Proceedings World Geothermal Congress 2015
Melbourne, Australia, 19-25 April 2015

Geothermal Development in Tanzania – a Country Update

Taramaeli T. Mnjokava[1], Kato Kabaka[2], Jacob Mayalla[3]

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

[2]Tanzania Electric Supply Company Ltd, P.O.Box 9024, Dar es salaam, TANZANIA

[3]Ministry of Energy and Minerals, P.O.Box 2000, Dar es salaam, TANZANIA

mnjott@yahoo.co.uk1, kato.kabaka@tanesco.co.tz2, jobmayalla@yahoo.co.uk3

Keywords: Tanzania, geothermal resources, Ngozi area, hot springs.

ABSTRACT

Tanzania is one of several countries that are favoured by being situated within the East African Rift system. It is thus endowed with an enormous geothermal potential which has not yet been tapped, and has only been explored to a limited extent. The estimated geothermal potential as per previous studies exceeds 650 MWe. Geothermal power is a reliable, low-cost, environmental friendly, alternative energy supply and an indigenous, renewable energy source, suitable for electricity generation.

The country's total grid installation capacity is 1,522.3 MWe. This is from hydro (37%), gas (33%) and other fossil fuels (30%), previously, the national power system was mostly relying on hydropower. Long and frequent periods of drought which might have been due to the climate change between 2003 and 2006; 2009 and 2010 lead 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. The country's indigenous power generation resources consists of hydro, gas, coal, wind energy, solar, geothermal and biomass.

Most of the geothermal prospects which show surface manifestations such as hot springs are located in areas transacted by the East African Rift System but some few others are outside the rift valley. Areas that are in rift system include the northern volcanic province of Kilimanjaro, Meru and Ngorongoro and the Rungwe Volcanic province in southwest Tanzania. Areas outside of the rift system include some coastal areas and other scattered areas with hot springs.

In Tanzania, several reconnaissance surveys and few detailed studies of hot springs and geothermal sites have been carried out since 1949; some of these early studies in geothermal potential areas include measurements of surface temperature, water and gas flow as well as water and gas chemical analyses of the hot springs. These studies have provided basic information on planning current geothermal development initiatives. In 2006 and 2007, the Ministry of Energy and Minerals (MEM); in collaboration with the Geological Survey Tanzania (GST) and the Federal Institute for Geosciences and Natural Resources (BGR) of Germany carried out geological, geochemical and geophysical investigations to assess the geothermal prospects as well as to locate a hydrothermal system and potential geothermal reservoirs in the Mbeya region, south-western part of the country. The results from the electromagnetic surveys (TEM, MT) conducted show zones of low resistivity in the Lake Ngozi area, which can possibly be correlated to alteration zones caused by geothermal activity and in turn indicating a potential geothermal reservoir (GEOTHERM 2006).

Further geophysical work was done near the flanks of Lake Ngozi in 2010 as a continuation of GEOTHERM 2006. The results obtained as used for planning the drilling of temperature gradient wells or exploratory wells. The temperature gradient wells have not been drilled yet. In 2013, a reconnaissance survey financed by JICA covering the whole country was undertaken with the objective of obtaining basic information for developing a systematic approach in the planning and development of geothermal resources in the country. Furthermore, the government has established a public company dedicated to geothermal development in Tanzania**.** The business environment for geothermal development including legal and regulatory framework and institutional set up are being improved to attract the participation of the private sector.

1. INTRODUCTION.

Tanzania is located in east Africa with a size of 945,087 km^2 and a population of 44.9 million (2012 census). Today, per capita electricity consumption in Tanzania is about 100 kWh per year but demand is increasing rapidly, owing mainly to accelerating productive investments, a growing population, and improving access to electricity. The power system master plan (2010–35) envisages that the population's electrification status will exceed 75% by 2035, whilst demand from connected customers will increase significantly as the country reaches middle-income status, as stipulated in the national development vision 2025. The Ministry of Energy and Minerals is mandated to develop energy resources and manage the sector. It is responsible for the formulation and articulation of policies to create an enabling environment for sustainable development. Promoting renewable energy is part of its mandate. while the ministry plays an essential policy guidance role, other major government institution

players in the sector include the Rural Energy Agency (REA), Tanzania Electric Supply Company (TANESCO), Energy and Water Utilities Regulatory Agency (EWURA). The functional relationships among the sector players are as shown in figure 1. The Rural Energy Agency (REA) is responsible for promoting improved access to modern energy services in the rural areas of mainland Tanzania and providing grants to TANESCO for rural grid distribution investments and to developers of rural energy projects. Tanzania Electric Supply Company (TANESCO) is the country's principal electricity generator, transmitter, and distributor. Currently, it provides nearly 60 percent of the effective generating capacity of the national grid, and is responsible for transmission and distribution, serving customers on the main grid and in 20 isolated grids. 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. In addition to the public sector, the private sector, development partners, NGOS and higher learning institution are involved in the development of geothermal energy resources.

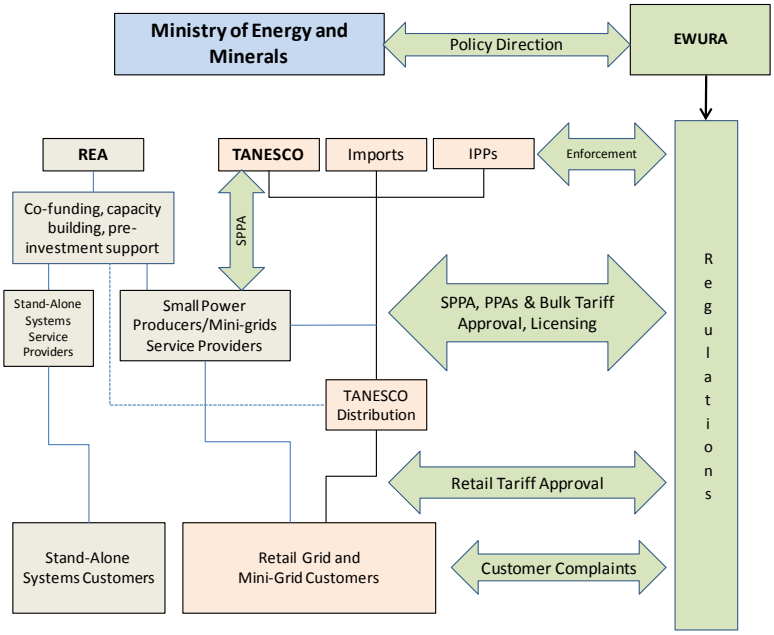

Figure 1: Institutional framework and market structure of the electricity sector

The Medium Term Strategic Plan (2012–16) and Power Sector Master Plan (2010-2035) envisage developing renewable energy sources to ensure national energy security. Key interventions under the Medium Term Strategic Plan (2012 16) include (i) increasing power generation, (ii) developing alternative and renewable energy sources, and (iii) promoting energy efficiency and conservation.

Regarding development of geothermal, the government is committed to reducing 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 that reason, the government has put an emphasis on developing appropriate policy and legal and regulatory framework and support high-risk phases of geothermal project implementation, especially test drilling.

2. GEOLOGY BACKGROUND.

Tanzania lies on the African Plate, which is one of the 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.

The Tanzania craton is composed of granites and zones of schist and gneiss containing greenstone belts. The craton is rimmed by Proterozoic crystalline rocks. Proterozoic formations distributed in the west and the south consists mainly of gneiss and schist associated with a small amount of amphibolites (Figure 3). 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 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 gabroo, dolerite, kimberlite, carbonatite granite, syenite and so forth.

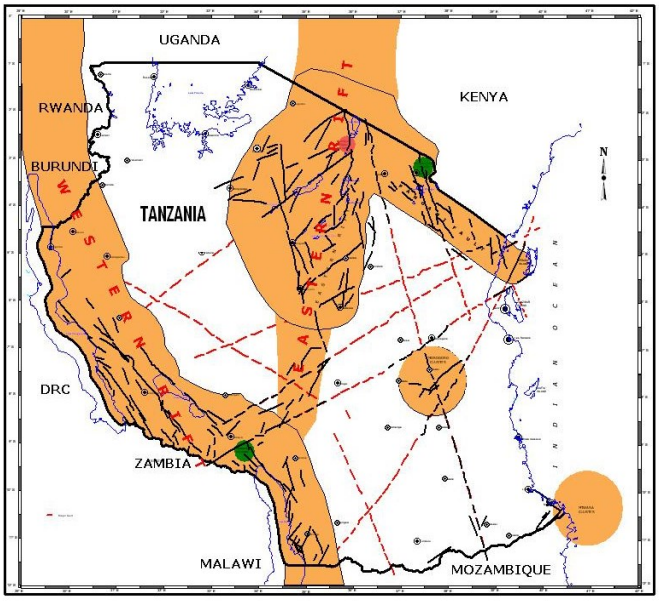

FIGURE 1: East African Rift System in Tanzania

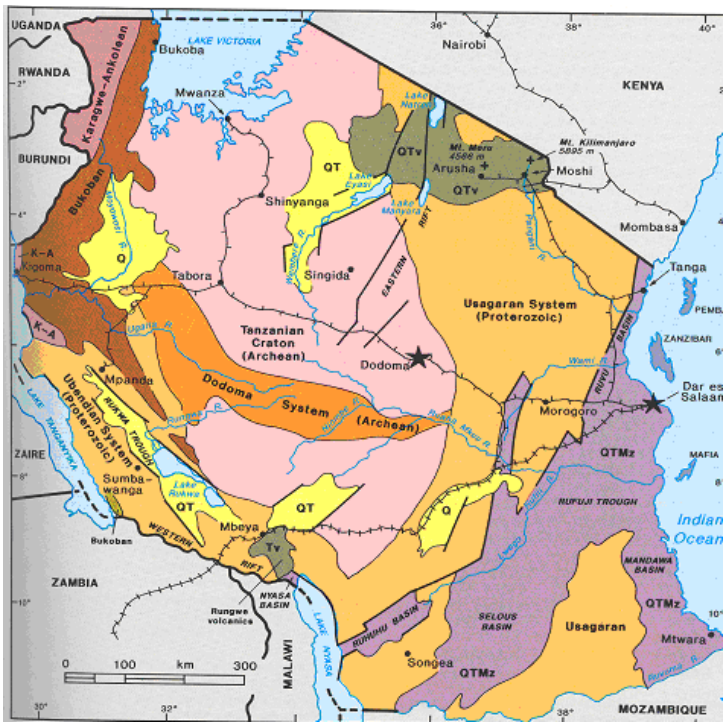

FIGURE 3: A simplified geological map of Tanzania. (*Q- Quaternary basins, QT- Quaternary Tertiary basins, QTv- Quaternary Tertiary volcanic, QTMz- Quaternary Tertiary Mesozoic basins, Tv- Tertiary volcanics, K-A- Karagwe Ankolean)*

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 graben occur near Arusha and further south. The western and eastern branch forms a triple junction at the Rungwe volcanic complex with the Malawi rift (Figure 2).

3. GEOTHERMAL RESOURCES AND POTENTIAL

In Tanzania, the areas with features of geothermal energy resources are mostly located in the Rift Valley and the common surface manifestations are in hot spring sites located in areas transacted by faulting (Figure 4). Such areas include the northern volcanic province of Kilimanjaro, Meru and Ngorongoro and the Rungwe Volcanic province in southwest Tanzania. In addition, some coastal areas show geothermal surface manifestations. Hot springs have been mapped in the Rufiji basin, south of Dar es Salaam and to the north in the Tanga region. The hot springs in the coastal sedimentary basin are attributed to rifting and intrusions.

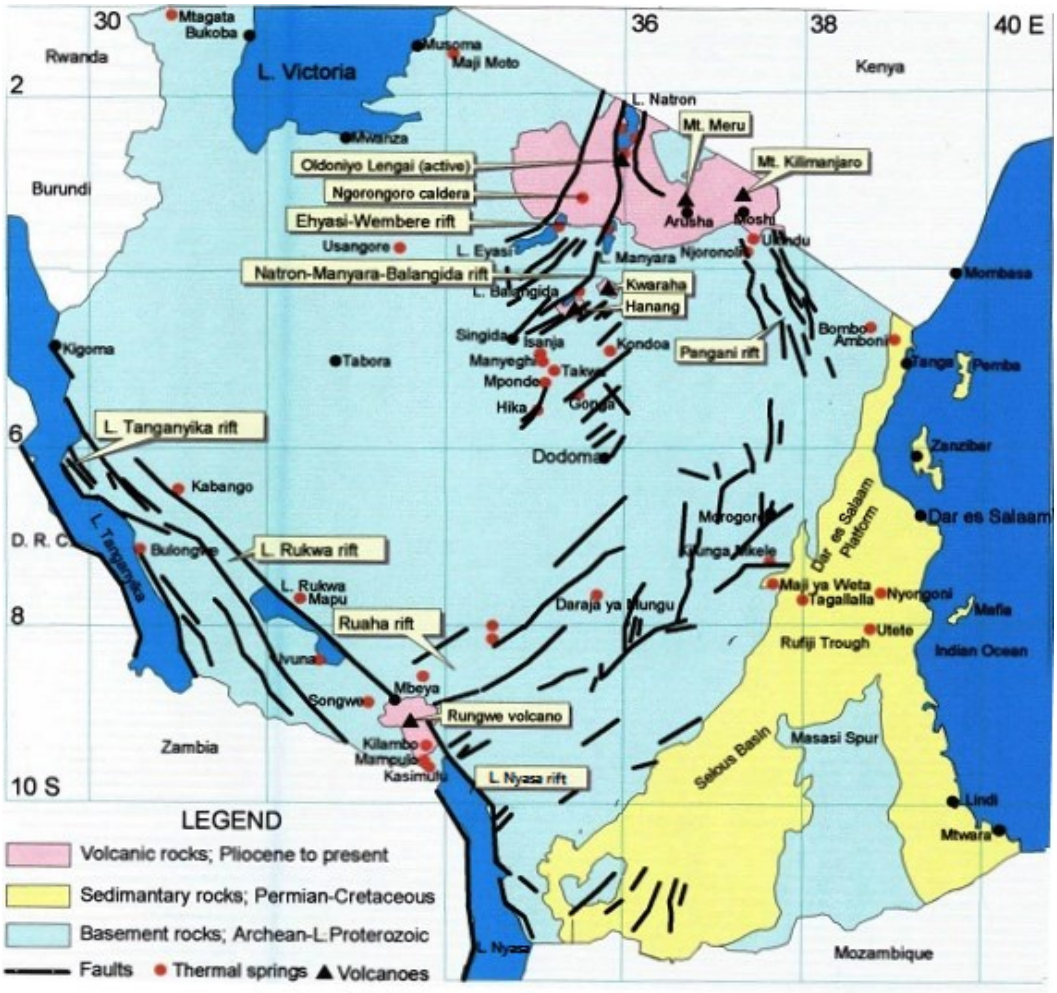

FIGURE 4: Location of geothermal sites in Tanzania

In ascending order the zones of geothermal resource potential of the prospective areas include the Mbeya area in the Rungwe volcanic complex, Lake Natron area in the Arusha region, Luhoi in the Rufiji district at the Coastal region, Kisaki area in the Morogoro region, followed by other areas outside the rift such as Maji Moto in the Mara region near Lake Victoria, Balangida lalu, Mbugwe in the Manyara region, central Tanzania in the Dodoma and Singida region, Amboni and Bombo in the Tanga region, and Mtagata in the Kagera region west of Lake Victoria (JICA, 2013.)

Existence of thermal energy is inferred from the presence of hot springs, volcanic activities and associated fault structures. Hochstein et al. (2000) argued that the geothermal resources of Tanzania appear to be rather small and limited in terms of existing technology. McNitt (1982-UNDP), based on analogy methods, concluded that the geothermal potential of Tanzania could be as high as 650 MWe. This value is based on the natural heat flow discharge from hot springs. The estimates are based on integrating the geophysical, geochemical and geological techniques without test drilling.

Despite the fact that Tanzania might have significant geothermal energy potential; it has not been included in the existing energy policy which is currently being revised because of capacity uncertainties. However, recent studies under a geothermal energy (as an alternative energy source for Tanzania) project conducted by MEM, GST, TANESCO and BGR from 2006 to 2010 have provided promising results which have led to the government to consider geothermal as an alternative source in the long term energy supply plan. According to the National Power System Master Plan, geothermal is supposed to contribute 100 MWe by year 2025. The Scaling Up Renewable Energy Program-Investment Plan for Tanzania envisages reducing the timeline significantly through joint efforts of the government, development partners and the private sector.

4. GEOTHERMAL UTILIZATION

In Tanzania there is no formal geothermal utilization; local uses of sinters for feeding animals, washings and skin bathing are the only informal geothermal utilization. The current grid connected generation stand at 1,522.3MWe and is expected to reach 5,000 MWe by year 2020 (Table 1). The main factors driving the load growth is the expanding mining activities, agro processing industries, rural electrification and the population increase. The power generation plan is developed based on demand for the forecast period. Other factors in selecting new power generation technologies include capital investment requirements, project implementation lead time, fuel costs and resource availability. In addition, confirmatory studies mainly technical, economic and environmental are key elements of the projects preparations and signals on the possibility of success for the identified projects to be included in the plan. Based on these factors the power sources that are considered for development include gas, hydro, coal, wind, solar and geothermal, almost in the order of priority. Geothermal was ranked low because of the upstream uncertain, upfront costs and absence of confirmed geothermal resource.

Gas and coal based generation is expected to grow from the current 957.3 MWe to over 4000 MWe because they are available locally have a short lead time. This strategy is adopted to get rid of the emergency power plants which are oil based, therefore expensive to run. It is expected that the wind and solar based generation will contribute up to 420 MWe by the year 2020. Despite their intermittences, wind and solar have been given a priority because the resource is abundantly available and the cost of technology is significantly declining.

TABLE 1. PRESENT AND PLANNED PRODUCTION OF ELECTRICITY

	Geothermal		Fossil Fuels		Hydro		Other Renewables (Wind, Solar and Cogeneration)		Total	
	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr
In operation in December 2014			957.3	5,638.2	565.0	2,820.5			1,522.3	8,458.7
Under construction in December 2014							150.0	603.0	150.0	603.0
Funds committed, but not yet under construction in December 2014			320.0	1,354.0			200.0	870.0	520.0	2,224.0
Estimated total projected use by 2020			4,277.3	26,748.2	870.5	5,256.2	410.0	1,683.0	5,557.8	33,687.0

5. DISCUSSION

Geothermal does not feature clearly in the Tanzania Power System Master plan despite the high potential in the country. The main reason is insufficient resource information needed for planning, investment decisions and project development. The government has realised this and has embarked on policy changes and creation of an enabling environment to include establishing legal and regulatory framework.

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. In addition, the National Climate Change Strategy will integrate the climate change dimension into national policies and programmes.

In the development of geothermal resources the challenges are inadequate capacity to develop geothermal; that is there is very few staff with adequate knowledge and skills on geothermal energy, there is no institution clearly mandated to deal with geothermal and an absence of policy, legal and regulatory framework as well as enabling environment in terms of conducive fiscal and regulatory regime. There is a need to set a catalytic investment environment to attract the private sector into investing in the development of medium to large scale geothermal energy sources.

The government has noted that the impetus for geothermal development in Tanzania is not at a pace that can enable realising geothermal energy production in the near future. Initial exploration phases for geothermal energy, before confirming the potential by well drilling, are perceived to be risky and capital intensive, thus unattractive to the private investors. On the other hand, the government itself does not have sufficient funds for this preliminary exploration work which should include drilling of temperature gradient measurement wells, deep exploratory drill holes and the subsequent logging of the boreholes.

The government has formed a Geothermal Development Company to which among other duties will be responsible for;

i. Promotion of geothermal development

ii. Carry out upstream geothermal exploration activities including surface exploration, drilling, reservoir appraisal, reservoir management, pre-feasibility and feasibility studies and design

iii. scientific data collection, data and information trade, training and capacity building in geothermal development,

iv. geophysics, geochemistry, hydrogeology, seismology, civil, electrical and mechanical engineering, hydraulics, geotechnics, engineering geology, surveying, economics, environment, design, project appraisals and planning of geothermal projects.

v. Among the planned first activities are: conducting a nation-wide preliminary geothermal resource assessment for production of a national geothermal resource map and ranking of the potentials.

vi. This will be followed by a detailed study in geothermal sites in priority areas, mainly Lake Ngozi in Mbeya, Lake Natron (Arusha region), Kisaki and Luhoi (Coast region). To promote the promising sites (including Lake Ngozi) for PPP development approach.

vii. To put in place policy, legal and regulatory frameworks for geothermal energy development, (at present there is no existence of renewable energy/geothermal policy, legal and regulatory).

6. ACKNOWLEDGMENTS

The authors thank the senior officials of their institutions for encouraging in the writing of this paper. Availability of the information needed during the writing of the paper and granted permission to attend the conference. Thanks to the sponsors for enabling the authors to attend the conference and the organizing committee of WGC2015 for good work that made possible for the authors to present this update in World Geothermal Congress 2015

REFERENCES

GEOTHERM, 2006. Geothermal Energy as an Alternative Source of Energy for Tanzania. Geotherm Programme. www.bgr.de/geotherm.

Hochstein, M.P., Temu, E.B & Moshy, C.M.A., 2000: Geothermal Resources of Tanzania.- *Proceedings World Geothermal Congress* 2000, Kyushu-Tohoku, Japan May 28 – June 10, 2000.

JICA, 2013: Data collection Survey on Geothermal Energy Development in East Africa, draft final report.

McNitt, J.R. (1982): The Geothermal Potential of East Africa. UNESCO/USAID Geothermal Seminar, Nairobi, Kenya, June 15-21, p. 1-9.

Walker, B.G., 1969. Springs of deep seated origin in Tanzania. *Proc. 23rd Intern. Geological Congress, 19.*