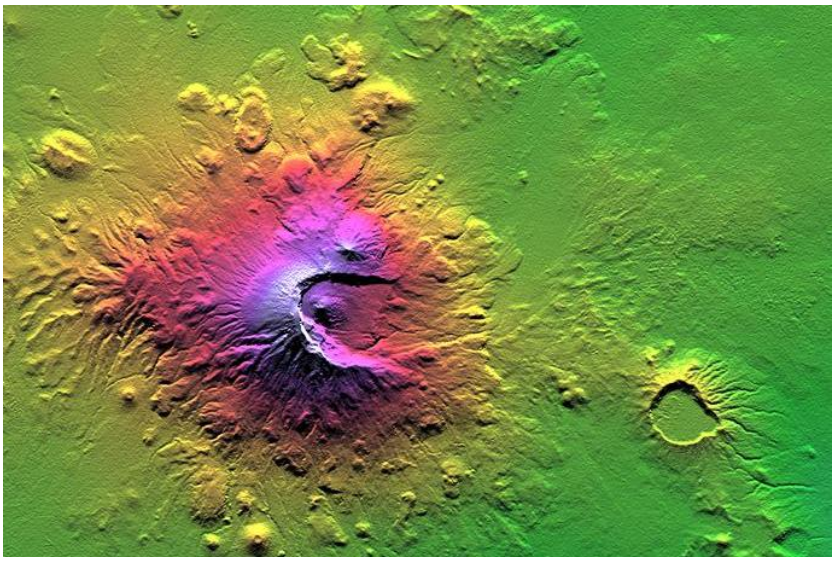
TANZANIA GEOLOGICAL SOCIETY (TGS)

2022 ANNUAL CONFERENCE

BOOK OF ABSTRACTS






ARUSHA

01st to 07th of October 2022

Front cover photos:

Top Left: *The Arusha Declaration Monument is a landmark monument and tourist attraction located in Kati ward in Arusha, Tanzania;* ***Top Right:*** *The Clock Tower in Arusha - it is thought to be located exactly between Cairo and Cape Town, and is in considered the center point of the three countries of Uganda, Kenya and Tanzania;* ***Bottom left:*** *The topography of Mount Meru in Arusha; and* ***Bottom right:*** *A Maasai woman wearing her finest clothes (https://en.wikipedia.org/wiki/Maasai_people).*

Message to Participants of the TGS 2022 Conference

Dear Conference participants,

On behalf of the TGS Executive Committee, it is our heartfelt pleasure to invite you (again) to this year's TGS Conference. The TGS Conference Organising Committee is particularly happy to be your host in the north-eastern Tanzania, Arusha Region, 'Geneva of Africa', an international diplomatic hub, the land of beauty and tourism. Tourism in this region is huge and the largest dollar-earning economic sector in Tanzania. This year's conference brings together a multidisciplinary group of geoscientists and engineers to this city, working in different sectors to interact and share different insights into the latest research, major milestones, experiences and new ideas related to mining, water, energy, geotourism and research & development.

The TGS Conference Organising Committee looks forward to an exciting and informative TGS 2022 Annual Conference, which is having a leading theme of '*Strategies in Creating Conducive Investment Environment in Extractive Industry*'; an appropriate theme for thought in this year's conference as our country and other countries in our region struggles to achieve a sustainable use of the environment and available resources for advancing our economies. The Committee is also excited and looks forward to high quality and informative oral and poster presentations, and exhibitions of products and activities by geoscientist stakeholders. The conference will offer platforms for discussions on different important geoscientific issues along selected sub themes, i.e. Mining Act, Regulations and fiscal regime; mining for development; energy mix for sustainable development; water for livelihood; geotourism in Tanzania - A sleeping giant; and collaborative research for stimulating development in the mineral industry.

In recent years Tanzania has witnessed signing of a number of important contracts on the mineral sector. This development is thought to be an important step after significant mineral sector reformation and improvement into the investment environment of the country. It is generally conceived that mineral sector reformation and improvements in Mining Act, Policy and

Regulations have become much better than in the past years. Nevertheless, does this hold water as it is now?

Another important question worth to be thought out is how Tanzania is set to benefit from the global clean energy transition that is poised to be significantly mineral intensive with Tanzania holding a substantial amount of critical minerals. On the same agenda, The East African Rift System, our hidden energy gem for sub-Saharan electricity production, estimated in Tanzania to have potential to generate more than 5000 megawatts of electricity, and with only 0.6% of Africa's known geothermal potential exploited. The energy has been dubbed potential to support Africa's move away from overreliance on fragile hydropower and toward becoming drought resilient in its energy sector.

Another geoscientific issue featuring out during this conference is water for livelihood. Mindful of the fact that sub-Saharan Africa is subject to more extreme climate variability than other regions, there is a need for improved water storage capacity. However, the debate between two major schools of thought persists; some experts say large dam projects (e.g. Rufiji Dam) would create more sustainable reserves of water resources to combat the burden of climate fluctuations, but others disagree, stating the harmful environmental impact of large dams, and yet water shortage and droughts keep growing as population increases. What is the best way forward on water for livelihood?

While Tanzania has seen a good progress and development of tourism, geotourism remains a sleeping giant. During this conference we would like to spark discussions, convictions and ideas to see this niche developing in the coming years. Mindful of global aesthetics degradation tied to human activity, geotourism can be a tool to foster environmental and cultural understanding, appreciation, and conservation, thus sustainable tourism development. Community members will take responsibility for geotourist destinations when they understand the benefits of geotourism.

The Tanzania Geological Society is grateful to all TGS members and all those who volunteered in one way or another to make this conference a success. Special thanks to our sponsors and partners for their generosity and

enthusiastic support: Geita Gold Mine, State Mining Corporation, Barrick Gold Corpporation, Franone Mining, NMB Bank, Petroleum Upstream Regulatory Authority (PURA), Geological Survey of Tanzania, University of Dar es Salaam, Mwamba Mining, Mining Commission, Ministry of Water, Ministry of Energy, Ministry of Minerals, Geofields, 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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Mr. Mofor Njakoi

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Geita Gold Mine | Anglogold Ashanti

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

Geita Gold Mine, one of the AngloGold Ashanti's flagship mines, is located in north-western Tanzania, in the Lake Victoria goldfields of Mwanza region, about 120 km from Mwanza and 4 km west of the town of Geita. It has been in operation as a large-scale mine since the 1930s. The Geita gold deposit is mined as a multiple open-pit and underground operation since 2016 and will continue to operate as such until the entire economic open-pit Mineral Resource is exhausted. The mine is currently serviced by a carbon-in-leach processing plant with an annual capacity of 5.1Mt.

As at 31 December 2018, the Mineral Resource was estimated at 6.26 million ounces. Approximately 4,130 m of development was completed for the Star & Comet and Nyankanga underground sections, to access new areas for stope mining and for further exploration, in 2018. Open-pit mining at Nyankanga and Geita Hill continued with Geita Hill reaching the end of its economic life and Nyankanga completed in the first half of 2019. Surface exploration continued at Selous, a satellite pit 2.4 km from Star & Comet, expected to supplement the underground operation. [Source: *http://www.geitamine.com/en.html#about*].

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STAMICO

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State Mining Corporation (STAMICO), a wholly owned Government enterprise, is a 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 to Tanzanians.

What STAMICO do – (1) Facilitating transformation of 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.

Our Gold Sponsor

Barrick Gold Corporation

https://www.barrick.com/

Barrick Gold Corporation is a mining company that produces gold and copper with 16 operating sites in 13 countries. It is headquartered in Toronto, Ontario, Canada.

Barrick Gold Corporation has currently two mining operations ongoing in Tanzania, in Bulyanhulu and North Mara. In 2019, it produced 5.5 million ounces of gold at all-in sustaining costs of $894/ounce and 432 million pounds of copper at all-in sustaining costs of $2.52/pound. As of 31 December 2019, the company had 71 million ounces of proven and probable gold reserves. [https://en.wikipedia.org/wiki/Barrick_Gold]

Our Gold Sponsor

Franone Mining

Franone mining is among the fastest-growing companies in Tanzania emerging to be the leading coloured stones producer in the region. It is a successful Tanzanian-focused gemstone miner with more than 13 years of experience as a miner of Tanzanite and spinel.

Our Silver Sponsor

Petroleum Upstream Regulatory Authority

https://www.pura.go.tz/

dg@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 the Mainland Tanzania and providing advisory services to the Government and the Minister responsible for petroleum affairs. The mandate is underpinned in 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, 2015 also requires PURA to observe transparency and accountability in its undertakings. PURA mandates is further derived from the National Energy Policy, 2015 which gives guidance on establishment of upstream regulator to effectively and efficiently manage petroleum upstream operations..

Our Silver Sponsor

The Geological Survey of Tanzania (GST)

https://www.gst.go.tz/

madini.do@gst.go.tz

Geological Survey of Tanzania (GST) was established as a Government Executive Agency in October 2005 under The Executive Agency Act No. 30, [CAP 245] of 1997, establishment order, 2005, Government notice no: 418 published on 9/12/2005. In July 2017, the Government of Tanzania amended the Mining Act of 2010 through the Written Laws (Miscellaneous Amendments) Act, No. 7 of 2017. Through the amendment, new functions were initiated on top of the other functions of GST described by the Mining Act 2010.

GST is administered by the Chief Executive Officer (CEO) who is assisted by four Directors of the Geological Services Directorate, National Geo-scientific and Minerals Database Directorate, Laboratory Services and Export Permit Directorate and Business Support Services Directorate. The Directors are assisted by ten Section Managers. In line with the existing Government Procedures there are four Units operating directly under the CEO and these are Internal Audit, Information, procurement, management and legal services. There is also a Board which monitors performance of GST and provides directives and advices accordingly. At present, GST has 145 staff where 66% are professional and technical staff with different geoscientific specialization in earth sciences. This gives GST a strong human resource base to execute its duties.

Recognition of the Outstanding Tanzanian Geoscientist

Dr. Isaac M. Marobhe

A token of appreciation is extended to our senior active TGS member, Dr. Isaac M. Marobhe for his dedication to serve the Tanzania Geological Society and overall geoscientific community. Dr. Marobhe still pays his TGS membership fees, participates actively by giving oral presentations in TGS conferences, whenever he gets a chance, and volunteers at TGS activities. The Tanzania Geological Society Executive Committee would like to congratulate and Thank Dr. Marobhe for his commitment to the TGS.

Recognition of the Outstanding Tanzanian Geoscientist

Dr. Meshack Kagya

A token of appreciation is extended to our senior active TGS member, Dr. Meshack Kagya for his dedication to serve the Tanzania Geological Society and overall geoscientific community. Dr. Kagya still pays his TGS membership fees, participates actively by giving oral presentations in TGS conferences, whenever he gets a chance, and volunteers at TGS activities. The Tanzania Geological Society Executive Committee would like to congratulate and thank Dr. Kagya for his commitment to the TGS.

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Mr. Amon Mwashela
Department of Geosciences,
University of Dar es Salaam..

TGS 2022 Conference Abstract Titles

Contents and Abstract Titles **page**

Conference Programme

DAY 1 - 3 (30-09-2022 to 03-10-2022)

EXCURSION

Friday 31.09.2022	
Time	**Place/ Activity**
06:00 - 00:00	Arriving in Arusha (Excursion participants)
Saturday 01.10.2022	
Time	**Place/ Activity**
05:30 - 06:00	Meeting at PUMA filling station near Triple A
06:00	Departing from Arusha Town
06:20 - 13:30	Driving to Serengeti
13:30 - 20:00	Activities at Campsite and it's vicinity at Serengeti National park
20:00 -	Spending night at the Camping site in Serengeti National Park
Sunday 02.10.2022	
Time	**Place/ Activity**
05:30 - 06:00	Gathering for Game drive
06:00 - 08:30	Game drive
08:30 - 09:30	Breakfast at Camping site
09:30 - 13:00	Game drive
13:00 - 14:00	Lunch at Camping site
14:00 - 19:00	Game drive
19:00 -	Spending night at the Camping site in Serengeti
Monday 03.10.2022	
Time	**Place/ Activity**
05:30 - 06:00	Gathering at the camp
06:00 - 09:00	Driving to Olduvai Gorge
09:00 - 14:00	Excursion at Olduvai Gorge, sightseeing at shifting sand, elephant caves and Meserani
14:00 -	Driving back to Arusha town

DAY 4 (04-10-2022) ***OPENING CEREMONY & CONFERENCE***

Time	**Activity**	
07:30 - 09:00	Arrival, Registration	
08:00 - 09:30	Refreshments, Exhibition & Poster Session	
09:30 - 10:00	Tour with Guest of Honour	
10:00 - 10:15	TGS General Secretary: Welcoming remarks	
10:15 - 11:00	TGS President: Speech, and to 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 - 13:50	Gerald Chuwa	The Role of Mineral Exploration for a Successful and Sustainable Mining Industry: Swot Analysis and Forward Proposals for the SADCC Region
13:50 - 14:10	Joas Kabete	Due diligence for mineral asset acquisition and/or financing: criteria moment for Tanzania Geosciences Registration Board (TGRB)
14:10 - 14:30	Athanas S. Macheyeki	Geodynamics of Western Rwanda: Implication for Regional Tectonics and Geo-Hazards
14:30 - 14:50	Karim Mtili	Origin of High Helium Concentrations in the Gas Field of South-western Tanzania
14:50 - 15:10	Ngabia M. Nyahili	Assessment Of Rock Mass Stability Around Haulage Drifts In Underground Mines: A Case Of New Luika Gold Mine In Lupa Goldfield Of Southwest Tanzania
15:10 - 15:30	HEALTH BREAK	
15:30 - 15:50	Joas Kabete	Advanced Small-Scale Mining and Geosciences: A Potential Marriage of Convenience in the Making
15:50 - 16:10	Julius Sarota	Strategies in Creating Conducive Investment Environment in Extractive Industry
PANEL DISCUSSION ON MINERAL SECTOR: Mining for development - Mining Act, Regulations and fiscal regime		
16:10 - 17:40 Convenor: **Prof. A. Mruma**	Mr. Julius Sarota, UDSM – Mineral Resource Insitute	
	Eng. Mchwampaka, Tanzania Chambers of Mine	
	Prof. Shukrani Manya, Member of Parliament	
17:40 - 18:00	Yusto J. Shine	Mineralogy and Geochemistry of the Asanje Iron Ore Deposit within the Mayamaya-Hombolo Belt, Dodoma Region, Central Tanzania
18:00 - 18:20	Godfrey Mwendenusu	Geospatial Programming for Delineating High Permeable Zones in Northern Tanzania: Implications to Geothermal Energy Prospectivity
18:20 - 18:30	End of Session & Announcements	
19:00 - onwards	**Icebreaking Cocktail Party - sponsored by FRANONE Mining**	

DAY 5 (05-10-2022) ***CONFERENCE***

Time	Presenter	Title
08:00 - 09:00	Arrival, Registration & Poster Session	
09:00 - 09:20	Makungu Madirisha	Biodegradable chelating agents as stand-alone stimulation fluids to enhance permeability in geothermal reservoir formations
09:20 - 09:40	Doreen Nyahucho	Long-Wave Infrared (LWIR) Spectroscopy on Feldspars From Rock Plugs for the Detection of Permeable Zones in Geothermal Systems
09:40 - 10:00	Charles H. Kasanzu	Isotopic and geochemical constraints on the protolith, redox state and paleo-tectonic setting of the Malagarasi Supergroup Of North-Western Tanzania: northwards flow of the proto-Congo River in the Rodinia realm
10:20 - 10:40	Ibrahim Rutta	The evolution of Ruvuma Basin and its implication to Mnazi Bay North Block Prospectivity
10:40 - 11:00	HEALTH BREAK	
11:00 - 11:20	Innocent Mvamba	Palynological Investigation of the Eyasi- Wembere Rift Basins, Implications for Alynofacies Analysis and Paleoenvironmental Interpretation for Hydrocarbon Potential
11:20 - 11:40	Ibrahim Mfungo	Geochemical Characterization of Wingayongo Oil Seep in the Rufiji Basin, Se Tanzania: Petroleum System Implication
11:20 - 11:40	Venance E. L. Mboya	Tectonic Evolution of Seagap Fault Zone: It's Implication to Sediment Distribution in Mafia Deep Basin
PANEL DISCUSSION ON ENERGY: Energy mix for sustainable development		
11:40 - 13:00 Convenor: **Dr. M. Kagya**	Representative – Tanzania Energy Platform	
	Representative - Tanzania Petroleum Development Corporation (TPDC)	
	Representative - Tanzania Geothermal Development Corporation (TGDC)	
	Representative - TANESCO	
13:00 - 14:00	LUNCH BREAK	
14:00 - 14:20	Eric Minani Elias	Multiproxy Review on Sedimentation and Paleoclimate of the Tanzanian Shelf During the Late Pleistocene To Holocene
14:20 - 14:40	Athanas S. Macheyeki	Morphostructural Analysis of the Eyasi – Durumo- Manyara - Faults, East African Rift System
14:40 - 15:00	Japhet N. Fungo	Remote Sensing Aided Geological and Geochemical Investigation of Sangu-Ikola Carbonatites, South-Western Tanzania
15:00 - 15:20	HEALTH BREAK	
15:20 - 15:40	Athanas S. Macheyeki	Application of Multidisciplinary Techniques to Search for Base Metals in the Gawler Area, South Australia
15:40 - 16:00	Damas Mushi	Geological Investigation of Gold Rush in Nholi Area in Dodoma Region Central Tanzania
PANEL DISCUSSION ON WATER RESOURCES: Water for Livelihood		
16:00 - 18:00 Convenor:	Representative - Rural Water Supply and Sanitation Agency (RUWASA)	
	Representative - Ministry of Water	
	Representative - Lake Victoria Basin Water Board	
18:00 - 18:10	**Announcements & End of day 5**	

DAY 6 (06-10-2022) ***CONFERENCE & CLOSING CEREMONY***

Time	Presenter	Title
08:00 - 08:30	Arrival & Poster Session	
08:30 - 08:50	Gerald Chuwa	Petrography, Geochemistry and U-Pb Zircon Ages of granites in the Karagwe Ankolean Belt of Northwest Tanzania
08:50 - 09:10	William Mremi	Groundwater Modeling Not Substitute For Thinking: Case Study of Central Regional Bus Stand Construction Site in Moshi Town
09:10 - 09:30	Charles D. Moye	Generation of Geochemical Exploration Targets from Regional Stream Sediment Data Using Principal Component And Factor Analysis: A Case Study of Kibaya-Kiteto, Manyara, Tanzania
09:10 - 09:30	Dickson Ngowi	Exploratory mapping to delineate prospective areas for gold deposits using weight of evidence model: a case study in the Lupa Goldfield, Chunya District, South West Tanzania
09:30 - 09:50	Joas Kabete	Capacity building in mineral supply chain value: critical recipe in advancing the minerals industry in Tanzania
09:50 - 10:10	HEALTH BREAK	
PANEL DISCUSSION: Geotourism in Tanzania – A sleeping giant		
10:10 - 11:00 Convenor: **Dr. R. Massawe**	Representative - Ministry of Natural Resources and Tourism	
	Representative - University of Dar es Salaam	
	Representative - Geological Survey of Tanzania	
CLOSING, TGS 2022 ANNUAL CONFERENCE		
11:00 - 11:15	TGS Vice President, TGS: Welcoming remarks	
11:15 - 11:45	TGS President: Speech, and to welcome Guest of Honour	
11:45 - 12:45	Guest of Honour	
12:45 - 12:55	Photo session	
13:00 - 14:00	LUNCH BREAK	
TGS ANNUAL MEETING		
Time	**Activity**	**Responsible**
14:00 - 14:30	Opening	TGS President
14:30 - 17:00	Reporting on TGS 2021/2022 Activities & Financial Report (Auditors report)	TGS General Secretary, Treasurer and Editor
17:00 - 17:10	TGS Consultancy Bureau	Deputy General Secretary
17:10 - 18:00	Election	All TGS leaders
18: 00 - 18:10	Closing	TGS Vice President
19:00 - onwards	**CONFERENCE DINNER**	

POSTER PRESENTATIONS

Presenter	Poster title
Rachel Sabuni	Review of hydrocarbons potential of the Rufiji Basin, Tanzania
Mkunde Adams	Development of a resource model with coal quality estimates for Jitegemee Coal Mine
Adam Sajilo & Victoria Godfrey	Tanzania Petroleum Development Corporation Laboratory Services
Emily B. Kiswaka	Mafia Deep Basin: Basin Development and Petroleum System Elements
Ester Stephen	The Karoo Organic Rich Successions of the Tanga Basin: Deposit Types, Depositional And Post-Depositional Parameters
Ernest Selestin	Distribution of Magmatic Intrusions and key petroleum system elements in the Pangani Rift Basin, N-E Tanzania
Adonias Mkangala	Surface Geology and Fluid Pathways of the Ibadakuli Geothermal Prospect, Northwest Tanzania
Rebeka Bonifas Mwakalinga	Paleostress Investigation along the NW-SE Pangani Rift, Northern Tanzania
Onesphorius Balambirwa	Geosite Inventory in the Ngorongoro Lengai Unesco Global Geopark (NLUGG) NE-Tanzania

MAFIA DEEP BASIN: BASIN DEVELOPMENT AND PETROLEUM SYSTEM ELEMENTS

Emily Barnabas Kiswaka* and Elisante Elisaimon Mshiu

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

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This study aimed at assessing basin development and petroleum system elements of the Mafia deep basin based on interpretation of 2D seismic data. Results have shown that development of the Mafia deep basin was influenced by several tectonic episodes including the Permo-Triassic Karoo rifting, the Mid Jurassic-Cretaceous tectonic event and the Cenozoic extensional and strike-slip faulting tectonics. The tectonic events created different structures that allowed migration and trapping of hydrocarbons in the study area. These structures include deep rooted faults and both negative and positive flowering fault structures. The positive flower structures along the Seagap Fault form potential petroleum prospects in the study area. Petroleum migration took advantage of both weak zones below sand filled channels and open fault systems resulting from episodic tectonic reactivations. Potential petroleum reservoirs include the Middle Jurassic shallow water deposits, the Cretaceous hybrid turbidite-contourite deposits, Paleocene-Miocene southward migrating channelized sands, and the Pliocene-Holocene channel deposits and their respective channel-levee successions. These reservoirs are interpreted to have been charged by the Middle Jurassic source rocks. Possible presence of gas generation, migration and accumulations in the Mafia deep basin is interpreted based on direct hydrocarbon indicators. These indicators include gas chimneys and wipe-outs and flat spots that are mostly available in the Paleocene-Holocene stratigraphy of the study area. Potential seal rocks in the area include extensive drift deposits and deep water shales deposited during marine transgressions.

SMALL-SCALE MINING GROUPS AND GEOSCIENCES: A POTENTIAL MARRIAGE OF CONVENIENCE IN THE MAKING

Joas M. Kabete

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In general, mining culture and availability of funding for exploration and development require understanding of how the mineral supply chain operates. That understanding allows strategic planning by involved stakeholders on how mineral assets could be developed from exploration and/or prospecting to mineral production. Given the state of the minerals industry, local junior exploration and small-scale mining groups, can team up into a group of "Potential Investors (PI), with comprehensive exploration and mining programs looking for financing from locally-available financial institutions and banks. For this to succeed, PI must be able to demonstrate to the financial institution and/or banks the technical-economic aspects of the exploration, development or production asset. The PI should clearly highlight potential risks and mitigation plans in place to counter any risks should they occur/happen.

Among mitigation plans, the PI may propose potential pathways for relatively small mineral assets (i.e. < 0.1 Moz Au prospects) requiring value addition into mid-tier project (i.e. 0.1-2Moz Au). For financial institutions/banks to financially facilitate this value addition process, they must be actively involved as major stakeholders in the minerals supply value chain. This is important in terms of financing of mineral assets, because all stakeholders involved will be openly discussing potential risks and mitigation plans. One risky area of concern would be financing exploration at any level. To mitigate this, the PI may propose splitting the project into relatively small components with clear growth pathway by sequential financing into a single mid-tier producing mineral asset. Given the wealth of knowledge and experience possessed by PI, the awareness possessed by the financial

institutions on how the mineral supply value chain operates, both parties may find a way through which sequential financing would work for both parties.

The sequential financing forms among many models that can be put forward for developing significant number of Tier 2 and 3 prospects, including ~0.5Moz Au Msasa, 0.7Moz Au Nyakafuru, 0.4Moz Au, Buhemba, 0.4Moz Au, Miyabi, 0.5Moz Kitongo, which failed to catch the attention of giant gold mining companies in the mid-1990 and early 2000. Fortunately, some of these projects, caught the attention of serious locally-owned mining companies and have since then been developed into producing gold mines. Tier 2 and Tier 3 gold prospects, fall under ~0.25-5 Moz at 0.78- 2g/t Au gold deposit class, which contributes ~69% of the world's gold production. China, which is the world's largest gold producer, is not even among top 10 countries with world class gold deposits such as Geita and Bulyanhulu. Instead it produces most of their gold from small gold prospect and Tier 2 and 3 gold deposits. This, and the growing awareness of how the minerals supply chain operates, especially amongst the government agencies such as Mining Commission and TRA, and high-ranking financial institutions and banks such as TIB, NMB, CRDB, the PI can successfully motivate mineral asset projects, apply and successfully get financed.

As a major stakeholder, government can successfully facilitate a "potential marriage of convenience" for financing of exploration projects to levels that will incorporate mining and mineral processing engineers, surveyors and associated technicians and field attendants. Together let us translate our mineral resources into financial resources for development.

A PALYNOLOGICAL INVESTIGATION OF THE EYASI-WEMBERE RIFT BASINS, IMPLICATIONS FOR ALYNOFACIES ANALYSIS AND PALEOENVIRONMENTAL INTERPRETATION FOR HYDROCARBON POTENTIAL

Innocent Mvamba

Tanzania Petroleum Development Corporation (TPDC), Dar es Salaam

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This study focused at investigating palynomorphs in core samples to identify age, comment on the depositional environment, thermal maturation of the palynomorphs, and hydrocarbon potential from three stratigraphic boreholes drilled in Eyasi-Wembere rift basins of the north-eastern Tanzania. Forty-three (43) core samples from the three boreholes (Kining'inila-1– Nyalanja-1 and Luono-1) have been processed and analysed for their Palynological content. The sample yielded fairly too well preserved terrestrial palynomorphs while other samples were barren. Thirty-four (34) terrestrial species were identified and systematically described from which most abundant species were recovered from pollen grain and very few spores. In addition, species from aquatic algae (Botryococcus sp), and various fungal fructification were observed. The palynomorph assemblages were used in a Palynostratigraphic age assignment based on comparisons with previously developed biozones for around the area. The Palynomorphs in biozones in Nyalanja-1 and Luono-1 boreholes evidence late Pleistocene to Holocene age while in the Kining'inila-1– borehole it was difficult to assign the precise age due to the wide range of species observed and barren sample to some depth. Palynomorphs recovered from the three stratigraphic boreholes are not evenly distributed; they differ in Palynological abundance. Based on the miospores, a detailed palynostratigraphic correlation was established, showing almost non-continuous deposition. Minor stratigraphic gaps are observed in the Kining'inila-1– borehole. Palynofacies and lithological analysis show a good correlation in Nyalanja-1 and Luono-1 boreholes compared to Kining'inila-1– borehole. Palynofacies in Nyalanja-1 and

Luono-1 suggests the depositional environment to be low-energy dysoxic-anoxic terrestrial deposits with a good preservation potential while Kining'inila-1–borehole shows the high energy environmental deposition. Fungal spores were highly abundant and diverse in Kining'inila-1– borehole and rare in both Nyalanja-1 and Luono-1. The hydrocarbon potential was conducted through estimation of organic maturation of sediments which involves the use of colour scales to get rough measurement on the degree of sediment maturation and their potential for generation of hydrocarbons. Maturation studies indicate that the Basin is oil prone and capable of producing oil. The high abundance of amorphous organic matter and aquatic algae (Botryococcus sp) is an indicator of Kerogen type I/II capable of producing oil. Most of these materials are marginally mature, ranging from light brownish yellow to yellowish in colour.

GEODYNAMICS OF WESTERN RWANDA: IMPLICATION FOR REGIONAL TECTONICS AND GEO-HAZARDS

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We conducted a geological survey on the eastern part of Lake Kivu (Western Rwanda) aimed at studying the current structural setting of the lake and surrounding areas in relation to its Precambrian structural setting. The motivation to do so came from the fact that of recent, the area has been affected by several earthquakes some of which are large enough to threaten people's lives both in Rwanda and Democratic Republic of Congo. We processed the structural data and compared the results with other published data in the area and find that: (1) the area is affected by multiple folding, shearing and faulting events; (2) there is evidence of stress permutations from strike-slip to normal faulting; and (3) the Lake rift basin is currently under sub-radial extensional regime. Based on the presented results, it is recommended to undertake detailed geological investigation (active tectonics studies) in this highly populated part of Africa in order for better characterization of the structures responsible for seismic activities. This will allow establishment of a possible link between seismicity and volcanic activities happening within proximity to Lake Kivu.

GENERATION OF GEOCHEMICAL EXPLORATION TARGETS FROM REGIONAL STREAM SEDIMENT DATA USING PRINCIPAL COMPONENT AND FACTOR ANALYSIS: A CASE STUDY OF KIBAYA-KITETO, MANYARA, TANZANIA

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A regional-scale stream sediment geochemical sampling was carried out with an average sampling density of one sample per nine-kilometre square in Kiteto District, Manyara Region, Tanzania. The samples were sieved with minus 80 mesh fraction sieve and analysed for major, minor and trace elements using X-Ray Fluorescence (XRF) and Fire Assay with Atomic Absorption Spectrometry (AAS) finish. Stepwise Factor Analysis and Principal Component Multivariate Analysis were applied to stream geochemical data to delineate factors with correlated variables, which were plotted as geochemical anomaly maps for target generation.

The methods have been successfully used in 358 stream sediments to delineate targets for gold, Ni and Cu exploration in the study area. In this work, four factors which account for 73.7 wt% of the total variance of the stream sediment geochemical data were established. These factors are: Factor 1, a Ni-Ba-Co-Cu-Sr probably underlying metamorphosed granitic units with some contribution from mafic and ultramafic rocks; Factor 2, a Cr-Zn-Mn defining crustal forming elements reflecting the parent rock in the study area; Factor 3, the Rb-Pb attributed to metamorphosed granitic lithology, which also demonstrates the parent rock in the area, and; Factor 4, Arsenic which is a chalcophile element with affinity to sulphide phases.

BIODEGRADABLE CHELATING AGENTS AS STAND-ALONE STIMULATION FLUIDS TO ENHANCE PERMEABILITY IN GEOTHERMAL RESERVOIR FORMATIONS

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Geothermal energy is a green renewable energy resource which is more reliable and sustainable with a lower carbon footprint and maintenance cost than other renewable energies. Some of the world's geothermal reservoirs are sandstone formations consisting of quartz grains that may be cemented by clay. The genetic characteristics of clay material, whether formed by allogenic or authigenic processes, affects the reservoir properties of rocks to a greater or lesser extent. The presence of clays can significantly affect the porosity and permeability of reservoir rocks. More specifically, if clay minerals are randomly distributed within the formation matrix, it becomes difficult to predict the reservoir characteristics, and clays may impede the flow of geothermal fluid through and in and out of reservoirs.

This paper reports on the influence of biodegradable chelating agents as stand-alone stimulation fluid to enhance fluid permeability of clay-containing geothermal reservoir formations. The interaction is investigated of various biodegradable chelating agents (BCA1, BCA2, and BCA3) and clay minerals kaolinite-natural (KN) and montmorillonite-K10 (MM) in a hydrothermal reactor in which the conditions of a geothermal reservoir are simulated under a CO_2 environment with a temperature of 230 ^{o}C and pressure of 85 bars. The porosimetry, ATR-FTIR, and infrared reflectance spectroscopy results show changes on surface properties and structure of MM and KN which suggests chemical interaction takes place. However, XRD results show insignificant changes on structure of MM and KN. The ICP-OES, pH, conductivity, and salinity results show the chemical interactions (dissolution

reactions) to take place on both KN and MM and therefore strongly support the results of the earlier techniques. These results show that BCA1 and BCA3 cause greater dissolution with lower precipitation as compared to BCA2 and no-BCA. This discrepancy in dissolution is due to differences in chemical functional groups as BCA1 and BCA3 have higher chemical functional groups compared to BCA2 and no-BCA. Chemical functional groups dictate the reactivity of any chemical species. Moreover, the difference in molecular weight is also a reason for this discrepancy. BCA chelating agents with high molecular weight are stable at high temperatures. BCA 1 and BCA 3 have greater molecular weight than BCA2. This paper therefore affirms that BCA1 and BCA 3 would be useful as stand-alone biodegradable chelating acids to enhance permeability in undamaged or damaged clay-containing geothermal reservoir formations.

MINERALOGY AND GEOCHEMISTRY OF THE ASANJE IRON ORE DEPOSIT WITHIN THE MAYAMAYA-HOMBOLO BELT, DODOMA REGION, CENTRAL TANZANIA

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The Asanje iron ore is hosted in Precambrian volcanic-sedimentary rocks in the Mayamaya-Hombolo Belt in Dodoma Region, within the Lake Nyanza Superterrane. The iron ores are found in two parallel ridges trending NW-SE. This paper presents the mineralogy, chemical composition, and impurities of iron ore to ascertain its suitability as raw material for industrial applications. The analytical instruments used are XRF, XRD, and Optical Microscope based at the Geological Survey of Tanzania laboratory. A total of 35 ore samples were collected and analysed for major and trace elements. The XRD results revealed that iron ore is mainly composed of hematite and goethite with bornite and covellite as the main accessory minerals. The XRF results showed that, the iron ore ranging from 49.90 to 61.44% Fe_2O_3 with impurities of 37.9% SiO_2, 0.9% Al_2O_3, 1.2% P_2O_5, and 0.2% S. By comparing the results from two ridges, ridge two have more iron content (61.44 wt% Fe_2O_3) occurs as massive iron whereas ridge one (49.9 wt% Fe_2O_3) vein and banded hematite iron ore. Its quality is classified as low to medium grade and can be used in metallurgical and cement industries.

PETROGRAPHY, GEOCHEMISTRY AND U-PB ZIRCON AGES OF GRANITES IN THE KARAGWE ANKOLEAN BELT OF NORTHWEST TANZANIA

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We present preliminary petrological, geochemical, and geochronological results on primarily S-type granites from the Mesoproterozoic Karagwe Ankolean Belt (KAB) in northwest Tanzania. The KAB is a NE-SW-aligned Mesoproterozoic belt that lies between the Tanzania Craton and Bangweulu Block to the East and South-East, and the Congo Craton to the West. The host siliciclastic-dominated sedimentary rocks were metamorphosed to greenschist and lower amphibolite facies, and intruded by multiple episodes of felsic, intermediate, and mafic-ultramafic igneous rocks.

The mineralogical composition of the granites includes quartz, microcline, plagioclase (oligoclase), albite, biotite, muscovite, and accessory tourmaline, apatite, and zircons. Our 22 granite samples share similar geochemical properties such as high SiO_2 (> 71 Wt %), Al_2O_3 (>10 Wt %), K_2O (3.99–7.10 Wt %), and Na_2O (2.04–3.04 Wt %), whereas their levels of MgO, TiO_2, and Fe_2O_3T are low. The granite samples are mostly peraluminous and range in chemical composition from calcic alkalic to alkalic calcic. Except for one granite sample that is an A-type, they all exhibit significant S-type traits. The sample's Rb-Nb-Ta-Hf contents indicate syn-collisional to orogenic granite types, highlighting their tectonic contexts. Enrichment of Cs, Rb, Th, U, and K, and the depletion of Ba, Nb, Ta, Sr, and Ti compared to primordial values characterise the samples. They are further distinguished by a modest enrichment of LREE over MREE and HREE, with $(La/Yb)_{CN}$ = 2.12–9.54 and a negative Eu^* anomaly = 0.05–0.24 in their chondrite normalised data. These features suggest a source characterised by feldspar abundance, free of garnets with crustal material input, and probably inherited subduction arc

magmatic signature. Fractional crystallisation is favoured by the evolved nature of the granites, their mineral composition and the association of these granitic samples.

The U-Pb ages from 4 samples in the northern part of the study area (Kyerwa) show a cluster around 1388 – 1378 Ma with predominantly Paleoproterozoic inherent age from xenocryst zircons at 1738±7 Ma and a lower intercept from one sample giving an age of 1406±7 Ma. One granite dyke sample with A-type geochemical character has the youngest age of 1374± 5 Ma. Similarly, ages from 4 dated samples in Ngara span the period from 1401-1389 Ma, indicating at least a period of 1 Ma earlier emplacement before Kyerwa granites. The xenocryst zircons in Ngara samples span the Paleoproterozoic period from 2376± 30 Ma to 2000±27 Ma, 1901±39 Ma, 1790±25 Ma and 1763±25 Ma. The emplacement over 50 Ma from 1421 – 1371 Ma with the incorporation of multiple crustal sources from the Paleoproterozoic basement rocks is suggested. One significant age resetting events occurred in the KAB as constrained by lower intercept ages around 1406±7 Ma, coinciding with the emplacement of a bimodal suite of igneous rocks during the “Kibaran event” of Tack et al. (2010).

MORPHOSTRUCTURAL ANALYSIS OF THE EYASI – DURUMO-MANYARA - FAULTS, EAST AFRICAN RIFT SYSTEM

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The Eyasi fault, the Eyasi antithetic fault, the Durumo fault and Manyara fault are located about 250km west of Tanzania Capital City, Dodoma. The faults, part of the East African Rift System, re-activate Archean rocks of the Tanzania craton. Whereas the Durumo fault trends almost N-S, the other faults trend NE-SW.

We establish 64 profiles of 30m-resolution SRTM data across the four faults in order to extract coordinates (X, Y) and elevation (Z) for each point along the profiles in order to compute morphostructural parameters such as vertical offsets, maximum slope angles and slope differences. We use the results to establish displacement profiles that help estimations of fault segments and modelling of propagation style (restricted or unrestricted).

Results show that fault vertical offsets are proportional to maximum fault scarp angles for scraps of vertical offsets in order of ≤0.85km and the corresponding constant of proportionality K = 15m/degree. We also show that maximum slope differences (Sdiff) of up to 60˚ can occur in areas where fault steps intersect (interact). We further show that the propagations of faults in the study area are being prohibited towards the north (or NE) but the same faults are freely propagating due south. As the faults are freely propagating through the Archean Tanzania craton, we therefore suggest that the Archean Tanzanian craton has little or no effect on the southern propagation of the studied faults. Finally, we show that the use of vertical offsets computed from fault steps adds contrast to the visualisation and characterization of fault displacement profiles as compared to displacement profiles established using cumulative or combined vertical offsets.

GEOLOGICAL INVESTIGATION OF GOLD RUSH IN NHOLI AREA IN DODOMA REGION CENTRAL TANZANIA

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The Nholi gold mine is located some 40 km northwest of Dodoma City in central Tanzania. Geological investigation of Nholi gold mine was done in April, 2018 with the aim of understanding factors that caused gold mineralisation in the area. The methods used were detailed geological mapping, ground magnetic survey, soil sampling, XRF and FAA. The results show that the geology of the area is largely underlain by quartz-mica schist, which is intruded by granites and diorites. Biotite gneiss occurs occasionally in the northern parts of the area. The biotite gneiss and quartz-mica schist have been deformed by NW-SE shear zone which hosts milky to brownish, lenticular gold bearing quartz veins and veinlets. The mineral alteration products in the shear zone include silicification, sericite, chlorite, kaolinite and Fe-oxyhydrates. Those alteration minerals occurring in the shear zone are related to Au mineralization in the area. All soil assays showed the value above average crustal abundance ranging from 0.01 to 0.09 g/t while in rock samples the grade was up to 6.89 g/t. Significant values of gold were found in the quartz-biotite schist rocks cut by multiple quartz stringers and form sericite and silica alterations along the shear zone. The magnetic interpretations have shown that most of the structures are trending NW-SE as were picked by geological mapping hence the subsurface structures conform to surface structure. The integration of ground magnetic, geochemical and geological results, it can be concluded that gold mineralization at Nholi area is related to shear zone and mineral alterations are of hydrothermal solutions.

GEOCHEMICAL CHARACTERIZATION OF WINGAYONGO OIL SEEP IN THE RUFIJI BASIN, SE TANZANIA: PETROLEUM SYSTEM IMPLICATION

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This study aimed at organic geochemical characterization of the Wingayongo Cretaceous bituminous sandstones in the Rufiji Basin was undertaken in order to investigate the origin of the seep. Four representative lithotype samples of Cretaceous bituminous sandstones were collected, soxhlet extracted and subjected to Gas Chromatography-Mass Spectrometry (GCMS) via various mass spectra ions (M/z 85, 191, 271) to geochemically characterize the seep, to determine the source of organic matter, to constrain depositional conditions, and to assess the degree of biodegradation and the thermal maturity of the seep. Further assessment of possible source rock in the region involved synthesizing literature information from the drill holes that penetrated the Upper Triassic-Lower Jurassic rocks. Based on the results of this study, the Wingayongo seep appears to have originated from the marine organic-rich shales deposited under oxidising conditions. This is indicated by a higher abundance of low to medium molecular weight (C_{13}-C_{19}) compared to long chain (C_{20}-C_{33}) compounds, low quantities of C_{29}-norhopane/C_{30} hopane and high pristane/phytane ratios (Pr/Ph >1). A complete suite of n-alkanes in the low-molecular-weight region, as well as a less prominent chromatographic baseline hump, indicate the seeps are somewhat to moderately biodegraded. It is plausible to conclude that Wingayongo seep was charged from matured source rocks, based on the Ts/Tm and C32 hopane ratios range between (0.06 to 1.12 and 0.55 to 0.93) respectively. Based on the Ts/Tm and C_{32} hopane ratios range between 0.06 to 1.12 and 0.55 to 0.93, respectively, it is plausible to conclude that the

Wingayongo oil seep was charged from a matured source rock. Oleanane signatures found in the seep indicate an active post Cretaceous source rock in the region. The correlation between Nondwa source rock and Wingayongo oil seep samples may suggest that the Mandawa and Rufiji basins were possibly under similar depositional conditions during the late Triassic and early Jurassic periods.

GEOSITE INVENTORY IN THE NGORONGORO LENGAI UNESCO GLOBAL GEOPARK (NLUGG) NE-TANZANIA

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Geosite inventories are gaining popularity around the world due to the societal benefits of geotourism, protection, scientific popularisation, conservation and geo-heritage. Because of insufficient and disorganised related information, inventories of geosites in the Ngorongoro Conservation Area Authority (NCCA) have been limited. As a result, the current study aims to identify, list, and describe the geosites available in the NCCA in order to promote their values at the national and global levels. The research was carried out by reviewing existing remote sensing data, geological maps and reports, and onsite field mapping. Previous studies identified six (6) major geosites in the NCCA: Ngorongoro Caldera, Eyasi basin, Engaruka basin, Engaresero/Natron basin, Olduvai Gorge, and Ngamuriak. This study, on the other hand, identified fourteen (14) sub-geosites within these six (6) major geosites, which are as follows: crater and crater pits, volcanic domes, composite, shield, and cinder volcanoes, batholiths, domes, depression, caves, moving sands, volcanic ashes, and lava flow. Both sub-geosites are dominated by various features that greatly classify the NCCA in terms of geological, historical, social, tourism, cultural, and conservational values. The sub-geosites identified in this study shared values; however, unique and different values were observed between sub-geosites. It was also discovered that a single sub-geosite, such as Ngorongoro Crater/Caldera, Eyasi and Natron Basins, and Engaruka, can provide multiple values.

The Ngorongoro crater/caldera has significant geological, conservational, and tourism values due to its rounded table like on top of Mount Nolkaria and its homeland features for various animal species. Engaruka's travertine formations, which include caves, caverns, sinkholes, stalagmite, and

stalactite, provide tourist, geological, and cultural value. Engaresero Gorge, waterfalls, and footprints at Natron Basin are tourist and historical attractions. Furthermore, the presence of a hot spring (50oC) at Maji moto site and Hadzabe tribe granite caves, caverns, and sinkholes in Eyasi Basin provides tourism and cultural values. Because of its unique feature, the crescent shapes (half-moon) of the Ootuni shifting "sand" at Serengeti Plain around Noibor-sot provide tourist and geological value. Empakaai Crater Lake, Mlima matiti Quartzite, Ngamuriak Granitic Dome and Caverns, Nasera Granitic Dome, Emugur Laccolith Rock, and Olkarien Gorge are among the other geological features with geological values.

THE ROLE OF MINERAL EXPLORATION FOR A SUCCESSFUL AND SUSTAINABLE MINING INDUSTRY: SWOT ANALYSIS AND FORWARD PROPOSALS FOR THE SADCC REGION

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The mineral resources in the Eastern Central and Southern Africa Region have enormous potential to develop the economies through an informed system of discovery, development and exploitation, which should be driven by the respective countries. This has not been the case, however, due to over-reliance on foreign direct investment and many other systemic factors. These mineral resources, on the contrary, are seen as a curse, a result of the existing systems which favours the inequitable extraction of the minerals leaving minimal benefits to the host countries and local communities.

To re-adjust the mining industry value chain to be positively owned by respective countries and generate equitable returns, a brief systemic strength-weakness-opportunities-and-threat (SWOT) review of the mineral exploration subsector in the Eastern Central and Southern Africa Region (ECSA) is presented. This aims to create discussion and further research around the benefits of sustained mineral exploration to the region and how these are realized and retained. The focus of the SWOT analysis is on the following mineral exploration drivers: 1) capital availability, 2) skills and expertise 3) geological settings, environment and location, and 4) policies and regulations. The systemic review highlights key systemic factors which can boost mineral exploration, sustain mining activities and trigger regional collaboration, value additions and expanded trading with other parts of the World. Successful mineral exploration activities that evaluated, discovered, and replenish minerals throughout the operations life, have served as the foundation for many prosperous and lucrative mining ventures, and therefore positively contribute to economical growth.

DUE DILIGENCE FOR MINERAL ASSET ACQUISITION AND/OR FINANCING: A CRITICAL ROLES AWAITING THE TANZANIA GEOSCIENTIST REGISTRATION BOARD (TGRB)

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Private sector, government institutions, agencies and communities from which domestic exploration and mining companies originates and foreign large mining companies operate, do not always appreciate each other in terms of opportunities and risks associated with the entire mineral supply value chain. Government agencies are major stakeholders with a mandate to implement policies designed to create, develop and maintain conducive environment for investment in the minerals industry. Stakeholders such as geoscientists have the obligation to highlight the geological attractiveness, quantify endowment and demonstrate the economic viability of a mineral asset project through scoping, feasibility and technical study reports. On the other hand, stakeholders such as financial institutions with appetite to finance mineral asset projects, can be slowed down in decision making due to lack of understanding of the technical-economic aspects of the project to be financed.

In order to fast-track the mineral asset project financing process, the feasibility and technical reports submitted to financial institutions for funding, will be trusted if signed off by qualified persons, registered as a Competent Person (CP) or Independent Competent Person (ICP) by one of 11 existing CODES. These CODES must be compliant with the Committee for Mining Research and International Reporting Standards (CRIRSCO) and Council of Mining and Metallurgical Institution (CMMI). Familiar "CODES" for public reporting of Exploration Results, Mineral Resources and Mineral Reserves, include SAMREC CODE (South Africa), JORC CODE (Australia), NI 43-101 (Canada), among others. The rationale for conducting due diligence is to ensure security of investment against any

fraudulent, misleading data and fault decision-making including: 1) errors emerging from drilling, sampling, laboratory analyses, and data entry; 2) mistakenly/deliberately use of un-clean data for resource/reserve estimation and designing of flow sheets; 3) misleading reporting of mineral resources/reserves by investors to the financial institutions. The CP/ICP must submits "Independent Due Diligence Report" to financial institutions/banks, which is essentially an audit report of a Feasibility Study or Technical Evaluation Reports presentable to the public, potential investors and financiers.

Therefore, as a co-watchdog of the minerals supply value chain in Tanzania, the "Tanzania Geoscientist Registration Board", once admitted to conduct business by government will be working closely with all stakeholders, more so the financial institutions and banks fasten the translation of under-explored/under-developed mineral assets in the ground into financial resources. Geoscientists registered by TGRB have responsibilities of either confirming the geological attractiveness, associated mineral endowment and economic viability of projects by generating and signing off feasibility and scoping studies and technical reports or conducting due diligence on the technical-economic aspects of the feasibility study and technical reports on behalf of the financial institutions. Together as stakeholders, TGRB is ready to take part in the overall mission of the government which is to translate natural resources in the ground into financial resources for socio-economic development.

SURFACE GEOLOGY AND FLUID PATHWAYS OF THE IBADAKULI GEOTHERMAL PROSPECT, NORTHWEST TANZANIA

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Surface geology and fluid pathways mapping in the Ibadakuli geothermal prospect were investigated by ground geological, structural mapping and Digital Elevation Model remote sensing, soil temperature mapping and CO2 diffuse degassing using accumulation chamber method. The study area is in the Intra-Craton Rift Basin (Eyasi-Wembere Depression) within the Archean Greenstone Belt of the Lake Victoria goldfield in Shinyanga Region, northwest Tanzania.

Surface geology in the area is dominated by greenstone belt rocks which form the northern part of the Tanzanian Craton. The rocks include granite, gneissose biotite-granite, basic volcanics, and schistose meta-sediments. The occurrences of gold and diamond deposits are found around the Ibadakuli area. The area with and around the manifestation is largely covered by clay-rich soil, possibly masking geological structures and limiting structural mapping by field observation.

Geothermal surface manifestations in the area include hydrothermal deposits, hot springs and hot pools discharging at temperatures ranging from 54.22℃ to 64.54℃. To locate permeable structures acting as pathways for thermal fluid in the prospect, soil carbon dioxide (CO_2) flux, soil temperature flux, and DEM-Shuttle Radar Topography Mission (SRTM) data of 30 m resolution were used. A total of 530 measurements for soil gas and soil temperature indicate that CO2 flux in the Ibadakuli prospect range from 0.33g/m^2/day to 264.7g/m^2/day while soil temperature ranges from 23.8℃ to 53.2℃.

Soil gas survey mapped a major structural zone trending NE-SW and less continuous structures trends of WNW-ESE and E-W. Soil temperature

mapping revealed that the central part of the area is the hottest, consistent with the location of the hot spring. Remote sensing data have delineated regional structures trending NE-SW which correspond with the Natron-Ngorongoro-Eyasi-Wembere Rift Basin in the EARS. Results from both methods complement each other and indicate that fluid flow in Ibadakuli may be controlled mainly by the NE-SW trending structures.

MULTIPROXY REVIEW ON SEDIMENTATION AND PALEOCLIMATE OF THE TANZANIAN SHELF DURING THE LATE PLEISTOCENE TO HOLOCENE

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The Tanzania continental shelf experienced significant variations in paleoclimatic and paleoceanographic conditions during the Last Glacial Maximum to Holocene which significantly influenced sedimentation patterns on the shelf. This review study was aimed at investigating the influence of climate on sedimentation patterns of the Tanzanian continental shelf during the last 19 Ka years. Dominant climate regime and sea level influence on sedimentation were constrained by using grain-size distribution, elemental composition, and stable isotope geochemistry. During the Last Glacial Maximum (LGM) period, low sedimentation rates influenced deposition of fine-grained hemipelagic sediments. This reflects a reduction in the fluvial inputs, which has been documented by lower elemental ratios of Al/Ca and was likely caused by a weak discharge from the Rufiji River in response to more arid conditions in the hinterland. Oxygen isotope and Al/Si ratios indicate that, during the deglacial period (Bølling-Allerød interstadial to early Holocene), a coarse fraction of sediments started to be deposited in the study area indicating humid climate and high sediment influx. During the early Holocene, fine-grained, river-derived (mainly Pangani and Rufiji) sediments were deposited at the outer shelf. This deposition regime, as a response to the humid climate and low rate of sea-level rise, was controlled by intense river discharge and subsequent resuspension of mud in shelf settings. Elemental ratios of biogenic proxies suggest the deposition of biogenic sediments from the end of the early to late Holocene, resulting from the weakening dilution effect of the terrigenous component. The sedimentation pattern on the Tanzanian upper shelf basin transited from

allochthonous to autochthonous sedimentation constrained by climatic changes and relative sea-level fluctuations at the end of the early Holocene.

GEOSPATIAL PROGRAMMING FOR DELINEATING HIGH PERMEABLE ZONES IN NORTHERN TANZANIA: IMPLICATIONS TO GEOTHERMAL ENERGY PROSPECTIVITY

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Geospatial programming was undertaken in northern Tanzania to demarcate highly potential zones for geothermal energy occurrence. Geothermal proxy indicators were extracted from the Landsat 9 imagery as well as ground geological investigations. These geothermal proxies include hydrothermal alterations, geological lineaments (including major faults), land surface temperature, seismic activities and geobotanical stressing level through the application of digital image processing techniques. A GIS - based Analytical Hierarchy Process (AHP) was used to integrate the geothermal proxies by standardising, weighting as well aggregating these layers of evidence to create a geothermal potential model. All involved processing and visualisation were done by using R programming and ArcGIS Pro, respectively. Results show that 36% of the study area has a very good geothermal energy potential; the Principal Component Analysis (PCA) discarded the geobotanical stressing level from contributing to the created geothermal potential model. The Receiver Operating Characteristic (ROC) curve analysis portrayed a very good predictive accuracy. Similar analysis techniques can be applied to establish understanding of the geothermal potential of Tanzania with even more geothermal proxies in a cost and time effective manner.

APPLICATION OF MULTIDISCIPLINARY TECHNIQUES TO SEARCH FOR BASE METALS IN THE GAWLER AREA, SOUTH AUSTRALIA

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This work is a result of "the Gawler Global Challenge / competition" launched by the Government of South Australia on the 2nd March, 2020. The challenge was aimed at giving the world scientific community an opportunity to look for and establish best mineral exploration models that can uncover hidden mineral deposits in that part of the world. There was no specific technique proposed and participants were invited to use any technique (s) of their choices. The authors of this article chose to use mineral prospectivity maps (favorability maps) using GIS driven approaches. In so doing, and in order to establish most important suitability map (s), geochemistry, structural geology and geophysics along with general geology knowledge driven techniques were employed.

Results show that the suitability (favorability) level within the map varies as a function of suitability scores that are derived from the effect and contribution of three key exploration criteria; lithologic units, structures and mineral / deposit locations. We derive several suitable areas and rank them as most, second, third, fourth and fifth suitable areas. The proposed most suitable area is defined by a N-S to NNE-SSW trend. This most favourable area is interpreted to be suitable for exploration of Au, As, Cu and HFS-REEs as defined by three derived mineral exploration models namely;

(a) Fe-Ni-Cu sulphides particularly in the vicinity of the contacts between mafic dykes and granites,

(b) Fe-Cu-Au (with As) just on the margins of the granites, particularly along N-S to NNE-SSW trending weakest zones; and

(c) HFS-REEs along or on the margins of the Neo-proterozoic granite of the Delamerian Orogeny..

THE KAROO ORGANIC RICH SUCCESSIONS OF THE TANGA BASIN: DEPOSIT TYPES, DEPOSITIONAL AND POST-DEPOSITIONAL PARAMETERS

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The middle Karoo interval of the onshore Tanga Basin contains dark grey-black, fossiliferous organic-rich rocks outcropping at Kakindu and Pangarawe areas. Deposit types and depositional and post depositional parameters characterising these rocks are not well understood. This work used outcrop descriptions and analysis of elemental proxies to interpret different depositional and post-depositional parameters characterising the middle Karoo rocks of the study area. Outcrop description results show that the studied rocks contain low density turbidites encased by black shales that were deposited during quiet periods intervening gravity flow sedimentation. Different depositional and post-depositional features that are commonly used to characterise low density turbidites were seen. These features include planar laminations, ripple marks, coal fragments, mud clasts, slumps and convolute laminations. Elemental distributions have shown that deposition of the middle Karoo rocks was influenced by land inputs from the same provenance. The inputs were supplied by eastward flowing paleo-rivers that traversed through the Tanzania mainland. Positive correlation between elemental proxies for biogenic and terrestrial inputs suggests that the organic-richness of the middle Karoo rocks may be partly attributed to sediments reworking by turbidity currents. This conforms to outcrop description results whereby significant coal fragments at Kakindu are also interpreted to indicate reworking of previously deposited sediments by gravity flows. Further geochemical studies will be needed to confirm this observation which may be decisive in determining source rock potential of the Karoo rocks in the Tanga Basin.

REVIEW OF HYDROCARBONS POTENTIAL OF THE RUFIJI BASIN, TANZANIA

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The Rufiji Basin is one of the underexplored and least studied basins in coastal Tanzania, despite the occurrences of oil and gas seeps that indicate presence of a working petroleum system(s). Consequently, geology and distribution of key petroleum system elements and hydrocarbon potentiality of the basin remains poorly understood. This study presents a geological review of the hydrocarbon potential of the Rufiji Basin based on a synthesis of published and unpublished reports of multifaceted studies in the basin, coupled with very limited additional data collected in the course of this study. This review identifies three petroleum plays (play I, play II, and paly III) along with associated components, and includes: hydrocarbons play I, which constitutes a Permian–Triassic source rocks that are characterized by kerogen type III with TOC of ~ 6.1 wt% and T_{max} values of 465℃, along with Permian–Triassic fluvial–deltaic sandstone reservoir units, with porosity varying from 7 to 18%; and a Bajocian (restricted marine shales) as a seal. Play II has Bajocian restricted marine shale source rocks that are correlated to kerogen type II/III and III Makarawe shales, which have an average TOC of 1.7 w% and Tmax of 450 ℃, and is marked by Middle Jurassic carbonate reservoirs with an average porosity of 15%, capped with mid-Late Jurassic marine shales. Play III is characterized by Campanian shales as source rocks, Early Cretaceous fluvial–deltaic sandstone reservoir with a porosity of 15–20%, and is capped by Late Cretaceous transgressive marine shales. The analyses indicate that plays I and II are particularly more prospective, as manifested by the gas reserves discovered in offshore Songo Songo Island,

making the Rufiji Basin a viable potential basin for hydrocarbon generation and accumulation. The findings of this review study support follow up exploration activities and researches, which can ultimately lead to a commercial discovery oil reserves in the basin.

DEVELOPMENT OF A RESOURCE MODEL WITH COAL QUALITY ESTIMATES FOR JITEGEMEE COAL MINE

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Jitegemee Coal mine which is located in Ngaka Coal field lies within the East African Rift system in the south-western Tanzania. The defined resource in the area is contained in the lower K2 unit characterised by eastward dipping strata with average dip angle of 10 degrees in most places; dip angle reaches 20 degrees in localised steep areas. Several coal horizons have been observed from the drill hole data. These horizons are composed of alternating bands of coal and carbonaceous materials resulting in an overall moderately to high ash content. This causes variation in coal properties such as calorific value, inherent moisture and volatile matter. These variations justified the need to develop a coal resource model with coal quality estimates within the Jitegemee Coal mine. The model will act as a guide during the mine plan process to produce the targeted value of coal. Coal resource estimation model and classification are highly dependent on the confidence in the model of the orebody geometry (known as the geological model) within which the estimates are constrained. Therefore, an understanding of the geology of the deposit was fundamental to the model creation and evaluation process which were based on step by step phases involving preparation stage(s). These stages include database creation and validation from the drill-hole data ensuring quality assurance and quality control, and investigation stage which builds an understanding of the obtained data set. Detailed investigation of the grade patterns within domains, statistical patterns and spatial patterns were key factors to meet the focus. The next stage was model creation by which a geological model and block model were generated and validated to ensure efficiency and high level of confidence. The validation process involved comparison between developed models and the input data. The obtained

results are then used to classify coal resources as either measured, indicated or inferred depending on the confidence in the understanding of the geology of the Jitegemee coal mine area. The obtained results are reliable for the mining plans of the Jitegemee coal mine by which regions of both high and low calorific values were observed and measured. Together with that, the estimated measured resource was approximately one billion and proved to be economical and met the targeted value of the Jitegemee coal mine.

He, Ne, Ar and CO_2 SYSTEMATICS OF THE RUNGWE VOLCANIC PROVINCE, TANZANIA: IMPLICATIONS FOR FLUID SOURCE AND DYNAMICS

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Over Earth history, volatile elements have played an essential role in the secular evolution of the solid Earth. Major volatiles such as carbon and trace volatiles (e.g., noble gases) have been continuously transported from mantle and crustal reservoirs to Earth's surface, via volcanism and faulting. The East African Rift System (EARS) is tectonically unique in that thick cratonic material is actively being rifted apart in the region. Here, we present He-Ne-Ar abundances and isotopes as well as major gas chemistry (CO_2, He, Ar and CH_4) data for (n = 13) naturally-degassing seeps in the Rungwe Volcanic Province (RVP) of the East African Rift System (EARS) in southwestern Tanzania, Africa.

Helium isotopes ($^3He/^4He$) suggest that trace gases are derived from mantle sources, with moderate crustal additions, in agreement with previous studies from RVP (e.g., Pik et al., 2006, Barry, et al., 2013). Samples broadly fall into two groups: 1) dominantly mantle-like, with $^3He/^4He$ ranging from 5.2–6.3RA, which can be explained by release of magmatic volatiles, and 2) those with slightly lower $^3He/^4He$ (3.0–4.1RA), representing more ^4He (i.e., crustal) additions preferably sourced from the Precambrian basement rocks nearby. Furthermore, we report the first Ne and Ar isotopes from RVP, which show $^{20}Ne/^{22}Ne$ from 9.67–10.0 and $^{40}Ar/^{36}Ar$ from 301.2–412.2, respectively, which are broadly air-like. We employ a solubility degassing model to show that elemental ratios ($^4He/^{40}Ar^*$, $CO_2/^{40}Ar^*$ and $CO_2/^3He$) in

the gases can be explained by variable extents of open and closed system degassing from a melt with an initial mantle-like composition. However, we note that $CO_2/^3He$ observations require additional carbon assimilation, likely derived from the thick nearby Pre Cambrian cratonic crust.

ORIGIN OF HIGH HELIUM CONCENTRATIONS IN THE GAS FIELD OF SOUTHWESTERN TANZANIA

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Gas seeps across the western arm of the East African Rift System (EARS) in the Rukwa Rift Basin (RRB), the Lupa Hydrothermal System (LHS) and the Rungwe Volcanic Province (RVP) were analysed for their bulk gas and noble gases isotopic composition in order to determine the origin of gases in natural seeps as well as processes that are involved in their formation and evolution. Results of this study reveal three geochemically distinct hydrothermal systems with distinctive N_2-^{4}He-CO_2 systematics as well as He-isotope (RA= air ^{3}He/^{4}He) and concentration distributions. The seep gases from the RRB are dominantly N_2 and He, with >90% N_2 concentrations, high ^{4}He concentrations (2.4 - 6.9%) and strongly radiogenic He-isotopes (0.16 - 0.20 R_A). Seeps in the LHS - located between RRB and RVP - are characterized by high CO_2-^{4}He gas, with little to no N_2, high CO_2 contents (72 - 84%), relatively low 4He contents (0.008 – 0.15%), and higher ^{3}He/^{4}He (0.95 – 0.99 R_A). The RVP gases have relative low contents of N_2 i.e. 18%, have high CO_2 and low ^{4}He contents, with He isotopes between 2.9 and 3.2 R_A. The Ne isotopes in all seeps are an admixture between air and Archean crust and air and Mid Oceanic Ridge Basalt (MORB). The largest ^{40}Ar/^{36}Ar anomalies occur in RRB, suggesting resolvable excess ^{40}Ar (^{40}Ar*) from the crust. In summary, these data demonstrate interaction between two distinct helium gas sources, one of which is crustal (RRB) and the other which is mantle-derived (RVP). The extent of mixing is shown to be influenced by proximity to rift-related fault structures, groundwater systems, and magmatic heat. The systematic increase of He-isotopes (R_A) and concomitant decrease in He concentrations from the RRB, into the LHS and

towards the RVP provides insights into the processes controlling these geochemical shifts.

GROUNDWATER MODELING NOT SUBSTITUTE FOR THINKING: CASE STUDY: CENTRAL REGIONAL BUS STAND CONSTRUCTION SITE IN MOSHI TOWN

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Moshi is a municipality and the capital of Kilimanjaro region in the North Eastern Tanzania. The municipality is situated on the lower slopes of Mount Kilimanjaro, a dormant volcano that is the highest mountain in Africa. The municipality covers about 59 square kilometres (23 sq. mi) and is the smallest municipality in Tanzania by area.

Twenty Seven 27 billion Shillings was planned for the construction of the Central Regional Bus Stand located in Ngangamfumuni area in Moshi Town. Construction of the stand under CRJE (East Africa) started in 2019 and was expected to be completed in 2021. In June 2020 the media reported about the flooding event on the construction site. The water was overflowing from the subsurface to the surface (inundation).

In a safety point of view the groundwater inundation event showed signs of natural hazardous phenomena in the area. The source of the water causing flooding is yet to be known and thus require investigations. Since the GW modelling is currently the most applicable methodology to come up with solutions to similar problems, here I present and emphasis on critical thinking of this problem and similar problems with our brain over the simplified models using software.

EXPLORATORY MAPPING TO DELINEATE PROSPECTIVE AREAS FOR GOLD DEPOSITS USING WEIGHT OF EVIDENCE MODEL: A CASE STUDY IN THE LUPA GOLDFIELD, CHUNYA DISTRICT, SOUTH WEST TANZANIA

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Global population is growing more rapidly than at any time in history, and mineral consumption is increasing faster than population as the global standard of living increases. In order to meet the global demand as well as the future mineral supply crisis, there is a need for innovative mineral exploration approaches to locate new mineral deposits. Lupa Goldfield is the second largest goldfield in Tanzania after the Lake Victoria Gold Field (LVGF). Lupa is found in the southwest of Tanzania, just north of Mbeya town where it occupies a triangular shaped block. Despite the intensive exploration and research works from 1922 during colonial time to recent, there is only one significant gold deposit in the area. The aim of this study is to delineate gold prospective areas in the Lupa goldfield by using Geographical Information Systems and Spatial Data Modeller (SDM) modelling techniques called weight of evidence. In this study the weight of evidence method was used to establish the spatial relationship between known mineral deposits and evidential maps resulting from geological, geochemical, geophysical and remote sensing exploration datasets.

Thereafter the model was used to combine the evidential maps to create mineral prospectivity maps within the study area. From the exploration data sets, four (4) binary evidential maps; geochemical, lithological map, structural lineaments and magnetic zonal anomaly including a training sites layer of 64 mineral occurrences were generated and integrated to produce mineral prospectivity map. Results of this study indicate; mafic and metamorphosed mafic rocks intruded by granitic rocks, geochemical gold anomaly, proximity to faults and high magnetic anomaly were the primary

geological features that control gold mineralization. These geological features were taken as predictor patterns in the creation of binary evidential maps. Based on the model results, the study area was classified into 5 classes, ranked from high to low potential for gold occurrences. Areas in red indicate those that have the highest probability or favorability values, yellow patterns indicate high favorability values, green indicate medium favorability values, blue indicate low favorability values and areas in grey indicate those with the lowest favorability values. The highest favourable areas have the best gold potentials based on the presence of predictor patterns from all the four evidential maps. The model was evaluated and validated of which the results have revealed that prediction of results with the use of weight of evidence model is successful and useful to predict gold occurrences in the study area.

STRATEGIES IN CREATING CONDUCIVE INVESTMENT ENVIRONMENT IN EXTRACTIVE INDUSTRY

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This article focuses on what a particular jurisdiction needs to do, to have a vibrant and sustainable mineral and mining industry. In other words they just said could also be equated to saying why some nations do better than others in making the mining industry thrive. It is not just having better geology. Other inputs such as appropriate policy-framework, overall tax take reflected in fiscal regime, ability to attract investment capital, skilled pool, and good infrastructure are part of the equation. Tanzania is fortunate to have geology and tectonic setting that harbours resources for precious metals (gold, silver and platinum group metals), base metals in particular copper, nickel, lead and zinc; ferrous metals (in particular iron ore), fossil fuel (coal), precious stones especially gemstones and diamond; and highly thought industrial minerals at local and abroad. After major macroeconomic reforms of late 1980s followed by adoption of appropriately policy and legal framework in the mining industry in mid-1990s, Tanzania witnessed increased exploration spending from foreign direct investment, which in a span of less than a decade thereafter it witnessed commissioning of about five large scale-gold mining and brought annual production to about 50 tons of gold per annual, compared to less than a ton that was being before then. In the recent past, gold production has declined to just above 40 tons per annum but surprisingly, revenue accrued from it has continued to rise probably due to higher prices of it. Also in the recent past, foreign direct investment in exploration has been sluggish and this is not healthy for the growth of the industry. It is finally concluded that for the mineral and mining industry in Tanzania to continue competing with other nations to attract exploration investment and for it to thrive the current settings need to be reviewed with the view to encourage vigorous exploration.

REMOTE SENSING AIDED GEOLOGICAL AND GEOCHEMICAL INVESTIGATION OF SANGU-IKOLA CARBONATITES, SOUTH-WESTERN TANZANIA

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Carbonatite is a magmatic rock composed mostly of carbonate minerals (more than 50%), usually calcite, dolomite, ankerite, and siderite. The rock is formed through the immiscibility of carbonate-silicate magma and fractional crystallization of carbonate minerals from carbonatite magma, it contains less than 20% SiO2 by weight and is enriched in Rare Earth Elements (REE). Its magma originates from the low-degree partial melting of the mantle and usually appears in the form of isolated batholiths, dykes, intrusions, lava flows and pyroclastic overburdens.

The East African carbonatites are related to extensional episodes of the rifting system, of which significant periods of carbonatite-alkaline intrusions reported are of Late Proterozoic, Cretaceous, and Cenozoic. These carbonatites are found in clusters, which from this study were categorized as the south-western cluster (Ngualla, Mbalizi, Panda Hill, Sangu-Ikola), the eastern-central cluster (Wigu Hill, Maji ya weta, Luhombelo), and the north Tanzania cluster (Oldoinyo Lengai, Hanang, Galapo).

Most of studies on carbonatites in Tanzania have focused on geology, geochronology, petrography, and mineralogy; however, less is documented on the Sangu-Ikola carbonatite. Furthermore, of all these studies aimed to understand conventional characteristics of carbonatites, however, their size and spatial extent are not well known. Thus, this research aims to apply the RS technique and other conventional geological methods to investigate the Sangu-Ikola carbonatites, to understand the spatial extent of the whole Sangu-Ikola carbonatite complex.

So far the reconnaissance fieldwork has been done and the samples collected for geochemistry, geochronology and RS study. The samples collected were

analysed using the Analytical Spectra Device (ASD) for the endmember spectra collection and mineralogical study later processed using the spectral geologist software. RS and the use of associated infrared active minerals have been used to examine the spatial distribution of carbonatites, this was based on their spatial and radiometric characteristics as well as the presence of infrared-active minerals in the carbonatite. The approach is capable in mapping carbonatites and their characteristic features, for example, fenitization zone, syenite plugs and mafic intrusions. The multispectral remote sensed images were pre-processed, then classified based on the collected carbonatite endmembers and finally the delineated spatial extent of the carbonatite in the study area done using ENVI software. The obtained result contributes to understanding geology of the area and will be used for the carbonatite study on similar occurrences.

LONG-WAVE INFRARED (LWIR) SPECTROSCOPY ON FELDSPARS FROM ROCK PLUGS FOR THE DETECTION OF PERMEABLE ZONES IN GEOTHERMAL SYSTEMS

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In geothermal systems, hydrothermal minerals indicate inferred permeability besides being indicative of formation temperature, fluid and host rock composition. Minerals, particularly hydrothermal feldspars; adularia and albite has proven to be useful in the detection of permeable zone within geothermal systems. Mineral spectroscopy is known to be an alternative approach relative to conventional methods in studying mineral alteration including the above-mentioned feldspars. This study explored Long wave Infrared (LWIR) spectroscopy on rock plugs from the Karangahake epithermal Ag-Au system, a fossil equivalent of geothermal systems, as part of the development studies of geothermal systems. The aim was to understand spectral characteristics of feldspars; adularia and other associated hydrothermal minerals, assess the performance of LWIR spectroscopy in mapping feldspar minerals, and establish mineral assemblage that can be used to identify adularia-rich areas for permeability studies in the future.

Various methods were employed for mineral identification and mapping of the LWIR hyperspectral images of 50 rock plugs including wavelength mapping, PCA, SAM and ISMA. The approach used in this study has demonstrated usefulness of these methods as each method provided unique spectral information. Feldspar minerals were characterized by broad spectral features within 8100-10000nm spectral range. The observed spectral differences in wavelength positions and shapes (defined by width, depth and symmetry) of the diagnostic features reflect subtle variability in their mineralogical composition and can be used to distinguish the identified feldspars. The performance of LWIR imaging spectroscopy relative to TIMA and XRD techniques was evaluated based on comparative analysis of the

mineral estimates showing a correlation coefficient of ~0.5. The relatively poor correlation was attributed by insignificant amount of minerals whose spectral features were hardly pronounced, mineral mixtures, differences in modes of data acquisition and spatial resolution. For the mineral mixture pixels, adularia and albite were spectrally and spatially confused with oligoclase and other feldspar minerals. However, emissivity peaks for other minerals in the mineral mixtures such as quartz persisted, therefore could easily be distinguished from feldspars.

Again, the observed inverse relationship between adularia and albite adds up to evidence on adularia to albite ratio, being a potential permeability indicator in geothermal systems. Other identified hydrothermal minerals that commonly occur with adularia were quartz, calcite, albite and pyrite; however, at this point, it is insufficient to establish mineral assemblage for the identification of adularia-rich areas given that LWIR imaging is limited to the identification of LWIR active minerals.

DISTRIBUTION OF MAGMATIC INTRUSIONS AND KEY PETROLEUM SYSTEM ELEMENTS IN THE PANGANI RIFT BASIN, N-E TANZANIA

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This study aimed at assessing the distribution of magmatic intrusions and key petroleum system elements in the Pangani rift basin (PRB), NE Tanzania. Tectonic and geological settings of the PRB are similar and age equivalent to the Albertine and Lokichar basins successions where hydrocarbons have been discovered in Kenya and Uganda, respectively. Development of these basins has been influenced by the Cenozoic extensional tectonics and the associated volcanism. Volcanic activities have significant impact on petroleum potential of the basin due to their influence in source rocks maturation, reservoir modification and formation of localised structural traps. However, sedimentary fills, structural styles and tectono-sedimentary evolution of the Pangani rift basin are not well understood. Therefore, this study involves quantitative and qualitative interpretation of the geophysical datasets, in particular 2D seismic, remote sensing and potential field (magnetic and gravity) data to assess the distribution of magmatic intrusions and key petroleum system elements.

Based on seismic interpretation results, sedimentary successions in the PRB are subdivided into six seismic sections marked by erosive boundaries. These sections were identified based on sedimentary fills geometries, stratal termination patterns, internal seismic characteristics and amplitude characteristics of the bounding reflectors. The identified strata geometries show different episodes of extensional tectonics regimes linked to occurrence of eye shaped features, velocity pull up effect for the reflectors adjacent to the faults that resulted from respective tectonic episodes, and localized

mounds/folds reflected by warping of the rocks. These eye shaped features, velocity pull-up effect and localised mounds are interpreted to represent igneous bodies in the PRB stratigraphy. Distribution and orientation of the identified faults are similar to the Quaternary fault system of the Tanga offshore basin, the fact used to assign tentative ages to the studies successions due to absence of well control in the Pangani rift basin.

Seismic results also show that the Pangani volcanic rocks/deposits become more obvious toward the surface and they increase laterally toward the NW of the study area, the fact that was confirmed by remote sensing results. Based on interpretation of 2D seismic and potential field data, the overall NW-SE major trending direction for the faults dissecting the PRB stratigraphy has been revealed, which agrees to regional structural trends in Tanzania. The identified igneous intrusions conform to locations of these faults, which are interpreted to be the magma conduits. Located Euler deconvolution and spectral depth analysis solutions of depth to the causative bodies of magnetic field give depth range for a basin from 0.25 to 2.5 km and 0.46 to 1.86 km, respectively. However, a maximum sediments thickness of 2.5 km is considered to be most likely due to reliability of the located Euler deconvolution over the spectral depth analysis for the studied successions. Integration of potential fields (gravity and magnetic), remote sensing and seismic interpretation of the Pangani rift basin revealed that tectonics; volcanism and rate of sediments supply were the main factors that controlled basin development. The seismic work facilitated identification of coarse and fine grained deposits based on high and low amplitude seismic reflectors, respectively.

Some of the coarse grained deposits form potential reservoir rocks while the associated fine grained deposits are the potential seals and source rocks in the basin. The localised seismic mounds, which were interpreted to have resulted from magmatic intrusions, and the faults dissecting the PRB stratigraphy form potential petroleum traps in the area. Some of these faults are believed to have formed potential migration pathways for the petroleum generated

from the deep buried source rocks in the PRB. Despite the potential of the associated magmatic activities to destroy reservoir quality and overcook the source intervals, the PRB still has a chance to contain petroleum deposits. The estimated sediment thickness is quite favourable for hydrocarbon potential in the PRB. Further work on a better seismic dataset and improved age control from drilled wells, which were not accessible during the current study, is recommended for the PRB. Detailed outcrop and core logging and thin section analysis may help to quantify the impact of magmatic activities in the PRB reservoir and source rocks quality and maturation respectively.

ASSESSMENT OF ROCK MASS STABILITY AROUND HAULAGE DRIFTS IN UNDERGROUND MINES: A CASE OF NEW LUIKA GOLD MINE IN LUPA GOLDFIELD OF SOUTHWEST TANZANIA

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Stability of underground excavations is of great importance to an operating mine because it ensures the safety of working people and operating facilities as well as successful ore production. The rock mass stability around underground excavations heavily depends on the mechanical behaviour of intact rock and discontinuities, the discontinuity geometry pattern and the in-situ stress system. In addition, the configurations of excavations and rock supports and the mine construction sequences also play essential roles. Due to the complex geological or in-situ conditions and the engineering constructions, the assessment of rock mass stability for an underground mine could be very challenging and difficult.

This thesis presents detailed procedures for the stability assessment and support design for an underground mine case study, that is, from the very beginning of collecting geological and geotechnical information, to the exploration of competent analysis tool to incorporate the most relevant factors and to the final part of discontinuum modelling of underground rock mass stability including the evaluation of applied rock supports.

TANZANIA PETROLEUM DEVELOPMENT CORPORATION LABORATORY SERVICES

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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 delivery of quality services. Currently, the Laboratory is in the certification process for 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 & 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..

THE EVOLUTION OF RUVUMA BASIN AND ITS IMPLICATION TO MNAZI BAY NORTH BLOCK PROSPECTIVITY

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Mnazi Bay North Block, situated in Ruvuma Basin adjacent to Mnazi Bay gas field and offshore Block-1 with potential gas discoveries. The block covers the total area of 254 sq. kms with 3D seismic data coverage of 111sq.kms and few regional 2D seismic data which were used to assess the exploration potential of the block. The basin came into existing due to longitudinal rift following break up of Gondwana land and initiation of continental drift. The rifting produced many horst and graben blocks along the plate boundary. Masasi basement spur is a large horst block and many graben areas formed different sedimentary basins on either side of it.

The initial sediments are derived from immediate horst areas and were deposited by fluvial systems to fill up the available accommodation spaces. The syn-rift marine shale deposited during Mid Jurassic form excellent source rocks which implies the change from fluvial to marine hence transgressive period. The basin subsidence was reduced during Early Cretaceous allows more fluvial deposits which were laid down on NE tilting beds as fluvial system of prograding delta fan deposits. Channel cut and fill features are common in onshore outcrops and in seismic sections. Termination of Early Cretaceous is marked by slump deposits which associated with Listric faulting rollover features and turbidite fans in the outer shelf and slope. Mid Cretaceous to Palaeocene age dominated generally by transgressive marine shale and platform carbonate deposits form excellent source rocks for hydrocarbon generation and covers the unconformity surface which was developed during Early Cretaceous.

Tertiary age is marked by tectonic readjustment and general eastward sag, where thick clastic sediments of Oligocene-Miocene of the Tertiary Ruvuma Delta form the potential reservoir interval were accumulated on narrow shelf

in deltaic environment. Listric growth faults and rollover structures are mapped in Mnazi Bay gas field and Mnazi Bay North which forms the potential primary targets for exploration, these structures also observed in the younger rocks and dominates the whole costal area which may associate with reactivation of older fault by the Tertiary rifting system.

Quaternary age marks development of passive margin by near-shore clastic deposits, carbonate and shoals. It presents a passive margin with moderate subsidence and emphasis of eastward sag and continues dominance of the Ruvuma delta as the main sediments input. The interpretation of the seismic data and outcrop studies of the Ruvuma Basin revealed the exploration potential of the Mnazi Bay North Block. The sequence of events through time show the generation of all elements of petroleum system within the block and the basin in general which provides the new insight of the block as the future investment.

TECTONIC EVOLUTION OF SEAGAP FAULT ZONE: IT'S IMPLICATION TO SEDIMENT DISTRIBUTION IN MAFIA DEEP BASIN

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The Sea Gap Fault (SGF) is a nearly N-S trending Mid-Jurassic sinistral strike slip fault, formed as a result of trans-tensional reactivation of extensional Lower Jurassic fault. The objective of this study is to provide understanding of the tectonic evolution of the SGF and its impact on sediment distribution in the basin. Interpretation of the 3D seismic data set was performed using Petrel software to generate isopach maps and fault planes in order to model sediment distribution through time. Orientation of the main SGF, fault splays (Riedel structures) and geometry of the restraining and releasing bends along the SGF determines orientation of the stress fields ($\partial 1$, $\partial 2$ & $\partial 3$) that caused strike slip deformation at SGF.

Four different fault sets were observed: Mid Jurassic Normal Faults that controlled syn-rift disconnected wedge-shaped sediment packages, NNW/N trending SGF that controlled deposition of localized sediment packages along the fault within releasing bend areas, NW-trending Riedel structures that join the SGF at an acute angle and the Upper Cretaceous/Paleogene Trans-tensional faults with flower structures on sea bed. The SGF was reactivated at different deformation phases in Mid Jurassic and Paleogene with effect on sediment distribution along, within and away from the SGF. The study confirms that the SGF controls sediment distribution in the Mafia basin.

PALEOSTRESS INVESTIGATION ALONG THE NW-SE PANGANI RIFT, NORTHERN TANZANIA

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The East African Rift System (EARS) at the North Tanzania Divergence is made up of three rift segments namely, the N-S trending Natron-Manyara-Dodoma rift, the NE-SW Eyasi-Manonga-Wembere rift and the NW-SE trending Pangani rift. Various geological studies including paleostress stress analysis have been conducted on the N-S Manyara- Dodoma rift segment leaving the two rifts (i.e. Eyasi and Pangani) unstudied.

This study is an attempt to study the Pangani rift in order to be able to describe its fault kinematics and stress field dynamics through establishment of stress tensor (s). We use the Win-Tensor software developed by Damien Delvaux in order to process the fault slip data from the field that actually estimates the principal stress axes, models the stress regime through establishment of stress regime indexes, and corresponding parameters such as maximum and minimum principal stress axes, etc. We compare the obtained results with the regional geological data and make interpretation in the context of the whole EARS dynamics.

Results show that the NW-SE trending Pangani rift is currently under compression (i.e. Strike-slip compressive regime, define by R=0.18; R'=2.18 and with maximum horizontal compression (SH_{max}=138) defined by the principal stress axes σ1=03/138; σ2= 18/229 and σ3=72/039. Most of the faults in the area portray sinistral sense of movement. Apart from this compressive regime, there is little opening perpendicular to SH_{max} defined by Sh_{min}= 048. Field investigation show that the faults through which measurements were taken are reactivating older structures, mainly the NW-SE trending Neo Proterozoic Mozambique structures, which, from σ-shear

clasts indicate Precambrian sinistral sense of movement at low-angles faults (preliminarily approximately 42˚ due NE).

CAPACITY BUILDING IN MINERAL SUPPLY CHAIN VALUE: CRITICAL RECIPE IN ADVANCING THE MINERALS INDUSTRY IN TANZANIA

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In the recent past, junior companies could raise funds from public (shareholders) and individuals with clear understanding of the business of mineral exploration, development and production. They could spend money wisely, conduct systematic exploration and upgrade projects to different confidence levels (i.e. Exploration Target, Inferred, Indicated, Measured Resource categories). During this value addition process, decision making would take place based on available technical-economic data, on whether to sell, joint venture, or walk away from the project basing on the geological attractiveness, economic viability and availability of funding for exploration. Therefore, the success of the mineral industry in Tanzania as is seen today is a combination of government initiatives, vibrant junior exploration companies and financial institutions aware of how the minerals industries operate.

When the mining industry was hit by a fall in industrial demand for minerals following the 2008 economic crisis, commodities and metal prices collapsed spectacularly losing nearly 50%. Following the period leading to 2015, financing of the junior exploration companies declined significantly, causing the average market capitalization to go down to -51.2%, and the money raised in equity and debt markets for exploration to go down to -33.4%. Caught up in the middle of funding complications, junior exploration companies, majority from South Africa, the UK, Canada and Western Australia, slowed-down, suspended and others left projects, altogether. The gap left by these junior exploration companies in Tanzania, could not be filled immediately by domestic exploration and/or mining companies. Instead, the small-scale mining industry, recognized and took advantage of

the gap and partially filled it by engaging in semi-mechanized small- to medium-scale mining and re-processing of tailings by VAT-leach and CIP techniques. Actually, that gap has never been fully filled. This is because there has still not been any local junior exploration company capable of sourcing funds be it from local or foreign banks/financial institution for exploration. This is despite existence of projects with attractive geology and mineral endowment, infrastructure and human capital with a wealth of knowledge and experience. Equally, on the same negative side, there has been lack of local financial institutions/banks willing to finance exploration projects in any form or structure.

For these initiatives to be successful, only capacity building programs involving stakeholders such as: 1) geoscientists, engineers, surveyors and associated professionals; 2) government agencies; 3) banks and/or financial institutions, can re-adjust the minerals industry. These programs will include tailor-made short-courses and workshops for scientists and non-scientists directly and indirectly involved the minerals supply value chain. Topics ranging from the geology of strategic mineral deposits, mineral endowment, mining, project evaluation/valuation (exploration, development and operational mineral assets), Mining law and the Commercial arrangements associated with mining including project financing decision (equity and/or debt) and their link to investment in the minerals sector. Other topics such as how conduct due diligence on financial valuations of mineral assets (exploration (feasibility study), development and operating submitted by foreign and/or domestic owners applying for funding. Funding may be either of: 1) start-up capital expenditure; 2) operating costs; 3) sustaining capital expenditure.

ASSESSMENT OF SLOPE STABILITY OF THE PHASE II EMBANKMENT OF THE TAILING DAM AT MMG GOLD MINE

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Extending the storage capacity of the tailing dam for a mining company involves the expansion and increase in height of the tailing dam. In the design and construction of the embankment issues of slope instability, increase in phreatic line and seepage may pose serious threat to the environment and economic loss if the immediate actions are not taken into account. This project presents a slope stability analysis of a tailing dam embankments and seepage analysis using the software SLIDE, and suggesting the remedial measures to eliminate or reduce seepage problem at MMG gold mine Musoma-Mara.

In order to simulate the performance of the tailing facility accurately engineering geological properties of the soil exposed in the study area were determined based on field observations or measurements and laboratory tests. The description of soil material characteristics was based on the British Standard methods (BS). Core samples were collected from the field for laboratory testing such as permeability and uniaxial compressive strength (UCS). All the data collected from the field and those from the laboratory, aims to enquire data for analysing the fact and the recommendation of the facility safety.

Analysis was based on limit equilibrium methods compare to factor of safety obtained from various load combination. The results show that new embankment increased can lead to seepage problem especially at the vicinity of the dam foundation and at the course of the second rise. Thereby the company should install the drainage system and establish trenches around the dam to capture all the seepage water.

ISOTOPIC AND GEOCHEMICAL CONSTRAINTS ON THE PROTOLITH, REDOX STATE AND PALEO-TECTONIC SETTING OF THE MALAGARASI SUPERGROUP OF NORTH-WESTERN TANZANIA: NORTHWARDS FLOW OF THE PROTO-CONGO RIVER IN THE RODINIA REALM

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We report detrital zircon U-Pb ages, radiogenic Sm-Nd isotopic compositions, major and trace element compositions of the intra-plate extensional rhomb-shaped Neoproterozoic Malagarasi Supergroup of north-western Tanzania in order to elucidate the paleo-tectonic setting, source rocks chemistry and paleo-oxygenation in the basin. Assuming that provenance trace element proxy ratios, including the rare earth elements (REE) contents, behave as closed systems during sedimentation and diagenesis, we suggest that the detritus for the basin originated from more felsic rocks than those for upper crustal composites (i.e. Post-Archean Australian Shale; PAAS, Proterozoic Shale; PS). This observation is also supported by enriched chondrite-normalized light REE (La/Sm_{CN} = 2.36-7.84; mean = 3.85), overall negative Eu anomalies (Eu/Eu^* = 0.56-0.93; mean = 0.69) and flat heavy REE patterns (Gd/Yb_{CN} = 1.01-2.04; mean = 1.47). Paleo-weathering proxies using the Chemical Index of Alteration (CIA ~59-78%) protocol indicate an overall moderate weathering intensity in the basin. V/Cr ratios (mean = 1.18; range = 0.48-1.69) coupled with intra-sample Ce anomalies reveal an overall oxidizing state during deposition. Mantle extraction ages (TDM = 1594-2394 Ma) suggest a diverse mixing of protolith terranes including Archean (Tanzania Craton), Eburnian (Ubendian Belt) and possibly the nearby Mesoproterozoic Kibaran Belt. Radiogenic laser ablation detrital zircon U-Pb ages of between 1826 to 2656 Ma may preclude contribution from the Kibaran. Given that Nd systematics in sedimentary rocks provide mixing ages of different hinterland source rocks

(1594 - 2394 Ma; in our study), we suggest relatively juvenile sources such as the local post-orogenic effusive bodies farther south of the basin in the realm of Rodinia Supercontinent. Thus a northerly flow direction of the proto/paleo river system in the region is inferred.

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