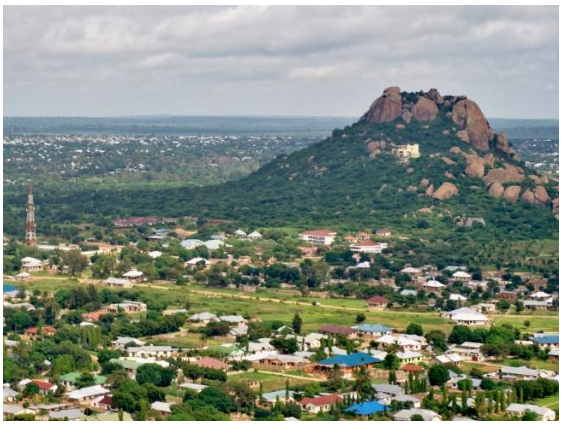
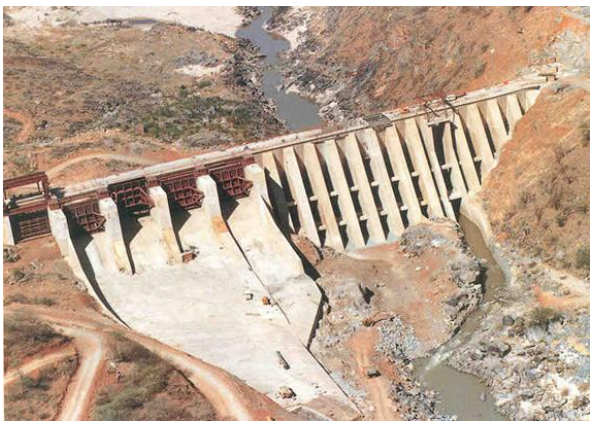
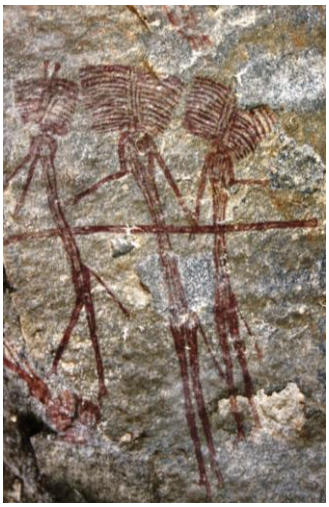
TANZANIA GEOLOGICAL SOCIETY (TGS)

2018 ANNUAL MEETING AND WORKSHOP

BOOK OF ABSTRACTS



DODOMA

27th September to 2nd October 2018

Front cover photos:

Top Left: *Dodoma City - the national capital of the United Republic of Tanzania (**Picture source:** https://www.tripindigo.com/blog/things-to-do-in-dodoma/). The name Dodoma literally means "It has sunk" in Gogo, one of the languages spoken in Dodoma;* ***Top Right:*** *Mtera Dam – hydroelectric dam located midway between Iringa and Dodoma regions on the border between the Iringa Region and the Dodoma Region. It measures 660 square kilometers and is feed by the Great Ruaha River and the Kisigo River;* ***Bottom left:*** *Mwl. Julius Kambarage Nyerere's statue in Nyerere Square Dodoma; and* ***Bottom right:*** *The Kondoa Irangi Rock Paintings one of the series of ancient paintings on rock shelter walls in central Tanzania, recognized as one of the UNESCO World Heritage sites.*

Message to Participants of the TGS 2018 Workshop

Dear Participants,

Welcome to the Tanzania Geological Society (TGS) 2018 annual geoscientific workshop and meeting to be held here in the Dodoma city from 27th of September 2018 to 2nd of October 2018. The event is anticipated to provide a timely opportunity to bring together geoscience stakeholders including members of the industry, academia, policy makers and related agencies from all over the country and beyond.

For this TGS colloquium, we received over 50 Abstracts, all converging to this year's main theme "***The role of geoscientists in the Tanzania Industrial Development***". The received abstracts are subdivided into 8 sub-themes as narrated below:

1. Energy for industrial development
2. Small scale mining in Tanzania
3. Legal and regulatory framework in the Tanzania's mining sector
4. New updates in the geology of Tanzania
5. Mine waste and water management
6. Geo-tourism and geo-ethics for industrial sustainability
7. Environmental management and conservation in extractive industry
8. Entrepreneurship and innovation in the extractive industry

Workshop organizers have designed the flow of presentations in a rather simplistic style to make sure that the agenda carried by the abstracts and presentations are articulated and understood by the geoscientists and the wider public present here and beyond. The workshop provides a platform for informed discussions on different issues encompassing the extractive industry, academia, health-safety, geo-tourism and the environment.

The sub-themes are designed to cover a wider range of contemporary geological issues, including the newly established Tanzania's legal and regulatory framework, entrepreneurship and innovation in the industry and new updates in the geology of Tanzania. The topics presented under the

sub-themes are not only familiar to the mainstream geoscientists but even to the general community. During the event, besides the oral presentations, there will be a session for poster presentations so as to provide an opportunity for a range of geoscientists to share and exhibit their works. A continuous research and a better understanding of the geology of our country and the continent at large represent an important input for improving socio-economic and sustainable development.

The success of this TGS workshop depended completely on shear efforts and commitment of TGS members and all stakeholders. The Tanzania Geological Society is grateful for the meeting and workshop secretariat and committees for their time invested in making this annual event success. Reviewers have done a great job in assessing multiple abstracts and selecting ones fitting for this year workshop.

With the high patronage of Helium One Ltd and the Department of Geology of the University of Dar es Salaam, the organizers received support from the following institutions and companies: Geological Survey of Tanzania, Tanzania Bureau of Standards, Pan African Energy, Petra Diamonds, TANESCO, and Ministry of Energy. TGS is hugely indebted for their continued support. TGS also acknowledges contributions by the Ministry of Minerals and the Ministry of Entrepreneurship and Innovation in the extractive industry.

Finally, TGS welcomes you to Dodoma, the capital city of Tanzania and the destination for best grapes and wines in the country. We hope that you will take advantage of the many sights to see in the region, as well as the many interesting historical and natural features that are nearby '*in-situ*' during your stay.

Workshop Organizing Committee

Tanzania Geological Society (TGS)

Organising Committee

Sub-Committee	Members
Workshop secretariat	Dr. Elisante Mshiu Mr. Chone Lugangizya Dr. Emmanuel Kazimoto Mr. Nyora Kobare Mr. Ernest Mulaya
Editorial committee	Dr. Emmanuel Kazimoto Dr. Kasanzu Charles Dr. Cassy Mtelela
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Helium One Ltd is dedicated to the exploration and development of primary helium projects in the United Republic of Tanzania. Helium was readily available until 2013, when the world's only large-scale primary helium reserve (USA Federal Helium Reserve) began to ration output, and whose final helium sale was this year. Since 2013, there have been several global helium shortages and the requirement for new deposits has become imperative. Helium One is focused on large-scale primary helium sources, where production is not secondary to another commodity and can bring stability to global supply. In 2015, Helium One identified that Tanzania has the necessary geology for large-volume, high-concentration helium occurrences – and became the World's first dedicated helium explorer. Since its inception, Helium One has, with its consultants, defined a prospective (P50) recoverable helium resource of 98.9 billion cubic feet at the Rukwa Project. This is the World's largest known primary helium prospective resource, and it is now the Company's intention to progress it toward reserves, and production. Geologically, helium originates from the radiogenic decay of uranium and thorium within granite or metamorphosed basement rock, the gas then migrates through fractures and becomes trapped in geological structures. It is Tanzania's unique geological setting that includes source rock (Tanzanian Craton), the East African Rift, and associated sedimentary basins that makes the country so prospective for helium. In partnership with the government and local industry, Helium One has the team required to unlock the potential of Tanzania's helium.

In Memoriam

Dr. Pascal Semkiwa (*Dr. rer. nat.*)

(1952 – 2016)

This book of abstracts represents homage to Dr. rer. nat. Paschal Semkiwa by his contributions to geosciences. A token of appreciation is also extended for his singular endeavours to the coal geology of Tanzania.

Dr. Pascal Semkiwa dedicated much of his time to research and development of earth sciences in the country and beyond. He made an impact that will live for generations to come.

May he rest in eternal peace and his family find solace in his memory.

Editorial Team

Dr. Emmanuel O. Kazimoto
Department of Geology, University of Dar es Salaam
Igneous and metamorphic petrologist & Economic geologist;
MSc Geology, University of Dar es Salaam,
PhD in Mineralogy and Petrology, CAU Germany.

Dr. Kasanzu H. Charles
Department of Geology, University of Dar es Salaam
Geochemist & Sedimentary petrologist;
MSc Geology, University of Dar es Salaam,
PhD in Thermochronology, UCT South Africa.

Dr. Cassy Mtelela
Department of Geology, University of Dar es Salaam
Sedimentary geologist;
MSc Geology, University of Dar es Salaam,
PhD in Sedimentology & Stratigraphy, JCU Australia.

TGS 2018 Workshop Abstract Titles

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Workshop Programme

DAY 1 (27-09-2018) OPENING

08:00 - 09:00	Arrival and Registration	
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09:10 - 09:15	Greetings from the Silver sponsor (Helium One)	
09:15 - 09:45	Chairman, TGS: TGS speech, and to welcome Ministers	
09:45 - 10:05		
10:00 - 10:05	Chairman, TGS: to welcome Minister of Minerals	
10:05 - 10:35	Minister of Minerals, and to welcome Guest of Honor	
10:35 - 11:30	Guest of Honor	
11:30 - 11:40	Photo session	
11:40 - 12.00	HEALTH BREAK	
12:00 - 12:30	**Keynote speaker**: Dr. Yohana Mtoni **Title**: Environmental management in Tanzania: mining for sustainable development	
12:30 - 13:30	LUNCH BREAK	
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	Chone Malembo	Geology and architecture of the Onshore Ruvuma Basin of Tanzania
	Ibrahim Lufyagila	Geophysical (gravity and magnetic) investigation of the subsurface structures of the Ruhuhu Basin, southwestern Tanzania
	Chonge Shekarata	Structural interpretation of 2D seismic profiles in the northern part of East Pande Block, Southern Coast of Tanzania
	Juma Mheluka	Petrophysical analysis of the Mpera well in the exploration Block 7, Offshore Tanzania: implication on hydrocarbon reservoir rock potential
	Emanuel Augustino	Geochemical characterization of hydrocarbon source rocks in the Mandawa Basin of Southern Coastal Tanzania: Its implication in petroleum generation potential
	S. P. Sanga R. Mlangwa	Assessment of physicochemical attributes of water and toxic metal contents of sediments and soils from the Kizinga River, Dar Es Salaam Tanzania
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DAY 2 (28-09-2018)

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11:50 - 12:15	Dr Cassy Mtelela	Sedimentology and lithostratigraphic overview of the newly identified Middle Lake Beds Unit in the Rukwa Rift Basin, Tanzania
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Time	**Presenter**	**Title**
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14:35 - 15:00	Adonias Mkangala	Geothermal Energy for Industrial Development in Tanzania: case study of Songwe Geothermal prospect
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09:50 - 10:15	Ernest Mulaya	Diagenesis and reservoir modelling of Rukwa Rift Basin in the south-western Tanzania: implication for helium potential
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11:00 - 11:25	Gerald Chuwa	Exploration in difficult terrains- the good, bad and ugly realities in the mineral resources business: the case of eastern Democratic Republic of the Congo
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14:10 - 14:35	Martha Kamuzora	The Role and Practice of Geologists in Environment Management in the Tanzanian Extractive Sector
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Time	**Presenter**	**Title**
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11:00 - 10:25	Johnmacdona P. M. Labia	Structural and stratigraphic interpretation of seismic data of southern East Pande Exploration Block and its association to the Petroleum Systems, southern coastal Tanzania
11:25 - 11:50	John Gama	Geochemical characterization of oil seeps in the Coastal Sedimentary Basins of Tanzania: implications of different oil families
11:50 - 12:15	Gerald Simon Manyara	Fueling the scientific knowledge for the Industrial Development
12:15 - 12:40	Dr Joas Kabete	An industry-academia-government collaboration model for precompetitive scientific targeting
12:40 -	Ester Njiwa	
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18:00 - onwards	**WORKSHOP DINNER** Venue: **MORENA HOTEL**	

ENVIRONMENTAL MANAGEMENT IN TANZANIA: MINING FOR SUSTAINABLE DEVELOPMENT

Yohana E. Mtoni

National Environment Management Council, P.O. Box 63154, Dar es Salaam
** ymtoni@hotmail.com*

Mining activities cause both positive and negative impacts across environmental, social, and economic boundaries. Tanzania is a well-endowed country in terms of minerals and other resources and wishes to optimise both economic growth and environmental protection. In 2004, the government introduced the Environmental Management Act (EMA) CAP. 191 to regulate the environment aiming at sustainable development. The main procedures to obtain a permit to perform an activity which is likely to cause significant environmental destruction are expressed in EMA and the Environmental Impact Assessment (EIA) conduct and Audit Regulations of 2005. Mining as a resource extractive industry is covered by the EIA process. Proponents of mining projects prepare an Environmental Impact Statement (EIS), which, after review by a Technical Advisory Committee (TAC), stakeholder consultations, and other processes, EIA Certificate is issued by the Minister responsible for the Environment.

Mining activities generates essential goods and services, provides employment opportunities, and is a source of wealth for companies, institutional and private investors and for government through the collection of taxes, royalties and levies. On the other side, the negative contribution of mining occur partly due the fact that many types of mining activity have had a severe and lasting effect on the natural and social environment. Some of these include topographic changes, vegetation and soil removal, change in fauna habitat conditions, and contamination of soil, groundwater, and surface water by chemicals from mining processes. Early assessment and planning are crucial to enhance the likelihood that alternatives and measures to environmental risks can be properly managed. The EIA process which inludes the Environmental Management Plan (EMP) helps to avoid, remove and/or reduce detrimental effect. It provides opportunity to improve environmental management through participatory approach and facilitates the involvement of relevant key stakeholders, including members of

indigenous communities, from scoping and review to monitoring of operations and closure. The EIA Certificate is attached with the “General and Specific Conditions” that must be adhered to by the Developer. Regular monitoring and inspection are carried out to ensure that the specified conditions are followed.

UPDATES ON THE GEOLOGY OF TANZANIA: THE CONTRIBUTION OF NEW MINERAL DEPOSIT DISCOVERIES TO INDUSTRIALIZATION

Shukrani Manya

Mining Commission of Tanzania, P.O. Box 2292, Dodoma, Tanzania
shukrani73@yahoo.com

The geology of Tanzania is predominantly comprised of the Precambrian rocks including the Archaean cratonic rocks in the central part (extending from Dodoma to Lake Victoria) and are surrounded by Paleo- to Neo-Proterozoic mobile belts made of sedimentary covers and metamorphic terranes. The Phanerozoic sedimentary basin, which includes the coal-bearing Karoo and the Mesozoic–Cenozoic sedimentary basins of eastern Tanzania, forms an important component of the geology of Tanzania as well as the East African Rift-related Neogene volcanic rocks of northern and southern Tanzania.

The Precambrian terranes of Tanzania are traditionally known for their abundance of metallic deposits including gold, silver, copper from the cratonic rocks and Pretorozoic belts; diamonds from the kimberlitic rocks within the craton; PGM, nickel, tin, iron and titanium from the Proetrozic rocks of western Tanzania and variety of gemstones (spinel, ruby, tanzanite, sapphires) from the Pan-African Mozambique Belt. New mineral deposit discoveries which are likely to play significant contribution in the industrialization of the country includes graphite deposits found in Proterozoic terranes in northern Tanzania (Mirerani), and southern Tanzania (Mahenge-Morogoro, Ruangwa – Lindi and Mtwara). Graphite (and lithium) is the major ingredient in batteries used for electric vehicles; an emerging technology within the car making industry.

Another recent discovery is the carbonatite-hosted Panda Hill Niobium deposit as well as the Ngualla Rare Earth Elements (REE, Nd and Pr). The beneficiation of the Panda Hill Nb will produce ferroniobium, an important alloy in high-strength low-alloy (HSLA) steel with best anti-corrosive properties. The REE finds its important use in a range of modern technology applications including electric vehicles.

With its long coastal plain from Tanga to Mtwara, Tanzania has an abundance of Heavy Mineral Sands deposits; important sources of zirconium, titanium, rutile, luocoxene and ilmenite which are used as pigments in paints and abrasives. Recent exploration has led to discoveries of large deposits and mining licences have been granted for exploitation of the HMS in Kimbiji (Dar es Salaam) and Mkuranga (Coast Region).

These mineral discoveries, along with abundant industrial minerals (e.g. kaolin, magnesite, talc, feldspar, mica, gypsum) found in various places in Tanzania places the country as important supplier (and user) of raw materials needed for modern technology and traditional industries.

THE MINZWEL GOLD DEPOSIT, TANZANIA: DISCOVERY, GEOLOGIC SETTING, AND CONTROLS ON MINERALIZATION

Sebastian Ndile
North Mara Mines
sebastian.ndile@gmail.com

The Minzwel gold deposit was discovered in October 2006 as results of AC-drill testing, where a 20 ppb anomaly occurred in a granite host rock, with peak 50 ppb gold soil-anomaly. Prior to this discovery, granites were considered not prospective for gold mineralization in the Archaean Tanzania Craton. The Au geochemical anomaly, which was related to the high value of Cr and Ni, indicated the presence of greenstone terrain in subsurface and the surface expression of the ore body. The deposit occurs within the inlier of eastern part of Rwamagaza Greenstone Belt, 20 km east of Buckreef deposit, and 50 km west of Bulyanhulu gold mine. Neither previous artisanal activities nor gold explorers in the recent times were documented in the area; however, the ore body became apparent along strike to Aureole historical mine 15 km to the southeast.

The Iamgold Tanzania Ltd had a joint venture arrangement with local partner in between 2006 and 2009, and had since then embarked with drilling campaign within the Minzwel-Busolwa trend. Detailed drilling on close-spaced drill pattern on the Minzwel-Busolwa area showed a strong mineralized system, with a strike length of more than 500 metres. The deposit was tested with 5,141 metres of RC drilling in 78 holes, and 176 metres of diamond drilling in two holes, resulting in inferred resource of 86,000 ounces at an average grade of 2.8 g/t of Au. The geology of the Minzwel Au deposit was constrained via a combination of geochemical survey, geophysics and surface (outcrop) geologic mapping. The results revealed that the Minzwel Au deposits is dominated by greenstone terrain, comprised of mainly high-magnesian (komatiitic) basalts, intercalated with ultramafic units and porphyry intrusive at the contact to different batholithic granite.

GEOLOGY AND MINERALIZATION OVERVIEW OF THE KIBARAN BELT OF CENTRAL AFRICA TOWARDS A MULTIFACETED EXPLORATION MODEL FOR GOLD, TIN, TANTALUM AND TUNGSTEN MINERALIZATION

Gerald Chuwa
gerald7chuwa@gmail.com

The important characteristics of the gold, tin, tungsten, tantalum and base metal deposits in the Kibaran Belt of central Africa are reviewed. The Kibaran Belt is an intracratonic Mesoproterozoic mobile belt located between the Tanzania, Bangweulu and Congo Cratons. It is one of the broadly synchronous Proterozoic mobile belts. Other mobile belts include Irumide and Lurio, which are located further south in Zambia and Mozambique.

In this review, the factors that can lead to a successful exploration, project definition and exploitation of deposits, similar to those in the Kibaran Belt are discussed. The results of which are capsulated into a multifaceted exploration model. These factors include: establishing earlier on the key economic drivers of value for the project; constraining geological characteristics in the regional, local and 3-dimension scales; understanding implications of the geology to exploration and exploitation; determining earlier on the geochemical and geophysical characteristics of the deposit; defining all geological and geotechnical risks on the project; establishing ore controls on the deposit and define high grade shoots; understanding key supply-demand cycles of commodities and their implications; establishing strike, down-plunge, parallel and potentials secondary resources in alluvials/regoliths to sustain and add to profitability of the operation; and having a solid strategy to deal and di-risk social, political and logistical challenges to the project.

The Kibaran Belt is known well known for hosting tin, tungsten, gold, tantalum, base metals and uranium deposits. This review focuses in selected deposits of gold, tin and tungsten located in the Democratic Republic of the Congo and Rwanda. The deposits includes: Manono Project, located in Katanga Province; Bisie Tin Mine located in Walikale area, North Kivu Province; Twangiza Gold mine in South Kivu, and the Gatumba tin and

tungsten fields in western Rwanda. In addition, the Kabanga Nickel project located in northwestern Tanzania is briefly discussed. The multiple perspective exploration models for these deposits will likely assist in the planning and execution of similar projects elsewhere in the Kibaran Belt and in similar terrains worldwide.

In Tanzania, the multifaceted exploration model would be applicable in the northwestern part of the country, where Kibaran belt borders the Tanzania Craton. As a solid basis for exploring the wider region underlain by Mesoproterozoic aged rocks the exploration model contributes to the quest of developing viable projects and is especially important in aiding the local and national wide developmental goals through the discovery of potential new minerals wealth and their prudent exploitation.

GEOLOGICAL STRUCTURES OF SEDIMENTARY BASINS OF COASTAL TANZANIA BASED ON SATELLITE GRAVITY DATA

Isaac M. Marobhe

University of Dar es Salaam, Department of Geology, P.O. Box 35052, Dar es Salaam
muneji.marobhe316@gmail.com

This study is based on the interpretation of Bouguer anomalies from the worldwide satellite gravity data released in 2014. The data, covering coastal Tanzania and zone of territorial waters, was downloaded and processed to produce Bouguer anomaly. The original data has been filtered to enhance medium- to long-wavelength regional anomalies. The satellite gravity Bouguer-anomaly map reveals geological structures such as grabens and uplifted blocks. The graben anomalies trends NE-SW, E-W and few others trending NNW-SSE direction, and defines the known sedimentary basins. In the north, the major structures are Ruvu and Tanga faults that define the Ruvu basin, forming a negative Bouguer anomaly that trends NE-SW, the Dar Es Salaam platform in-line with Unguja and Pemba islands form distinct gravity highs, the Kimbiji-Mafia graben trending NE-SW, the Mandawa basin NNW-SSE, the Lukuledi and Ruvuma grabens trending ENE-WSW. The data also reveal that the area from Mafia to Mtwara is characterized by gravity highs trending in N-S direction, bounded by a strong gravity low in the offshore area. Most of the gas discoveries lie on the gravity highs that include Songo Songo, Mnazi Bay and recent offshore discoveries. Most of the amplitudes of Bouguer anomalies are quite moderate, which is attributed to low density contrasts, and presence of limestone deposits that have relatively high density compared to the crustal density.

GEOTECTONICS OF THE UBENDIAN-USAGARAN BELT: NEW THINKING

Nelson Boniface

University of Dar es Salaam, Department of Geology, P.O. Box 35052, Dar es Salaam
nelson.boniface@udsm.ac.tz

Review of petrological and geochronological data from Tanzania and northern Mozambique indicate that the Orosirian Ubendian-Usagaran Belt was reworked by subduction- and collision related tectono-magmatic events during the Ediacaran to Cambrian (600 and 500 Ma). The Neoproterozoic tectonics of the Ubendian-Usagaran Belt poses a question to when did rift and formation of Neoproterozoic ocean basins that subducted between 590 and 500 Ma occur?

Petrological and geochronological data from Tanzania and northern Mozambique indicate that Ediacaran to Cambrian (600 and 500 Ma) subduction and collision events resulted to the reworking of the southern and eastern margins of the Tanzania Craton, the Orosirian Ubendian - Usagaran Belt, and the Cryogenian Mozambique Belt. The distribution of the 600 - 500 Ma tectono-magmatic events in Tanzania and Mozambique connect to define a regional subduction and collisional event termed as the Ufipa Orogeny.

The onset of the Ufipa Orogeny was about 590 Ma when the subduction started in northern Ubendian Belt to close the oceans that rifted and opened between 1340 and 655 Ma. Following the subduction, a major collisional event occurred between the Tanzania Craton and the Bangweulu Block between 570 and 550 Ma and the final accretion due to subduction was about 500 Ma in southern Ubendian Belt.

Geochronological data indicate that the Ufipa Orogeny occurred concomitantly with Kuunga Orogeny between 600 and 500 Ma, which implies that the Bangweulu Block collided with the Tanzania Craton along the Ubendian Belt (Ufipa Orogeny) in the north, and during the same time, the Bangweulu Block collided with the Zimbabwe-Kalahari Craton along the Damara-Lufilian-Zambezi (Kuunga Orogeny) Belt in the south.

MINERAL PROSPECTIVELY MAPPING A CASE STUDY IN SOUTH WESTERN UGANDA

Maruvuko. E. Msechu
Geological Survey of Tanzania (GST), P.O. Box 903 Dodoma
msechu@hotmail.com

Accurate prediction of potential zones for the occurrence of new mineral deposits requires an understanding of controls of mineral deposits, which are normally geological processes that were active during formation and preservation of the deposits. Quartz-vein hosted gold mineralization, typical of orogenic gold deposit type, occurs in the south-western part of Uganda, in which the study area lies. Geologically, it is characterized by deformed and metamorphosed lithologies of the Karagwe Ankole Belt (KAB), predominantly biotite gneisses, amphibolites, intebedded schist, metasediments, granites and mafic volcanics.

In order to understand geological processes that are conceived to control mineralization, airborne magnetic and radiometric methods were employed. In addition, digital elevation model (DEM) outlined several surficial deformation features that were used to infer structural conduits related to transportation and preservations of gold bearing fluids. Interpretations of these structural features were to some extent supported by the presence of existing ground structural measurements. Otherwise, standard procedures used to interpret magnetic and radiometric datasets were used.

The results of this study show that the indicative geological processes that control mineralization include: 1) age of mineralization (Neoproterozoic) 2), proximity to NW-trending faults/shear zones 3) proximity to NE-trending faults/shear and 4) proximity to anticlines. On the other hand, the results of the analyses of magnetic and radiometric datasets were further used to study and understand lithological variations of existing lithological units. Contrasts within the magnetic dataset are related to either variations within similar/different lithological units or major structural sutures. This understanding led to the identification of new deformation zones and lithological units and subsequently added value to the geological map of the area.

A TEST OF GEOLOGICAL CONTROLS OF COAL SEAM GAS PRODUCTION DOMAINS IN THE MORANBAH GAS PROJECT, BOWEN BASIN

Brycson B. Ruyobya
University of Queensland
bryson104@geologist.com

Targeting a good 'Coal Seam Gas' (CSG) reservoir is sometimes a chase of synergistic influences of geology and reservoir conditions. Geological features such as faults, coal properties, interburden thickness and depth of burial influence reservoir behaviours; as such, they cause changes in fluids dynamics and permeability hence affect gas adsorption/desorption, saturation and generation patterns which can be decoded in the chemical and isotopic signatures of the fluids.

This study analyses chemical and stable isotope compositions of gas and co-produced waters from 13 CSG wells and examines additional data from 24 historical wells from the Monranbah Gas Project (MGP) of the Bowen Basin. The results are correlated to geological features such as the central fault, which separates north and south side of the reservoir, seam type, and depth of burial in order to establish a dominant geological control over gas production and generation pathway.

The results from gas isotope analysis showed that most good production wells produce gas from mixed sources, and are located north of the central normal fault, mainly in the Gonyella Middle (GM) seam and deeper than 300m. Further results from fractionation analysis of hydrogen from H_2O to hydrogen from CH_4 demonstrated that a large proportion of the mixed gases observed in gas isotope analysis have been affected by methanogenesis, which indicates overall dominance of biogenic sources. Water isotope and sodicity analysis results also showed that the central fault is an effective barrier to fluid movement between north and south of the reservoir and has a more pronounced influence on gas generation, retention and production behaviours in the reservoir than seam type and depth.

The impermeable central fault barricades fluid flow from north to south as such, it restricts meteoric ingress to the south and hence limits the degree of secondary methanogenesis. Parallel orientation of structures (cleats and

joints) to the regional horizontal stress direction enhances the permeability and gas desorption during production. Coal properties (thickness, brightness and low ash GM seam) provided a favourable organic matrix, which encouraged more gas generation, adsorption, saturation, permeability and good production.

INFLUENCE OF GEOLOGICAL STRUCTURES ON SLOPE STABILITY OF NORTH WALLS OF NYABIRAMA OPEN PIT

Erick Byemelwa, Keneth Lupogo*

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

** kennlupogo@gmail.com*

The North Mara Gold Mine is located in the tropical and seismically active region of East Africa, near Lake Victoria. Recognition of the potential for slope instability in geologically disturbed, weathered, jointed, sheared and altered rocks of the North Mara mines requires detailed investigation on the nature of the rock masses forming pit walls. Local and overall slope angles for use in pit designs are based on assessment of geological structures, rock strength properties and hydrogeological conditions. Structural geological conditions have the dominant influence on wall stability, hence investigations place strong emphasis on identifying structural discontinuities, particularly defect orientations and shear strengths; as well as rock compressive strengths and hydrogeological conditions of the area. Based on the analysis of field data and laboratory tests, stability of slopes are analysed. Slope analysis is performed using conventional slope methods, assisted by the DIPS and SLIDE computer programs, which are based on Stereographic Projection and Limit Equilibrium methods, respectively.

SEDIMENTOLOGY AND LITHOSTRATIGRAPHIC OVERVIEW OF THE NEWLY IDENTIFIED MIDDLE LAKE BEDS UNIT IN THE RUKWA RIFT BASIN, TANZANIA

Cassy Mtelela

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

cassy.mtelela@gmail.com

This study presents sedimentology and stratigraphic overview of a series of previously unrecognized lithostratigraphic unit in the Rukwa Rift Basin, Tanzania. Based on the cross-cutting relationship and pilot detrital zircon geochronology, these isolated, enigmatic strata are herein informally termed the middle Lake Beds (mLB). Facies analysis reveals that the mLB units were deposited within a complex array of depositional environments, ranging from alluvial to fluvial channels, floodplains and shallow lakes. The mLB are characterised herein as isolated outcrop exposures with uncertain age relationships, but which can be divided into five distinctive lithostratigraphic units herein identified as informal members (A-E). These are: (1) at least 36 m-thick lacustrine (limestone) unit (member A); (2) a thin (< 15 m-thick) volcaniclastics succession of alluvial sandstones, siltstones, mudstones and thin conglomerates (member B); (3) well-sorted siliciclastic fluvial sandstones (member C); (4) tuffaceous/ash-rich siliciclastics fluvial sandstones and conglomerates (member D); and (5) thin lacustrine volcaniclastics siltstone unit, termed member E. Deposition of the mLB was most likely transpired during tectonically active periods, at times contemporaneously with explosive and effusive volcanism associated with the Rungwe Volcanic Province. The identification of the mLB unit provides an important insight into revising the Lake Beds stratigraphy, and establishing a formal nomenclature of this uppermost mega-sequence in the basin.

CHALLENGES AND IMPACT OF RENEWABLE ENERGY (RE)

Roy Namgera
WWF International
rnamgera@wwftz.org

High oil prices, population growth, ever-increasing energy demand, energy security and the threat of climate change have all stimulated investment in the development of alternatives to conventional oil and hydro. “Alternative energy” generally falls into two categories: Substitutes for existing petroleum liquids (ethanol, biodiesel etc.), both from biomass and fossil feedstocks, and lternatives for the generation of electric power, including power-storage technologies. Technology pathways to these alternatives vary widely, from distillation and gasification to bioreactors of algae and high-tech manufacturing of photon absorbing silicon panels. Many are considered “green” or “clean” although some, such as coal-to-liquids and tar sands, are “dirtier” than the petroleum products. Others, such as biofuels, have concomitant environmental impacts that offset potential carbon savings.

Unlike conventional fossil fuels, where nature had stored energy over millions of years inform of energy-dense solids, liquids, and gases requiring only extraction and transportation technologies; alternative energy depends heavily on specially engineered equipment and infrastructure for capture or conversion, making it a high-tech manufacturing process. Alternative energy faces challenge of how to supplant a fossil-fuel-based supply chain with one driven by alternative energy forms themselves, in order to break their reliance on a fossil-fuel foundation; other challenges on RE sector include: scalability and timing, commercialization, substitutability, material input requirements, intermittency, energy density, water, the law of receding horizons, energy and return on investment. Although RE sources produce relatively low Green House Gases emissions and conventional air pollution, manufacturing and transporting them may have impacts on air and land. Production of some photovoltaic cells generates toxic substances that may contaminate water and land resources. Renewable Energy installations can also disrupt land use, wildlife habitat and high consumption of water.

INVESTIGATION OF THE GEOTHERMAL RESOURCE POTENTIAL SITES IN AREAS AROUND LAKE NATRON IN THE EAST AFRICA RIFT SYSTEM BY USING REMOTE SENSING SATELLITE DATA

Maswi Mwita[1, 2*] and Elisante E. Mshiu[1]

[1]*Department of Geology, University of Dar es Salaam, P. O. Box 35052, Dar es Salaam*
[2]*Geological Survey of Tanzania (GST), P.O. Box 903, Dodoma Tanzania*
** maswi.mwita@yahoo.com*

Despite the fact that areas around Lake Natron are potential for geothermal energy resources and several studies have been conducted, there is still limited information about potential sites. This study aimed to delineate potential sites for geothermal resources in areas around Lake Natron by using remote sensing satellite data.

Remote sensing data with relatively high spatial and spectral resolution such as ASTER data were used to map land surface temperature and hydrothermal alteration minerals specifically those used as geothermal indicator minerals. The empirical approaches applied to validate the results were field mapping and measurements, laboratory analyses and structural determination using aeromagnetic and SRTM data. Field mapping realized the presences of geothermal manifestations such as thermal springs with temperatures range between 32 and 51 °C and pH between 8 and 10, respectively, the hot springs are linearly oriented along the major faults of the rift. Some part of the study area found to be characterized by thermal anomalies and hydrothermal alteration minerals such as clays, SO_4^{2-}, silica, CO_3^{2-} and Fe^{3+}. Findings of the study revealed a strong correlation between remote sensing mapped hydrothermal alteration minerals as well as thermal infrared anomalies and the mapped geothermal surface manifestations, for example, the hot springs and faults. Overall observation from this study indicates the L. Natron study area is prospective for geothermal resources particularly in the western part where hot springs are located, along the Natron-Wembere-Eyasi fault system and Natron-Manyara- Barangida faults. Despite these impressive results, there is a need to conduct more detailed investigation using high spectral and spatial resolution remote sensing data and other geological approaches such as geophysics and geochemistry so as to confirm for the geothermal resources of the area.

GEOSCIENCE EDUCATION IN TANZANIA (GET): AN OVERVIEW

Rosemary Olive Mbone Enie
Salama Heritage Ecovillage (SHE) Tanzania
shetanzania2015@gmai.com

Geoscience educational publications need to be reviewed in several areas to identify future directions for curriculum development, professional development and research. The review must show that effective teaching methods encompassing broad geoscience studies still need extensive research. Some valuable materials have to be developed for the teaching of systems approaches to geosciences, which need to be evaluated in different curriculum contexts. Different methodologies for teaching spatial awareness in geosciences need to be more widely applied and researched. There is much scope for development and evaluation of approaches to geosciences fieldwork in Tanzania. Geosciences misconceptions are widespread and need to be identified and reviewed; and studies of the effectiveness of professional development in geosciences education should be implemented more widely across Tanzania. Geoscience Education in Tanzania (GET) will progress most effectively through: extending geosciences education to lower levels of education pathways (Primary and Secondary Education); educating teachers in effective implementation of new curriculum initiatives; evaluating the progress of the initiatives and using the results to refine them; and researching the whole process to demonstrate its effectiveness and to ensure wide dissemination on the basis of well-founded research findings.

GEOTHERMAL ENERGY FOR INDUSTRIAL DEVELOPMENT IN TANZANIA

Taramaeli Mnjokava*, Adonias Mkangala, Fatumati Mnzava, Ariph Ole Kimani

Tanzania Geothermal Development Company Limited

** mnjott@yahoo.co.uk / taramaeli.mnjokava@tanesco.co.tz*

Tanzania is one of the countries in the East African great Lakes blessed with various energy sources including but not limited the hydropower, coal, biomass, solar, natural gas and geothermal energy. The country relied on hydropower and thermal energy sources (fossil fuels) to generate electricity since long, despite of the facts that these sources were unsteadily available to meet the demanded energy consumption due to long drought season and constantly high fuel price respectively. Rescuing an energy crisis situation, the government set policy emphasizing energy diversification in the country. The policy enables development of other remaining available sources, firmness the energy demand and boost economic growth toward a middle-income country. Tanzania Geothermal development Company (TGDC) is the company mandated to develop geothermal resource in the country. Geothermal energy as a renewable energy has been developed into different exploration stages in various sites (prospects) across the country mostly localized on the areas crossed with the great East African rift system. Among many geothermal potential areas, four projects have been developed to advanced surface exploration stage including Ngozi, Kiejo-Mbaka, Songwe and Luhoi geothermal projects. Ngozi project is at more advanced level of which the preparation for subsurface exploration or test drilling is currently ongoing. The drilling operations for Ngozi project anticipate starting on June 2019 where the results will confirm and update the existing defined geothermal model in the area and possible reservoir extension. The national power master plan as well as TGDC strategic plan, target to produce 200 MW from geothermal resource by the year 2025. Geothermal energy can be used for power generation and direct utilization such as space heating and cooling, food processing, crops drying, bathing (spa), tourist attractions, aqua and horticulture. The use of geothermal energy both on power generation and on direct applications in Tanzania will enhance

industrialization and foster economy growth of the country at large since it is reliable, affordable and environmental friendly energy. However, to develop a sustainable energy mix in the country for the next 25 years, the government should positively diversify its supports on energy sources and geothermal particularly (TGDC) requires support on building financial sustainability, build up research and development capabilities, create a conducive enabling environment for geothermal and develop human resource and technical equipment's.

A PALYNOLOGICAL INVESTIGATION OF THE LATE CRETACEOUS SEDIMENTS OF THE NANGURUKURU FORMATION OF SOUTHERN COASTAL TANZANIA

Innocent Mvamba

Tanzania Petroleum Development Corporation (TPDC), Azikiwe/Jamhuri Street
P. O. Box 2774 Dar es Salaam
imvamba@tpdc.co.tz

The aim of this study was to investigate palynomorphs in rocks in order to identify, date, and comment on depositional setting and thermal maturation of palynomorphs in the Nangurukuru Formation from selected boreholes. Thirty-five core samples from Tanzania Drilling Project (TDP) sites 21 and 24 from the Nangurukuru Formation, Kilwa Group from the southern coast of Tanzania have been processed and analyzed for their palynological content.

The samples yielded abundant well preserved marine and terrestrial palynomorphs with very few barren samples. One hundred and twelve species were identified and systematically described. These include 35 species of dinoflagellate assigned to 22 genera, 49 pollen grains of both gymnosperm and angiosperm accommodated in 31 genera, and 28 species of spores were placed in 21 genera. In addition, a single species of Chlorophycophyten algae, two species of Prasinophyta algae, Foraminifera test linings, and various fungal fruitifications were observed.

The palynomorph assemblages are used in a palynostratigraphic age assignment based on comparisons with previously developed biozones for the Late Cretaceous of Gondwana. The recognized palynomorphs suggest Coniacian-Paleocene age for the Nangurukuru Formation. Palynofacies analysis was carried out and used to reconstruct palaeoenvironment, which revealed deltaic or shallow marine to open marine depositional settings. The thermal maturation of palynomorphs indicates that the sediments are marginally mature and capable of producing gas but not for commercial purposes.

TURNING FINITE RESOURCES INTO ENDURING OPPORTUNITY – COMPARATIVE REVIEW OF MINERAL SECTOR GROWTH IN BOTSWANA AND TANZANIA

Dafrosa W. Lyimo*, Crispin Kinabo

[1]*Department of Geology, College of Earth Sciences, University of Dodoma,*
[2] *University of Dar es Salaam, Department of Geology, P.O. Box 35052, Dar es Salaam*
** dafrosa.lyimo@yahoo.com*

The mining industry in Tanzania is one of the vibrant and fastest growing sectors that have attracted foreign capital inflows, still with limited benefits to the local citizens. The Government of Botswana however, their mining industry has managed to maximize the minerals economic inflow benefits while enabling private investor to earn competitive returns. Although both countries offer a democratic and stable political framework, good and sound Mineral Policies, no significant growth impetus is expected to originate from the Tanzanian mineral sector in the near future. This paper compares taxation principles of minerals in Botswana to that of Tanzania and concludes what can learn from Botswana in terms of minerals policy objectives, fiscal regimes and local participation in the mineral sector.

EFFECTIVENESS OF TANZANIA LOCAL CONTENT POLICY IN CREATING LINKAGES BETWEEN OIL AND GAS SECTOR WITH OTHER SECTORS OF THE ECONOMY: SETBACKS AND PROPOSED MEASURES

Ebeneza P. Mollel

Ministry of Energy

ebenezamollel@yahoo.com

Since the discovery of significant amount of natural gas in the past few years in Tanzania, the local content agenda has gained tremendous grounds, and caught the interest of various stakeholders within and outside the realm of the Tanzania oil and gas industry. Aiming to optimally leveraging opportunities brought by this discovery, the Government of Tanzania in collaboration with key industry stakeholders has taken pragmatic approaches to put in place policy, legal, regulatory and institutional frameworks, specifically for local content. By using the qualitative methodology, this study analysed the effectiveness of local content policy in creating linkages of oil and gas sector to other strategic sectors of the economy. Content analysis, together with a case study approach, was deployed to thoroughly examine Tanzania local content policy. A wide range of secondary data collected from numerous sources was triangulated for validation, prior to being used for this study. This study revealed a high degree of conformity between Tanzania local content and broad government development plans, namely the Tanzania Development Vision (TDV) 2025 and Integrated Industrial Development Strategy (IISD). However, the policy was found to have several deficiencies, which might potentially hamper its effectiveness in the creation of linkages. Firstly, the policy does not require the establishment of a local content fund to support costly local content initiatives such as local supplier development programmes. Secondly, set up of hard targets in regulations prior to having a clear picture of the capacity shortage in the industry. Thirdly, even though the policy has a key focus area, it does not clearly state priority sectors. Fourthly, there is inconsistency in defining some local content related terms across Tanzania local content instruments. Fifthly, neither Act nor Regulations require the establishment of a local content specific committee, which could have played a key role in

the implementation of local content initiatives. In conjunction with addressing the above-mentioned deficiency, the Government of Tanzania needs to create enabling environment for local suppliers to become competitive. Moreover, the Government has to aggressively invest in strengthening the capacity of the local supply-chain and put emphasis on transferable skills. Above all, in order to achieve the desired outcome, the Government has to highly engage IOCs, private sector and civil societies in the implementation of local content.

INTEGRATING GEOSCIENCE WITH LEGAL AND MANAGEMENT ISSUES IN PETROLEUM INDUSTRY: AN APPROACH FOR POSTGRADUATE TRAINING

Ernest S. Mulaya

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

ernestsm@udsm.ac.tz

In Tanzania, exploration for oil and gas goes back to 1950's. The first natural gas discovery was made on the Songosongo Island in 1974, which was followed by another gas discovery in the Mnazi Bay in 1982. From 2000's, Tanzania has witnessed further exploration and discoveries of significant quantities of natural gas both on- and off-shore, accounting to 57.25 Trillion Cubic Feet (TCF) as per 2018. These discoveries have prompted renewal and extensive exploration activities across on- and off-shore Tanzania by various oil companies. Currently, the oil and gas sector is one of the new and fast-growing sectors in Tanzania. To fully realize the economic, government industrialization agenda and other benefits of this potentially promising sector, the government has been making efforts on several fronts particularly, development of adequate human resources (capacity building) to fill up the local content gap. It is from this basis, taking part in these concerted efforts and since the value chain of oil and gas is multidisciplinary, there is a need for integrated training of Oil and Gas Operations, Legal and Management related programmes at the level of postgraduate diploma to professionals with different academic backgrounds. The overall vision by the Department of Geology at University of Dar es Salaam for this approach is to produce human resources, who had previously graduated in other disciplines with their requisite knowledge and skills to apply their professional skills in the oil and gas industry either as middle-level management or provider of logistical support.

A SEARCH FOR JUSTICE TO THE TRAGEDY OF THE COMMONS: A CASE OF TANZANIA MINING INDUSTRY

Albert Aidan Balati

balati6@hotmail.com

We live in the anthropocentric age, a geopolitical era of the geopolitics of globalization. The philosophy of geopolitics is rooted in anthropomorphic behavior, which posits: States, like animals in a Darwinian theory live by predating on each other to assure their survival; because a global scarcity of resources force states to predate upon each other. From this state of nature, the parable of the tragedy of the commons was born.

This paper will show that; all conflicts that rage in the world today have their underlying causes in geopolitics; That is; in the struggle of states to acquire political supremacy : making war and conflicts to acquire resources is a necessary human enterprise in seeking Wealth and Power to assure Political Dominance over global scarce resources. War economy coupled with economic development therefore, are what makes all highly industrialized nations to develop and thrive. To this point, the paper will show; however disguised, geopolitics is a recipe for only one brew: Power politics and aggression.

To analyze the topic we have to search for the truth about the matter: To do so; We begin by the questions ; 1) what kind of a fourth new world order do Tanzanian's want after the end of the of the cold war and the bipolar world system? 2) What contribution will Tanzania make in propagating the fourth Industrial revolution? Answers to these questions will need theories; the social contract theory, a theory of constructivism, Galtung's Mini-Power theory and David Mitrany's functional approach theory, which advocates the human species to live together in harmony and others.

That Tanzania mires in the doldrums of the tragedy of the commons; No question about it: A search for justice in the Tanzania mining sector requires us to understand earth. Planetary science will show us that; Earth our home (a terrestrial spec in the universe) is the only planet in the Milky Way galaxy that we so far know to have life.

Planetary science will show us that; human living space ; land for mining and land for other human enterprises is only about 20% of all earth land surface; more than 70% of earth land surface is covered in water and about 10% of land surface is inhabitable land for humans . That explains why European settlers and other others who know best the value of land from a geopolitical standpoint migrate to occupy and dominate idle land cum empty land (terra nullius) all over the world because it did not have white European habitation or their kind.

It tells why (litterae) or letters of patents were used as instruments of conquest from the sixth century; they were used for colonization and for establishing import monopolies. During colonial times patents were aimed at conquest of territory, today patents are aimed at the conquest of economies. The inception of GATT/WTO arose from this back background. Third world nations view patents as tools of recolonization; Vandama Shiva (2001) assert that; Western powers view patents as a natural right, as conquest was during colonialism. Only that; whereas today: Territory, gold and minerals are no longer the objects for conquest: Markets and economic systems are what have to be controlled.

To consolidate his contention, Shiva emphasize that: Today, knowledge is converted into property just as land was during colonization, so much so that; - patents -have been covered by the broader label of -intellectual property- or property in terms of products of the mind. Hence therefore; the garb of reward for intellectual property rights hide the real object - Control over global economy. For; this secular conquest of diverse knowledge systems and economies is at the heart of intense conflicts and controversies on patents.

Africa is a shatter belt. It is the richest continent in industrial minerals on earth. Likewise, it has got a lot other strategic minerals and rare earth. Burundi for example produces exotic rare earth oxide (bastnaesite) a second world producer only after USA (Silicon Valley). Tanzania is on the verge of becoming a mineral economy country; but like DRC, Zimbabwe Nigeria etc Tanzania is not a mineral power.

Only mineral powers have the capacity to own and control extractive industries. It is why Tanzania is a morsel suffering from the mineral curse syndrome inflicted to it by predatory investment. Lack of technical

expertise; lack of a serious minded human capital (committed people with good IQ and EQ) and lack of capital for investment are drawbacks that make Tanzania to fail to utilize its comparative advantages profitably . It is not by accident that Tanzania falls victim to Garret Hardens parable of the tragedy of the commons; The polities of the geopolitics of globalization through the role of patents, are behind this predatory nature of investment: It is why Hans Morgenthau (1904 - 1980) counselled that; All nations are compelled to protect their physical, political and cultural identity against encroachments by other nations. It is why South African miners challenge the South African mining laws established by South Africa's Chamber of Mines which has applied to High Court to block the Government's new mining charter by claiming that the legislation, aimed at accelerating black ownership in the sector, will destroy the industry.

The above contentions will show that the establishment of a legal and regulatory framework to Tanzania's mining sector will not curb predatory investment in full as expected; Namibia and Botswana are sighted to have exemplary legal and regulatory frameworks: but as long as they are not mineral powers, they will continue to mire in the theatre of predatory investments. They will end up being usurped by ersatz capitalism

This paper will show that; A nation must have wealth and power if it wants to benefit from its extractive industry, but: There is no mineral power that will let a wealthy developing nation especially if proved to have resources that can boost industry and trade in the developed world economy to prosper; Only a trusted close ally can do that. China, The US during JF Kennedy's era, Canada, Sweden (Olof Palme era) and the then Yugoslavia(under JB Tito era) to name a few were such trusted allies to Tanzania in the 1960's to early 1980's - History tells how Tanzania's strong alliance with China was secretly tempered by subtle intervention and weakened after the wars of liberation in Africa .

Nyerere (Co-Founding father of Tanzania) was left alone to do it with China The intuition of visionary strategists of doom to Tanzania's economic development were right ; Had Tanzania kept alliance with China to this day; Magufuli's dream alongside Nyerere could have been realized earlier - However; Opportunities like flying arrows never come back once thrown .

Today we have a State Capitalist China (A Confucius Communist China that applies Capitalist economic development strategies to prosper.

Magufuli (Fifth term President of United Republic of Tanzania) on the right path which Nyerere treaded is facing great challenges towards achieving his vision 2025 by advocating and preaching justice to the extractive industry ;That; Tanzania must equally benefit economically from her mining sector in a win - win situation ; Where the mining industry is a winner take all enterprise ; Tanzanian like China did must rally behind Magufuli without wavering as they did to Nyerere; because: Geostrategicians in the shadow of Rudolf Kjellen (1864 - 1922) knows that;

The life of a State is ultimately in the hands of an individual ; recalling the emergence of most great powers coupled with mineral powers were a result of strong leadership from strong individuals who extenuated their strong state's influence to expand - A geopolitical world of predatory investment is fearful of Magufuli's bold leadership on his fight for justice to the Tragedy Of the Commons; This paper besiege the moral world in the footsteps of Thomas Hobbes et al; The founding fathers of the United States of America (USA) ; Confucius theorists and the world of true liberal democrats ; social democrats and people of good will all to stand for Magufuli's ideals and noble course ; to make the world a better place for all humans to live together in harmony in a global village that we aspire to build.

Above contention will show that; Currently :frantic moves based on long term grand strategies of mineral powers are made to dismantle SADC (a brain child of oppressed Africans searching for true sovereignty to their countries) and deny Tanzanians to have strong alliance with South Africa and former Frontline states' colleagues; some seasoned geostrategicians; expert on intervention are bent on consolidating the revival of EAC (a brainchild of a colonial British chartered company of the 1800's) which own the present Trade Mark of EAC to realize Cecil Rhodes dream of dominating Africa from Cape to Cairo. Be it remembered; when Adam Smith published his book; Wealth of Nations; The Mercantilist state was protectionist, autarkic, expansionist and militaristic.

During the industrial revolution in Europe; commerce and trade euphemized mercantilism. It made Bismarck to advocate that- free trade is the weapon of

the strongest. Tanzania should borrow wisdom from Bismarck by contemplating Adam Smith's counsel when he admonished that;

It is very common clever device that when anyone has attained the summit of greatness, he kicks the ladder by which he has climbed up in order to deprive others of the means of climbing up after him; Here lies the secrets of Intellectual Property Rights (IPR); Economic Partnership Agreement (EPA); Agreement to Technical Barrier to Trade(TBT);Agreement on Trade Related Aspect of Intellectual Property Rights(TRIPS)

In emphasizing Smith's idiom; Edward Mead(1943) observed that ; In this lies the secret of the cosmopolitical doctrine of Adam Smith and the cosmopolitical tendencies of his closer allies William Pitt et al Who admonished that: Any nation which by means of protective Duties and refraction on navigation has raised her manufacturing power and her navigation to such a degree of development that no other nation can sustain free competition with her, can do nothing wiser than to throw away these ladders of her greatness to preach to other nation the benefits of free trade

The many World trade policies and forums on economic development have nothing new to offer; most preach liberal mercantilism, a geopolitical euphemism of mercantilism proper in modern ways which propagates Bismarck's benefits of free trade without giving a thought to the tragedy of the commons

The paper will insist to show that; whatever a good legal and regulatory frame work will be established to make Tanzania benefit from her extractive Industry; The tragedy of the commons will continue to exist as predatory investors will continue to struggle for their survival, because: the mining industry in Africa have built a conservative culture of predation; impunity: Deceit, sadism, treachery, fraud; corruption; theft , tax aversion and many other dirty tricks vices

In conclusion, the paper will present observations on 1)The Anatomy of resource curse 2)The Kimberley processing certificates 3) Control of resources by Transnational Corporation (TNCs) and Multinational Corporations (MMCs); Government Institution; Cartels and Syndicates 4)It will extrapolate the Concept of Mineral power; The significance of language rule; the second coming of the scramble for Africa; The concept of

Informal Imperialism; The paradigms of Conflict ;War and Genocide as nurtured by the conditions for mineral resource use

A way forward will be suggested. Solution sought from the condition for Use of Mineral Resources will be presented. Emphasis on condition for use of mineral resources will be stressed on the first; second and fourth articles; That is; the concept of Mineral Rights and an exclusive political dominance of area for extractive Industry to be occupied; will be reviewed by observing strategies of divide and rule, strategies to acquire minerals resources and strategies to have an access to a mineral mining area will all be highlighted. As Tanzania is an ardent believer in the oneness of human beings the paper will end by advocating Mitranys call for human cooperation through a functional approach.

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COMPOSITION OF PYROCHLORE FROM THE MESOZOIC PANDA HILL CARBONATITE DEPOSIT, WESTERN TANZANIA

Nelson Boniface

Department of Geology, University of Dar es Salaam, P. O. Box 35052 Dar es Salaam
nelson.boniface@udsm.ac.tz

The Mesozoic Panda Hill carbonatite deposit in western Tanzania hosts pyrochlore, an ore and source of niobium. This study was conducted to establish the contents of radioactive elements (uranium and thorium) in pyrochlore along with the concentration of niobium in the ore.

The pyrochlore is mainly hosted in sövite and is structurally controlled by NW-SE (SW dipping) or NE-SW (NW dipping) magmatic flow bands with dip angles of between 60° and 90°. Higher concentrations of pyrochlore are associated with magnetite, apatite and/or phlogopite rich flow bands.

Electron microprobe analyses on single crystals of pyrochlore yield very low UO_2 concentrations that range between 0 and 0.09 Wt. % (equivalent to 0 atoms per formula unit: a.p.f.u.) and ThO_2 between 0.55 and 1.05 Wt. % (equivalent to 0.1 a.p.f.u.). The analyses reveal high concentrations of Nb_2O_5 (ranging between 57.13 and 65.50 Wt. %, equivalent to a.p.f.u. ranging between 1.33 and 1.43) and therefore the Panda Hill Nb-oxide is classified as pyrochlore sensu stricto. These data point to a non-radioactive pyrochlore and a deposit rich in Nb at Panda Hill.

The Panda Hill pyrochlore has low concentrations of REEs as displayed by La_2O_3 that range between 0.10 and 0.49 Wt. % (equivalent to a.p.f.u. ranging between 0 and 0.01) and Ce_2O_3 ranging between 0.86 and 1.80 Wt. % (equivalent to a.p.f.u. ranging between 0.02 and 0.03), Pr_2O_3 concentrations range between 0 and 0.23 Wt. % (equivalent to 0 a.p.f.u.), and Y_2O_3 is 0 Wt. % (equivalent to 0 a.p.f.u.). The abundance of the REEs in pyrochlore at the Panda Hill Carbonatite deposit is of no economic significance.

APPLICATION OF REMOTE SENSING IN EXPLORATION EARTH RESOURCES: A CASE STUDY FROM NGUALLA REE-CARBONATITE DEPOSIT, SW TANZANIA

Elisante Elisaimon Mshiu*, Nelson Boniface, Cyprian Alex Rutagwelela
Department of Geology, University of Dar es Salaam, P. O. Box 35052 Dar es Salaam
** mshiutz@gmail.com*

Mining sector is one of the main economic backbones of the country in Tanzania. This is manifested in the shares of mining and quarrying activities to GDP, which is reported at 4%, in the recent (2015) records of National Bureau of Statistics (NBS). Based on Tanzania's Development Vision plan, the mining industry is expected to account for 10 % of the GDP by the year 2025. However, the major world-class gold mines (e.g., the Tulawaka Gold Mine, Resolute's Golden Pride Mine and the Buhemba Mine) are rapidly becoming depleted; with very low to zero rate of new mine discoveries. This trend is alarming, and calls for unequivocally improvement in the search for deposits using advanced, cutting edge technology.

The geology of Tanzania indicates that the country is still prospective for variety of different mineral resources including more world-class metal deposits. However, for a long time now, the search for mineral deposits has been relying on conventional geologic methods; perhaps explaining why the rate of new discoveries has been low in the recent years. In this study, we propose the application of remote sensing technology in the search for earth resources, show casing its successfully application in the Ngualla Rare Earth Elements (REE)-carbonatite deposit, southwestern Tanzania. This recent mineral exploration technology, i.e. remote sensing, is reported to have played a great role in the discovery new mineral deposits elsewhere in the world in the recent decade. Examples include the discovered world-class deposits in South America and Australia. The techniques can be used alongside the conventional exploration methods. Hyperspectral and multispectral remote sensing techniques, among the recent exploration techniques, have been increasingly applied in mineral exploration campaigns in the last two decades, which they have contributed to a large extent in revolutionizing the mineral exploration industry.

Geological remote sensing has not been applied effectively in Tanzania, and its potential in mineral exploration is still not well known. Ongoing studies on the application of geological remote sensing, particularly application of multispectral remote sensing data, has yield positive results, indicating a promising future in the Tanzania mining sector. Innovative use of the simple remote sensing datasets such as ASTER data, has effectively depicted signals related to different mineralisation. The designed method from this study has precisely mapped the Ngualla REE-carbonatite deposit. Results have revealed the extent of the deposit, and further indicate possible new targets that are directly related to the main REE deposit. The advantage with the multispectral remote sensing techniques, using multispectral data sets such as ASTER, is that most of them cover a relatively large area when compared to the conventional methods; making the dataset useful in studying mineralization trends in large areas. Hence, by innovatively applying remote sensing data, it can have a significant impact in the Tanzania mining sector.

EXPLORATION IN DIFFICULT TERRAINS OF THE EASTERN DR CONGO: THE GOOD, BAD AND UGLY REALITIES OF MINERAL RESOURCES BUSINESS

Gerald Chuwa
gerald7chuwa@gmail.com

Mineral exploration in simple terms can be defined as a process of information gathering that assesses the mineral potential of a given area. It starts with an idea or geologic model that identifies land worthy of further exploration. In the period 2005-2010, a good number of Tanzanian geologists and especially those in the gold mining industry had the opportunity of practicing their trade in the Democratic Republic of Congo (DRC). The key areas being the southern mineral rich Katanga Province, the eastern Provinces of South Kivu and North Kivu and in the north-eastern part of the country in the Oriental Province. In this paper, the experience of doing exploration in the eastern DRC is shared.

Out of many experiences, events, challenges and lessons learned, the few are summarized as follows: mineral richness and under-explored country; excellent and often "scandalously" complex and rich geology; the vast and huge potential and opportunities of the country for development; under-developed infrastructure and its impact on logistics; significant stakeholder's risks and how to mitigate them; diverse and different French culture of courtiers and ambiances; significant tribal and regional tensions and how to navigate them; huge similarity in our African culture of the Bantu origin; challenges of setting up, putting standards in place and maintaining focus towards objective; misinformed foreigners and media about realities on the ground, leading to a lot of misinformation and dramatization; and the perils of war, its remnant factions and looming threat of another one.

A synthesis of these experiences projects a positive future for the DRC. Its vast minerals sector is an asset that if well managed will project the country to a giant in Africa and in the world. In that, there must be change to how the wealth of that nation is explored, exploited and benefits distributed to ensure there is sustained multi-sector development that will, in our humble view, impact its neighbours and Africa at large.

DIAGENESIS AND RESERVOIR MODELING OF THE RUKWA RIFT BASIN, SOUTHWESTERN TANZANIA: IMPLICATION FOR HELIUM POTENTIAL

Ernest S. Mulaya

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

ernestsm@udsm.ac.tz

The most recent research in the Rukwa Rift Basin (RRB) in the Southwestern, Tanzania has documented a huge helium gas potential estimated to contain prospective recoverable reserves of about 98.9 BCF (P50) of helium gas. This preliminary discovery of large volumes of inert gas in Tanzania is coming at the time when world supply of helium from major producing countries like USA, Quartar Algeria, Australia, Canada, Poland and Russia is dwindling significantly while the global demand is rapidly increasing. The ever-increasing demand of helium particularly in medical cryogenics where helium demand is critical in cooling the superconducting magnets in MRI scanners is of great concern towards making a healthier and social welfare of many societies. This discovery and the potentiality of the RRB still remain uncertain in different geological dimensions, which motivate further research curiosity and deployment of scientific approaches.

This project explores the RRB towards providing a better understanding of the basin in terms of diagenesis, geological model, risk analysis, understanding of the helium system from charge to accumulation, thus increasing helium prospectivity and resource potentiality in the East African Rift System (EARS) of Tanzania.

ROLE OF GEOPHYSICS IN PLANNING AND MINIMIZING RISKS IN CIVIL WORKS

Onesphorius Balambirwa*, Sudian Chiragwile
Geological Survey of Tanzania (GST), P. O. Box 903, Dodoma Tanzania
**mgishaonesphory@gmail.com*

Geophysical investigations prior to commencement of civil works in an area are vital for the safety of the structures that would be erected. Such investigations provide necessary information about subsurface geological structures, seismic responses of the ground and erected structures etc., and thus useful for planning purposes to prevent failure or collapse of civil structures.

The Geological Survey of Tanzania (GST) provides, on request, geological and geophysical assessment of the area before commencement of civil works for the purpose of identifying lithologies, soil types and thickness, which are required by civil engineers for planning the foundation and length of the building to adhere to seismic impact and other ground movement.

Here we present a summary of magnetic survey results that were obtained at Tambukareli area, south of Dodoma Convention Centre in Dodoma, an area which is planned to have public offices. Results show that the area is underlain by tonalitic orthogneiss as a bedrock. Top of the bedrock is weathered rock (ferricrete and calcrete) that also forms a reddish brown and whitish clay soil cover. The thickness soil ranges between 0 and 5 m. Magnetic signatures reveal that the area is stable enclosed within deep seated inactive structure trending NE – SW at a distance of 600 m to the north and 1200m to the south. The geological characteristics of bedrock and soils suggest that the area is prone for a fairly low earthquake amplifications compared to other surrounding areas northwards.

Basin on geophysical investigations the Tambukareli area is suitable for building of any civil structure governed by building engineering codes with respect to designing and materials to withstand at least the earthquakes of magnitude 6.5 on Richter scale.

WATER RESOURCES MANAGEMENT IN THE 21st CENTURY WITH PARTICULAR REFERENCE TO AFRICA

Hudson H Nkotagu

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

hudson@udsm.ac.tz

Africa is the world's second-driest continent after Australia, and has only 9% of global renewable water resources to support 15% of the global population. The issue of water security in Africa is further aggravated by climate change, insufficient treatment of water and waste-water. The growing population, accelerated urbanization and the rising economy through industrialization has resulted in increased consumption of water and discharge of waste-water being 80% of the consumed amount, which ends up causing heavy water pollution. Water pollution not only reduces available clean-water but also affects human health and ecosystem.

Drought in many parts of Africa, latent national and transboundary water conflicts, frequent occurrence of floods, groundwater pollution and industrial effluents, poor sanitary situation in many African states, are mirroring water crisis, which will undoubtedly increase in magnitude in the 21st century in the whole rendering water scarcity in the continent. It is estimated that by 2030, global demand for fresh water supply is expected to grow by 50% and most of this demand will be in our cities; hence, the inevitable need for new approaches to waste-water collection and management as well as instituting measures to sustain freshwater supplies.

Furthermore, wastewater is considered by many as a nuisance, but opportunities from exploiting it as a resource are enormous. Safely managed waste-water has the potential to be an affordable and sustainable source of domestic water supply, energy, nutrients and other recoverable materials. The costs of wastewater management are greatly out-weighed by the benefits to human health, economic development and environmental sustainability – providing new business opportunities and creating more green jobs. Therefore, Africa must uphold the fact that water has to be carefully managed during every part of the water cycle: from water abstraction, treatment, distribution, use, collection of wastewater and its treatment, to the use of treated wastewater and its ultimate return to the

environment, ready to be abstracted to start the hydrologic cycle again. In addition, Africa must embark on rigorous training at various levels of manpower in all sections of water management, and should overcome unethical professionals who more often than not end up causing unsustainable management of the resource.

Finally, political will, coupled with application of science and technology, should be able to solve the water-resources related problems in the future for supporting industrialization and sustainable management of the water resources in the continent.

ARE THE GOLD RUSHES TO THE SOUTH AND SOUTH WEST OF DODOMA CITY AN INDICATION OF EXISTING BIG GOLD DEPOSIT IN DODOMAN ROCK FORMATION?

Manyama M. Makweba
Consulting Geologist, P. O. Box 833, Dodoma
mmakweba@yahoo.com

In recent 26 years (1992 – to date), there has been a 'gold rushes' into the areas lying between 30 and 50 km south and southwest of Dodoma. These areas include Nsimba Nguru (Mafurungu Village) on QDS 178/3, Iluma Hill (Iluma Village) on ODS 160/3, Nholi (Nholi Village), QDS 161/2 & 162/3, Mpinga, QDS 162/1, Kipanga, QDS 161/2 and Isangha, QDS 162/3, which is 5 km west of Bihawana. The locations of these gold rushes appear to occur in the geological terrane that has not been explored in details; and artisanal miners have blown the whistle to geologists that these areas require immediate geological attention.

Geologically, the gold rush areas occur within the rocks belonging to the Dodoman metamorphic basement in the central part of Tanzania, mainly comprised of amphibolites, schists, quartzites , migmatitic gneisses that were intruded by granites. The gold mineralization at Nholi area appears to have been formed in multiple sheared zones at the contact of amphibolites and felsic rocks that trend NW-SE. The width of mineralization has not been fully explored, but it is considered to be worthy for small- and medium-scale mining venture.

Mined gold ores have been processed by crushing using locally made ball mills, and later the ground materials are taken to the VAT - leaching processing plant coupled with activated carbon that captures/adsorb gold from leached pregnant solution. The gold is recovered from the activated carbon with adsorbed gold through elution plants, which have recently been constructed in Dodoma City. Previously the activated carbon with adsorbed gold were transported to Mwanza.

Despite to the fact that small-scale miners have been using poor mining equipments, their gold production has been increasing yearly since July 2016 when gold rush was reported at Nholi. The recorded gold production have shown that from July 2016 to December, 2016, a total of 6,513.66 g

were produced, whereas January 2017 - December, 2017, it was recorded a total of 60,586.39 g of gold produced and January 2018 - July, 2018, which is almost half way of the year, a total of 26,625.30 g has been produced.

The implications of gold rushes in the areas south and south west of Dodoma indicate that there is existence of a potential big gold deposit that need thorough geological and geophysical investigations through the government partnership with potential investors.

THE ROLE AND PRACTICE OF GEOLOGISTS IN ENVIRONMENT MANAGEMENT IN THE TANZANIAN EXTRACTIVE SECTOR

Martha Kamuzora
Statoil Tanzania AS
kamma@equinor.com

Geologists locate and quantify resources, advise for development and follow up extraction. These practices make them one of the pillars of extractive industry and call for them to play the core role in the industry's environmental management. The latter is not the case for various mining and oil and gas industries in Tanzania due to the nature of the extractive sector, its legal and administrative framework, local norms, and geology education system in the country. Environment management is generally driven by compliance to legislation and financial institutions requirements, and in cases reputation. The level of compliance is usually in accordance to exposure to enforcers; policies of parent companies and funding needs.

Environment management roles of different institutions in Tanzania are spelled out in the Environment Management Act of 2004 (EMA 2004). In turn its principles have been incorporated in the Mining Act of 2010 and the Petroleum Act 2015 the key legislation governing the sector particularly when awarding concession licenses although with limited focus on the process of determining exploration areas. This has focused environment management responsibilities to geologists engaged by the License holders and operators rather than those in policy and regulatory agencies.

It should be noted that many Tanzanian extractive industry operations are illegal, informal, and/or small-scale artisanal mining practices which utilize local (informal) knowledge, informal financial schemes, brokerage systems for getting supplies, and selling products. Plus access to minerals for building purposes is commonly governed by the Local Government (Urban and District Authorities) Acts of 1982/RE 2002 and the Roads Act of 2007 where materials investigations are undertaken by informal knowledge and civil engineers. These normally exclude geologists in the process hence not covered in this presentation.

Geology education includes general environmental awareness with specific environment management related courses being in optional. Environment management roles of geologists may be improved by; embedding EMA 2004 principles in core sector governance by assigning the extractive sector ministries and regulators responsibilities for undertaking Strategic Environmental Assessments during determination of concession/exploration areas; requiring mandatory input of environment experts in determination of projects; and having an environment management executive with adequate authority. This model is adopted by international organizations governing or funding extractives, where sustainability/environment management principles are imbedded in the decision and operational processes. For example, in Equinor, the decision processes management principles and geologist functional requirements encompass sustainability in addition to having a permanent environment expert in the decision panel.

Furthermore, environment aspects of geology courses should become mandatory at universities, preferably to be undertaken during the final year to influence responsible geology practices in young professionals. In Equinor, these are included in the mandatory induction program for new employees.

ARTISANAL AND SMALL-SCALE MINING TOWARDS 2025 INDUSTRIALIZATION IN TANZANIA

Crispin Kinabo

Department of Geology, University of Dar es Salaam, P. O. Box 35052 Dar es Salaam
kinabo_2003@yahoo.co.uk

Mining in the country is a major and rapidly growing part of the economy. Recent data shows that about 1.5 million people are directly involved in mining, of which 99.99% is dominated by small scale mining and rest 0.01% is large scale mining. In addition, small scale miners dominate almost 100% of the country's building and industrial minerals and coloured gemstone production, employing both low to middle income miners. The sub-sector has shown positive and negative impacts on economies and livelihoods in rural communities. Assessing the impacts, it is inevitable that economic impacts of Artisanal and Small-scale Mining (ASM) are generally positive. Social and environmental impacts on livelihoods are manifold and considerable. Poor technologies have severe impact on the health, safety of miners and the environment. There is also a significant gender inequality as women make up 27 per cent of the overall ASM workforce and often face the greatest hardships. Nonetheless, on the positive side, the sub-sector stabilizes rural-urban migrations; create local value addition activities and spin-off jobs, which is the most important multiplier effect, benefitting communities around mines.

This study shows that in order to maximize the net economic contribution of the ASM sector and significantly contribute towards industrialization 2025, negative impacts must be mitigated. This requires, from a sustainable livelihoods perspective ‘transforming structures and processes’. The underlying core process is formalization, which was launched since 2016, in form of dialogue initiated by International Institute for Environment and Development (IIED).

GEOPHYSICAL STUDY OF THE SUBSURFACE STRUCTURES OF THE RUFIJI BASIN, TANZANIA

Janeth Matoke*, Isaac Marobhe

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

**janethmatoke21 @gmail.com*

This study presents detailed results of subsurface investigation of the Rufiji basin, which is one of the onshore coastal sedimentary basins in Tanzania. Despite limited number of geological and geophysical research works that have been conducted in the area, there is limited information about the structures controlling the basin and the spatial variations of sediments thickness. This study aims to delineate the subsurface geological structures controlling the basin, establish the spatial variations of sediments thickness and link between structures and the basin configuration. The results from geophysical techniques have been obtained by combining gravity, magnetic, SRTM-DEM and geological field structural data where, Oasis Montaj, ArcGIS, Polar plots and Win tensor software's were used to process, enhance and model the data to produce maps and Rose diagrams. Four distinct structural trends have been distinguished: the dominant were NE-SW and NW-SE, less structural trends were E-W and NNW-SSE. Gravity and Magnetic data unveiled mainly normal faults in the basin. The structural sets are mainly basement inherited and some of the trends influence the general trend and/or configuration of the basin itself. Depth estimations obtained from located Euler deconvolution, spectral analysis and modelling of the profiles indicates that the basin has a range of depth between <1 km to 12.78 km with the maximum depth being in the NW, SW, N and NE parts of the basin. Results of this study suggest that the basin consist of young sedimentary deposits, most likely deposited between Pliocene to Pleistocene epochs. Estimated depths from three methods suggest adequate burial depth to allow maturation of hydrocarbon. Furthermore, the basin is potential for hydrocarbon exploration.

ROCK-TYPING METHOD FOR UNDERSTANDING HETEROGENEITY OF THE CLASTIC HYDROCARBON RESERVOIR

Erick Barabona Kivera

Tanzania Petroleum Development Corporation, Directorate of Upstream Operations
P.O Box 2774, Dar es Salaam
ekivera@tpdc.co.tz

Conventional hydrocarbon system is in places characterized by complex geological and petrophysical system as well as heterogeneities at various scales. This leads to difficulties in understanding the hydrocarbon reservoir and factors controlling reservoir rock quality for production. Thus, highlighting the importance of studying the distribution and the quality of the reservoir rock for hydrocarbon production. In this study geology (rock types) band petrophysical parameters of two wells from clastic reservoir rock of a gas-field were evaluated in order to understand reservoir rock quality and heterogeneity.

Before rock-typing, detailed reservoir characterization was conducted to identify reservoir rock zone, hydrocarbon-bearing rock units and distribution of porosity and water saturation in the reservoir. Two approaches were used for rock typing: first based on sedimentary rock types, and second was based on core porosity and permeability. Sedimentary rock types provided calibration for predicting log-facies distribution within the cored and uncored interval, whereas core porosity and permeability used for identification of hydraulic rock types. Using Winland r35 equation, pore throat radius was identified and enable establishment of petrofacies classes dominated in the reservoir. Artificial Intelligence methods –Self Organizing map (SOM) was then employed to predict rock types based on classified sedimentary rock types and identify Hydraulic Flow Units (HFU) together with set of well logs (GR, NPHI-Hydrocarbon corrected, DT-Hydrocarbon corrected). For better understanding of the reservoir rock, each sedimentary rock types were integrated with HFUs. Rock typing prediction was then tested to the cored interval of one well to understand if predicted rock types model works to uncored interval.

The study identifies three petrofacies and eleven (11) HFUs, categorizing the reservoir into poor to good quality. Petrofacies 3 observed to associate with lower HFUs (1-5), representing poor rock type, whereas Petrofacies 1is associated with HFU 9-11, indicatingvery good quality rock. Integration of the results reveal that no direct relationship of the sedimentary rock types with the quality of the reservoir; however, post depositional effect appeared to be most influential factor and has affected both lithofacies. This study will be essential when used to understand reservoir quality especially for the uncored well or uncored interval in a well.

THE EMERGING FIELD OF GEOETHICS: IMPLICATIONS TO THE ROLE OF GEOSCIENTISTS IN THE TANZANIA'S INDUSTRIAL DEVELOPMENT

Michael M. Msabi

Department of Geology, College of Earth Sciences, University of Dodoma, P. O. Box 11090, Dodoma

mmsabi@yahoo.com

All geosciences fields' practitioners should possess an ethical conscience and the desire to act reasonably and responsibly. Both integrity and ethics are the paramount important components in the achieving the sustainable industrial development in any country, such as Tanzania. Ethically responsible geoscientists will contribute and foster successful achievements. This is only possible when they satisfactorily carry out excellent research and professional activities, and by maintaining honest and openness in collaborating with fellow geoscientists regardless of gender, race, culture and/or other social dimensions. It is through geoethics that such individuals will be able to positively contribute towards building a resilient society, be better prepared to encounter global economic, climate and environmental challenges and be willing to take concrete steps for the conservation of the geo-environment. Geoethics provides ethical, social, and cultural values for the scientific community and for society as a whole. Geoethics represents a new vision of a world in which it is possible to maintain a more balanced relationship between humans and nature, considering modern economic and social development expectations. This talk is intended to shade light on some aspects of geoethics, provides an overview of its basic values and themes, and highlights prominent global issues that involve geoethics, including climate change, geo-risks, land management, exploitation of geo-resources, and sustainability.

DISCOVERY OF HADEAN EARTH IN THE CENTRAL TANZANIA: IMPLICATIONS ON GEOSCIENTIFIC RESEARCH AND PROMOTING GEOTOURISM

Joas M. Kabete[1*], N. J. McNaughton[2] and Abdul H. Mruma[3]

[1]*Mazoka Resources Limited, 11 Usutu Avenue, Sandton, Johannesburg RSA*
[2]*Curtin University of Technology, Bentley, Western Australia, 6845*
[3]*Geological Survey of Tanzania*
** jkmuganyi@gmail.com*

We present hitherto unrecognised early Archaean (3604 Ma) crust with detrital early Archaean and Hadean zircons (4013 – 3604 Ma) from a fuschitic-sericite quartzite in the central Tanzania. The fuschitic-quartzite is part of relatively continuous package of siliciclastic metasedimentary rocks, which crop out extensively in the Simba-Nguru hills, situated within the Undewa-Ilangali Terrane, some 130 km southwest of Dodoma. Other regions reported to have these early Archaean and Hadean zircons worldwide include: 1) the ca 3.0 Ga quartzite and conglomerates from the Jack Hills, north-western Yilgarn Craton, Western Australia; 2) the ~3.5 Ga quartzite east of Beijing, China; and 3) ~3.2 Ga quartzite from the Beartooth Mountains, Wyoming, USA, all of which potentially make the ~3.6 Ga quartzite from the Central Tanzania the oldest in the world. Relative to the above-mentioned examples, very little is known about the Simba Nguru fuschitic quartzite with an age bracket of detrital zircon populations extending to the Hadean (i.e. >3.8 Ga). The findings of this study call for government or government agencies to fund development of the locality as one of the potential geotourism sites.

THE AGE OF Au-Cu-Pb BEARING VEINS IN THE POLY-OROGENIC UBENDIAN BELT

Emmanuel O. Kazimoto[1, 2*], Volker Schenk[2], Peter Appel[2]

[1]*Department of Geology, University of Dar es Salaam, P. O. Box 35052 Dar es Salaam*
[2]*Institut für Geowissenschaften, CAU Kiel, Ludewig Meyn Str. 10, 24118 Kiel, Germany*
**ekazimoto@udsm.ac.tz*

The age of gold-copper-lead mineralization in the Katuma Block of the Ubendian Belt remains controversial because of the lack of radiometric ages that correlate with the age of tectonothermal events of this poly-orogenic belt. Previous studies reported whole rock and mineral Pb-Pb ages ranging between 1660 Ma and 720 Ma. Here, we report U-Th-total Pb ages of monazite from hydrothermally altered metapelites that host the Au-Cu-Pb bearing veins. Three types of chemically and texturally distinct monazite grains or zones of grains were identified: monazite cores, which yielded a metamorphic age of 1938 ± 11 Ma (n=40), corresponding to known ages of a regional metamorphic event, deformation and granitic plutonism in the belt; metamorphic overgrowths that date a subsequent metamorphic event at 1827 ± 10 Ma (n=44) that postdates known eclogite metamorphism (at ca. 1880 Ma) in the belt; hydrothermally altered monazite, representing the third type of monazite, constrain the age of a hydrothermal alteration event at 1171 ± 17 Ma (n=19). This Mesoproterozoic age of the hydrothermal alteration coincides with the first amphibolite grade metamorphism of metasediments in the Wakole Block, which adjoins with a tectonic contact the vein bearing Katuma Block to the southwest. The obtained distinct monazite ages not only constrain the ages of metamorphic events in the Ubendian Belt, but also provide a link between the metamorphism of the Wakole metasediments and the generation of the hydrothermal fluids responsible for the formation of the gold copper lead veins in the Katuma Block.

USING Sm-Nd SYSTEMATICS TO CONSTRAIN SEDIMENT SOURCES OF THE IKORONGO GROUP OF NORTH-EASTERN TANZANIA

Charles Happe Kasanzu

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

** kcharls16@yahoo.com*

Shales and siltstone samples from the Ikorongo Group of north-eastern Tanzania yield TDM ages of between 2049 and 2597 Ma and εNd(0) ranging from ca. -28.3 to -17.3. These ages are interpreted as representing the mean mantle extraction ages of the protolith of the Ikorongo rocks. The data are consistent with most of the detritus being derived from lithologies of the Archaean Musoma-Mara Greenstone Belt. The TDM data also suggest participation of the Mozambique Belt rocks, although less in proportion when compared to the cratonic protolith. Mixing calculations indicate that the samples' protolith can be modelled as mixtures of detritus from cratonic granitoids (42.2%) and andesites (40.4%) of the MMGB with those from Proterozoic granulites (17.4%) of the Mozambique Belt. The fact that the basin received material from the Pan-African Mozambique Belt, which is known to have cooled below ~300 °C at about 540 Ma, points to a Cambrian or younger age for the Ikorongo strata deposition.

INTEGRATED SITE INVESTIGATION OF EROSION GULLIES IN SOUTH EAST IRINGA, TANZANIA

Keneth P. Lupogo*, Richard W. Ferdinand

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

**kennlupogo@gmail.com*

Exploration for oil and gas in Tanzania goes back to 1950's. The first natural gas discovery was made on the Songosongo Island in 1974, which was followed by another gas discovery in the Mnazi Bay in 1982. During 2000's, Tanzania has witnessed further exploration and discoveries of significant quantities of natural gas both on- and off-shore, accounting to 57.25 Trillion Cubic Feet (TCF) as per 2018. These discoveries have prompted renewal and extensive exploration activities across on- and off-shore Tanzania by various oil companies. Currently, the oil and gas sector is one of the new and fast-growing sectors in Tanzania. To fully realize the economic, government industrialization agenda and other benefits of this potentially promising sector, the government has been making efforts on several fronts particularly, development of adequate human resources (capacity building) to fill up the local content gap. It is from this basis, taking part in these concerted efforts and since the value chain of oil and gas is multidisciplinary, there is a need for integrated training of oil and gas operations, Legal and Management related programmes at the level of postgraduate diploma to professionals with different academic backgrounds. The overall vision by the Department of Geology at University of Dar es Salaam for this approach is to produce human resources, who had previously graduated in other disciplines with their requisite knowledge and skills to apply their professional skills in the oil and gas industry either as middle-level management or provider of logistical support.

INTEGRATION OF SEISMIC, WELLS AND OUTCROP DATA TO EXPLAIN EVOLUTION OF NORTHERN MANDAWA SUB-BASIN

Ibrahim Rutta* and Shaidu Nuru

Tanzania Petroleum Development Corporation (TPDC), Azikiwe/Jamhuri Street
P.O. Box 2774, Dar es Salaam

** irutta@tpdc.co.tz / baburutta@gmail.com*

This study presents the geologic evolution of the northern Mandawa sub basin using outcrops, well cuttings, seismic and well core data from Songo songo gas field. Our findings reveal that the Neoproterozoic metamorphic basement was faulted and created the accommodation space for the deposition of the basal conglomerate (Mbuo Formation?) and the overlying fluvial sandstone. This is clearly evident in seismic data, although not exposed in the field. The tectonic faulting event is related to rifting of the Gondwana Supercontinent during Late Triassic to Early Jurassic Epochs. The increase of fluvial activities and accommodation space led to the reworking of the basal conglomerates and deposition of poorly sorted conglomerates and sandstones of the Mihambia Formation farther to the basin. During the Middle Jurassic, small retrogradation led to the deposition of the oolitic limestone and sandy limestone of Mtumbei Formation in the marginal marine environment. Whilst fluvial influence to the basin was still significant at the onshore where oolites and pisolites were deposited, the claystones were deposited to the basin centre.

TECTONIC CONTROLS ON GEOTHERMAL SYSTEMS AND IMPLICATIONS FOR RESOURCE ASSESSMENT IN THE EAST AFRICAN RIFT OF TANZANIA

Epiphania G. Mtabazi[1, 2, *], J. D. van Wees[1], J.H.P. de Bresser[1], Nelson Boniface[2]

[1]*Utrecht University*

[2]*Department of Geology, University of Dar es Salaam, P. O. Box 35052 Dar es Salaam*

* *mtabaziepiphania@yahoo.com*

Tanzanian geothermal potential and prospectivity is subject to debate as exploration is in an embryonic stage (only few potential prospects has been identified and starting to be drilled). The Rungwe Volcanic Province (RVP), the focus of this study is located in the Southwestern part of Tanzania. It is an area where the Western and Eastern branches of the East African Rift System (EAR) meet. The area is currently the focus of geothermal exploration in Tanzania due to the existence of favourable conditions for a geothermal system such as the occurrence of thermal springs, active volcanoes, and active faults. This part of the rift is poorly investigated compared to the Northern part of the EAR, Kenya and Ethiopia. Most of the detailed studies related to geothermal potential were only based on surface exploration techniques such as geochemical and geological studies, with few geophysical studies. So far, the advanced regional tectonic analysis focusing on the critical elements of geothermal systems is lacking, consequently hampering full identification of the geothermal resource potential. This project aims to quantitatively assess the thermal and structural framework of the earth in the EAR branches in Tanzania and to use this framework to assess the temperature distribution, and to identify geothermal resource potential in sedimentary basins and the underlying basement. The PhD project will result in a comprehensive thermos- tectonic model of Tanzania, integrating structural, compositional, thermal, rheological and chemical information of the basement-and sediment/volcanic framework underlying the geothermal systems. The integrated model will improve the robustness for concepts on prospectivity, through deploying synergy in minerals, oil and gas and geothermal E&P in the rift system. Moreover, the model will strengthen the national energy policy, through a quantitative assessment of

the potential of geothermal energy and it will enhance exploration and research capacity, adopting modeling concepts from frontier international science.

TECTONIC EVOLUTION OF THE EAST PANDE EXPLORATION BLOCK AND ITS ASSOCIATION TO THE PETROLEUM SYSTEMS

Johnmacdona P. M. Labia, Evelyne Mbede

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

** macdonaproty@gmail.com*

We present tectonic evolution of the East Pande Exploration Block via 2D seismic and well data analyses. The 2D seismic data and well-log data from the East Pande Hydrocarbon Exploration Block were processed (organizing, processing and analyzed) by Petrel software in order to establish the synthetic seismogram, lithology, stratigraphic and structural setting.

Results reveals that the East Pande Exploration Block is characterized by multiple faults (including normal and reverse faults), folds, and north eastward tilting of the sedimentary strata. The faults to have different sets of orientations with dominant ones in the WNW–ESE direction, and others being in NNW–SSE, NW–SE, N–S, W–E, and NE–SW directions. The stratigraphy is characterized by by the transgressive and regressive depositional cycles, and associated progradational and retrogradational sedimentary patterns. The extracted subsurface information were useful in the analysis of the existence of petroleum system elements: potential source rocks, reservoir rocks, seal rocks, and overburden, which are laterally significant.

Generally, the area is mainly affected by local and regional extensional and compressional forces as a result of rifting, drifting, and uplifting tectonic events. The modern topography of the area seems to be controlled by later phases of tectonic activities. To have a meaningful interpretation, more two and three dimensional seismic data, and biostratigraphic data are needed. These will enable the detailed analyses of the subsurface information, which will assist in providing a crystal-clear understanding of the basin evolution and hydrocarbon prospectivity.

GEOCHEMICAL CHARACTERIZATION OF OIL SEEPS IN THE COASTAL SEDIMENTARY BASINS OF TANZANIA: IMPLICATIONS ON DIFFERENT OIL FAMILIES

John Gama, Ernest Mulaya, Elisante Mshiu

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

** johngama71@yahoo.com*

Several oil seeps have been reported in various parts of the Tanzanian coastal sedimentary basins, few studied oil seeps indicated a Permian and lower to Middle Jurassic sources. In this study we present geochemical analyses (GC/MS) carried out in order to determine composition, organic facies, and establish oil to oil correlation of unstudied oil seeps.

Results indicate that Wingayongo, Mnuyo, Tambalani seeps were deposited under type II algal marine kerogen, whereas the Kilwa Kisiwani and Tambalani oil seeps were deposited under mixed type III/II kerogen. Tongoni oil seep was deposited under terrestrial/humic kerogen. Extracts from Tongoni, Kilwa Kisiwani and Mnazi bay condensates show C29/ C30 hopanes greater than 1, suggesting a carbonate-marl source of origin for these seeps. Extracts from Wingayongo and Mnuyo are characterized by the presence of anomalously higher value of gammacerane, which indicate hypersaline source of origin. Mnazi bay condensates and Kilwa Kisiwani oil seeps are dominated by relatively higher Oleanane index, ranging from 27 to 29%, indicating a Cretaceous or younger sources of these liquid hydrocarbons, contrary to extracts from Wingayongo and Mnuyo that are characterized by the presence of lower oleanane index of 7.3; indicating that these seeps are derived from older sources (Jurassic?) and was contaminated by a younger source (Cretaceous or younger) during migration.

The study further reveals that coastal sedimentary basins are characterized by multiple active source rocks of different facies and age including post Cretaceous to probably Lower Jurassic. Examined biomarkers indicate three major source rocks for oil seeps, including: an algal marine deposited, under hypersaline environment; mixed kerogen; and Carbonate (post Cretaceous). The Mnazi bay and nearby oil seeps do not correlate. A positive correlation established from this study is Wingayongo and Mnuyo oil seeps only.

THE TECTONIC EVOLUTION OF THE SEAGAP FAULT ZONE AND THE IMPLICATION TO SEDIMENT DISTRIBUTION IN OFFSHORE TANZANIA

Venance Emmanuel Mboya

Tanzania Petroleum Development Corporation (TPDC), Azikiwe/Jamhuri Street
P. O. Box 2774, Dar es Salaam
vemanuel@tpdc-tz.com

The understanding of the tectonic history of East Africa Continental Passive Margin (EACPM) development is vital in understanding offshore basin evolution and the distribution of potential petroleum system in the region. This study focuses on the evolution of the Sea Gap Fault (SGF) and its control over sediment distribution, as well as applying the knowledge on Seaward Deeping Reflectors (SDRs) to locate the possible source rock within the Oceanic-Continental Transition zone.

The SGF is N-S trending failed sinistral strike slip fault system, which formed prior to a successful dextral Davie strike slip fracture zone (DFZ) during the Late Jurassic. It extends from the basement to the sea bed, where it appears to have been reactivated during Early Jurassic rift with some effects on sediment distribution near, along and to the far east of the SGF. Moreover, the SGF and the DFZ are related to continental drift of eastern Gondwana, only that the former appears to have failed due to an eastward shift and change of stress field concentrations to a successful dextral strike slip DFZ; and hence, saving as the current boundary locations for eastern and western Gondwana. Borehole data reveals no intersection of the Jurassic syn-rift section in the region, which was anticipated to be source rock for most of the offshore gas discoveries. The SDRs on seismic sections within the Oceanic-Continental transition zones, which are commonly expected to aid locate highly rifted hydrocarbon source rocks prone zones have not been found in the offshore Tanzania. An alternative approach is then employed by mapping the syn rift Jurassic strata related to tectonic development of the EACPM.

STRUCTURAL INTERPRETATION OF 2D SEISMIC PROFILES IN THE NORTHERN PART OF EAST PANDE BLOCK, SOUTHERN COAST OF TANZANIA

Chonge Rashid Shekarata *, Evelyne Mbede, Nelson Boniface

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

** csheka85@gmail.com*

Seismic reflection data (profiles) were employed to characterize geological structures in the northern East Pande Block for the aim of assessing the hydrocarbon potential of the area, which lies in the southeast offshore coast of Tanzania. Structures were evaluated using 8 seismic profiles in 2D; 6 cross-lines trending EW and 2 in-lines trending NS directions plus Well data that included well tops, well header and well logs all of which were imported into the interactive workstation with the use of Petrel and Techlog Software. Twelve-third order sequence boundaries (horizons) and two kinds of faults trending in NNW-SSE direction were successfully traced and picked. Faults identified are of different age resulting from two rifting events and more than one deformation episode that occurred in the area. Identified horizons were traced to produce Time structure map in which later were converted to depth structural map using Time-depth relation curve. The lithology identification helped to delineate two reservoirs in the area at depth range of 3399.4m – 3835m and 4480m – 4591m for Top Tikiti North deep Channel-Base Tikiti North deep Channel and Top Tende-Base Tende respectively. Also, the existences of reservoirs were marked by presence of perfect contour closures on surface maps produced. Through all interpretation, the faults associating to reservoir were marked as possible hydrocarbon traps. Therefore, the principal structures responsible for the hydrocarbon entrapment are the structural high that corresponds to normal faults.

GEOPHYSICAL (GRAVITY AND MAGNETIC) INVESTIGATION OF THE SUBSURFACE STRUCTURES OF THE RUHUHU BASIN, SOUTHWESTERN TANZANIA

Ibrahim H. Lufyagila*, Isaac M. Marobhe

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

** lufyagilaibrahim@gmail.com*

Ruhuhu basin is one of the intracratonic continental basins located southwest of Tanzania, and covers the area of about 10343 km2. The basin is significantly potential for coal and hydrocarbon but the subsurface structures and spatial distribution of sedimentary strata within the basin are less known/understood. Digital Elevation Model (DEM), gravity and magnetic data were used in this study to investigate the subsurface geology. The gravity data were gridded by Geosoft Oasis Montaj software to produce images that were filtered to enhance the quality of the images for easily structural identification.The Euler deconvolution, spectral analysis of magnetic and gravity modelling determination of depth to basement. Results reveal that the majority of faults, dyke and lineaments (structures) trends on NE-SW, NW-SE and few trends on NNE/NNW directions. The basin is shallow in the north, northwest, south and southeastern parts, with depth less than 1.5 Km, and deepen southwest and northeastwards to maximum depths of 3-5 Km. Depth estimates from magnetic and gravity data suggest northeastward tilting of the basin, and that basin is deep enough to allow maturation of hydrocarbon. Further studies are recommended to the southwest and northeastern part of the basin.

PETROPHYSICAL ANALYSIS OF THE MPERA WELL IN THE EXPLORATION BLOCK 7, OFFSHORE TANZANIA: IMPLICATION ON HYDROCARBON RESERVOIR ROCK POTENTIAL

Juma M. Mheluka, Gabriel D. Mulibo

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

** mmheluka@gmail.com*

This study presents analysis of petrophysical parameters, assessment of lithologies in the Mpera well-log data,and ultimately assessment of potential hydrocarbon reservoir rocks in the Exploration Block 7, offshore Tanzania. The Techlog software program was used in the data processing and analysis. The results indicate three (3) non hydrocarbon-bearing reservoir rocks: Mpera splay (sandstone), Mpera deep sandstone-dominated 1 (sandstone and limestone), and Mpera deep sandstone 2 (sandstone and limestone); with gross thickness of 94.335 m, 28.905 m and 12.967 m, respectively. The average permeability values of the reservoir rocks were 9.47 mD, 6.45 mD and 4.67 mD, whereas average porosity values were 14.57%, 17.4% and 16.75%, with average volume of shale 25.7%, 23.5% and 9.7% at Mpera splay, Mpera deep sand 1 and Mpera deep sandstone 2, respectively. These results indicate poor permeability, good porosity and good quality reservoir, in terms of volume of shale. Fluid type defined in the reservoirs was basically water. High water-saturation (90.6% - 97.7%) in the reservoir zones of the Mpera well suggest that the proportion of void spaces occupied by water is high; thus, indicating less than 10% hydrocarbon saturation. The findings indicate that Mpera well reservoir rocks are of low quality with non-hydrocarbon bearing such that it is not potential for hydrocarbon production.

ASSESSMENT OF PHYSICOCHEMICAL ATTRIBUTES OF WATER AND TOXIC METAL CONTENTS OF SEDIMENTS AND SOILS FROM THE KIZINGA RIVER, DAR ES SALAAM TANZANIA

Emmanuel O. Kazimoto*, Rehema Mlangwa, Sarafina P. Sanga, Mohamed Hashim, Yusuph S. Pharles, Fanuel P. Sifi, Charles W. Messo, Jean K.T. Mujumba, Elisante E. Mshiu

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

** ekazimoto@udsm.ac.tz*

We present preliminary results of a study that was conducted along the Kizinga River, which flows adjacent to an industrial area and a densely populated area in Dar es Salaam. The study was conducted on water, sediments and soils, with an aim of assessing physicochemical attributes of river waters and the levels of toxic metal contents in sediments and soils from the river valley at the end of rain season between April and July 2018. A total of 17 samples of water and 32 sediments and soil samples were collected from upstream to downstream along the river valley. Physicochemical parameters of water were determined using pH & EC meter, spectrophotometer and digital titrator at the Department of Geology of the University of Dar es Salaam, whereas toxic metal contents of sediments and soils were determined using portable x-ray fluorescence spectrometer (pXRF).

Water from Kizinga River was found to have a normal pH range for river water of 5.98 – 7.72, mean pH = 7.12, although with fairly high conductivity values of 459 – 1901μS/cm (mean = 1212.9 μS/cm) that corresponded with high Total Dissolved Solutes (TDS). Chemical parameters like nitrite, nitrate, phosphate, chloride and sulphate contents were variable along the river valley, but generally as high as 40.28 mg/l NO_3^-, 5.45 mg/l PO_4^{3-}, 500 mg/l Cl^-, and 98 mg/l SO_4^{2-}, which suggests a most likely input from anthropogenic sources (e.g. industrial and domestic effluents). Toxic metals (e.g. Pb, Zn, Mn, Fe, Cu, Co and Ti) content in sediments and soils were all within acceptable ranges in sediment and soils along the river valley, with exception of Zn, which was mostly above acceptable concentration limit by the Tanzania Bureau of Standards for soils/sediments in urban environment

(Zn > 150 ppm). Lack of metallurgical facility near the Kizinga River that might be the probable source for observed high Zn content in samples leaves anthropogenic sources as the culprit for the observed Zn contents in sediments and soils.

High TDS, conductivity and Zn contents affect the quality of water from the Kizinga River and limit the use of water for different purposes (domestic and industrial). Moreover, high zinc contents in river sediments from upstream to downstream Kizinga River potentially have an effect on aquatic organisms in the river and in the ocean at the river mouth. Further studies are still ongoing to assess the environment along the Kizinga River valley.

GEOLOGY AND ARCHITECTURE OF THE ONSHORE RUVUMA BASIN OF TANZANIA

Chone L. Malembo [1*], Isaac Marobhe[1], Emmanuel O. Kazimoto[1], Nelson Boniface[1], Obeid Saitabau[1, 2], Randell Stephenson[1], Ian Alsop[1]

[1]*Department of Geology, University of Dar es Salaam, P.O. Box 35052, Dar es Salaam*
[2] *Department of Geology and Petroleum Geology, University of Aberdeen, Scotland*
cmalembo@gmail.com

This project aimed at establishing basin structural architecture, and provide petrographic descriptions of rocks and geologic structures in the Onshore Ruvuma Basin (ORB), in order to facilitate exploration for hydrocarbons in the basin. This work involved integration of field surveys, processing and interpretation of magnetic and gravity data, generation of geophysical derivatives maps coupled with processing and supplementing the results with the study of thin sections of some of the selected representatives samples of the outcrops encountered in the field.

Field surveys and petrographic studies reveal that the basement of the western end of the ORB consists of orthogneisses and metasedimentary rocks, which are overlain by the basal conglomerate (Cretaceous?) that is poorly sorted with rounded cobble to pebble sized lithic clasts that are supported by a matrix of sand and clay materials. Overlying these basal conglomerates are sandstones, locally known as Makonde beds (Cretaceous?), which have a predominantly WNW–ESE strike direction (strike ~120º) and dipping gently (<10º) to the NE. The youngest strata in the ORB are limestones, poorly indurated lime and pebbly sands that crop out overlying the Makonde beds. Makonde sandstones are poorly sorted to moderately and well sorted, composed of angular to sub-rounded grains of quartz, feldspar and rock fragments. Proportions of feldspars, quartz and rock fragments in the rocks is variable such that the sandstone can be classified as arkose, quartz arenite and quartz wacke.

Total Magnetic Intensity (TMI) over the ORB clearly revealed areas that are underlain by shallow basement from those of the basin, with the centre? of the basin reaching up to 8 km depth. Areas of high magnetic intensity (high relief) and gravity high correspond with areas underlain by basement or with basement highs, in contrast, areas of gravity high and relatively low magnetic intensity corresponds to reefal limestones in the east of the ORB.

Moreover, magnetic data has clearly picked magnetic lineaments, e.g. those trending N – S, which crosscut those trending NE – SW, E – W and WNW – SSE. The former are interpreted to represent basin structures related to formation of the basin, whereas the latter are older structure related to older tectonic events (Karoo rifting and Pan-African Orogeny).

Our preliminary results suggest that the Makonde sandstones that is supposedly potential reservoir rocks of ORB, have actually poor reservoir qualities. Conversely, young strata (post Cretaceous) of ORB and different structures are interpreted and considered constitute important plays for the observed/discovered hydrocarbon in the basin.

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