TANZANIA GEOLOGICAL SOCIETY (TGS)

2019 ANNUAL MEETING AND WORKSHOP

BOOK OF ABSTRACTS




DAR ES SALAAM
25th - 27th September 2019

Front cover photos:

Top Left: *Fishing activities at one of the fish markets in Dar es Salaam;* ***Top Right:*** *Tanzania Portland Cement Public Limited Company/TWIGA Cement (image source: https://www.twigacement.com/en). The company is found at Wazo Hill area, which has an elevation of approximately 100m above sea level, making the highest fossil reef in the region and one of the largest carbonate occurrences on the Tanzania coast;* ***Bottom left:*** *Dar es Salaam City with beautiful Indian Ocean Coast; and* ***Bottom right:*** *Askari Monument in Dar es Salaam, memorial to the askari soldiers who fought in the British Carrier Corps in World War I.*

Message to Participants of the TGS 2019 Workshop

Dear Participants,

Welcome to the Tanzania Geological Society (TGS) 2019 annual geoscientific workshop and meeting to be held here in the Dar es Salaam city from 25th to 27th of September 2019. This year event is done not only traditionally but in commemoration of 50 years anniversary of the Tanzania Geological Society (TGS). It 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.

In reflection of the selected theme for this year's workshop: "***Fifty years of geosciences profession in Tanzania: Power of the Past – Force of the Future"***. We present 20 Abstracts that directly or indirectly address one of these 5 sub-themes:

1. Artisanal and small scale mining in Tanzania (the past and future)
2. Responsible mining for socio-economic sustainability
3. Legal and regulatory framework in the Tanzania's mining sector
4. Developments in energy sector of Tanzania
5. Water resource management in Tanzania: Water demand, quality and safety

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 also provides a platform for informed discussions on different issues encompassing: development in energy sector of Tanzania, water resources management, responsible mining for socio-economic sustainability, artisanal and small scale mining in Tanzania, and legal and regulatory framework in the Tanzania's mining sector.

During the event, besides oral presentations, there will be 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 efforts and commitment of TGS members and all stakeholders. The Tanzania Geological Society is grateful for the workshop and meeting secretariat and committees for their time invested in making this annual event success. Reviewers have done a great job in assessing multiple abstracts for this year workshop.

This year's workshop and meeting could not be possible without the significant support from Helium One Ltd, Geita Gold Mine, Petra Diamonds, Ministry of Energy of Tanzania, Pan African Energy, University of Dar es Salaam, Geological Survey of Tanzania (GST), TANESCO and STAMICO. Tanzania Geological Society (TGS) is hugely indebted for their continued support.

Finally, TGS welcomes you to Dar es Salaam, the commercial city of Tanzania and the University of Dar es Salaam for a unique TGS workshop experience.

Workshop Organizing Committee

Tanzania Geological Society (TGS)

Organising Committee

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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.

Geita Gold Mine | Anglogold Ashanti

http://www.geitamine.com/en.html
TTenga@AngloGoldAshanti.com

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

As at 31 December 2018, the Mineral Resource is 6.26 million ounces. Approximately 4,130m of development was completed for the Star & Comet and Nyankanga underground sections, to access new areas for stope mining and for further exploration, in 2018. Open-pit mining at Nyankanga and Geita Hill continued with Geita Hill reaching the end of its economic life and Nyankanga scheduled to be completed in the first half of 2019. Surface exploration continued at Selous, a satellite pit 2.4km from Star & Comet, expected to supplement the underground operation in the near term.

Other notable projects at Geita were completion of the 40MW power plant and the purchase of underground mining plant and equipment. The power plant was commissioned in August and is currently in full operation, providing reliable, low-cost power to the mining operations. The purchase of the underground mining plant and equipment is in line with the strategy to transition to owner mining at Star & Comet, planned for the first half of 2019, with the full change over for the rest of the mine's sections expected to follow in coming years. [Source: *http://www.geitamine.com/en.html#about*].

Recognition of the Outstanding Tanzanian Geologist

Dr. R. H. Kimambo

A token of appreciation is extended to Dr. R. H. Kimambo for his singular endeavours in promoting industrial minerals and rocks of Tanzania. He dedicated much of his time for development of earth sciences in the country and beyond. He has made an impact that will live for generations to come.

Editorial Team

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

Dr. Kasanzu H. Charles
Department of Geology, University of Dar es Salaam.

TGS 2019 Workshop Abstract Titles

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Workshop Programme

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	Eng. Kato Kabaka	General Manager, TGDC
	Dr. Tito Mwinuka	Tanzania Electrical Supply Company, TANESCO
	MoE-Commissioner	Commissioner for Petroleum and Gas
	MoE-Commissioner	Commissioner for Electricity and Renewable Energy
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11:25 - 11:50	Charles B. Athuman	Assessment of groundwater recharge using multivariate statistical analysis in a semi-arid fractured basement-aquifer system of Iramba Sub-Basin, Singida, Tanzania.
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	Eng. Aron Joseph	Dar es Salaam Water and Sewerage Authority (DAWASA)
	Eng. Gonzalves Rutakyamirwa	Rural Water Supply and Sanitation Agency (RUWASA)
	Eng. Herbert J. Kashililah	SHAHIDI wa MAJI Board, TAWASANET Board
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	Mr. Gamba Mtoni	CSR, Mwadui Williamson Diamond Mine

	Ms. Patricia Mhondo	Shell Exploration and Production Tanzania Limited
	Mr. Terence Ngole	Assistant Commissioner, LC & CSR, MoM
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	Representative	Tanzania Women Miners Association, TAWOMA
	General Secretary	The Federation of Mining Associations , FEMATA
	Dr. Joas Kabete	Project Director, Mazoka Resources
	Mr. Francis Mihayo	Assistant Commissioner for Small Scale Mining, Ministry of Minerals
	Mrs. Yorkberth Myumbilwa	CEO, Geological Survey of Tanzania, GST
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	Prof. Shukrani Manya	Executive Secretary, Tanzania Mining Commission
	Mr. Altert Balati	Planetary Politics
	Prof. A. Mruma	Board Member, Tanzania Mining Commission
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Goodluck Ngulo	Mapping of geological structures at Ibadakuli in a reconnaissance survey for geothermal resource
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Zortosy M. Mpangile	Characterization of gold mineralization at Misaki area Singida using integrated prospecting techniques
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Post workshop Excursion

Leader	Date & Place
Dr. Cassy Mtelela	28-09-2019; to Pugu, Pugu Kaolin deposit
	29-09-2019; to Chalinze, Jurassic Sedimentary Successions

ILMENITE CONCENTRATES FROM SHUNGUBWENI BEACH SAND MINERALS: A CHALLENGE IN MINERAL CLASSIFICATION

Manyama M. Makweba

Consulting Geologist, P.O. Box, 833, Dodoma

** mmakweba@yahoo.com*

Ilmenite concentrates are minerals recovered from Beach Sand deposits (placer deposits) and hard rock deposits. The former are normally composed of minerals such as ilmenite, magnetite, rutile, zircon, quartz, monazite and other minor elements, and the latter comprises of ilmenite which is the source of titanium, magnetite, plagioclase, pyroxene, amphibole, and quartz. In other parts of the world such as Australia, China, Canada, India, South Africa and Brazil, ilmenite, rutile and zircon concentrates have been produced in appreciable quantities and valuable elements such as Ti, Zr are extracted for industrial use.

The Shungubweni Beach Sand Minerals deposit at Mkuranga District composes mainly ilmenite, rutile, magnetite and zircon, whereas mineral such as monazite occur in minor quantity. These minerals have been recovered by gravity separation followed by magnetic and electrostatic separation methods producing ilmenite, zircon and rutile concentrates.

The quantifications of the ilmenite, zircon and rutile concentrates have been done by X-Ray Fluorescent (XRF) method for chemical composition whereas the mineralogical compositions have been identified based on their physical characteristics rather than X-Ray Diffraction (XRD) method due to the absence of such facility in the recognized national laboratories.

In this case, the exportation of ilmenite and zircon concentrates, which are produced from Shungubweni mine in Mkuranga District, is facing challenges on whether the percentage of mineralogical composition should be used to determine the value of the ilmenite and zircon concentrates or their chemical composition. Thus, this abstract tries to explain how the beach sand mining companies are in the dilemma on conforming with the New Mining Act, 2017 and its regulations 2018, which promote the value addition of mineral raw materials prior to exportation.

The abstract also show how the categorization of beach sand minerals such as ilmenite is classified as metallic minerals when it acts as a source of titanium *metal*, whereas when it acts as a source of TiO_2 for pigment industries, then it becomes an industrial mineral. This makes uncompromising royalty fees calculation when ilmenite concentrates are considered as titanium ore source materials rather than industrial minerals materials.

COPPER MINERALIZATION IN THE NEOPROTEROZOIC MOZAMBIQUE BELT OF EASTERN TANZANIA: CLASSICAL EXPLORATION MODEL AND POTENTIAL FOR SMALL SCALE MINING INITIATIVES

Gerald L. Chuwa

Department of Geology, University of Dar es Salaam, P.O. Box 35052, Dar es Salaam
gerald7chuwa@yahoo.com

Numerous copper occurrences and deposits are hosted in Proterozoic rocks of Tanzania. Of particular interest are the copper-rich showings and occurrences, located within the Neoproterozoic Mozambique belt. The belt comprises of granulite to amphibolite facies metamorphic, igneous and sedimentary rocks. The copper deposits and occurrences include the Pare copper mine in the Mwanga District, several workings in the Same District, several occurrences in the Handeni and Kilindi Districts, the Kilosa area and recently workings in Lindi Region.

Elsewhere around the world, Proterozoic copper mineralisation has received extensive attention and research following discoveries and development of significant copper rich mines such as the world-class Mt. Isa Zn-Pb-Ag and Cu deposit located in the Mt Isa inlier of Queensland, Australia. The example of Mt. Isa deposit Cu-Mineralisation and its exploration model was applied to deposits and occurrences of copper mineralisation in eastern Tanzania. Several characteristics and features such as geological settings of the Cu mineralisation, tectonic complexity, grade distribution, mineralisation environment and potential for significant vast volumes of material were highlighted.

In the case of copper operations in eastern Tanzania, these are owned and operated by small scale mining companies, individuals and cooperatives of artisanal miners. There exists opportunities to upscale research and exploration, and undertake serious research work in these areas for large scale mineral resources generation. Furthermore, in the current small scale operations, addressing some critical issues in those areas is paramount in the quest of turning these occurrences and deposits into net producers of value.

In the proposed remediation of the current situation and going forward, quality exploration using modern tools such as stream sediments and soil geochemistry, geophysical surveys and detailed geological mapping is

critical to the understanding of the lithological and structural features associated with known mineralisation zones. Proper evaluation of inferred resources over a long stretch of exposed workings should follow, preferably using advanced drilling and down hole geophysical surveys targeting high-grade pods and features to provide impetus to proper mine planning. When mineral resources are proven and geologically viable for mining, a proper feasibility study addressing all technical issues, and design for processing of ores available, should be implemented. In the same venue, additional regional exploration should continue for the generation of future copper resources for replenishment and sustaining operation.

In order to achieve the above, the need for a trustworthy and sustainable relationship between license owners, the Government of Tanzania, capable investors and entrepreneurs, is proposed and emphasised. The relationship will address the technical, financing and market optimisation issues while ensuring artisanal and small-scale miners are mobilised in workable cooperatives to use the opportunity to participate in operations. Additionally, entrepreneurs can review the progress of the mining operation, continue to explore for better and additional ores while confirming the geological features and true down depth mineral potential of these deposits and occurrences of copper in eastern Tanzania.

PLIOCENE-PLEISTOCENE RECORDS OF PROTOLITH AND WEATHERING INTENSITIES IN THE PALEO-LIFE RICH SEDIMENT-TUFF SEQUENCES OF OLDUVAI AND LAETOLI BASINS OF NORTHERN TANZANIA

Charles H. Kasanzu*, Makenya A.H. Maboko, Shukrani Manya

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

** kcharls16@yahoo.com*

Major and trace elements and $^{87}Sr/^{86}Sr$ isotopic compositions were analysed for samples from the Pliocene-Pleistocene to Recent Olduvai and Laetoli basins of northern Tanzania with the aim of constraining their provenance and paleo-climatic conditions. Our results reveal contrasting chemical weathering intensities between the two basins with Laetoli recording intermediate Chemical Index of Alteration (CIA) values (58 – 78%) while the same indices are very low (31 – 49%) for Olduvai. The Mean Annual precipitation (MAP) values for Laetoli (mean = 950 mm/yr) are relatively higher than those for Olduvai (mean = 692 mm/yr), consistent with increased precipitation in the Pliocene relative to the Pleistocene. The relatively higher MAP values at Laetoli suggest a wetter climate whereas the lower values in Olduvai are indicative of relatively drier conditions.

Th/Sc, La/Cr and $^{87}Sr/^{86}Sr$ data suggest the felsic volcanic facies of Olmoti as a possible source for the Olduvai sediments whereas a relatively mafic protolith from Sadiman volcano has been inferred for the Laetoli protolith using Th/Sc, Zr/Nb, Nb/Ta and Zr/Hf ratios.

The climatic inferences drawn from CIA and MAP data may point to a more favourable habitat for life proliferation in the wetter environment of Laetoli compared to the drier environment of Olduvai. This inference is consistent with archaeological evidence which indicates a greater abundance of hominin fossils including well preserved footprints in Laetoli.

GEOCHRONOLOGY AND GEOCHEMISTRY OF THE KONSE PILLOW BASALTS, TANZANIA: IMPLICATION FOR A NEW STRATIGRAPHIC SEQUENCE OF THE USAGARAN BELT

Nelson Boniface [a,*], Tatsuki Tsujimori [b], Abdulkarim Mruma [c]

[a] *University of Dar es Salaam, P.O. Box 35052, Dar es Salaam, Tanzania*
[b] *Center for Northeast Asian Studies, Tohoku University, Aoba, Sendai 980-8576, Japan*
[c] *Geological Survey of Tanzania, Box 903, Dodoma, Tanzania*
[*] *nelson.boniface@udsm.ac.tz*

The Paleoproterozoic Usagaran Orogenic Belt in East Africa preserves relics of Paleoproterozoic volcanic-arc magmas, and subducted and displaced oceanic-crust. This article describes geochemical characteristics of displaced pillow basalts from the Usagaran Belt (Konse Group) along with their ages. The major goal of this work is to establish the age and stratigraphic position of the Konse Group and its tectonic settings. Our data indicate that the Konse pillow basalts have tholeiitic composition and are overprinted by greenschist facies metamorphic conditions but their primary geochemical signatures are preserved by REE and fluid immobile elements. The $(La/Sm)_N$ ratios (0.62 - 1.09) and REE patterns point to Normal-MORBs and Transitional-MORBs mantle source. The analysis of high-valency elements and trace element patterns points to a mixed signature of MORB tholeiites and island-arc tholeiites with elevation of Ba, Th, U, Eu and Sr. This composition is similar to that of Phanerozoic back-arc suprasubduction-zone ophiolites. Therefore, Usagaran Belt pillow basalts make analogue of the Tethyan-type suprasubduction-zone ophiolite evolution and emplacement in the Precambrian. Our new U-Pb zircon geochronological data yield an age of 2048.6 ± 3.8 Ma from a gabbro that is associated with pillow basalts. The age is hereby interpreted as a magmatic crystallization age and marks the time of operation of suprasubduction-zone back-arc systems at the southeastern margins of the Tanzania Craton. The findings indicate that the Konse Group is the oldest tectonic unit of the Usagaran Belt. Based on the new geochemical and geochronological data we conclude that, the Konse pillow basalts and gabbros (Konse Group) eclogites (Isimani Suite) were probably derived from the common oceanic plate. The Konse group is, therefore, a deformed relics of a displaced Oceanic Plate Stratigraphy (OPS) formed about 2050 Ma while the Isimani eclogites is a HP/LT metamorphic

interface derived from the same oceanic plate but attained eclogite facies conditions in a subduction zone about 50 Ma later i.e. 2000 Ma ago.

NEW TECTONIC MODEL AND DIVISION OF THE UBENDIAN–USAGARAN BELT, TANZANIA: A REVIEW AND IN-SITU DATING OF ECLOGITES

Nelson Boniface [a,*], Tatsuki Tsujimori [b]

[a] *University of Dar es Salaam, P.O. Box 35052, Dar es Salaam, Tanzania*
[b] *Center for Northeast Asian Studies, Tohoku University, Aoba, Sendai 980-8576, Japan*
[*] *nelson.boniface@udsm.ac.tz*

Records of HP/LT metamorphic interface are not common in Precambrian orogens. It should be noted that the association of HP/LT metamorphic interfaces and strongly deformed oceanic plate stratigraphy that form accretionary prisms between trenches and magmatic arcs are recognized as hallmark signatures of modern plate tectonics. In East Africa (Tanzania), the Paleoproterozoic Ubendian-Usagaran Belt records HP/LT metamorphic interface that we consider as a centerpiece in reviewing the description of tectonic units of the Ubendian-Usagaran Belt and defining a new tectonic model. Our new U-Pb zircon age and the interpretations from existing data reveal an age between 1920 and 1890 Ma from kyanite bearing eclogites. These data add to the information about known HP-LT metamorphic events at 1890 – 1860 Ma and 590 – 520 Ma in the Ubendian Belt and at 2000 Ma in the Usagaran Belt. Arc – back-arc signatures from eclogites that occur with metasediments implies that their mafic protoliths were probably eroded from arc basalt above a subduction zone and were channeled into a subduction zone as mélanges and got metamorphosed. The Ubendian-Usagaran events also record rifting, arc- and back-arc magmatism, collisional, and hydrothermal events that preceded or followed HP-LT tectonic events. Our new tectonic subdivision of the Ubendian Belt is described as: 1) Western Ubendian Corridor mainly composed of two Proterozoic suture zones (subduction at 2000 Ma, 1920 - 1890 Ma, and 590–500 Ma) in the Ufipa and Nyika Terranes. 2) Central Ubendian Corridor is predominated by metamorphosed mafic – ultramafic rocks in the Ubende, Mbozi, and Upangwa Terranes that include the 1890 – 1860 Ma eclogites with MORB affinity in the Ubende Terrane. 3) Eastern Ubendian Corridor (the Katuma and Lupa Terranes) characterized by reworked Archean crust.

NEW INSIGHTS ON THE GEOLOGY AND GOLD MINERALIZATION IN THE GEITA GREENSTONE BELT, NW TANZANIA

Shimba Daniel Kwelwa

Geita Gold Mine, P.O. Box 532, Geita
Skwelwa@AngloGoldAshanti.com

The Geita Greenstone Belt forms the northern arm of the Sukumaland Greenstone Belt and hosts several world-class gold deposits such as Nyankanga, Geita Hill, Kukuluma, and Star and Comet. These deposits are spatially distributed in three districts namely; Nyamulilima, Central and Kukuluma. Historical discoveries of these deposits were a result of discovery of soil geochemical anomalies between 1990 and 2000 and information inherited from colonial times. Since then, no new deposit has been discovered, partly due to the lack of solid regional geological framework, which hindered establishment of large-scale geological controls to gold mineralization. Starting 2013, intensive regional studies have been conducted, aiming at establishing the belt-deposit scale lithostructural framework and their possible link to gold mineralization.

In the light of this effort, we present the newly established stratigraphy of the Geita Greenstone Belt, eruption events of mafic volcanics (Kiziba Formation) deduced from Sm-Nd ages ~2.8 Ga, timing of emplacement of intrusive from U-Pb ~2.68 Ga, sedimentation ages from U-Pb ~2.7–2.5 Ga and their implications to the greenstone belt stratigraphy and crustal evolution of the northern Tanzania Craton. In addition, the role of regional deposit-scale structures such as fold hinges, intersections of shear zones in controlling high grade shoots is presented.

THE FIRST RECORD OF THE PERMO-TRIASSIC PALYNOMORPHS, AND SIGNIFICANT PALYNOLOGICAL TURNOVER ACROSS THE TRIASSIC–JURASSIC TRANSITION IN THE RUVU BASIN, COASTAL TANZANIA

Stephen Magohe[1, *], Cassy Mtelela[1], Roel Vereuessel[2], Alexander Houben[2], and Nico Jansen[2]

[1]*Department of Geology, University of Dar es Salaam, P.O. Box 35052, Dar es Salaam,*
[2]*Geological Survey of the Netherlands (TNO)*
[*]*magohesteve@gmail.com*

We present the first comprehensive palyno-stratigraphic investigation of the pre- and post Gondwana strata penetrated by the Makarawe-1 well in the Ruvu Basin, coastal Tanzania. The results, which are pretty much preliminary at this stage, reveal a number of palynozones including the Alisporites- Falcisporites Assemblage Zone and Reduviasporonites Fungal Zone in the lower part of the Makarawe-1 well. Both of these palynozones represents a typical end of Permian assemblages; suggesting that the lower part of the section might be as older as late Permian in age. Furthermore, a few other terrestrial microspores are observed to retain unseparated tetrad outline, and are interpreted to represent an evidence of end of Permian ecological crisis. Significant changes occur in the upper portion of the section, where mid-Jurassic dinoflagellates and classopolis assemblages dominate. The significant dinoflagellates genus from this interval includes: the Wanaea sp. (Bathonian- Kimmeridgian), Nannoceratopsis pellucida (Callovian-Oxfordian), Mendicodinium groenlandicum (Kimmeridgian-Tithonian), Dingodinium spinosum (Callovian-Oxfordian), Glossodinium dimorphum (Callovian-Oxfordian) and Dissilodinium (?) sp. (Bajocian-Callovian), which altogether forms a Concurrent Range Zone. The ages of these zones are based on palynological correlation with similar biozones in the southern hemisphere. These findings provides important insights into understanding paleoenvironmental changes and associated floral and faunal evolution during the Permian to Jurassic period, in addition to contributing better stratigraphic constrains on the least studied Tanzania coastal basin.

APPLICATION OF ENVIRONMENTAL ISOTOPES AND HYDROCHEMICAL TECHNIQUES TO GROUNDWATER RECHARGE STUDIES IN A SEMI-ARID FRACTURED BASEMENT-AQUIFER SYSTEM OF IRAMBA SUB-BASIN, SINGIDA, TANZANIA

Charles B. Athuman[1,*], Hudson H. Nkotagu[1] and Tyler B. Coplen[2]

[1]*Department of Geology, University of Dar es Salaam, P.O. Box 35052, Dar es Salaam*
[2]*U.S. Geological Survey, 431 National Centre, Reston, VA 20192, USA*
buteta@yahoo.co.uk

Environmental isotopes (δ^2H *and* $\delta^{18}O$) and the hydrochemical data have been interpreted to provide understanding of the groundwater recharge processes in a Semi-arid Fractured Basement-Aquifer System of Iramba Sub-Basin, Singida, Tanzania. Water samples from boreholes, dugouts and shallow wells were collected using appropriate gears and analyzed by employing standard analytical methods.

Higher levels of chemical parameters such as fluoride and chloride were recorded in shallow wells samples consequent to evapotranspiration process. The study area is dominated by Na-CO3 water type. Isotopically, the distribution of δ^2H and $\delta^{18}O$ in various water sources indicates that groundwater recharge is due to local rainfall. The variations between δ^2H and $\delta^{18}O$ among the water sources indicate evaporation process. It has been concluded that the isotopic and chemical character of groundwater in this part of the world set as a measure for groundwater recharge assessment and hence facilitating to the sustainable management of water resources.

STRUCTURAL INTERPRETATION OF EXPLORATION BLOCK 3 USING SEISMIC DATA: ASSESSING ITS HYDROCARBON PROSPECTIVITY

Cliff J. Msanya* and Evelyne Mbede

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

**msanyacliff16@gmail.com*

The purpose of the study has been to widen the understanding on the tectonic evolution and stratigraphy of the exploration Block-3 in the southern offshore Tanzania and its association to the petroleum systems. The study was done by using 2D seismic data and borehole data from Papa-1 well, the only well drilled in this block so far. In accomplishing this task, two softwares were key; Schulmberger Petrel was used in organizing, processing and analyzing seismic data so as to establish the synthetic seismogram, structural and stratigraphic setting, whereas the Schulmberger Techlog was used to process and analyse well data in order to establish the lithology.

Structural interpretation of seismic data unveils that the area is comprised of faults (both normal and reverse faults), folds as well as the tilting of the sedimentary formations. Different sets of fault orientations were established as well, where the dominant one was NW-SE direction; others have different orientations such as NE-SW, NNW-SSE and N-S directions. The stratigraphy of the area has been influenced by both transgressive and regressive depositional cycles. These depositional cycles resulted to the prograding and retrograding sediments deposition. The extracted subsurface information played a key role in the analysis of the existence of petroleum system elements; potential source rocks, reservoir rocks and seal rocks.

Generally the area was affected by both local and regional extensional and compressional forces due to some tectonic events such as rifting, drifting and uplifting. A meaningful interpretation of this particular area will be more meaningful if more 2D and 3D seismic data are captured together with biostratigraphic data. Such data will be helpful in the whole interpretation exercise so as to have a more detailed and comprehensive subsurface information which will assist in making a clear conclusion of the area.

PRELIMINARY PETROGRAPHICAL AND GEOCHEMICAL CHARACTERISTICS OF ROCKS IN THE NYAMULILIMA IGNEOUS COMPLEX, GEITA GREENSTONE BELT

Deborah A. Mlawa[1, 2, *], Emmanuel O. Kazimoto[1] and Shimba D. Kwelwa[2]

[1]*University of Dar es Salaam, P.O. Box 35052, Dar es Salaam, Tanzania*
[2]*Geita Gold Mine, P.O. Box 532, Geita*
[*]*deborahmlawa@gmail.com*

We report preliminary petrographical and geochemical results of a study conducted in Nyamulilima district within the Geita Greenstone Belt. This study was done in order to provide salient petrographical and geochemical features of the rocks of Nyamulilima district, which would be used to improve exploration models and facilitate ongoing exploration efforts at the Geita Gold Mine. Geochemical analyses were done using a combination of X-ray Fluorescence spectrometer for major elements and Inductively Coupled Plasma Mass Spectrometer for trace elements. Six rock types have been identified basing on petrographical and geochemical works, which are: dacite, andesite, trondhjemite, tonalite, granodiorite and gabbro. Trondhjemite, tonalite and granodiorite (TTG) have SiO_2 contents ranging from 58.1 to 67.4 wt. % and metaluminous character. The rocks show steep to moderate gradient of REE patterns in the chondrite normalized spider diagrams and a moderate gradient of trace elements patterns in Primitive Mantle normalized spider diagram. Rare Earth Elements (REE) in the tonalite and andesite are less fractionated compared to dacite, trondhjemite or granodiorite. Tonalite and andesite display no europium anomaly whereas the rest do show moderate to weak europium anomaly. Gabbro is subalkaline and tholeiitic with SiO_2 concentration ~ 50 wt. %. The rock has both flat REE patterns in chondrite normalized spider diagram and trace elements patterns in Primitive Mantle normalized spider diagram. Gabbro shows geochemical similarities with the present Mid Oceanic Ridge Basalts (MORB). The volcanic rocks share similar geochemical characteristics as their intrusive equivalents TTG. It can be concluded that for now these geochemical features suggest formation of the rocks in the compressional tectonic setting or a similar setting as that of MORB.

ASSESSMENT OF GROUNDWATER RECHARGE USING MULTIVARIATE STATISTICAL ANALYSIS IN A SEMI-ARID FRACTURED BASEMENT-AQUIFER SYSTEM OF IRAMBA SUB-BASIN, SINGIDA, TANZANIA

Charles B. Athuman[1,*], Hudson H. Nkotagu[1] and Tyler B. Coplen[2]

[1]*Department of Geology, University of Dar es Salaam, P.O. Box 35052, Dar es Salaam*
[2]*U.S. Geological Survey, 431 National Centre, Reston, VA 20192, USA*
[*]*buteta@yahoo.co.uk*

The multivariate statistics (descriptive, correlation, cluster and factor analyses) of the groundwater recharge are studied from 18 boreholes, 5 dugouts and 13 shallow wells in Iramba Internal Drainage sub-basin, Singida. Standard methods were used to determine the levels of groundwater quality parameters from the water sources both in the field and the laboratory. Data show higher levels of Na^+ compared to other cations (Ca^{2+}, K^+ and Mg^{2+}). Sporadic variation is also noted amongst other parameters as indicated by high concentration of Cl^-, SO_4^{2-}, NO_3^- and F^-. These variations of chemical parameters at the sampled sites are controlled by factors including cation exchange, dissolution and evaporation processes along with the anthropogenic activities thus defining the groundwater recharge mechanism of the area. Future work is recommended to focus on the intensive seasonal studies using statistical approaches on the hydrochemical parameters to address the climatic impacts for appropriate management of water resources.

ESTABLISHMENT OF MINERAL AND GEM HOUSES IN TANZANIA: A SOLUTION TO THE PROBLEMS FACING SMALL SCALE MINING INDUSTRY

Shukrani Manya

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

The establishment of Mineral and Gem Houses in Tanzania is the requirement of the Mining Act 2010 as amended through the Written Laws (Miscellaneous Amendment) Act No. 7 of 2017 as well as Mining (Mineral and Gem Houses) Regulations of 2019. Following these amendments, 28 Mineral and Gem Houses have been established in various regions in the country to serve the small scale miners in the country.

Some of the major challenges that were facing the small scale industry in Tanzania prior to the 2017 changes were the absence of sales market for minerals produced by the small scale miners and true price of the commodities, loss of revenue from mining proceeds by the government as well as incorrect statistics of the small scale production in Tanzania. Such challenges could only lead to smuggling of minerals by the small scale miners in the hunt for better prices and markets for their production outside Tanzania.

Data analysis made for the period of March to July 2019 shows that the amount of minerals (particularly gold) traded in the established Mineral and Gem houses doubled compared to the period before that. This is also true for the government revenue collected for the same period. Citing the Geita Mineral house for instance, an average of 102 Kg of gold was produced by small scale miners prior to the Mineral house establishment (an average taken over the October 2018 to February 2019 period) whereas an average of 220 Kg of gold was traded in the Geita Mineral house for the period of March to July 2019, with a peak of 328 Kg traded in July, 2019.

This paper evaluates the performance of the established Mineral and gem houses in Tanzania, discusses the success stories of the implementation of Mining Act 2010 as amended in 2017 and the challenges that remains to be addressed in the small scale industry in Tanzania.

ARTISANAL AND SMALL SCALE MINING FOR GREAT ECONOMIC SIGNIFICANCE IN DODOMA

Japhet N. Fungo
Freelance geologist, Dodoma
japhetnfungo@gmail.com

Artisanal and small-scale mining (ASM) in Dodoma have significantly grown in recent years, due to the rise of mineral prices and the high city growth rate reflecting demand for building materials as government officially shifting its main offices to Dodoma. The contribution of mining activities to economic development of Dodoma is well acknowledged. Although, ASM is generally pursued by people as a route out of poverty especially in communities where alternative employment is hard, it is also a very diverse sector with its main challenges varying from place to place or even from site to site.

Broadly, speaking, it is difficult to make general conclusions about small-scale mining in Dodoma. The economic, developmental, geological and social backgrounds in the region are very diverse in many cases. Nevertheless, this study tries to draw up information, statistics and details about mineral potential from all Dodoma districts and provide information to open doors for one wishing to get involved in mining sector in Dodoma, and through that facilitating growth of the sector in the region.

PETROPHYSICAL ANALYSIS OF THE POTENTIAL RESERVOIR ROCKS INTERSECTED BY PAPA-1 WELL OF EXPLORATION BLOCK 3, OFFSHORE TANZANIA

Mariamu J. Kiaze* and Evelyne Mbede

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

**mariamkiaze59@gmail.com*

This work reports the petrophysical analysis of the late Cretaceous (Campanian) deep water turbidite sandstone reservoir of Papa 1 well at exploration Block 3, offshore Tanzania. The main objective of the study was to assess the hydrocarbon reservoir potential of sedimentary units encountered in Papa-1 well using well log data. The data sets that were available to the study included the gamma ray log, density log, neutron log, resistivity log and sonic log. The organization, processing and evaluation of the well log data were done using the Schlumberger Tech-log software in order to establish lithology, porosity, permeability, water saturation (S_w) and the hydrocarbon saturation (S_h) of formations encountered in the Papa-1 well at block 3.

The Papa-1 well was evaluated and one sandstone reservoir zone, which is a gas bearing was encountered at a depth interval of 4657.7 m - 5049.6 m. Average porosity of the reservoir is 17.5 v/v and average permeability of 4.53 mD that indicate good porosity but poor permeability as a result of high shale volume (0.184 v/v). The net thickness of this reservoir is 391.9 m and has a net gross of a reservoir 0.87. The water saturation (S_w) of the reservoir is 58.5% and its hydrocarbon saturation (S_h) is 41.5%.

Generally, the reservoir is petroliferous and this well could serve as a control well for future petroleum exploration activities in this area with channel fills as targets. It is recommended that more wells need to be drilled in and around block 3 in order to confirm the presence of oil and gas and more information about distribution of reservoir in the deep waters of Southern Coastal Tanzania should be collected.

HELIUM GAS SEEPS AND PROCESSES INVOLVED IN THE FORMATION OF THE HELIUM GAS FIELD WITHIN THE RUKWA RIFT BASIN TANZANIA

Karim M. Mtili[1,*], Emmanuel O. Kazimoto[1] and Peter Barry[2]

[1]*Department of Geology, University of Dar es Salaam, P.O. Box 35052, Dar es Salaam*
[2]*Marine Chemistry and Geochemistry Dept., Woods Hole Oceanographic Institute, USA*
[*]*karimmtili@gmail.com*

Helium gas is one of the important and strategic resources in the world, as it has both high supply risk and impact of supply restriction. This is true because the major known and exploited deposits of helium (He) are dwindling, while He is widely used in critical facilities like Magnetic Resonance Imaging (MRI) machine in medical industry or ultra-low temperature research instruments and superconductors. Most of the current world helium gas resource, amounting ~ 1.58 billion cubic meters is produced as by-product of hydrocarbon extraction, making its supply following that of hydrocarbon products.

Using the new Portable Mass Spectrometer (miniRUEDI) available at the laboratory of the Department of Geology, University of Dar es Salaam, we have identified a number of new localities within the Rukwa Rift Basin with helium gas seeps. The seeps have gas composition dominated by nitrogen and helium (~ N: He = 10:1). This seep composition is a similar to that of the known and rare nitrogen-helium producing gas fields in the United States of America (USA).

Furthermore, by applying novel geochemical approaches of using noble gases isotopic composition and ratios such as: ^{20}Ne, ^{21}Ne, ^{22}Ne, ^{36}Ar, ^{40}Ar, $^{3}He/^{4}He$ and $^{4}He/^{20}Ne$, we have identified at least three (3) different groups of gas seeps in the Rukwa Rift Basin that distinctively source their volatiles, namely: Ivuna-Itumbula-Tete group, Ibaya-Ngwilo-Kajundu group and Songwe-Nanyara group. The $^{4}He/^{20}Ne$ in the seeps is about 15268, which is more than five orders magnitude (5000 times) if compared to the air (0.3), indicating involvement of local hydrothermal systems in the transport of the volatiles. Nonetheless, this work is still on progress to understand how these "geochemical reservoirs" interact, and identify processes that control the regional ^{4}He concentration variability.

MAPPING OF GEOLOGICAL STRUCTURES AT IBADAKULI IN A RECONNAISSANCE SURVEY FOR GEOTHERMAL RESOURCE

Goodluck Ngulo

University of Dar es Salaam, P.O. Box 35052, Dar es Salaam, Tanzania
ngulo67@gmail.com

Geothermal exploration involves investigation of earth's surface and subsurface in searching for viable active geothermal regions. The goal is to establish potential areas for exploitation of geothermal energy resource for different applications. This study aimed at performing a reconnaissance survey of the Ibadakuli, which is a geothermal potential area.

Ibadakuli is among the areas earmarked by TGDC as geothermal potential areas. The area has been mapped and has preliminary data required for reconnaissance survey e.g. detailed geological maps, topographical maps, geochemical data as well as geophysical data. For a successful geothermal exploration strategy, structural maps are necessity especially in understanding fluid flows of a geothermal system. Available geological maps of the area lacked information on geologic structures, thus proved to be a challenge for successful exploration at the early stage.

This study used Digital Elevation Model-derived flow direction to enhance crustal lineaments in Ibadakuli. The method delineated different crustal blocks based on the specific clusters of flow direction, of which the clusters are made according to the general trend of the nature of structures of the area. Validation of the results was by using Carbon dioxide (CO_2) flux map produced through interpolation of the concentration of CO_2 flux using SUFFER software.

Lineaments/structures revealed correlate well with anomaly trends of CO_2 flux, which the latter has a linear pattern that follow, interpreted structures. Moreover, the mapped hot springs in the area plots on the extracted lineaments. A total of 33 lineaments were mapped, among them the major structure trends are E-W, NE-SW and NW-SE, were the SSE-NNW-trending structures constitute the minor set. The hot springs in the study area reveal to plot at the triple junction where a NW-SE structure converge to the

NE-SW structure, probably the area provide enough space for hydrothermal fluids circulation.

In future, studies focusing on detailed geological mapping using different approaches are recommended for Ibadakuli area in order to get enough information for establishing a complete geothermal system geological model.

ASSESSMENT OF THE AQUIFER SYSTEM PERFORMANCE FROM PUMPING TEST DATA FOR WATER WELLS IN ZANZIBAR

Prisca Josephat

Don Consult Limited, P. O. Box 4218, Dar Es Salaam
josephatprisca@gmail.com

The Government of Tanzania (GoT) has prepared National Urban Water Supply and Sanitation Program (UWSSP) as a part of its water Sector Development Program (WSDP). It was purposely designed to enable the Government achieve its National Strategy for Economic Growth and Reduction of Poverty (NSGRP-MKUKUTA) targets of the country Millennium Development Goals(MDGs) and the Joint Assistance Strategy for Tanzania (JAST). The Government recognizes the importance of Universal access to improved water supply and Sanitation (WSS) and the need to develop institutions and methods capable of rapid expansion of services across the country.

Zanzibar Urban Water and Sanitation Project (ZUWSP) was designed for the implementation of the UWSSP. The project involved the exploration for Groundwater sources, drilling, pumping test and aquifer analysis for sustainable exploitation. Ground water exploration involved Resistivity Imaging to locate the potential water sources; this was integrated with other information collected prior to surveys to delineate the presence of the aquifer system and locating sites for well drilling.

After well location, drilling was conducted, before which pumping test was performed to test for the presence of a performing aquifer system. A total of nine (9) new wells were drilled, two (2) existing wells were re-drilled while twenty (20) existing boreholes were camera inspected, rehabilitated to enhance their yield capacity. Pumping tests were run for all new drilled, re-drilled and rehabilitated wells.

Results from the pumping test data analysis, show that most of the borehole have high efficiency and capacity drawn from pumping rates, drawdown and recovery with respect to time. Aquifers are observed to be of good capacity as the transmissivity values range between 354 m^2/day to 1871.4 m^2/day for new drilled boreholes in exception of BH. No. U-064 with transmissivity

value of 129.2. Transmissivity values of existing boreholes ranges from 200.9 m^2/day to 3695 m^2/day. The values of transmissivity depend on drawdown as a result of the effect of the amount of water pumped from the borehole, which in turn reflects the well capacity.

Geology logging of the drilled wells indicated the presence of Blackish top soil, clays, sandy clays, clayey limestone, limestone, calcareous limestone, coarse calcareous sandstone, gritty limestone, coral limestone, calcareous marlstone and marlstones. Coarse calcareous sandstone, gritty limestone, coral limestone and weak limestone make important aquifer systems in the project area.

CHARACTERIZATION OF GOLD MINERALIZATION AT MISAKI AREA SINGIDA USING INTEGRATED PROSPECTING TECHNIQUES

Zortosy M. Mpangile[1,2,*], Emmanuel O. Kazimoto[2] and Michael Msabi[1]

[1]*Department of Geology, University of Dodoma, Dodoma, Tanzania*
[2]*Geological Survey of Tanzania, P.O. Box 903, Dodoma*
[3]*University of Dar es Salaam, P.O. Box 35052, Dar es Salaam, Tanzania*
[*] *zortosym@gmail.com*

Here we present results of geological, geochemical and geophysical investigation of Misaki area in Singida region. This work was done in order to characterize gold mineralization at Misaki areas, so as to enrich information on gold deposits of the area. A combination of geological mapping work, geochemical survey and laboratory work was applied in order to characterise lithologies, hydrothermal alteration of rocks and gold mineralization. For areas occupied by thick regolith, high resolution geophysical dataset was used to study the subsurface geology and structures.
Misaki area is occupied by an amphibolite, meta-gabbro and several kinds of granites including biotite rich and xenoliths rich granites. Xenoliths rich granites has been deformed and intruded by mafic igneous bodies that were associated with sulphide bearing hydrothermal fluids that precipitated gold in the rock. The geophysical dataset delineated lineaments that crosscut different rocks at Misaki, from which using a rose diagram 3 major structure orientations are defined: NE-SW, NW-SE and ESE-WNW.
On the other hand, radiometric data revealed hydrothermal alteration zones with different radiometric elements contents (U, Th and K) that are associated with geological structures cutting different lithologies. Soil geochemical survey in the areas identified gold anomalies (> 2 ppm Au) that showed strong affinity between Au and Pb. These geochemical anomalies call for a follow up detailed exploration work to uncover gold deposits of Misaki area.

THE STRUCTURE AND TRADE CHAIN FOR LEGAL MINERAL TRADING IN TANZANIA

Japhet N. Fungo
Freelance geologist, Dodoma
japhetnfungo@gmail.com

Mineral resources have been used for millennia and are a key to society's development. It is a high price commodity in world market and so attracts foreigners and local people to invest in mining sector. There are a lot of mineral resource and reserves in Tanzania including gemstones, metallic minerals, building and industrial minerals. All these influence mineral trading in the country as it is of high demand and hence profitable. Recently there has been a lot changes in legal aspects of Mining Industry in Tanzania, a lot has been introduced and a lot has been eliminated or rearranged. The changes on Legal and regulatory framework in the country's mining sector affects the chain of mineral trading. This entails the need to understand what are the major changes and how we cope and adapt to them, so that to create an awareness on the legal procedures for the mineral trading, how, when, where and who can sell, deal or buy minerals. How to acquire import or export permit minerals?, valuation and what are government charges, and which authorities monitoring throughout the whole chain of trading. There has been misunderstanding and misinterpretation of the legal procedures of mineral trading thus referring to the Mining act and its amendments.

This abstract and poster aim to tell the legal procedures from the scratch at the mining site to the market of gemstones, metallic minerals, building and industrial minerals, how holders of mining licenses, brokers and dealers licenses participate in trading chain, with limits of each license. Why the mineral trading markets have been introduced on every region and what are the government goals for these markets. The offences related to unauthorized trading of minerals and the potential minerals as per current local and world market. By following the legal procedures for the mineral trading will make the trade more beneficial to both owners of mineral rights and the government.

GEOCHEMICAL ANALYSIS OF THE NOBLE GASES IN THE RUNGWE VOLCANIC PROVINCE, TANZANIA: IMPLICATION ON VOLATILES SOURCES AND DYNAMICS

Clarah Kimani[1,*], Charles Happe Kasanzu[1] and Peter Barry[2]

[1]*University of Dar es Salaam, P.O. Box 35052, Dar es Salaam, Tanzania*

[2]*Woods Hole Oceanographic Institute, Marine Chemistry and Geochemistry Department*

[*]*clarahkimani@gmail.com*

Rungwe Volcanic Province is a volcanically active area with widespread surface manifestation of active faults, hot springs and gas emanations. The occurrence of silica under-saturated alkaline magmatism, indicates that there is an active magma chamber below the surface on well interconnected active fault systems. In particular, the sources/origin of volatiles emanating from this area and the physical processes (e.g. fluid mixing) that are involved during the transport of these volatiles are not well characterized and are likely to be heterogeneous i.e. being contributed from different end members. Therefore, this study aims at using noble gas isotopic ratios and elemental composition on ascertaining the source characteristics and processes involved in thermal fluid transfer from mantle and crustal regions to the surface. Preliminary results on isotopic ratios and elemental composition reflect contributions from different end-members e.g upper mantle, lower mantle (plume), crust and the sub-continental lithospheric mantle (SCLM), hence heterogenous. Therefore this study will add new knowledge of using noble gases as geochemical tracers of volatiles and various geological processes associated with them.

PRELIMINARY ASSESSMENT OF WATER-ROCK INTERACTION IN NGOZI GEOTHERMAL PROSPECT, TANZANIA

Sadock Josephat, Albano Mahecha and Fatumati Mnzava*

Tanzania Geothermal Development Company, P. O Box 14801, Dar es Salaam

**fatumati.mnzava@tanesco.co.tz*

Ngozi geothermal prospect is located at the triple junction of Rukwa trough, Ruaha- Mtera- Usangu segment and Karonga-Malawi Rift of the East African Rift System (EARS). The triple junction area is characterized by complex tectonic forces leading to the development of structures in different orientations. The prominent volcano in the area is Ngozi volcano which is believed to be the heat source powering the Ngozi geothermal system and is one of the four volcanoes comprising the Rungwe Volcanic Complex.

The Surface geology is dominated by pyroclastic cover while outcrops of basalts, trachy-andesite, phonolitic trachyte, alluvial sediments and sandstones occur in some parts. Geothermal surface manifestations in the area include the thermal spring of temperature ranging 30 – 82.4 ℃, gas vents and young volcanic eruption centres including caldera, cones, marls and alteration minerals. X-ray Diffraction (XRD) analysis of rocks fragments and lithics from eruption centres including volcanic cones, domes and marls resulted to identification of different type of clay minerals including illite, smectite and kaolinite. Petrographic analysis identified the presence of secondary minerals like calcite, clays, epidotes, quartz, and zeolites. This assemblage of secondary minerals suggests the occurrence of hydrothermal activities in the area. Water chemistry is modified by several processes including mixing, conductive heat loss during ascent to the surface and water-rock interaction. Water-rock interaction leads to alteration of rock hence formation of alteration mineralogy and increased concentration of rock forming elements in geothermal water.

Most of the thermal spring waters are enriched with rock forming elements including SiO_2, Na, K, Ca and Mg. From results, it can concluded that such waters have been interacting with Na-Al silicates and Ca-Al silicates, which belong to the zeolites group of minerals, Na-Ca-Al-Mg silicates belonging to smectite group of minerals and silica bearing rocks.

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