Current Status of Geothermal Exploration in Burundi: Contribution to Regional Energy Needs in Central Africa

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ABSTRACT

Despite efforts made in the Burundian energy sector, hydropower, the most important energy resources, remains insufficient faced with growing energy needs in the country. Renewable energy resources like geothermal can constitute a solution to overcome this challenge.

Chemical geo-thermometers made on historical data (1969 to 1982) and recent hot springs prospection (2010) point out some geological, structural and physicochemical parameters (faulted Precambrian rocks and recent volcanism context mostly in connection with the rifting, high porosity of thick sediments layers) which indicate the existence of underground heat inside the Great Rift Valley thus providing conditions for geothermal resource development.

However, further investigations in the regional context by new exploration campaigns are required to update available data and to conduct a feasibility study in order to find the underground geothermal source. This program needs modern equipment and experienced interdisciplinary team in geological/geophysical/geochemical exploration.

1. INTRODUCTION

Only a limited portion of the Burundian population has access to modern energy. Hydroelectricity, oil and biomass account for 2%, 3% and 95% respectively, of the available energy. The consumption of 25 Kwh/hab/year is inadequagte. The increasing modern energy demand in Burundi is not covered owing to the very low percentage produced by hydropower. Even if regional electricity interconnection is to be employed in an attempt to solve the energy problem in Burundi, climatic changes have negatively affected the potential of water to produce hydroelectricity. The total available power is still very low with a peak load of around 164 Mwh.

Faced with the increasing demand and high costs of fossil fuels, the energy sector needs to urgently review its policies. A shift to an alternative source - the geothermal energy - as envisaged in regional context like ARGeo program, can contribute to solving the Burundian energy problem.

In accordance with the provisions of the “Mining and Petroleum Code” of the Republic of Burundi by the Law n°1 / 138 of July 17- 1976, geothermal activities (the prospecting, exploration, exploitation, processing, transportation and sale), are granted by a concession.

2. HISTORIC DATA

Several synthesis of dispersed data from literature exist, describing sources in East Congo (G. Passau, 1933; H Rollet 1957), in Tanzania (T.C. James 1967), in East Africa (P.Kilham 1972), around Lake Kivu (N. Boutakaff 1933), in Burundi (J.R’ Mac Nitt 1969). Burundi belongs to the western branch of the Rift Valley, and the Ruhwa and Mahoro sources were pinpointed.

To increase geothermal prospects, H.Deelstra et al (1969) and other local unpublished authors made inventory and description of principal hot springs in Burundi. They confirmed available data and pointed out geothermal events along African Great Rift in a particular geo-structural context, with geochemical considerations.

In Burundi, these historical studies (1969 to 1982) covered eight geothermal locations. A description of 15 hot springs, 14 geothermal locations and chemical analysis from 13 of them has been reported. The surroundings’ geology was described and a geochemical examination of the discharges recommended.

Fig. I. Burundi Sampling locations

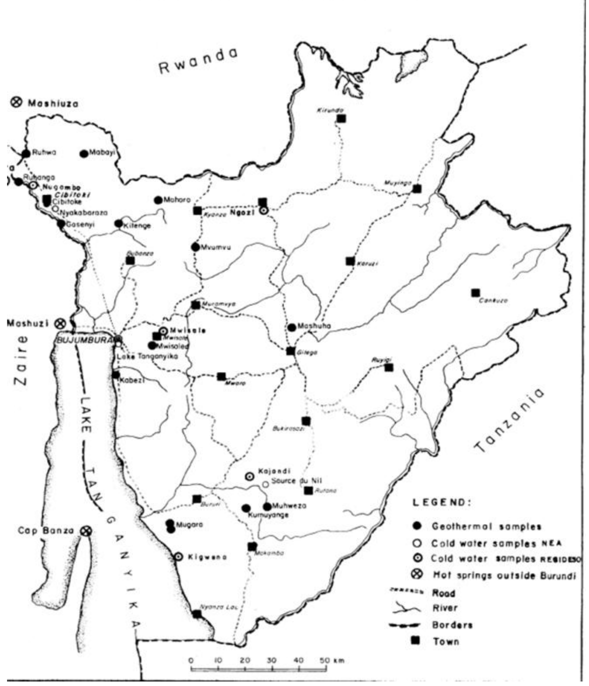

Fig 1 Sampling hot springs locations, historic data

2.1 Geological and Structural Survey Reports

The geothermal activity is mostly connected with faults which affect Precambrian rocks or sediments and there is apparently no record of a connection between regional recent volcanism and geothermal activity. However, we note that in Burundi one of the geothermal locations is in an area of basaltic formations according to the geological map.

Little attempt has been made to relate the existence of geothermal heat to the general geology of the country. It is however clear that all the sources are situated in the western or central parts of the country and none in the eastern where intrusions are absent and which lies part farthest away from the active rift zone.

All reported geothermal sources in Burundi are water pools. There is no record of surface steam (fumaroles) or mud pools. The highest surface temperature of hot springs is 68°C at RUHWA (McNitt 1969), Deelestra and al (1972). This observation is confirmed by our recent field observation (2010).

The geothermal manifestations in Burundi are found mainly in two types of environment: in Precambrian rocks mostly outside the rift valley and in sediments inside the valley. The old age and low porosity of the Precambrian rock make the existence of an exploitable geothermal system within it highly unlikely. On the other hand, high porosity of thick sediment layers and the recent volcanism in the rift valley constitute favourable conditions which could lead to exploitable geothermal systems.

There is considerable volcanism around Lake Kivu, in whose vicinity geothermal heat has been reported. The chemical composition of the lake water is affected by geothermal heat. As the north-western part of Burundi is on the edge of the volcanic region of Lake Kivu, this part, from a geological point of view, is the most promising of the geothermal areas in Burundi and should be investigated more.

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 at some distance from the Lake (the Mugara springs). In the Rusizi Valley and at Kabezi the hot water rises from sediments, while at Mugara it comes from Precambrian rocks. Thus the former sources are likely to originate from larger and more open aquifers than the latter.

2.2 Chemical Considerations

Chemical geo-thermometers suggest the highest source temperatures at locations in the Rusizi Rift Valley rising through the porous sediments (Ruhwa spring records 68°C at surface). Quartz geo-thermometer application (Fourrier 1966) suggests underground source T° around 110°-120° C. He notes all discharges arising from sediments were carbon dioxide rich, indicating the presence of a powerful heat source. The high carbon dioxide concentrations observed in his analyses, lead to super saturation with respect to calcium carbonate in some cases. Therefore care would have to be exercised in order to avoid calcium carbonate deposition in the event exploitation.

In summary an exploitable geothermal source whose temperature lies in the range of 100°-160°C, may exist in the Rusizi valley and probably extend well into RDC and Rwanda. This source is thought to be connected to the volcanic area south of Lake Kivu. Therefore, an anomalously geothermal gradient may be expected in this region.

The base temperature in Burundi is unlikely to be high enough for electricity production, but is suitable for many industrial and domestic uses. The geothermal water in Rusizi valley is carbon dioxide rich, and a minor exploitation might involve its cooling and bottling as mineral water. The most chloride rich sources would, however, be unsuitable in this respect

3. SUMMARY OF RECENT FIELD TRIPS

In 2010, hot springs prospection to gather more information on geological, structural and physico-geochemical (temperature, pH) data have been conducted on 12 known sites. Only 10 sites were visited and surveyed, where a description of the environment was followed by data collection. These are distributed along the Rift and located in the western half of the country. Sub-surface geothermal springs are manifested through ancient fluvio-lacustrine terraces sediments, around rivers (on Ruhagarika Rusizi) or even in water (Ruhwa River, Rwandan-Burundian border). Less spectacular, hot springs located near the Imbo Plain, spring from the alluvial deposits to the source of the valleys carved in Precambrian Meta sedimentary formations.

Each site was described using various parameters including the location coordinates, physic parameters (temperature, flow, aromatic substances, bubbles, visible minerals concretions or deposits), geologic environment and current use, as shown below.

BURUNDI Geothermal sites						
Fourth day : Wednsday 14 th July 2010 Departure: 9 h 00 Arrival: 19 h 00						
Name		**Ruhagarika**		**Mugara**	**Ruhwa**	**Kumuyange** (Ho)
Locality		Cibitoke		Mugara (SW)	Rugombo (NW)	Buta
Date of visit		7/14/2010				
GPS coordinates	Lat	741072	741055/ 741008	780158/780152	727083	808083
	Long	9671920	9671958/ 9672136	9552486/9552484	9697650	9559260
Description of site	RN near Gatete village			Two emanations with yellow	Three point Bur-Rwanda-DRC	On Sikuvyaye river,from West
	Along the West side of Rusizi plain,			to red braun deposits	Near and on Ruhwa river	Kibimbi Quartzitic mountain,
	visible opened hot water springs from			(out of water).	Several springs occure	two sources
	Fluviatil now colmated by argilic material			limit of the plain	in sediments of the Plain	Elevation : 1930 m
Current utilization		not rehabilited		Bathing		Source from rocks
Rate of flow		not easy to estimate		15 to 20 L / sec	around 10 L / sec	Bath 6m/6m of the bassin
pressurized steam/		No steam,no vapors		no vapor, no steam	no	no
vapors/mist				strong emergences	Some vapor,	no
Aromatics		no	no	no smell	Some sulphures smell	some Bulles, no smell
Water quality		green colorations,		clear	clear at emergence point	bubles emanations, clear
		vegetables (algues)				dispersed emergences
Deposits		white and yellow deposits(salted)		Yellow, red deposits	White deposits	No deposits, some algues
Temperate and PH		48° C	48 ° C	48°C	68 ° C	39 -40°C
Geology		Pegmatitic, sandstones quartzites		sandstone & quarztites,	Recent fluviatil sediments	
		and poudingues & conglomeratics		altered shales , red-yellow		from fractured quartzites
		sediments with boulders .		impregnations , Brecchia		

Figure 2: Parameters of sources in recent deposits (Ruhwa, Ruhagarika) and in Precambrian rocks (Mugara; Kumuyange).

In general, all sources are characterized by fumes from a few gas bubbles, but have no distinctive odour. All sources except the one Kabezi which is currently poorly maintained, have almost no deposits apart from some algae, with clear water. Deposits (evaporates) are observable for the sources of the plain.

As highlighted in Figure 2, three categories of thermal springs based on temperature can be pointed out:

- The temperature interval between 30 and 40 ° C mark (away from the Rift);
- The temperature around 48° C (near or in the Rift (Mugara) and further north); and
- The temperature of 68 °C as Ruhwa (Burundi's extreme NW).

4. CONCLUSIONS

The Burundian energy sector presents a deficit in producing enough power for its population. This is a big challenge that must be analyzed from different angles in the regional context. Renewable energy sources- like geothermal - are pointed out with each sub-sector providing its contributions. Historic data confirmed by recent field observations indicates that the rift area has potential geothermal resources.

It is important to update historic geological, geochemical and geophysical data in Burundi. Although a lot of financial resources are required to build up this project, some recent (2011) fieldtrips have been initiated, to update the geothermal database. To solve or minimize financial handicap, Burundi should take advantage of and integrate this project into the Regional Program of Geothermal Energy Resources Promotion

In different workshops organized by EARS (East African Rift System) countries, some propositions and recommendations were made to install a geothermal project in Burundi. This Burundian part of the Rift is still unknown, since no recent scientific research has been conducted using modern techniques. Some of the recommendations were as follows:

- Carry out more investigations including geological, geochemistry and geophysical studies to define the geothermal potential assessment (especially in the whole common border region of DRC, Rwanda, and Burundi);
- Establish a policy for an integrated geothermal exploration and development of the resources;
- Mobilize funds and human capital both locally and through development partners to support the above initiatives; and
- Establish good collaboration with other East African countries where geothermal system is known better.

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