY, APPROACHES TO COVER THE EXISTING GAP BETWEEN WATER RESOURCES AND THE NATIONAL ECONOMY TOGETHER WITH BENEFITS FROM THE OUTCOME

Mussa Kimweri
University of Dar es Salaam, School of Mines and Geosciences, Department of Geosciences, P. O. BOX 35052, Dar es Salaam
mussaathumani00564@gmail.com

Water is a unique resource, at once an element of life, a human right, and mainly an input for economic development. This study presents the impacts of water on the national economy as a result of poor or unsustainable utilization of water resources. Different approaches to cover the gap for a fortunate national economy and the benefits from the outcome are also presented herein. As a crucial resource through its multiple uses, water links with nearly every Sustainable Development Goal (SDG) especially the economic goals; clean energy (SDG 7), economic growth (SDG 8), and industry, innovation, and infrastructure (SDG 9). Access to clean and reliable water is essential for economic development. Poor water sanitation infrastructure and services can lead to illness, reduce worker productivity, and hamper local investments. Economic growth is a thirsty business and water is a vital factor of production, so diminishing water supply translates into slower growth. Some regions could see their growth rates decline by as much as 6 percent of GDP by 2050 as a result of water-related losses in agriculture, health, income, and prosperity. So far, no serious measures have been implemented to ensure maximum water security as a solution to water losses. During heavy rains, there is huge water loss whereby millions of

volumes of water are poured into oceans by rivers. There are no serious measures implemented to conserve the plenty of available water during excess rainfall to secure different economic activities during the drought period. Tanzania has been a victim of shortage and supply interruption of electric energy during drought periods, hence undermining economic activities and the provision of public services, since 45 percent of the country's electricity comes from hydro. During heavy rainfall, floods are responsible for extreme damage and destruction to property, public areas, and the environment which incurs enormous costs for the government leading to a decrease in productivity and losses in GDP. Systematic approaches can be implemented to cover or reduce the existing gap between water resources and the national economy. Infrastructural investment can be implemented to cover the gap to achieve a sustainable national economy. Hard infrastructure such as bank-side reservoirs can be constructed to store water during heavy rains from flooding rivers whereby will help to supply water to the hydro-power plants to ensure constant production of electricity even during drought periods waiting for the next rainy season, especially in Tanzania. soft infrastructure such as system technologies and techniques used to monitor and manage water resources, policy, and regulatory tools will help to optimize the use of water through better planning and incentives will help to improve welfare and increase economic growth. Economic instruments such as water permits and prices, if well implemented and enforced can improve stewardship of water resources. Maximizing productivity in agricultural, industrial, and energy sectors throughout, ensuring long-term water security, and promoting sustainable economic development will be a great achievement for the nation.

UNCONVENTIONAL HYDROCARBON RESOURCES IN TANZANIA

Ronald Machumu
School of Mines and Geosciences (SoMG), University of Dar es Salaam, P.O. Box 35052, Dar es Salaam, Tanzania
ronaldtumsime@gmail.com

Unconventional hydrocarbon resources refer to the oil and natural gas resources that cannot be exploited by traditional methods and technologies. This is due to the poor physical properties of the reservoir rocks inhibiting the natural flow of hydrocarbons. Production of these reservoirs requires special and highly sophisticated technologies. This study aimed to review the potential of unconventional hydrocarbon resources in Tanzania using published reports. The coal bed methane, shale gas, and shale oil are the only unconventional hydrocarbon resources that are possibly existing in Tanzania. The possible occurrence of economic unconventional hydrocarbon resources in Tanzania is reported in several places including Songwe-Kiwira coal fields, Ruvu Basin, and Namwele, Mbamba Bay, Njuga, and Mhukuru coal fields. Despite the existence of potential unconventional resources in Tanzania, there are limited reports regarding the use of sophisticated industrial-standard methods in the detailed assessment of these resources. Tanzania needs to attract petroleum companies to invest in unconventional resources. The current worldwide trend is to move from conventional to unconventional resources because of the decreasing trend in discovering new conventional resources as well as the decreasing hydrocarbon reserve.

GEOTHERMAL EXPLORATION METHODS DEVELOPMENT IN THE CONTEXT OF ARTIFICIAL INTELLIGENCE REVOLUTION: A CASE OF TANZANIA GEOTHERMAL PROSPECTS

Hobokela Mwakajumba
Department of Geosciences, P.O. Box 35052, University of Dar es salaam, Tanzania
hobokelamikael@gmail.com

Geothermal energy resources are significant and crucial as sustainable and renewable sources of energy in Tanzania. Tanzania is endowed with a relatively high geothermal potential of about 5000Mwe of electric power generation from the sources within the eastern and western branches of the East African rift system. Other regions with geothermal potential in Tanzania include sedimentary reservoirs with elevated temperature gradients. Artificial intelligence (AI) is a crucial tool that has in recent decades played a significant role in geo-scientific exploration projects, where easy detection and quantification of earth resources including geothermal energy has been evident. A review of Tanzanian geothermal prospects and their respective exploration approaches has been made. The magnitude of AI machine learning algorithm utilization in Tanzania for the detection, quantification, and characterization of geothermal systems has been found to be negligible. The approach is also limited in nature explicitly showing that less data has been used in the construction of the existing conceptual models for different geothermal systems within Tanzania. The gap of AI algorithm projects missing in the exploration equation is thought to have reduced the detection efficiency of rather important prospects and/or improperly quantified and characterized the known prospects. The AI method should be widely

employed in geothermal exploration, as well as during prospect characterization.

UNDERPINNING THE ALTERATION PROXIES FOR GOLD MINERALIZATION AT BUCKREEF GOLD DEPOSIT IN THE RWAMAGAZA GOLD CAMP, SUKUMALAND GREENSTONE BELT

Jessica Walter Kiritta*, Elisante Elisaimon Mshiu, Joas Kabete
Department of Geosciences, School of Mines and Geosciences, University of Dar Es Salaam
*kirittajessica@gmail.com

Historically, the Buckreef Gold deposit has been challenging to explore due to the unpredictable nature of orebody characteristics. The characteristics caused past production stoppages and companies to withdraw from the project. The current study aims to investigate if hydrothermal alteration zonations mapped during routine core logging provide enough insights into understanding the ore body geometry for mining purposes. This research is focused on the Buckreef Shear Zone (BSZ), a 20-30 m wide zone of strongly shear foliated tholeiitic basalts with intermittent zones of quartz veins and stringers, some associated with gold mineralization. Core logging and petrographic studies revealed a link between gold mineralization and specific alterations in zonations. The latter comprises proximal alteration zonation defined by carbonatization, sericitization, and silicification.

In most cases, it is difficult to distinguish between intermediate and distal zonations visually. These challenges have been tested by employing advanced spectral analytical techniques, which identified complimentary but critically important alteration minerals that needed help to detect visually. Alteration minerals identified include ankerite, siderite, dolomite (carbonate group), and Fe and Mg-rich chlorite, thus providing a more comprehensive understanding of the orebody-alteration model for the BSZ. These advances

can greatly facilitate targeting orogenic gold deposits in the new mineral district and delineating the mining blocks in the mining operation.

POTENTIAL DISCOVERY OF > 1 MOZ AU DEPOSITS FROM MKURUMU-MAGAMBA PROVINCE IN THE SOUTHERN EAST AFRICAN OROGEN OF TANZANIA: A PRODUCT OF FRONTIER EXPLORATION AND BASIC RESEARCH INITIATIVES

Kabete, Joas M.
Bubango Resources Tanzania Limited, Block 397 Mwai Kibaki Rod, Dar es Salaam,
*jkmuganyi@gmail.com

Until the first discovery of the Mkurumu gold prospect in 2003 and a ~1 Moz Au Magambazi gold prospect in 2008, the entire Proterozoic South-East African Orogen of Tanzania was perceived unfavorable for hosting significant gold deposits. These perceptions were based on traditional interpretations, which invoked high-grade metamorphic rocks as products of reworked continental crust with insignificant addition of juvenile crust. These discoveries motivated junior exploration companies to conduct extensive systematic exploration and fund basic research projects. These studies outlined three high-ranking gold camps, from west to east: 1) the Mkurumu Gold Camp of Mkurumu, Vuju and Seita gold prospects; 2) the NW-SE-trending Handeni-Wami Gold Camp of Negero, Kwandege, Magambazi gold prospects; and 3) the NW-SE-trending Kwamkono Camp of numerous under-explored gold-copper prospects, among others.

Gold in these Camps occurs free and in association with pyrite, pyrrhotite, arsenopyrite, and chalcopyrite, hosted by brittle-ductile structures in: 1) deformed interlaminations of quartz veins and sulphidic-silicate-garnet rock (Magambazi, Negero and Mkurumu); 2) silica-flooded garnet-silicate rocks

with intercalations of silica segregations and/or flooding (Magambazi, Negero and partly Mkurumu prospects); and 3) calc-amphibole (tremolitic-actinolitic amphiboles) altered mafic rocks (Mkurumu prospect). These gold-hosting lithostructures are part of anticlinoria and synclinoria lithostructural bodies, which resemble, at least geometrically to Archean anticlinoria/synclinoria bodies in the gold-rich Sukumaland Terrane (e.g., Sanza-Geita Domain).

From domain-scale perspectives, exploration results so far undertaken in the Mkurumu-Magamba Province including: a) East African Metals (Canaco)'s ~1 Moz Au Magambazi deposit; b) Dhahabu Resources (Benzu)'s Negero prospects with intercepts such as 23m @ 2.27g/t Au (DDH KWBDD010) and 16m @ 6.40g/t Au (DDH KWBDD017); and c) Handeni Gold (Douglas Lake)'s Magambazi East with intercept such as 5m @ 4.2 g/t Au (DDH MZD_01) and Kwandege prospect with 12m @ 4.40g/t Au (DDH KW2_01) and 5m@ 6.20g/t Au (DDH KW2_07) point to high discovery potential of >1 Moz Au deposits from the Mkurumu-Magamba Province. From a global perspective, the geologic-tectonic setting of Kilindi-Handeni Superterrane points to high discovery potential of world-class orogenic gold deposits similar to:

a) the >100t Au Tropicana deposit in the Mesoproterozoic Albany Frazer Orogeny, sited in close geographic proximity to the Eastern Goldfields in the Yilgarn Craton, Western Australia (Doyle et al., 2009);
b) the >150 t Au Plutonic deposit and Marymia lode-gold deposits in the >2.6 Ga. amphibolite-facies Plutonic-Marymia Greenstone Belt (Falcon et al., 2010)

c) the potentially metamorphosed >150 t Au Hemlo deposit in the Wawa Belt, situated along strike with the gold-endowed Abitibi Belt, Superior Craton, Canada (Tomkins et al., 2004);
d) the > 500 t Au, at 9.70 g/t Au from Ling Long Gold Camp in the Yanshanian Craton, China with gold mineralization post-dating the peak of high-grade metamorphism of the hosting terranes by over 2 billion years (Goldfarb et. al., 2004);
e) the >15 t Au Challenger deposit in the ~2.9 Ga. Christie Domain, Gawler Craton, South Australia, with gold originally hosted by the ~2800-2550 Ma greenschist-amphibolite facies rocks that are almost completely overprinted by the ~2450 Ma granulite-facies Sleafordian Orogeny (Tomkins et al., 2004).

Among those examples, the geometrical setting of the Plutonic-Marymia Greenstone Belt in the Paleoproterozoic Capricorn Orogen and Tropicana in the Neoproterozoic Albany Frazer Orogen pose similarities in terms of geometry to the Nyakahura-Burigi Terrane in the Mesoproterozoic Kibaran Belt and Mkurumu-Magamba Terrane in the Southern East African Orogen. Both terranes lie in close proximity to the gold-endowed, NW-SE-trending Lake Nyanza Superterrane in the Archaean Tanzania Craton.

On the basis of domain-scale solid bedrock geology, crustal growth history, and knowledge of how orogenic gold systems form, gold in the Mkurumu-Magamba Province is hosted by metamorphosed/reworked proto-Archean lithostructures, which were tectonically uplifted from hypozonal to mesozonal crustal levels, prior to deformation and metamorphism in brittle-ductile environments and subsequent gold mineralization during Neoproterozoic orogenic and Pan-African tectonothermal events.

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