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CURRENT STATUS AND THE WAY FORWARD FOR GEOTHERMAL EXPLORATION IN BURUNDI

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ABSTRACT

Burundi is currently being confronted by energy challenges largely due to factors relating to climatic fluctuations. The negative climatic effects have led to highly variable precipitation patterns hence affecting significantly the hydropower production which is the main source of energy for Burundi. More complications have arisen due to the growing energy market in the country that is largely going unsatisfied. This has necessitated considerations for other sources of energy for reliability and bridging the countries deficit. As one of the solution, geothermal energy is being looked into. Geothermal exploration studies in Burundi have been conducted since 1969 where studies mainly on geology has resulted in geothermal manifestations like hot springs being mapped.

1. INTRODUCTION

Burundi is located within the western arm of the African Rift Valley. Due its geological setting and location (Figure1) geothermal resources are highly considered as possible source of clean renewable energy for Burundi in the near future. Statistics indicated that a limited portion of the population in Burundi have access to electricity. Only 2% of available electricity comes from hydroelectricity, 3% from oil and 95% from Biomass. The increasing demand for energy in Burundi cannot be satisfied by the already compromised hydropower generation. The total available power is still generally low with a peak load of around 164 MWe.

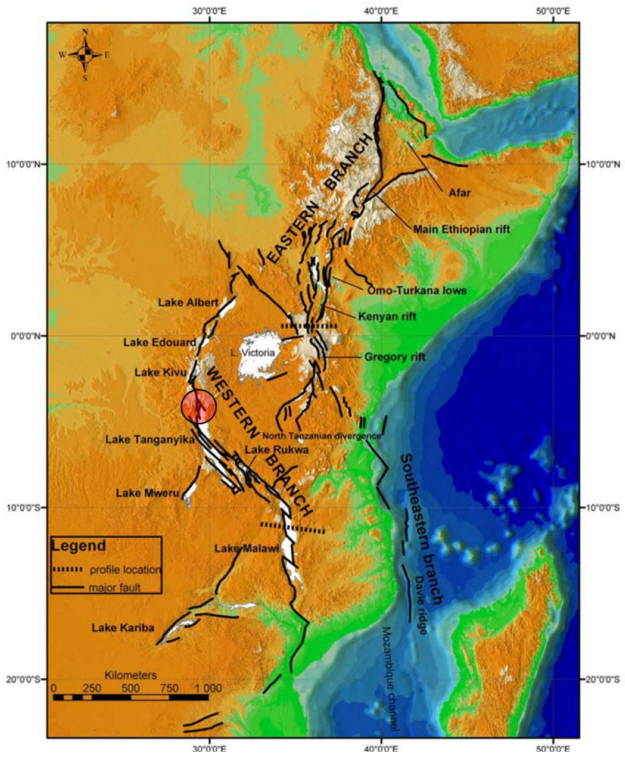

Figure 1: Location and geological setting of Burundi (marked in red)

Faced with the increasing demand and possibly fluctuations in costs of fossil fuels, Burundi energy sector needs to urgently to review its policies and shift to alternative sources of energy. In this regard geothermal energy development is being considered as favourable and can be accelerated with the assistance from regional bodies like ARGeo programme.

2. HISTORY OF GEOTHERMAL EXPLORATION

Previous studies have identified 14 geothermal sites where hot springs manifestations occur (Figure 2). The results were published by (Deelstra et al 1969) and are also obtained from other unpublished reports. In

these studies only geology was described relatively in detail while geochemical studies were proposed as recommendations.

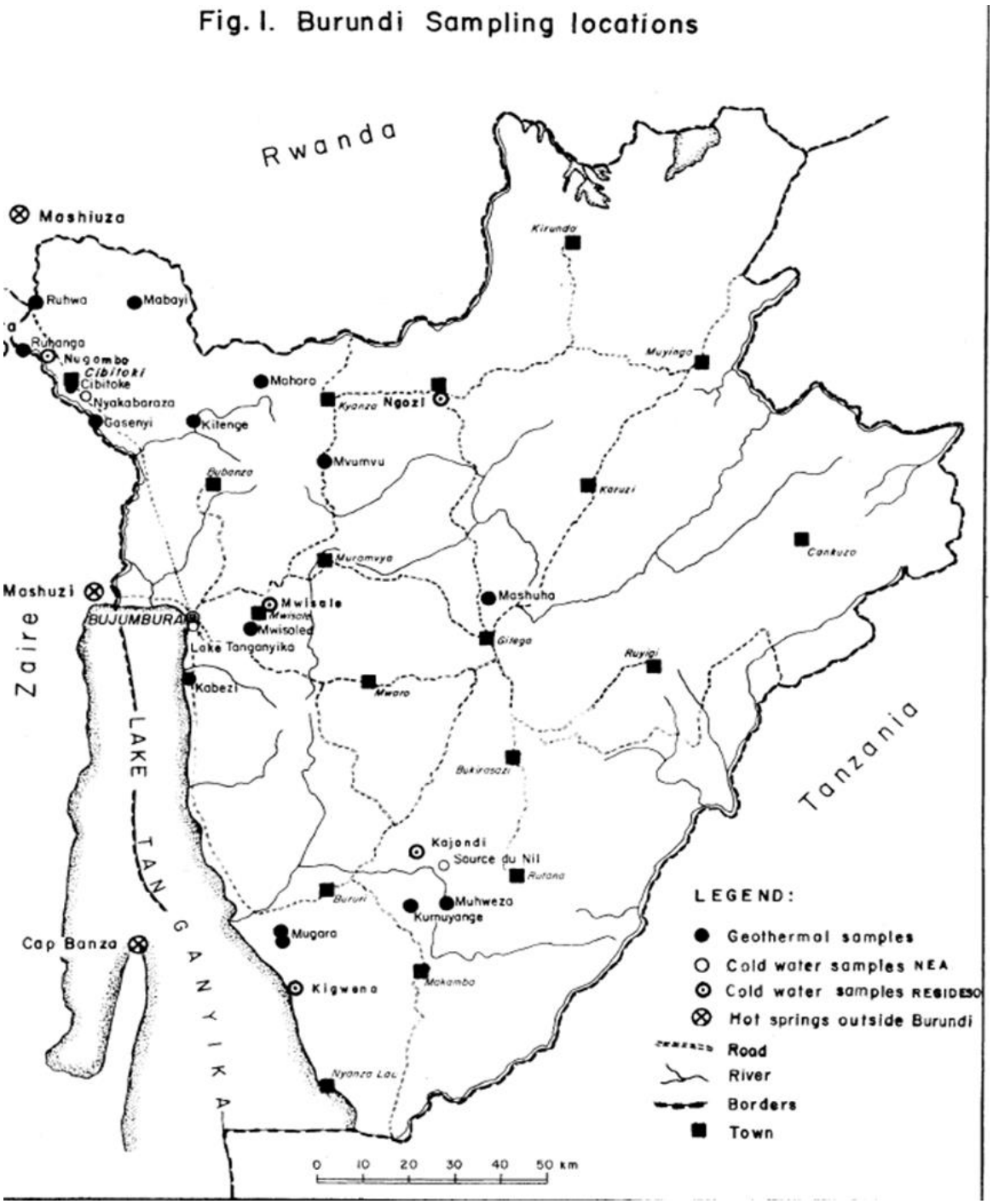

Figure 2: Burundi sampling locations (Deelstra et al, 1969)

2.1 Geology and Structural studies

Geothermal activity in Burundi is highly controlled by faults which have affected the Precambrian rocks and relatively younger sediments. There is apparently little evidence showing relationship between recent volcanism and geothermal activity. It has been identified that all the geothermal sites are located in the western and central parts of the country. No geothermal sites are found in the eastern part of the country where volcanic activity is absent and lies further away from the active rift zone. All reported geothermal manifestations in Burundi are within water pools and no record of surface steam (fumaroles) or mud pools

have been reported. The highest hot springs surface temperature is 68°C at Ruhwa (McNitt et al 1969), this observation is confirmed by a recent field observation (2010). In general geothermal manifestations in Burundi are constrained within two types of environment; (i) In the Precambrian rocks, mostly outside the Rift Valley, and (ii) The sediments inside the Rift Valley. The old and less porous nature of the Precambrian rocks away from the Rift Valley makes the existence of an exploitable geothermal system within it highly unlikely. The highly porous and thick sediment layers however coupled with association to recent volcanism in the Rift Valley constitute conditions which could lead to exploitation of low to medium enthalpy geothermal systems.

There is considerable volcanism around Lake Kivu northwest of Burundi and in whose vicinity geothermal manifestation has been reported. The chemical composition of the Lake water is also points to an underlying geothermal activity in the area. Thus from a geological point of view this is the most promising geothermal areas in Burundi which must be investigated further.

In the recent past six geothermal locations in the Rift valley were visited; four in the Rusizi valley, one on the east coast of Lake Tanganyika (Kabezi), and one further south known as the Mugara springs. In the Rusizi valley and at Kabezi the hot springs oozes from sediments, but at Mugara the hot springs are associated with the Precambrian rocks. Thus the former sources are likely to originate from larger and more open aquifers than the latter.

2.2 Geochemistry studies

Geothermometers using quartz geothermometer (Fournier, R. O. and J. J. Rowe 1966) suggests reservoir temperatures of between 110°-120° C for the hot springs at the Rusizi oozing from the porous sediments. The hot springs is known as Ruhwa spring and has surface temperatures of 68°C ,they originate from a sedimentary terrain and are carbon dioxide rich. The high carbon dioxide concentrations lead to super saturation with respect to calcium carbonate, hence calcite scaling is highly likely in the event of geothermal development. In summary an exploitable geothermal source whose temperature could be between 100°-160°C, may exist in the Rusizi valley and probably extend well into DRC and Rwanda. This source is thought to be connected to the Thibinde volcanic area south of Lake Kivu. Therefore, an anomalously geothermal gradient may be expected in this region.

The reservoir temperatures in Burundi geothermal sites are unlikely to be high enough for conventional electricity production. However, other commercial applications can be exploited, for example the geothermal waters from Rusizi valley are carbon dioxide rich and can be cooling and bottled as mineral water. The chloride rich waters however would be unsuitable in this respect (Figure 3).

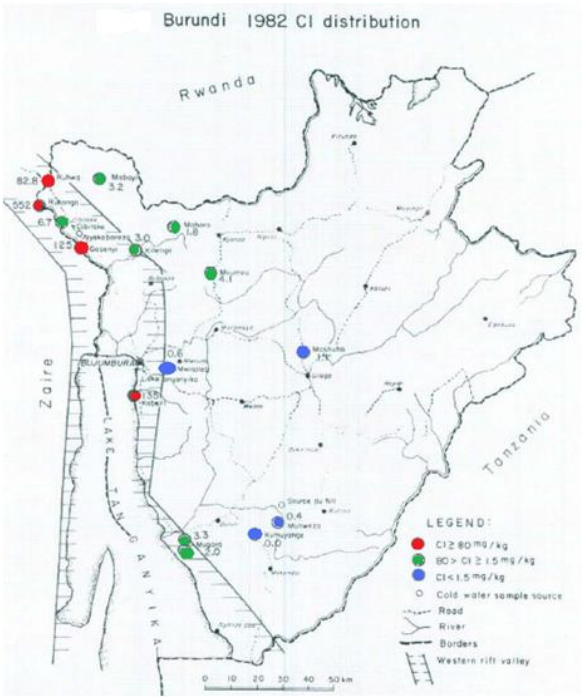

Figure 3: Chloride distributions

3 RECENT SURVEYS

In 2010 studies were proposed for the 12 known geothermal areas to gather more information on geological, structural and physico-geochemical (temperature, pH). Only 10 sites were visited and surveyed, where detailed environmental description and data collection was undertaken. The studied areas are located along the Rift and in the western half of the country. Surface geothermal manifestations in form of hot spring through ancient fluvio-lacustrine terraces, around Ruhagarika Rusizi and Ruhwa river and in Rwandan-Burundian border were mapped. Other manifestations mapped were the less spectacular, hot springs located near the Imbo plain, where a hot spring from the alluvial deposits of the valleys are carving into the Precambrian Meta sedimentary formations. The collected data included ; the location coordinates, physic parameters (*Temp, flow, aromatic substances,*

bubbles, visible minerals concretions or deposits), geologic environment and current use (Table 1). In general, the hot springs were characterized by gas bubbles with no distinctive odor, and with no surface depositions but only thermo algae presences. Three categories of thermal springs were described based on their temperature ranges.

Table 1: Field data from a recent survey

BURUNDI Geothermal sites					
Fourth day : Wednsday 14 th July 2010 Departure: 9 h 00 Arrival: 19 h 00					
Name		**Ruhagarika**		**Mabayi**	**Ruhwa**
Localitie		Cibitoke		Mabayi	Rugombo
Date of visit		7/14/2010		7/14/2010	
GPS coordinates	Lat	741072	741055/ 741008	749086	727083
	Long	9671920	9671958/ 9672136	9699672	9697650
Description of site	RN 5: at 2 km from Buganda commune to the Rusizi River,			several little springs in	At the border of Rwanda and RDC
	after Gatete village. Along the West side of Rusizi plain			alluvial (gravel, sand) of	Near and on Ruhwa river
	some (two visible) opened hot water springs from Fluviatil sa			Nyamagana river, 1 km	Several springs occure in sediments of
	now colmated by argilic material			to reach the commune	the Plain
Current utilization		not rehabilited		Is permananrly remamied bu artisanal work for gold	
Rate of flow		not easy to estimate		not easy to estime	not easy to estime (10 L / sec ??)
pressurized steam/		No steam,no vapors		no	Some vapor, and some pression not seen
vapors/mist					in others sources
Aromatics		no	no	no	Some sulphures smell
Water quality		green colorations,		clear when no works	clear at emergence point
		vegetables (algues)			
Deposits		white and yellow deposits(salted)		no	White deposits, green microorganisms
Temperate and PH		48° C	48 ° C	40° C	68 ° C
Geology		Pegmatitic, sandstones quartzites blocs		Recent fluviatil sediments	Recent fluviatil sediments
		and poudingues & conglomeratics		gravel	
		sediments with boulders . The plain is marecageous			
Samples		2 samples	2 samples	2 samples	

4 CONCLUSIONS

Geothermal manifestations occurrences in Burundi are constrained in two types of environment; faulted Precambrian rocks mostly in connection with the rifting, and recent porous sediments inside the Rift Valley. All the manifestations are located in the western or central parts of the country where magmatism is more expressed and lies nearest of the active rift zone. The highly porous thick sediment layers and the recent volcanism in the Rift Valley structural context constitute conditions which could lead to exploitable geothermal systems. Geothermometers suggests reservoir temperatures of 110° -120° C at the Rusizi rift valley where carbon dioxide rich hot springs rises through the porous sediments. An exploitable geothermal source whose temperature could be in 100°-160°C range, may exist in the Rusizi valley and probably extend well into DRC and Rwanda. These hot springs manifestations are thought to be connected to the volcanic area south of Lake Kivu. Therefore, an anomalously geothermal gradient may be expected in that region. In 2010 addition studies focusing on geology, structural and physicochemical (temperature, pH)

were conducted. From these studies thermal springs were characterized as follows; (i) those with surface temperature of 30 - 40 ° C located away from the rift (ii) hot springs discharging at 48 °C located in the rift i.e. Mugara (iii) Finally those with discharge temperature of 68 ° C i.e. Ruhwa located further to the north. Additional Investigations were recommended so as to update available data.

Since geothermal development is highly technical and a multidisplinary more needs to be done in Burundi concerning capacity building and training. In a recent workshop organized by EARS (East African Rift System) countries, some propositions and recommendations were pointed out to fast tract geothermal progress in Burundi and other western Rift countries e.g. Rwanda. The Western Rift is still largely unknown, since not much scientific research has been conducted. To ensure that the accelerated development is achieved several recommendation were made as follows;

- More investigations including geology, geochemistry and geophysics studies are involved to define the geothermal potential assessment (especially in the whole of the common border region of DRC, Rwanda, and Burundi).
- Establish a policy for an integrated geothermal exploration and development of the resources
- Mobilize funds both locally and through our development partners to support the above initiatives.
- Establish a good collaboration with East African's countries in which geothermal system is best known.

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