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GEOTHERMAL DEVELOPMENT IN TANZANIA – STATUS REPORT

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ABSTRACT

Tanzania is among East African countries that are traversed by the East African Rift System. The geological settings for the occurrences of geothermal resources in Tanzania are variable and include potentials that are likely to be associated with typical young volcanic provinces in the north, intersection of eastern and western arms (triple junction) in the south west, faulted granite areas in central Tanzania (craton), and intrusives in young coastal sedimentary formations. This makes the occurrence of geothermal resources in Tanzania quite different from other countries. In addition the eastern arm and western arms tend to have different geological conditions that need to be differently considered during the exploration of geothermal energy resources in Tanzania.

Tanzania's power system has for decades relied on hydro and oil based generation mix. As a result, the power supply has been prone to variability and uncertainty due to frequent drought spells and oil price fluctuations. As a short term remedy, the government has resorted to emergency fuel oil based power plants to bridge the supply gap. This solution is not only expensive but also environmentally unfriendly. Tanzania's aspirations to reach the middle income status as enshrined in the country's Vision 2025 need to support the energy sector to access its agriculture and industrialization potential, and targets. Knowing that energy is vital for economic, social, and human development, Tanzania has determined to develop a sustainable energy mix that will ensure that households, communities, businesses and industries receive supply that is adequate, available when needed, reliable, convenient, healthy and safe for supporting the county's development agenda.

The country's current total grid installed capacity is 1,435.56 MW. This is from hydro 567.7 MW, natural gas 782.82 MW, liquid fuel 70.54 and biomass 10.5 MW. Previously, the national power system mostly relied on hydropower. Long and frequent periods of drought, which may have been caused by climate change, between 2003 and 2006, 2009 and 2010 led to shortfalls in electricity supply from the hydropower stations. Thus, the government of Tanzania resorted to thermal based generation sources as a short term solution. As a long term power development strategy the government intends to diversify the country's energy generation mix and is focusing on increasing the proportion of renewable energy generation, whereby geothermal development is ranked high on the list. Other renewable sources being considered are wind and solar.

Geothermal resource studies in Tanzania date back to 1949 but have been limited to surface studies mainly, measurements of surface temperature, water and gas sampling

and analyses of hot springs. To date, drilling exploration wells program is planned for Ngosi geothermal prospect, with the consultant on site. Songwe, Kiejo-Mbaka and Luhoi geothermal fields rank next to Ngosi. The detailed surface study supported by ICEIDA/MFA was completed for Kiejo-Mbaka and Luhoi propects by year 2017. Additional scientific study in Songwe has been undertaken with the support of EAGER consultants.

This paper presents the progress of geothermal development and lessons learned since year 2018 when the last Tanzania status report on geothermal development update was presented. It also presents some important results of the surface exploration studies, geothermal development strategies, mobilization of funds, investiment opportunities and development of local capacity to implement geothermal projects in Tanzania.

1. INTRODUCTION

The United Republic of Tanzania (Figure 1) is located between latitude 1°S and 11°45´S and between longitude 29°2´E and 40°29´E. It has a size of 945,087 km^2 and a population of 44.9 Million (2012 census). According to Tanzania Development Vision 2025 which is the main document that guides the general development, the country envisages to become a middle income country by 2025. By 2025, Tanzania envisions having transformed itself into a newly-industrializing, middle-income country, with a prosperous, globally competitive economy and a high quality of life in a clean and secure environment. In order to achieve this goal, energy is one of the infrastructural sectors which have been accorded high priority so as to support the envisaged social and economic development. It is anticipated that by 2025 the level of economic development will require about 10,000 MWe. To attain this goal, sustainable, renewable, reliable and affordable energy technologies are needed to strengthen and increase energy security and diversity. Geothermal, being a renewable energy source is expected to be one of the main contributor to the country's energy mix (MEM, 2014).

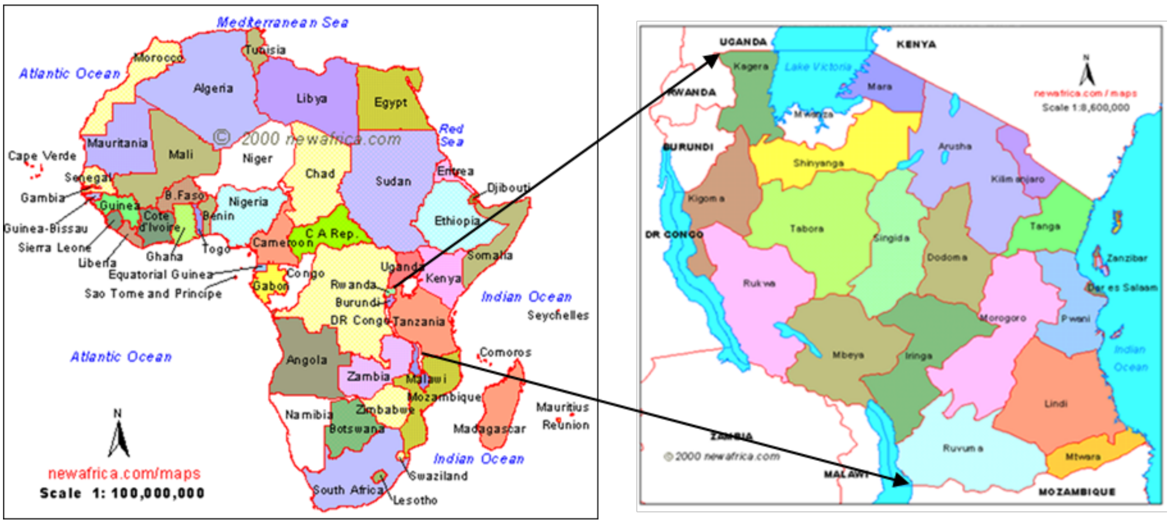

FIGURE 1: Map of Tanzania

Recognising the importance of geothermal energy in improving the country's energy mix, the Government of Tanzania is taking necessary measures to stimulate geothermal development. In 2013, it demonstrated its commitment towards geothermal development by establishing the Tanzania Geothermal Development Company Limited (TGDC), which is a public company that exclusively deals with geothermal energy development and utilisation. The company was incorporated in December, 2013 and became operational in July 2014. It is currently enhancing capacity development for staff, acquisition of equipment, soliciting of funds and other resources to enable it to take up its responsibilities. In addition, the government under the Scaling Up Renewable Energy Program (SREP) is establishing an enabling environment for geothermal development in Tanzania. Geothermal development has been prioritised with the target of getting power online by 2025.

Under the long term Power System Master Plan (MEM, 2013) diversification of generation mix is emphasised and geothermal is included in power generation sources. Both the Power Sector Master Plan (2010-2035) and Medium Term Strategic Plan (2012–16) envisage developing renewable energy sources as a measure of enhancing reliability of power supply. Key interventions under the Medium Term Strategic Plan are:

i. Developing alternative and renewable energy sources mainly from solar, biomass and wind; and
ii. Promoting energy efficiency and conservation.

Regarding development of geothermal, the government is committed to reduce geothermal resource uncertainty, partly mitigate development risks, and improve sector governance and capacity to encourage the private sector participation in the development and supply of dependable and cost-competitive geothermal electricity for power neneration and direct uses. For that reason, the government has put emphasis on developing appropriate geothermal policy and legal and regulatory framework and support high-risk phases of geothermal project implementation, especially test drilling.

2. ELECTRICITY SUB-SECTOR OVERVIEW

From the 1980s to 2000, the national power system was almost 100% reliant on hydropower. Long and frequent periods of drought which could be linked to climate change have led to shortfalls in electricity supply from the hydropower stations. Under this situation, the government had to resort to contracted Emergency Power Projects (EPPs), which are thermal-based generation sources, primarily because they have short implementation periods. These thermal power plants are expensive and depend on imported fuel. For medium term solution the government accelerated implementation of gas based generation. As a long term solution of ensuring reliability of power supply and diversification, the country’s energy generation mix including generation from gas, hydro, wind, solar, coal, and geothermal is being pursued. Implementation of solar and wind projects is at various levels of development while for geothermal projects establishing of enabling environment and exploration studies are on-going and at various stages of progress.

2.1 Sector governance

The Ministry of Energy and Minerals is responsible for formulation and articulation of policies that promote the supply of reliable, accessible and affordable power for the economy to reach middle income status by 2025. Other major government institutions in the sector include the Rural Energy Agency (REA), Tanzania Electric Supply Company (TANESCO), Energy and Water Utilities Regulatory Agency (EWURA), and the currently incorporated company, Tanzania Geothermal Development Company Limited (TGDC). In addition to the public sector, the private sector, development partners, NGOs and higher learning institution are key stakeholders in the sector.

The Rural Energy Agency (REA) is responsible for promoting improved access to modern energy services in the rural areas of mainland Tanzania. Tanzania Electric Supply Company (TANESCO) is the country’s principal electricity generator, transmitter, and distributor. The Energy and Water Utilities Authority (EWURA) is empowered to (i) promote effective competition and economic efficiency; (ii) protect the interests of consumers; (iii) protect the financial viability of efficient suppliers; (iv) promote the availability of regulated services for all consumers, including low-income, rural, and disadvantaged groups; and (v) enhance public knowledge, awareness, and understanding of the regulated sectors. The structural relationship among the key players in the power subsector is as shown in Figure 2.

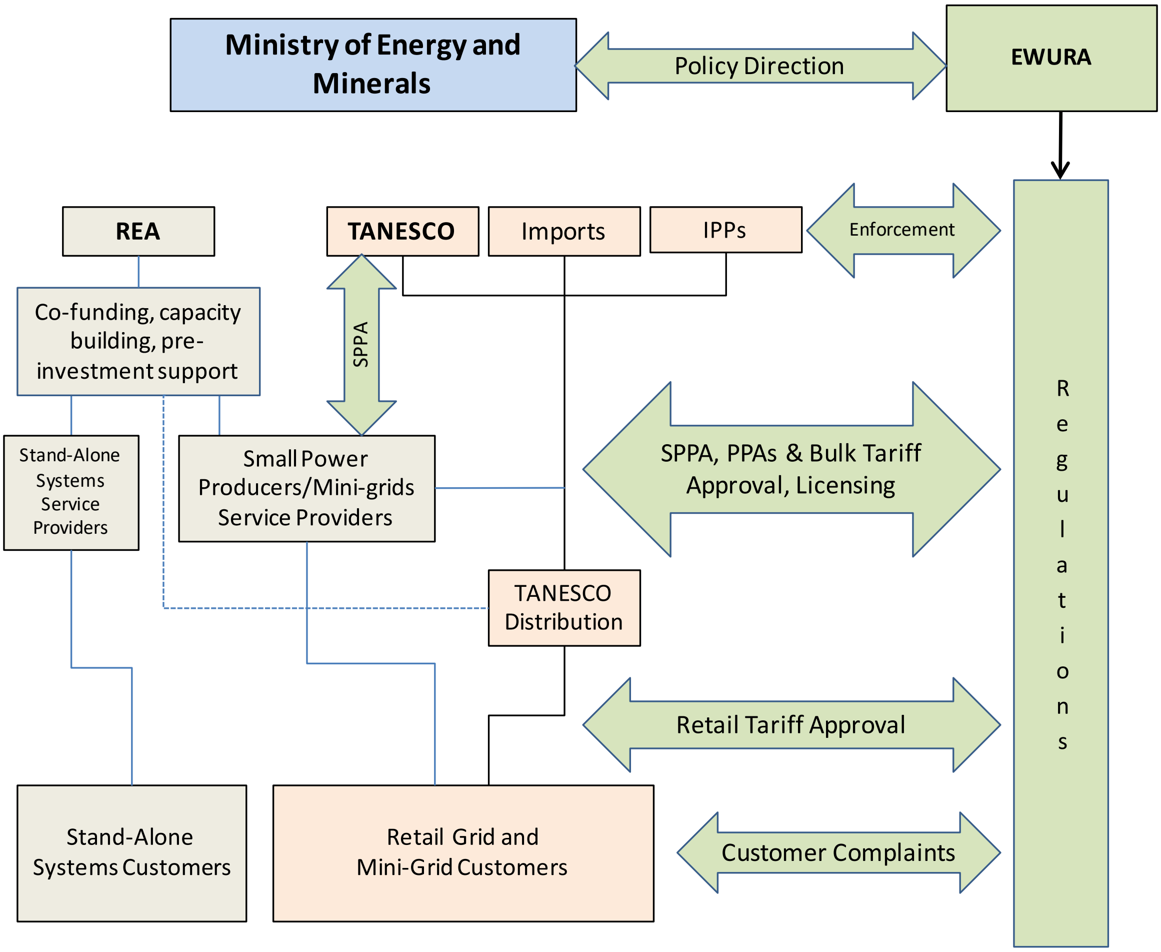

FIGURE 2: Institutional framework and market structure of the electricity sector

2.2 Policy, legal and regulatory frameworks

There are several published documents guiding the power sector since 2003 when the energy sector policy was published. Update on the policies, legislation and guidelines relevant for the energy sector, including geothermal, are as listed in Table 1.

2.3 Current situation

The country's power system mainly relies on gas based generation, hydropower and gasoline. As of April 2018, total installed generation capacity for the grid system is 1,435.56 MW; grid installed capacity is 1351.1 MW and off-grid plus the imports is 84.46 MW. This is from hydro 567.7 MW (39.6%), natural gas 782.82 MW (54.5%), diesel 70.54 MW (5.2%), and biomass 10.5 MW (0.7%) (Figure 3). The imported power is from Uganda (10 MW), Zambia (5 MW) and Kenya (1MW) for cross boarder supply. Independent power producers (IPP) contribute 205.36 MW (16.3%) to the total grid installed capacity.

Most of the fuel oil based emergency power plants have been put out of service. The annual electricity consumption per capita was 105 kWh in 2014, which is below acceptable global average per capita consumption of 500 kWh. The generation is from the national utility (TANESCO), independent power producers (IPPs), Emergency Power Producers (EPPs) and Small Power Producers (SPPs). A sharp increase is expected in generation from gas due to implementation of BRN initiatives and Stiglers Gorge projects.

TABLE 1: Published documents guiding the power sector

Document	Current status and plans
National Energy Policy 2003	Published in 2003, under review
Roadmap for Sector Reform	Published 30 June 2014.
PPP policy	Published in 2010
MEM Three Year Strategic Plan 2011/12-2015/16	Published Nov 2012
Public Procurement Act 2011	In place
Electricity Act 2008	In place
Rural Energy Act 2005	In place
Power System Master Plan	2012 Update, under review
Environmental Management Act 2004	In place
Geothermal development strategy, institutional legal and regulatory framework	Geothermal strategy, legal and regulatory framework has been developed. In the process to be enacted.

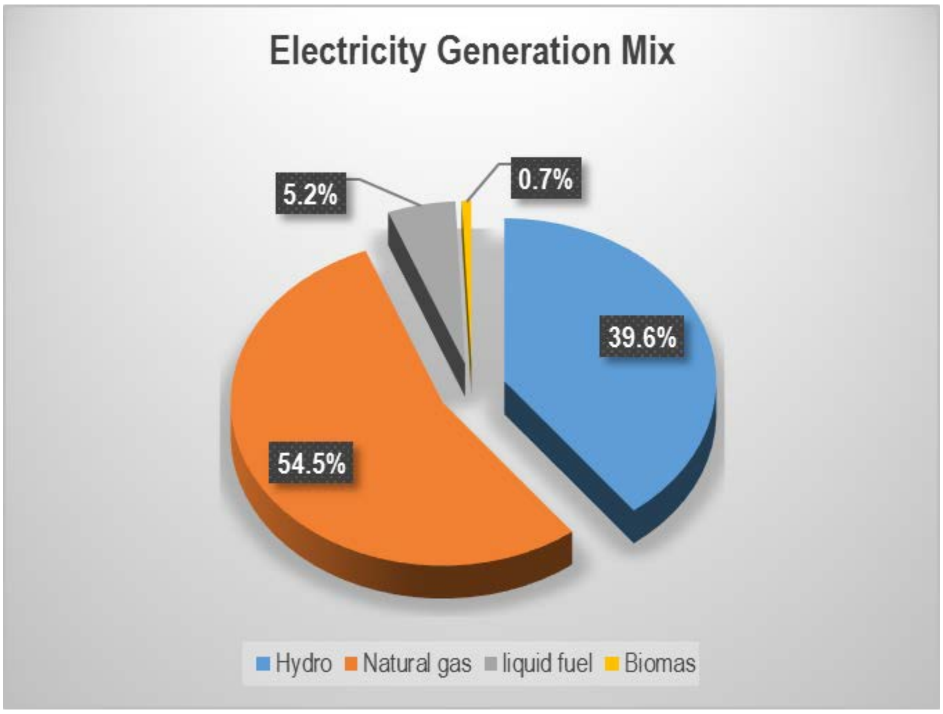

FIGURE 3: Electricity generation mix

The demand for electricity is growing at a pace of between 10% and 15% per annum and is forecast to increase more due to growing energy requirements in the transport, mining and industry sectors. The annual electricity consumption per capita is about 133 kWh, but the government vision is to become a middle income country by 2025 with electricity consumption of at least 490 kWh/capita (MEM, 2016). Tanzania aims to increase the connection level to 50% by 2025 and 75% by 2033 using renewable energy generation mix, and geothermal energy is one of the target resources.

So far, there is no contribution from geothermal generation, but according to the Power System Master Plan (MEM, 2016), geothermal energy is expected to contribute 100 MW to the national grid by 2025.

3. GEOLOGY BACKGROUND

Tanzania lies on the African Plate, which is one of Earth's largest slabs of continental crust. The African Plate contains Archean cratons which are over 2.5 billion years old, which preserve evidence of rock-forming events shortly after solidification of the earth's crust. The geological framework of Tanzania reflects the history of this part of the African continent and elucidates the setting of the mineralization. Tanzania's present form is the result of a series of events which began with the evolution of the ancient Archean craton shield that was subsequently modified by metamorphic re-working and accretion of other continental matter, and later covered with continentally-derived sediments of the Karoo sequence and, most recently, began the process of sundering of the craton along the East African Rifts.

Tanzania craton is composed of granites and zones of schist and gneiss containing greenstone belts. The craton is rimmed by Proterozoic crystalline rocks (Figure 4). Proterozoic formations distributed in the west and the south consists mainly of gneiss and schist associated with a small amount of amphibolites. Schist, gneiss, granite and a small amount of marble are distributed in the eastern region, and a series of Karoo group formations is distributed in the southwestern region where continental meta-sediments and marine sediments have accumulated successively over the basement. Younger sediments and

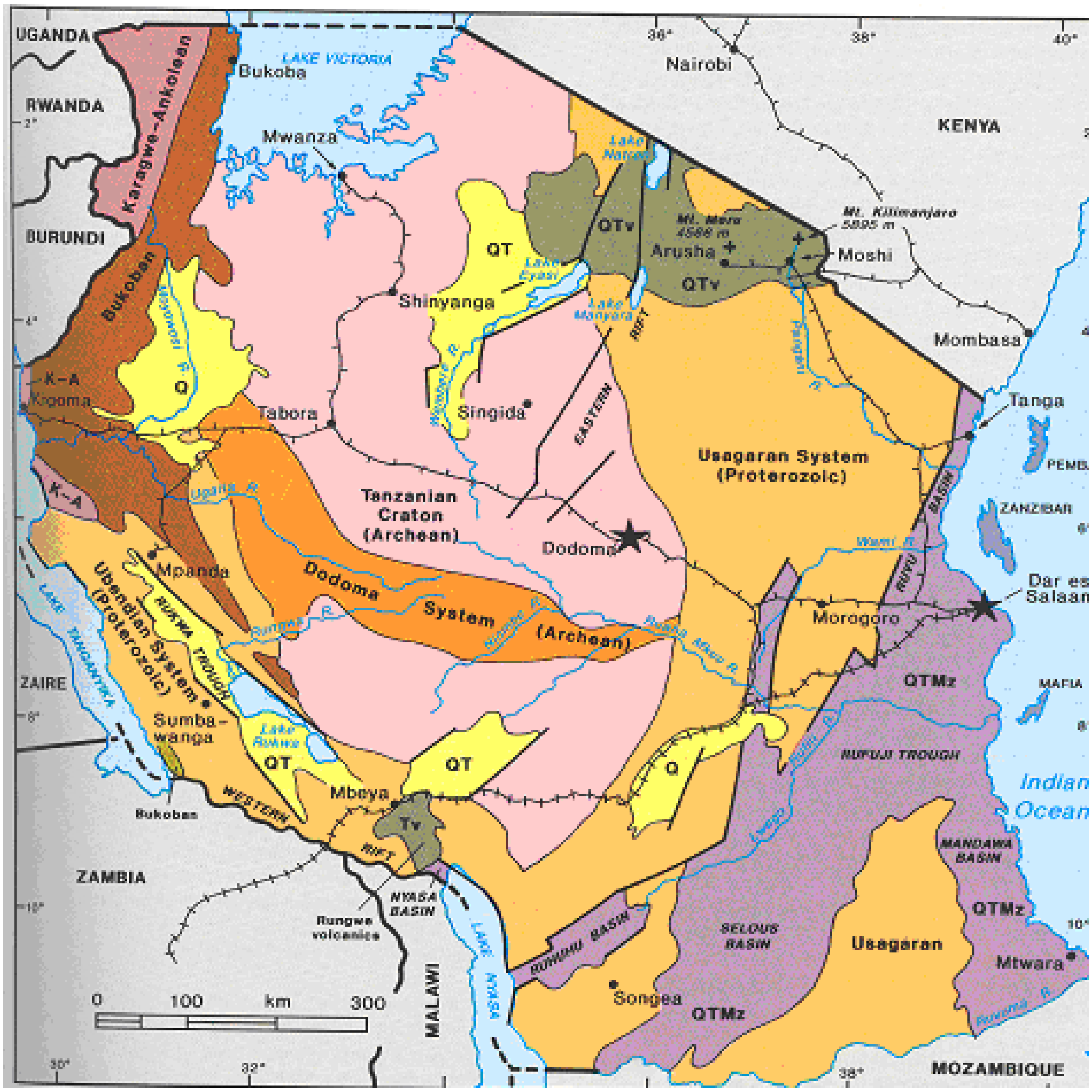

FIGURE 4: A simplified geological map of Tanzania (Source: GST)

volcanoclastics of recent times occupy the rifted graben, coastal plains and inland basins. There are many intrusive rocks ranging from old to young in age showing ultramafic to felsic composition such as gabbro, dolerite, kimberlite, carbonatite granite, syenite and so forth.

Tanzania is traversed by both eastern and western branches of the rift system. The western branch of the rift runs along the western side of Lake Victoria and along the edge of the East African plateau. The western branch is composed typically of half-grabens characterized by high-angle normal rift faults. The eastern branch runs from the southern extreme of the Kenya segment through northern Tanzania segment, where both segments are dominated by alkaline and carbonatitic volcanism of which Ol Doinyo Lengai is a well-known example. The prevalence of the carbonatites in the region is attributed to the deep source of the lavas occasioned by the thick cratonic crust in the region. Alkaline lavas are predominant in the areas around Kilimanjaro, where micro-rift grabens occur near Arusha and further south.

4. GEOTHERMAL POTENTIALS OF TANZANIA

Reconnaissance surveys and a few detailed studies of hot springs on geothermal sites have been carried out since 1949. Some of these early studies are referenced in Walker (1969) and SWECO (1978). A recent study was done by Alexander et al. (2016). The geothermal potential of Tanzania is shown in Figure 5. Existence of thermal energy is inferred from the presence of hot springs, volcanic activity and associated fault structures. Hochstein et al. (2000) argue that the geothermal resources of Tanzania appear to be rather small and limited in terms of existing technology. McNitt (1982) concluded based on analogy methods that the geothermal potential of Tanzania could be as high as 650 MW. Today, the potential is estimated to be over 5000 MW. This value is based on the natural heat flow discharge from hot springs. The estimates are based on integrated the geophysical, geochemical and geological techniques without test drilling.

The areas with features of geothermal energy resources are mostly located in the Gregory (Eastern) and Albert (western) arms of the great East African Rift Valley. The most common surface manifestations are hot spring sites. However, there are many areas outside the main rift valley with indications of geothermal resources. It is therefore possible to categorise the occurrences of geothermal energy resources based on geological settings into five distinct geological areas:

a) The volcanic provinces of Kilimanjaro, Meru and associated with the eastern arm. This type is found in Northern Tanzania close to the border with Kenya (Lake Natron, Lake Manyara, Ngorongoro Crater).
b) The volcanic province of Rungwe and associated with the triple junction in south-western Tanzania, near the border with Malawi and Zambia. This is the junction of the western and eastern arms of the Eastern Africa rift valley. This zone is CO_2 dominated system and travertine deposits where the outflow reaches the surface at Mbeya area.
c) Granite dominated craton of central Tanzania. These areas are dominated with discontinuous faults associated with rifting (Singida, Dodoma and Shinyanga).
d) Coastal belt geothermal resource potentials. These are linked with young intrusives in sedimentary formations, attributed to rifting and intrusions (Luhoi, Kisaki, Utete and Tanga).
e) The western arm. The occurrence of geothermal resources in the western arm is not well studied but there are hot rings extending from Mtagata in Karagwe near the border with Uganda, Uvinza in Kigoma and Majimoto in Mlele and areas near the border with DRC and Zambia.

There are also scattered hot springs throughout the country with no clear faulting or volcanism.

TGDC’s contribution to sustainable development and poverty reduction in line with the Tanzania National Development Vision 2025 is to realize about 100 MWe by 2025, 500 MWe by 2033 and 800 MWe by 2035 from geothermal generation.

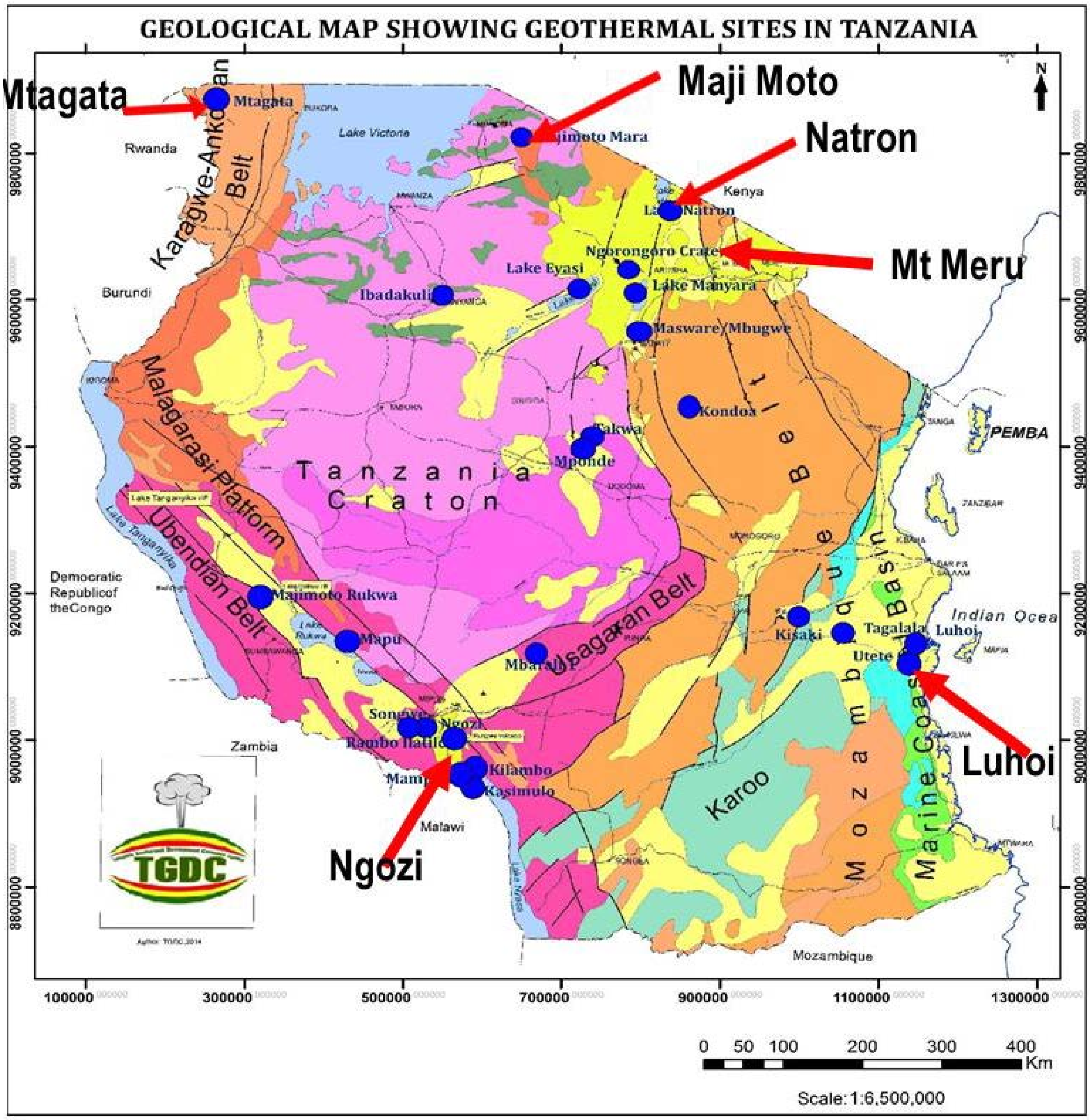

FIGURE 5: Map for geothermal potential areas in Tanzania

5. GEOTHERMAL UTILIZATION

In Tanzania there is no formal geothermal utilization but local uses of sinters for feeding animals, washings and skin bathing are quite common. The oldest documented use of geothermal for skin bathing was in 1876 when Mtagata hot spring in Karagwe district, Northwest Tanzania was visited by Henry Morton Stanley in 1876. He reports the temperature as 129.0 F (54.0°C) and that the water had healing properties for sick people around and that the water tasted pure, that a bath had a very invigorating and refreshing effect, and that the water burst out in a tolerably strong jet. The skin bathing is practiced at Mtagata. There is no commercial usage of geothermal water, but there are various opportunities ranging from domestic to industrial heating and the like once the resource is brought to the surface. The exploration for geothermal resources is going in parallel with evaluation of direct uses in the respective project areas.

6. STATUS OF PLANNED GEOTHERMAL PROJECTS

Geothermal energy is a clean, indigenous strategic energy resource for supporting development of the country's economic growth. In this respect, the Government of Tanzania through TGDC has already developed a Strategic and Business Plan that will guide the company business decisions, processes and growth for a horizon of 25 years. The country's target is to generate 200 MW from geothermal by year 2025 (MEM, 2016), which is firmly supported by TGDC 25 years Strategic Plan (2017).

The TGDC 25 years Strategic Plan (2017) has identified four (4) flagship projects that will help in achieving the 2025 target (200 MW), namely Ngozi, Songwe, Kiejo-Mbaka and Luhoi. To date, all four flagship sites are ready for test drilling to confirm the resources. Mobilization of funds for carrying out test drilling is underway.

The following section presents detailed descriptions, important results of the surface exploration studies, development strategies and current status of each site.

6.1 Ngozi geothermal prospect

Ngozi geothermal prospect is located within the Rungwe Volcanic Province (RVP), southwest Tanzania. The prospect is at the Mbeya triple rift intersection of the Western, Eastern and Southern Branches of the East African Rift System. It has been studied by many workers since the 1950s, mainly regional geology, geophysics, and geochemistry without going further for geothermal energy exploration (Harkin, 1960; DECON et al., 2005). The Ngozi and Songwe prospects were once believed to be one system and hence studied in combination.

GEOTHERM Phase I (2006-09) carried out a study in the Mbeya region and concluded that Rungwe and Ngozi are two different systems. Based on that conclusion, GEOTHERM Phase II (2009-13) concentrated on Ngozi and concluded that Ngozi and Songwe are part of one geothermal system, where the heat source is underneath Ngozi volcano with outflows at Songwe.

TGDC with technical support from UNEP/ARGeo and MFA/ICEIDA has carried out gap filling studies in the area with the intention of defining the geothermal system model and selecting drilling targets to confirm the resource potential and characteristics. The study was completed in September 2016, concluding that Ngozi and Songwe are two distinct systems. For Ngozi prospect, the geothermal reservoir is beneath Ngozi with an estimated temperature of 232 ± 13°C, TDS of 15,800 ± 2,300 mg/kg (Na-Cl composition), and a PCO_2 of 15 ± 4 bar.

Geologically, Ngozi is the major eruptive centre of the Rungwe Volcanic Province (RVP). It is characterized by young volcanic deposits of Plio-pleistocene to Holocene age that are mainly composed of pyroclastics, basalts, phonolites and trachytes. The early phase of volcanism that dates ~12 ka produced mainly phonolites while the second phase lasted <1 ka and mainly involved basalts and phonolites/ignimbrites (Fontijn et al., 2012). The later eruption is related to the formation of the Ngozi caldera which is about 2.5 km long and 1.6 km wide with a surface area of 3 km^2. The primary geothermal features are thermal water discharges (up to 89°C) at the bottom of the Ngozi Crater Lake. The heat source is likely a trachytic magma chamber, perhaps 5 to 7 km deep, which was replenished after the Ngozi Tuff eruption less than 1,000 years ago. The reservoir temperature is estimated at 232± 13ºC based on the observed outflow temperature on the lake bed of 89ºC (Alexander et al., 2016). Figure 6 is the possible conceptual model of Ngozi geothermal system.

The study identified five (5) locations for test drilling around Ngozi; TGDC is planning to start with drilling three (3) slim wells in fiscal year 2019/2020. The Geothermal Risk Mitigation Facility (GRMF) is co-financing the drilling programme. Currently, the consultant has already procured for the drilling program and is on site. An environmental permit for test drilling has already been obtained from the Government.

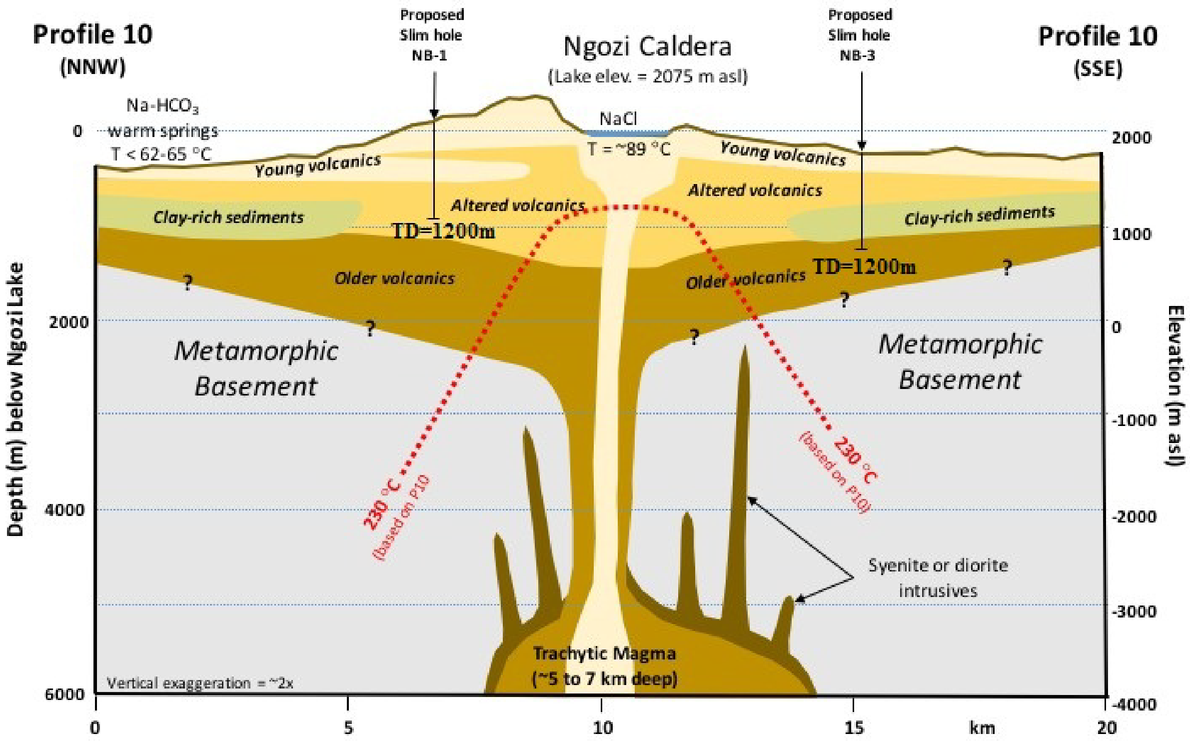

FIGURE 6: Conceptual model for Ngozi geothermal system

6.2 Kiejo-Mbaka geothermal prospect

Kiejo-Mbaka geothermal prospect is located in the southern part of the Rungwe Volcanic Province (RVP) which hosts Ngozi, Rungwe and Kiejo volcanoes in the southwest of Tanzania, in Mbeya Region (Figure 7). The prospect is located south of the Mbeya triple junction of the East African Rift System (EARS) where the N-S Nyasa basin splits into the NE-SW trending Ruaha-Mtera segment and the NW-SE trending Rukwa-Tanganyika basin (Fontijn et al., 2012). Different studies have been undertaken in the prospect area either for geothermal assessment and/or for general geoscientific academic researches. The most prominent studies include those by ELC (2017), Fontijn et al. (2012), de Moor et al. (2013), Delalande et al. (2011), and Ebinger et al. (1989). The most recent study is by ELC (2017), which concluded that Kiejo-Mbaka is a medium temperature geothermal system based on both water and gas geothermometric assessments with estimated reservoir temperature of around 140°C. Further, the system is manifested on the surface by hot springs which discharge in the areas of Kilambo, Kajala and Ilwalilo with temperature of 59-64°C and are recharged by meteoric water as confirmed by the isotopic studies.

The study by ELC (2017) recommended resource confirmation by test drilling and seven (7) possible locations have been identified. TGDC is planning to start with four wells (4), three of them being slim wells and one (1) full size well. The test well drilling programme is planned for in the fiscal year 2020/21. Mobilization of funds from different sources to carry out test drilling is underway.

6.3 Songwe geothermal prospect

Songwe prospect is located in Songwe Region, just northwest of Ngozi prospect. Detailed surface study for this prospect was completed in 2016 by UNEP/ARGeo technical consultants and was carried out together with Ngozi prospect. The study shows that Songwe is a low to medium temperature resource (112 ± 16°C) more suitable for direct use applications and binary power plant. The study further recommended to undertake a gap filling study for Songwe prospect to determine appropriate locations and number of wells prior to embarking on test drilling.

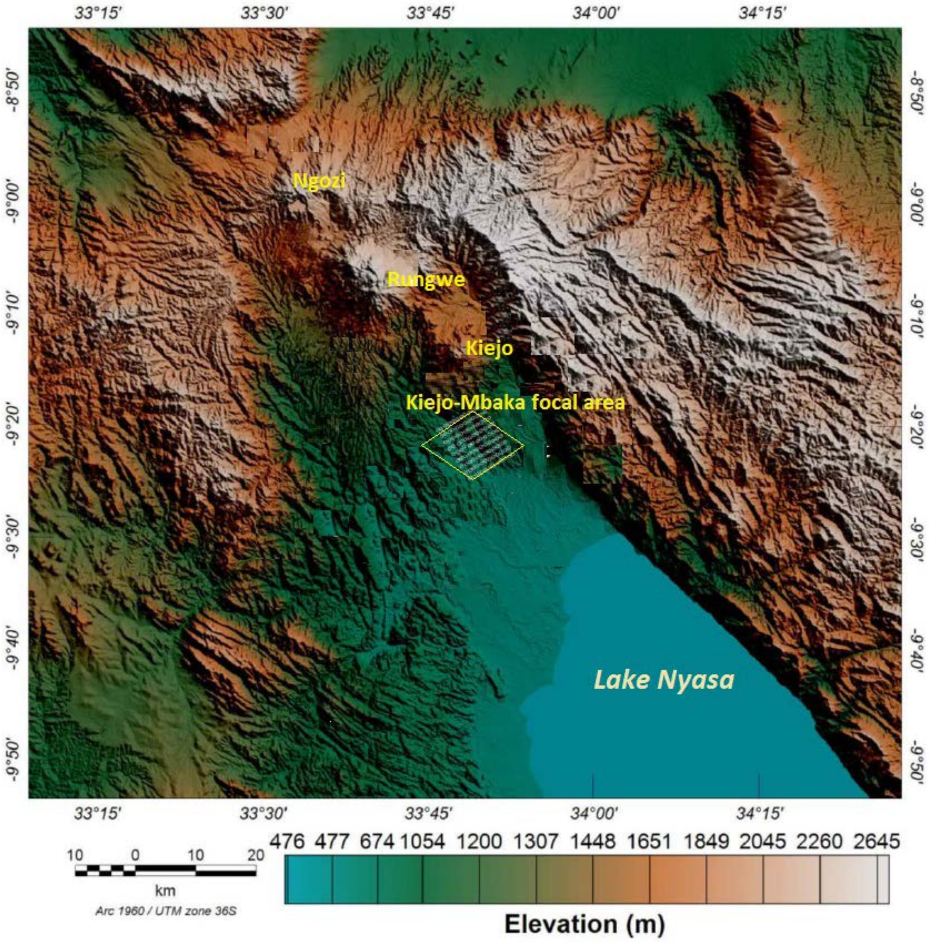

FIGURE 7: 3D topography view of Kiejo-Mbaka volcano in Rungwe Volcanic Province (RVP)

TGDC in collaboration with East Africa Geothermal Facility (EAGER) carried out an additional gap filling study in the area between November 2017 and June 2018. The study recommended Temperature Gradient Holes (TGH) drilling programme comprising fourteen (14) drilling locations to increase the knowledge about the system and resource suitability for direct use applications and power generation (Figure 8).

TGDC in collaboration with EAGER has conducted a pre-feasibility study for direct use applications for Songwe prospect. The study shows that the prospect is suitable for a number of multi direct utilization mini projects such as aquaculture, drying agricultural crops, and recreational (tourism). With consideration that Songwe region is famous in agricultural activities like growing of coffee, pyrethrum, tea, beans and the like, TGDC believes that, introducing agri-processing technology such as drying of crops and fish farming to the farmers and developing tourism can have significant economic effect and benefits not only to the local community, but also to the regional and national economy.

6.4 Luhoi geothermal prospect

Luhoi geothermal prospect is located in the Coast Region, about 150 km from Dar es Salaam. It is situated along the southern extension of the East African Rift System, “Coastal Basin”, which formed mainly in response to progressive fragmentation through time of the super continent of Gondwana. The detailed surface study was finalized by a consultant from Italy in 2017 (ELC, 2017) in the joint project framework with Kiejo-Mbaka under technical support from the MFA/ICEIDA. The results from the technical report show that Luhoi geothermal prospect hosts a low temperature geothermal system (95-145°C) and is suitable for direct uses and power generation using binary technology.

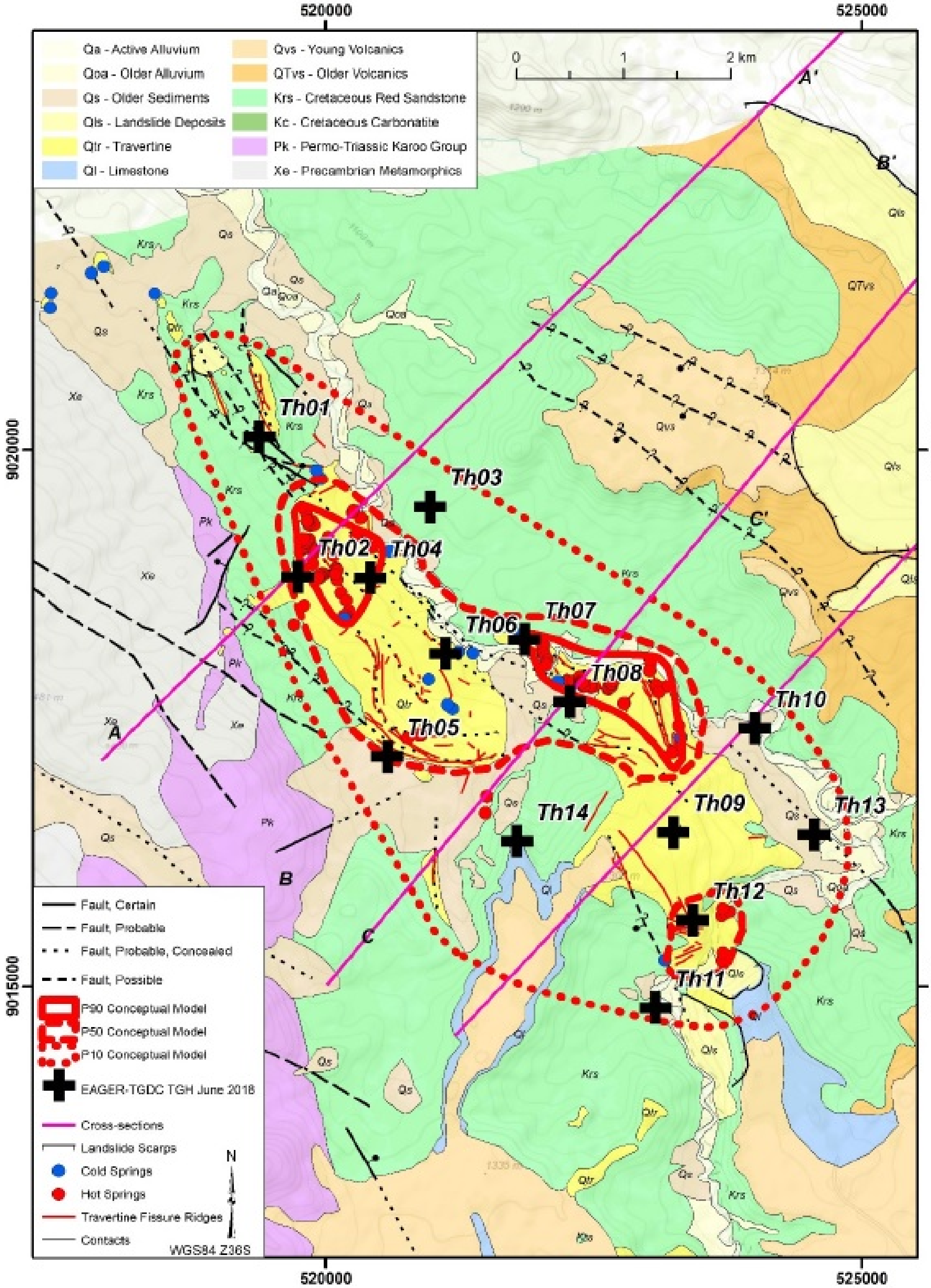

FIGURE 8: Map showing Songwe conceptual model and TGH locations

Geologically, Luhoi is located on the southern extension of the EARS in the southeastern coastal basin of Tanzania which split into the NNE-SSW trending Selous sub-basin and NNW-SSE trending Mandawa sub-basin where the two are separated by a spur of Pre-Cambrian basement (Figure 9). The prospect area occurs at the northern intersection of the two sub-basins within Rufiji trough. This is the E-W trending basin which is covered by the sedimentary sequence which becomes thicker and younger toward the Indian Ocean in the east. The coastal basin of Tanzania was formed in response to progressive fragmentation of Gondwana where a series of tensional regime and spreading events split the continental crust creating sedimentary basins along the eastern coast of the continent.

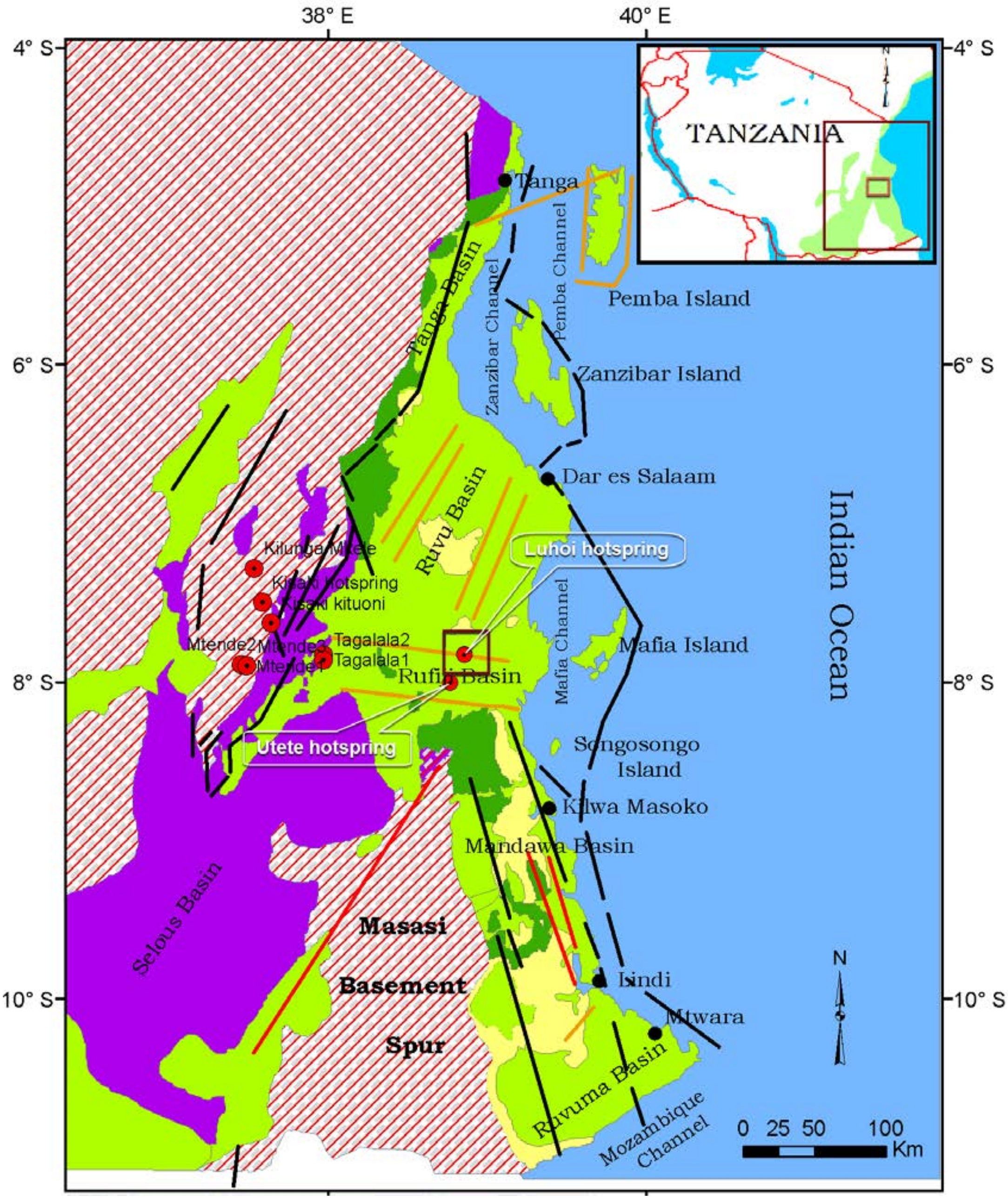

FIGURE 9: Luhoi geological map

The prospect is manifested by several hot springs (about 72°C and 20-30 l/s flow) along the Luhoi River over a stretch of about 600 m and large amounts of accumulated travertine.

7. CAPACITY BUILDING

Capacity building in terms of human skills and equipment is the cornerstone of sustainable geothermal development in the country. Tanzania is progressively developing strategic local capacity in terms of specific knowledge and skills relevant to exploration, development and utilization for supporting the geothermal development. As such, TGDC accords high priority to capacity building and it is currently preparing a grand plan for acquiring the required skills and equipment to enable it to execute its mandates. At present there are TGDC candidates attending long courses at universities abroad including Iceland and Japan.

8. INVESTMENT OPPORTUNITIES

Tanzania's electricity demand is on average growing between 10 and 15% per annum. This requires significant investment in generation, transmission and distribution systems. In this regard development of geothermal resources in Tanzania is essential so as to transform the country's energy sector to become balanced, diversified and sustainable.

Development of geothermal energy resources requires investment catalysts which among others are to establish an enabling environment, legal and policy framework, financial sustainability for geothermal projects and developing requisite local capabilities. The country is currently working on attracting and creating a suitable investment environment with a number of opportunities in geothermal development.

At present, there is no specific law governing geothermal development. However, the Government is putting efforts in formulating a legal and regulatory framework. The draft bill for regulatory framework and institutional set up were already prepared and completed in September 2017. The draft was developed under support from Scale up Renewable Energy Programme (SREP), formulating a legal and regulatory framework for geothermal. The draft bill takes into consideration and addresses the challenges surrounding geothermal development in the country including current licensing and regulatory mechanism. Also, it is anticipated that the legal and regulatory framework will encourage private investments in power generation and direct use applications.

The country has already conducted a number of surveys on the direct use opportunities in areas around geothermal potential areas. The surveys conducted in Mbeya, Songwe, Coast and Shinyanga regions identified several direct use opportunities. They include agricultural uses, industrial uses, recreational and geo-tourism. Specifically, the agricultural uses may include greenhouse farming, drying of crops, aquaculture, and chicken hatching.

The Government of Tanzania offers some investors the possibility to become strategic investors through the Tanzania Investment Centre (TIC), which is the Primary Government Agency that is responsible for the coordination, encouragement, promotion and facilitation of investment in Tanzania.

9. DISCUSSION AND CONCLUSION

Recognising the potential contribution of renewable energy to the country's future energy mix, the Government of the United Republic of Tanzania is ambitious to foster the development of low-carbon energy initiatives through harnessing its renewable-energy resource base. Renewable energy, which is environmentally benign, can improve access to sustainable modern and cleaner energy services with the potential for contributing to job creation, income generation, and improved livelihoods of marginalised social groups, particularly women and children in rural areas. As one measure of climate change mitigation and adaptation, the government has developed the National Adaptation Plan for Action 2007 and the Sector Environmental Action Plan 2011–2016.

The government has embarked on changes to policy, as well as the legal and regulatory framework, to create an enabling environment and a streamlined institutional framework. Among the results of these efforts is the formation of Tanzania Geothermal Development Company Limited (TGDC). The establishment of TGDC as a government vehicle has increased the pace toward making geothermal a reality in Tanzania. Within five (5) years of existence, TGDC has completed detailed surface studies of geothermal projects (Ngozi, Songwe, Kiejo-Mbaka and Luhoi) and is negotiating for GRMF grants for Ngozi drilling program and Kiejo-Mbaka (DP); also accepted grant from GRMF for financing for and Natron (SS). Presently, the government has contracted the consultant (ÍSOR/Verkís) for test drilling at Ngozi to confirm the availably of commercial geothermal resource for power generation and direct use.

There are still challenges in developing geothermal resources in the country, the main ones being inadequate human capacity and equipment. There are few people in Tanzania with formal training in geothermal energy. The immediate solution is to utilise all available experts locally and hire expertise from outside, while extensive training programs are underway to develop the required people.

At present, the appropriate legal and regulatory framework that addresses specific geothermal peculiarities are under procedural process machinery. This will provide enabling environmental and the private sector risk averseness will be addressed in order to attract them in investing in the development of geothermal energy projects.

The government is and has been improving the conditions catalysing geothermal development. But it is known that the initial exploration phase for geothermal energy, before confirming the potential by well drilling, is perceived to be risky and capital intensive, thus unattractive to the private investors. That is why the government has stepped in to form a public company that will take care of the upstream exploration works. The government alone can support the preliminary exploration works which include drilling of exploratory wells to confirm the resource. It is expected that the current practice where public funds from the government, development partners and concessional loans will unlock geothermal development by taking part to finance the initial phases of geothermal projects. Given the above plans, strategies, programs and efforts, the future of geothermal development and utilization seems to be bright in Tanzania.

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