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Geothermal Resource of Rwanda

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Keywords

Rwanda, geothermal, African rift

ABSTRACT

Rwanda presents a number of high, medium and low enthalpies geothermal zones of interest. Currently, 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 theses resources.

This article presents Rwanda geothermal information available confirming that its geothermal zones on the rift valley are of good interest for more detailed surface exploration and feasibility studies.

Geographycal Setting

Rwanda, a country sited between Central Africa and Oriental Africa, is bordered by Tanzania (East), Uganda (North), Burundi(South) and the Democratic Republic of Congo (West) and is located exactly on the parallel 1°04'30" and 2°51' South latitude and meridians 28°53'30" and 30°53'30" Greenwich East longitude. (Figure 1).

The Republic of Rwanda is a small landlocked country with an area of 26,328 sq-km and its lakes covers 1246 sq-meters (Figure 2, overleaf).The natural borders are:

- In the North-West, the Birunga volcanic chain;
- In the West, the Lake Kivu and the Rusizi valley
- In the South-West, the Akanyaru up valley
- In the South, Cyohoha South lake, Rugwero lake and the Nyabarongo down valley
- In the East, Akagera valley

Figure1. General map of Rwanda in East African Region.

Energy Context

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. Rwanda has a significant potential for generation of electricity from hydro in numerous, steep fast flowing rivers and streams. However, hydro sites are generally costly to develop because of the small capacity and the difficult topography. 85% of the total energy is consumed in the rural areas where the majority of Rwandans live. Biomass, particularly woodfuel, constitutes 90% of rural energy consumption, which has significant impact on the process of environmental degradation. The balance 10% is met by other options such as kerosene, diesel, dry cells, grid and non-grid electricity, biogas, solar, wind and other renewable energies. The low consumption of commercial energy has sup-

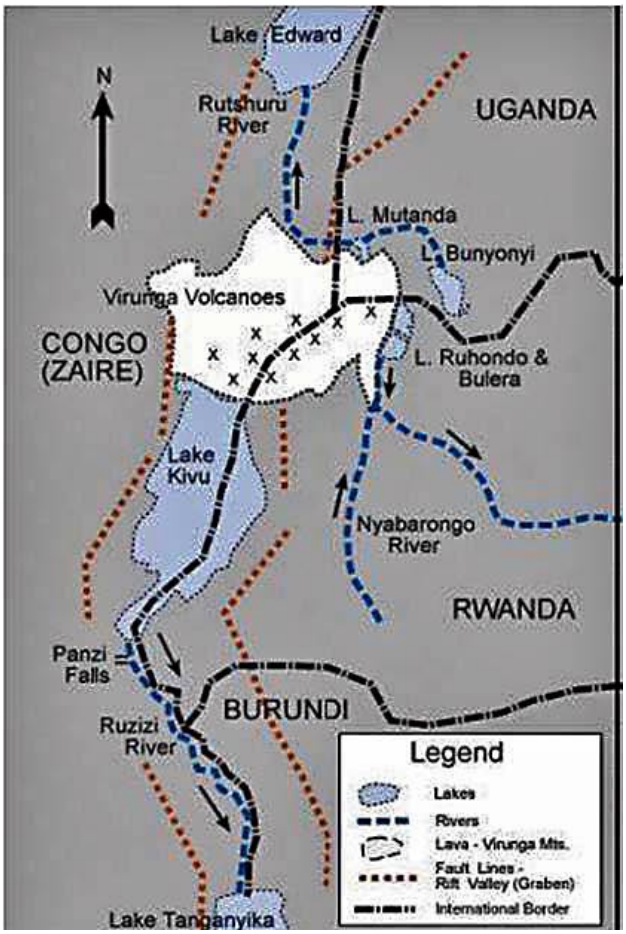

Figure 2. Geographical setting of Rwanda in the regional context.

pressed economic growth, which is manifested in low levels of agricultural mechanization and industrialization.

Presently, the existing energy supplies especially electricity are delivered at high cost. There is a lack of adequate investment and insignificant private participation in Rwanda energy development. It is, therefore, a national challenge to increase access to commercial energy in the rural areas and facilitate a diversification of energy services.

The government of Rwanda embarked on the general socio-economic sustainable development process. The intention is to become a middle-income country, prosperous nation, strong and united, worthy and proud of its fundamental values, politically stable, in social cohesion and equity by the year 2020. To achieve this objective, the energy sector is recognized as the most important useful input to create income generation activities and ensure living standards improvement. Rwanda is one of the countries with the lowest energy consumption in the world and thus it can't reach the Millennium Development Goals without enough and affordable energy.

The country has a large range of renewable resources that can improve its energy situation as solar energy, wind energy, micro hydro, geothermal energy and methane gas. Consequently, the Government of Rwanda through the Ministry of Infrastructure formulates a national energy policy with the aim of developing alternative energy resources of the country to face the high energy crisis and reducing pollutant thermal stations and biomass fuels by using clean and environmental friendly energy sources.

Electricity Context

The current major of energy consumed in Rwanda are biomass, petroleum and electricity. 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 which was mainly 100 % from hydro resources changed in 2005 to 40% from hydro and 60% from thermal as an emergency action plan to reduce power shortages. The installed capacity of hydro plants is approximately 27 MW but the available capacity today has lower to 5.1 MW as a consequence of low rainfall, not enough to refill the reservoirs for the hydroelectric dams. To overcome the energy deficit, thermal stations were installed in 2004 and 2005 with an installed capacity of 29 MW. However, these fuel-oil powered generators put a further strain on the national budget. Currently, the total installed capacity in Rwanda is 72.05 MW but the available energy capacity is only approximately 41 MW. This capacity satisfies slightly less than half the national demand. (Table1)

Table 1. Rwanda electricity situation.

POWER SUPPLY IN 2006

			2006		
	Installed Capacity(MW)	Designed KWh/yr	Available Capacity(MW)	Available Energy (KWh/day)	Available Energy (KWh/yr)
NTARUKA	11,5	22 000 000	1	13 699	5 000 000
MUKUNGWA	12,75	48 000 000	3	57 534	21 000 000
GISENYI	1,2	10 000 000	0,6	11 507	4 200 000
GIHIRA	1,8	7 000 000	0,5	15 068	5 500 000
S/TOTAL HYDRO	**27,25**	**87 000 000**	**5,1**	**97 808**	**35 700 000**
SINELAC	12	66 666 666	6	150 685	55 000 000
SNEL	3,5	21 000 000	2,5	49 315	18 000 000
IMP - EXP (Uganda)	0	0	0	4 110	1 500 000
S/TOTAL IMPORT	**15,5**	**87 666 666**	**8,5**	**204 110**	**74 500 000**
GatSATA 1-3	1,8	0	0	0	0
GATSATA 4	4,7	34 310 000	4,7	80 000	29 200 000
JABANA	7,8	28 470 000	7,8	68 831	25 123 320
RENTAL AGGREKO 1	10	87 600 000	10	232 000	84 680 000
RENTAL AGGREKO 2	5	43 800 000	5	78 904	28 800 000
UERP	0	0	0	0	0
S/TOTAL THERMAL	**29,3**	**194 180 000**	**27,5**	**459 735**	**167 803 320**
TOTAL	72,05	368 846 666	**41,1**	**761 653**	**278 003 320**
% Available/Designed			**57%**		**75,37%**

Figure 3. Location map of Gisenyi and Mashyuza.

Rwanda Geothermal Energy Resources

Rwanda hosted two prospective areas for geothermal potential; the Virunga volcanoes and the faults associated with the East African Rift near the Lake Kivu.

Preliminary geothermal investigations have been carried out since more than three decades both in the Southern and Northern part of Kivu Lake by the French bureau BRGM in 1982 and 1983 and recently in 2006 by the company CHEVRON. Those investigations led to the definition of preliminary working hypothesis, the selection of one or more preferential areas, and the proposal of work programs of surface explorations and feasibility studies. The absence in the past of a National Geothermal Institution in the country did not allow the experts to coordinate their conclusions and recommendations. In that context, different authors tried, separately, to conclude by a selection of one or more areas as a high priority geothermal zones. The reconnaissance studies indicate three important zones presenting a geothermal interest:

- Volcano of Karisimbi,
- Graben of Bugarama and
- Hot springs of Gisenyi and Mashyuza (Figure 3)

Geological Context

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 created a very important magmatism on the axe of the Rift and progressively decrease out of the axe.

Two volcanic zones can be distinguished in Rwanda:

- Birunga zone in the Northern part of Kivu Lake (A) with the eight big volcanic structures. Five of them are situated in Rwanda (Muhabura-Gahinga-Sabyinyo-Bisoke-Karisimbi). The volcanic structure of Birunga exists at different level (on horsts and Graben) (Figure 4).

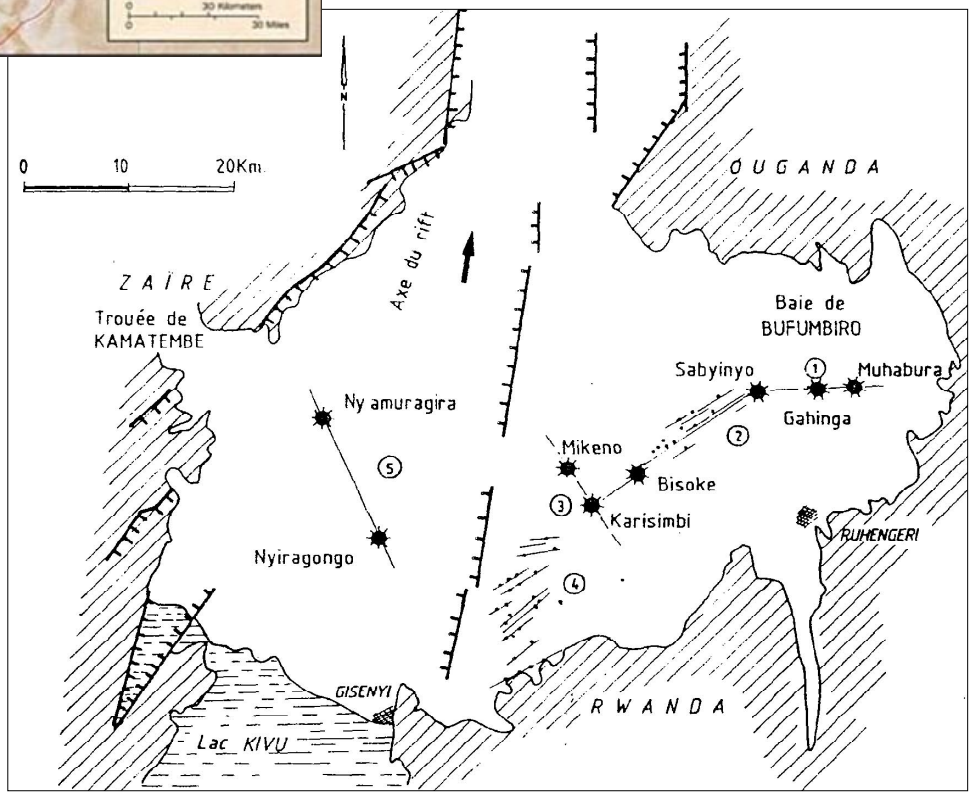

Figure 4. Rwanda volcanoes in Birunga area (North Kivu Lake).

- Cyangugu zone in the Southern part of Kivu Lake (B). It is situated in the Eastern part of the distensive system on the Graben with an orientation similar to Birunga system NE-SO. The hydrothermal manifestations (hot springs and the travertine deposit) are linked to this type of structure (Figure 5).

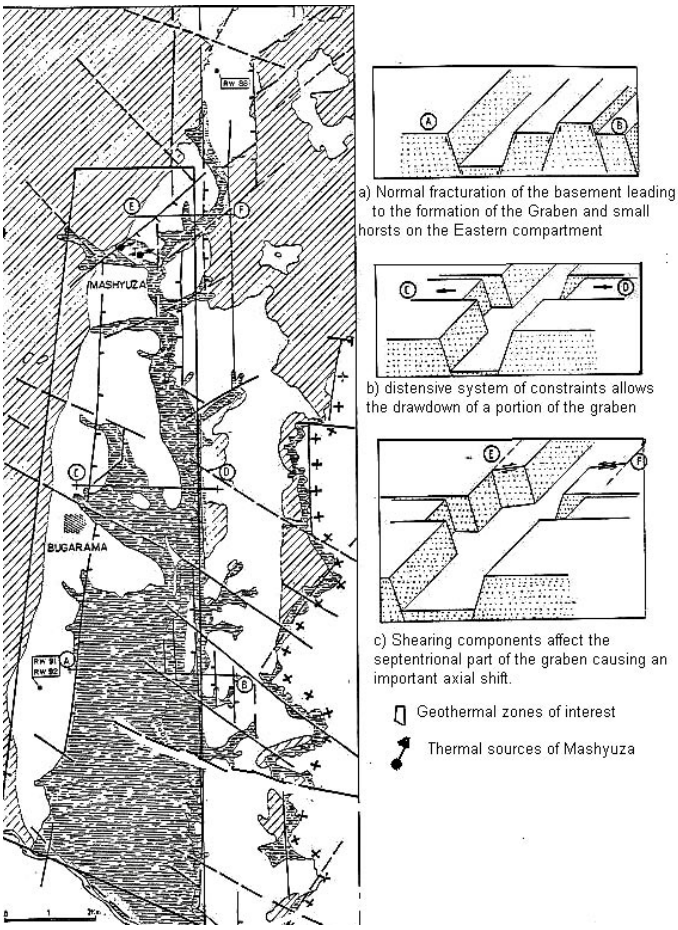

Figure 5. Bugarama Graben (Cyangugu zone) and its tectonic evolution of different portions.

Geochemical Parameters

Among number of chemical geothermometers some of them have been applied to the Gisenyi fluids in order to estimate the reservoir temperature. Based upon these geothermometers, the reservoir temperature is estimated to be between 150 and 210°C.

This includes the quartz geothermometers which is based on silica concentrations in the fluids and N-K-Ca and N-K-Ca-Mg using concentration in the thermal waters (Nicholson, 1999).The Giggenbach NKM applied to Gisenyi water suggests a reservoir temperature of 210°C. This result confirms the geothermal interest of this zone, area of simultaneous volcanic, thermal and tectonic activities.

The other zones of interest (Graben of Bugarama and Karisimbi Volcano) present several favorable geothermal criteria. In the case of Mashyuza hot springs, the quartz geothermometer indicates a reservoir temperature between 100-130°C. Further assessment on these two zones must be carried out.

Future Development

An assessment of Rwanda geothermal resources is urgently needed. The Government of Rwanda is willing to help and support international investments needed to evaluate the country geothermal resources by undertaking feasibility studies and building of Rwanda geothermal capacity. Our actual positive cooperation with the World Bank is a real opportunity to reinforce Rwanda capacity building in this field and in Geosciences domains.

Conclusion

Given the frequent drought that affect the national hydropower, variation of fossil fuel prices in the world and the rapid demand for more power, geothermal offers an indigenous environmentally friendly alternative to Rwanda. The deficiency in Rwanda geothermal resource development has been due to the availability of cheap hydropower but due to the current energy context, the development of this resource is crucial.

The geological context and hydrothermal manifestations of Rwanda indicate that geothermal surface exploration and probably subsurface investigations can be carrying out for feasibility study and accelerate geothermal development for electricity needs and other sectors activities in Rwanda.

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