"GEOTHERMAL EXPLORATION AND DEVELOPMENT IN RWANDA"

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Keywords: Rwanda, Geothermal, African rift

Abstract

Given the frequent drought that affect the national hydropower, variation of fossil fuel prices in the world and the increasing demand for more power, geothermal energy offers an indigenous environmental friendly alternative to Rwanda today.
Rwanda could deliver about 170 to 300 MW of energy from geothermal power (GEA, 1999). The exploration for a geothermal development in Rwanda is still at an early stage. Limited surface exploration work has been carried out in the 80's both in the Western, Southern and Northern provinces of the country. The reconnaissance studies indicate three important zones presenting a geothermal interest: the National volcanoes park, the Graben of Bugarama (Mashyuza) and the hot springs of Gisenyi.
Presently, the principal objectives of the Government of Rwanda and international institutions are the evaluation of the high and medium enthalpy geothermal resources of the country, and the selection of a site of prime interest which could lead to future electricity generation from these resources. It is in this context that a joint project between the Government of Rwanda and the Federal Institute for Geosciences and Natural Resources (BGR, Germany) for the geothermal resource assessment started in November 2007.

INTRODUCTION

The Republic of Rwanda is a small landlocked country in east central Africa along the Western branch of the Great Rift Valley, which is its western border. The country is bordered by Tanzania on the East, Uganda on the North, Burundi on the South and the Democratic Republic of Congo on the West **(Fig.1)**. The total area of the country is 26,338 km^2 with a population of approximately 10 million of inhabitants. The climate is temperate with two rainy seasons each year, February to April and November to January.

Fig 1: Geographical setting of Rwanda in the regional context

STATUS OF ENERGY SECTOR

Rwanda faces serious energy problems. Most of the population use wood and agricultural by-products for their basic energy needs making fuel wood increasingly scares and creating serious deforestation problems all over the country. 85% of the total energy is consumed in the rural areas where the majority of Rwandans live. Biomass dominates as the principal source of primary energy for 90% of the population. Imported petroleum fuels on the other hand dominate the local industries energy supply. In the third level is electricity, which is used by only 4% of the population.

Production of electricity in Rwanda was mainly 100 % from hydro resources but since the year 2002, it changed to 40% from hydro and 60% from thermal. The installed capacity of hydro plants is approximately 27 MW but the available capacity today has lowered to 5.1 MW as a consequence of low rainfall, not enough to refill the reservoirs for the hydroelectric dams. In order to overcome the energy deficit, thermal stations were installed in 2004 and 2005 with a total capacity of 29 MW. This can only be regarded as a short-term solution, since importation of fuel put a further strain on the national budget.
Currently, the total installed capacity in Rwanda is 72.5 MW, of which the available capacity is 54.6 MW. The bulk of the capacity is derived from hydro (20 MW domestic, 11.5 MW imported) and thermal plant (22.8 MW), with only 0.33 MW from micro-hydro and solar sources (0.6% of the total). This capacity satisfies slightly less than half the national demand. **(Table 1)**

Category	Name	Installed Capacity (in MW)	Available Capacity (in MW)
In house Hydro Power	Ntaruka	11.75	6
	Mukungwa	12.5	11
	Gihira	1.8	1.8
	Gisenyi	1.2	1.2
Imported Hydro Power	Rusizi 1 (SNEL)	3.5	3.5
	Rusizi 2 (SENELAC)	12	8
Micro Hydro Power	Nyamyotsi	0.075	0.075
In house Thermal Power	Jabana	7.8	7.8
	Gatsata2	4.77	0
	Gatsata1	1.8	0
Rental Thermal Power	Aggreko 1 (Gikondo)	10	10
	Aggreko 2 (Mukungwa)	5	5
Solar Power	Kigali Solar	0.25	0.25
Total		**72.445**	**54.625**

Table 1: Rwanda electricity situation

GEOTHERMAL POTENTIAL

The geothermal potential of Rwanda was estimated to be in the order of 170 to 300 MW by the Geothermal Energy Associates (GEA, 1999). Rwanda hosts two prospective areas for geothermal potential; the Volcanoes National Park and the faults associated with the East African Rift near the Lake Kivu.

The Volcanoes National Park was identified as potential hosts for large, high temperature geothermal systems, while the rift provides an environment for small, low to moderate temperature resources.

Hot springs have been previously identified in the country near the Lake Kivu and the prospective areas for geothermal energy development are Gisenyi and Mashyuza with respective surface temperature of 74 C and 54 C **(Figures 2 and 3)**

Fig. 2: **Thermal area in Gisenyi**

Fig. 3: Thermal area in Mashyuza.

GEOTHERMAL DEVELOPMENT HISTORY

Rwanda does not have a long history of geothermal resources development. Geothermal has not progressed beyond the reconnaissance exploration stage. Limited surface exploration works have been carried out in the 80's by the French Bureau of geology and mining research (BRGM) in 1982 with a focus on hydro geological data collection and some of the hydrothermal springs of the country were identified **(Fig. 4)**.

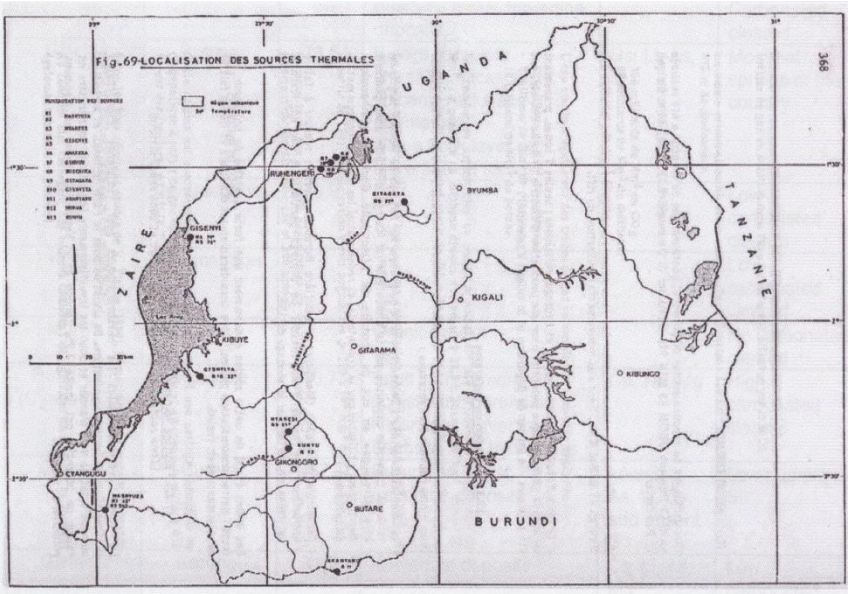

Fig. 4: Location of hot and/or mineralized springs in Rwanda (BRGM, 1987)

The major areas which have been investigated in the country are:

- In the Western province, Mashyuza (district Rusizi), Gisenyi (district Rubavu) and Kibuye (district Karongi);
- In the Southern province, Ntaresi (district de Karaba);
- In the Northern Province, district Musanze

According to existing studies, most favorable conditions appear to exist in N-W of the country, in the vicinity of the National volcanoes Park. Additionally to the W-E ranging volcanic system between Rwanda, DRC and Uganda, the cyangugu area also hosts a geothermal system with surface manifestations.

In 2006, serious initiative to begin developing geothermal project started. Preliminary assessment of two geothermal prospects (Gisenyi and Mashyuza) was carried out by the American company Chevron and presently detailed geothermal surface and subsurface explorations in the North-West area of the country **(Fig. 5)** are being carried out jointly by the Federal Institute for Geosciences and Natural Resources from Germany, BGR and the Government of Rwanda. Results on this survey will soon be available for detailed exploration.

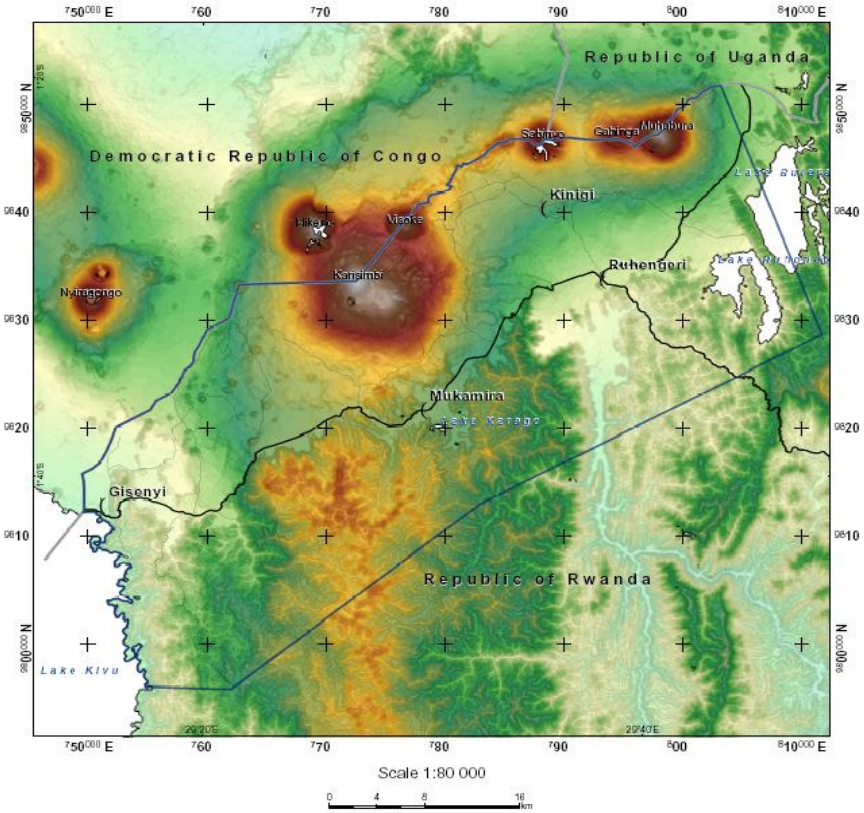

Fig. 5: Study area by BGR

GEOTHERMAL ZONES

The geology of Rwanda Republic is dominated by the Major Structure of the Region: the East African Rift Valley. The rifting in the East African rift system has been associated with intense volcanism and faulting. The Western part of Rwanda corresponds to a boundary between two lithospheric plates. The movement of extension is slow in the continental zone. These phenomena create a very important magmatism on the axe of the Rift and progressively decrease out of the axe. **(Fig. 6)**

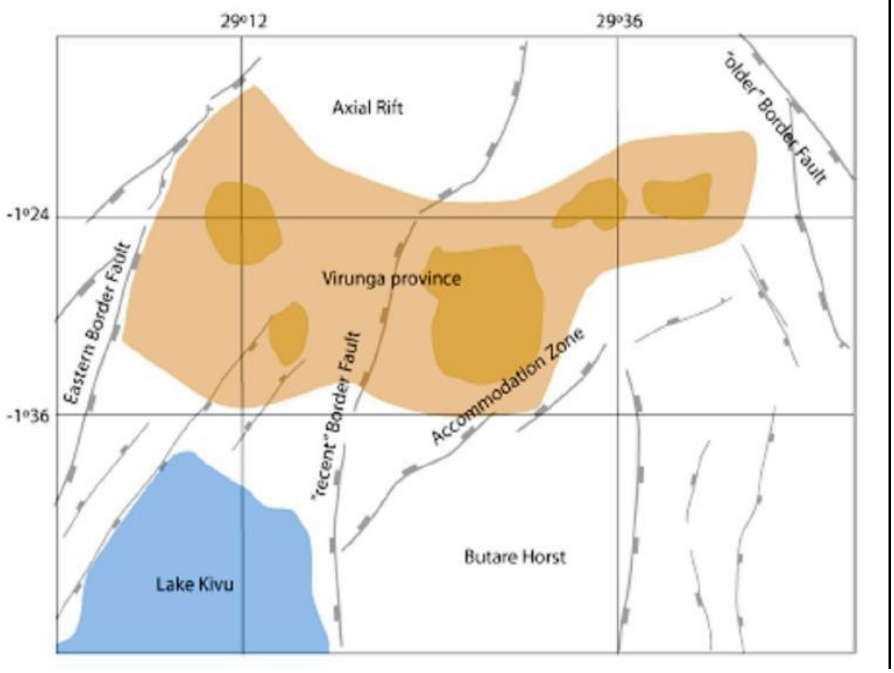

Fig.6: Major structural trends in the North-West of Rwanda

Two volcanic zones can be distinguished in Rwanda:

- National Volcanoes zone in the Northern part of Kivu Lake with the eight big volcanic structures. Five of them are situated in Rwanda (Muhabura-Gahinga-Sabyinyo-Bisoke-Karisimbi) **(Fig. 7)**. The volcanic structures exists at different level (on horsts and Graben)
- Cyangugu Zone in the Southern part of Kivu Lake. It is situated in the Eastern part of the distensive system on the Graben with an orientation similar to Virunga system. The hydrothermal manifestations (hot springs and the travertine deposit) are linked to this type of structure.

The geochemical analyses conducted in 1982 and 2006 respectively indicate that the most favorable conditions appear to exist in the North-West of the country and to the West-East volcanic system in the graben of Bugarama **(Table 2).**
Based upon the chemical geo-thermometers (quartz, N-K-Ca and N-K-Ca-Mg) used, the reservoir temperature was estimated to be between 150 and 210°C.

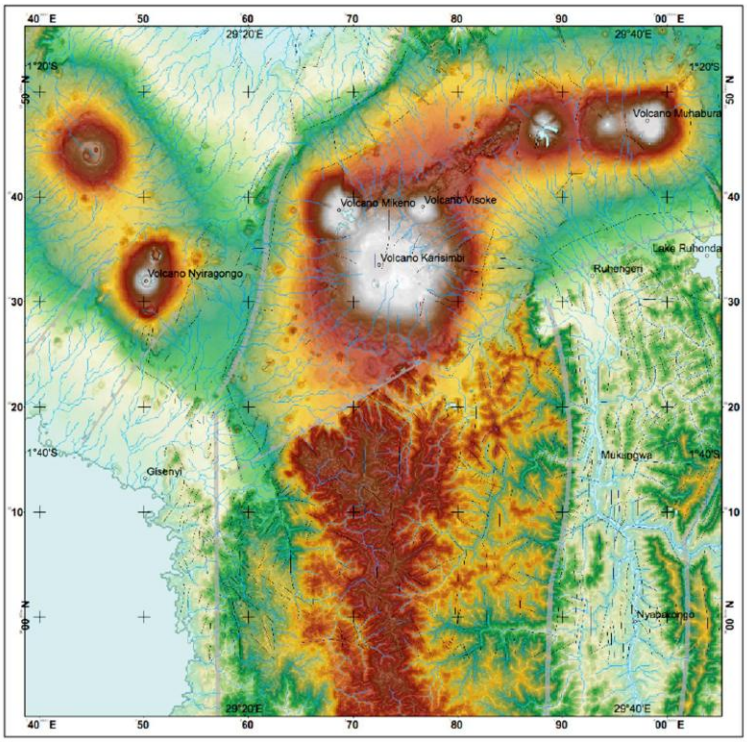

Fig. 7: Rwanda volcanoes in National Park

Prospect	SampleID	Sample Type	Date	Temp., C	pH (field)	pH (lab)	Na	K	Ca	Mg	Li
Gisenyi	G (1982)	Water	1982	70.6		6.47	528.8	40.7	37.8	11.1	0.41
Gisenyi	G (2006)	Water	2006	69	7.0	7.03	518.8	39.8	36.4	11.1	0.42
Lake Kivu	LK (1982)	Water	1982	24.6		8.89	116.1	92.7	9.0	82.9	0.04
Lake Kivu	LK (2006)	Water	2006		8.0	9.05	110.9	87.5	8.1	80.1	0.05
Mashyuza	M-1 (1982)	Water	1982	41.8		6.45	287.4	45.4	77.0	51.8	0.90
Mashyuza	M-1 (2006)	Water	2006	33	6.5-7.0	6.76	291.2	45.3	89.5	53.1	0.93
Mashyuza	M-2 (1982)	Water	1982	54.2		6.26	298.9	47.3	72.9	54.0	0.95
Mashyuza	M-2 (2006)	Water	2006	47	6.5	6.72	307.8	48.0	76.0	55.0	0.96

Prospect	SampleID	Sample Type	Date	B	SiO2	Cl-	SO4	HCO3	TDS
Gisenyi	G (1982)	Water	1982	5.01	105.8	234.0	44.0	1122.7	
Gisenyi	G (2006)	Water	2006	0.55	58.5	236.8	62.1	1137.3	2101.90
Lake Kivu	LK (1982)	Water	1982	4.00	19.0	36.2	18.0	799.3	
Lake Kivu	LK (2006)	Water	2006	0.10	7.9	32.0	22.3	796.1	1145.09
Mashyuza	M-1 (1982)	Water	1982	1.50	84.7	120.9	48.0	1049.5	
Mashyuza	M-1 (2006)	Water	2006	1.18	50.2	141.0	50.5	1115.8	1836.78
Mashyuza	M-2 (1982)	Water	1982	4.50	75.1	128.0	46.0	1061.7	
Mashyuza	M-2 (2006)	Water	2006	1.07	48.3	137.9	55.3	1122.6	1855.00

Table 2: Geochemical analyses for samples taken in 1982 and 2006 from Gisenyi, Mashyuza, and Lake Kivu

FUTURE DEVELOPMENT

Detailed assessment of Rwanda geothermal resources is urgently needed in order to properly evaluate the country geothermal prospects. It is in that view that the Government of Rwanda signed a joint project in November 2007 with the German Federal Institute for Geosciences and Natural Resources (BGR) for the geothermal resource assessment and capacity building.
The Government of Rwanda has in parallel started to develop the geothermal capability within the country. Successful contacts were made with the United Nations University Geothermal Training Program for its assistance in capacity building of Rwandans.
The Government of Rwanda is inviting private investors to participate in the development of the country's power generation capacity by developing its geothermal resource that will be identified.
Again, the Government of Rwanda is looking in ways to request support from the African Rift Geothermal Development Facility project, ARGeo, for financial resources and know-how transfer for the development of its resource.

CONCLUSION

Given the frequent drought that affect the national hydropower, fluctuations in fossil fuel prices in the world and the rapid demand for more power, geothermal energy offers an indigenous environmental friendly alternative source of energy for Rwanda. The deficiency in Rwanda geothermal resource development has been due to the availability of cheap hydropower however due to the existing energy context, the development of this resource is now fundamental.

The volcanoes areas, the geological context and the hydrothermal manifestations of Rwanda indicate the existence of potential geothermal system. Detailed geothermal resource assessment, the development of geothermal capability within the country and the financing of viable project are highly needed for a sustainable development of Rwanda Geothermal Resources.

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