GEOTHERMAL ENERGY DEVELOPMENT IN UGANDA - A COUNTRY UPDATE 2016

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Presented at a Workshop for Formulation of Geothermal Energy Policy, Legal and Regulatory Framework in Uganda

Kabira Club, Kampala

4-8th July 2016

Country Overview

- Area 241 000 km^2.
- Over 35 Million people.
- Economy depends mainly on agriculture.
- Oil products imported (100%).
- Biomass represents 84% of the national energy balance.
- Renewable energy policy 2007 goal is to increase the use of modern renewable energy from the current 4% to 61% of the total energy consumption by 2017.
- Energy development a priority in the 5 year National Development Plan II (2015/16 – 2019/20).

Status of power supply in Uganda

- Installed capacity for electricity generation is 892.7 MW.
- The current power generation capacity is 724 MW (hydro, cogeneration and thermal).
- Peak Demand is about 550 MW.
- Electricity coverage is 18% for the whole country and 7% in rural areas.
- Annual demand for electricity is growing at about 9% per year.

Plan for increased power supply in the Short to Medium term (2015 – 2020)

- Increasing generation capacity using fossil fuels.
- Construction of two large hydropower plants; Karuma (600 MW) and Isimba (183 MW) to be commissioned in 2018.
- Enhancement of renewable energy development.
- Development of Geothermal (33 MW).
- Emplacement of energy efficiency measures.

Long-term measures (2015 – 2025)

- The development of large hydro power sites, namely, Ayago (840 MW) and Oriang (392 MW).
- Interconnection of the regional power grid.
- Use of locally produced oil to generate thermal power (100 MW).
- Use of new and renewable sources of energy which include; biomass, peat and geothermal.
- Development of the country's geothermal resources estimated at 450 MW.

Renewable Energy Policy for Uganda 2007

- The aim of the policy is to provide a framework to increase in significant proportions the contribution of renewable energy in the energy mix from the current 4% to 61% by 2017.

- Main features include:
  - Feed-in tariffs.
  - Standardized Power Purchase Agreements.
  - Obligation of fossils fuel companies to mix products with biofuels up to 20%.
  - Tax incentives on renewable energy technologies.

- Gives a legal and institutional framework.

- Institutional framework
  - Front for surface development – Department of Geological Survey and Mines (DGSM), and Energy Resources Department (ERD).
  - Front for power generation – Electricity Regulatory Authority (ERA).

- Regulatory framework (Licensing/Permits)
  - Surface exploration and drilling – Department of Geological Survey and Mines (DGSM) *Mining Act 2003*.
  - Power production – ERA * Electricity Act 1999*

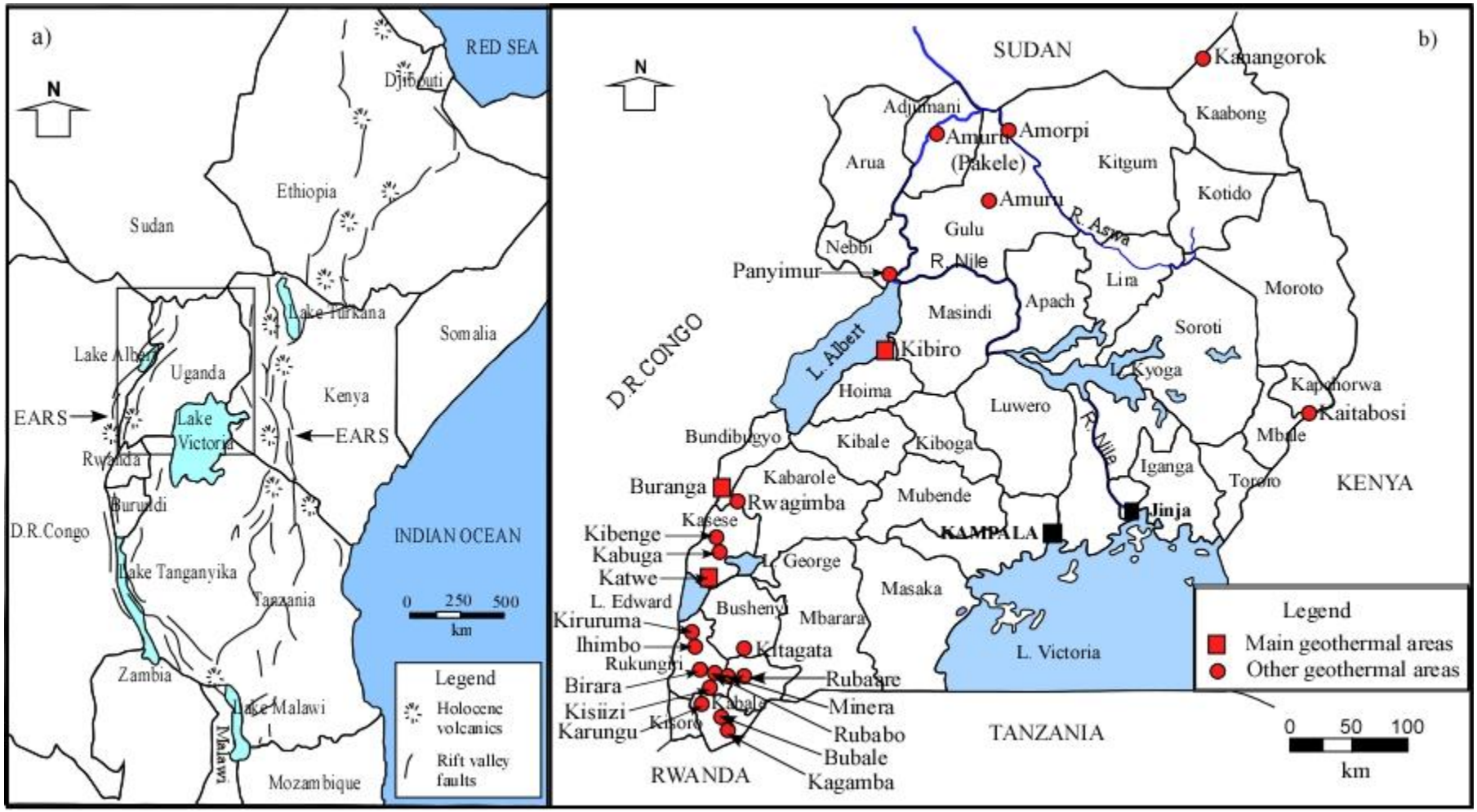
Geothermal Policy and Legislation

- Government with support from the Climate Technology Centre Network (CTCN) of the United Nations Framework Convention on Climate Change (UNFCC) is formulating a geothermal policy.
- The main objective of the CTCN assistance is to address the policy and regulatory barriers for geothermal energy development in Uganda with a view to attract geothermal investment in terms of Public and Private Partnerships (PPPs), and Independent Power Producers (IPPs).
- The project aims to establish a draft Geothermal Energy Policy for Uganda, and supporting draft Laws and Regulations that work to implement the objectives of the policy.
- The project which started in November 2015 has since produced an Inception Report, and two (2) progress reports and is currently carrying out stakeholder consultations.
- The policy will give clearer direction on how geothermal energy projects can be developed, by whom, over what time frame, and using which sources of finance and support mechanisms.

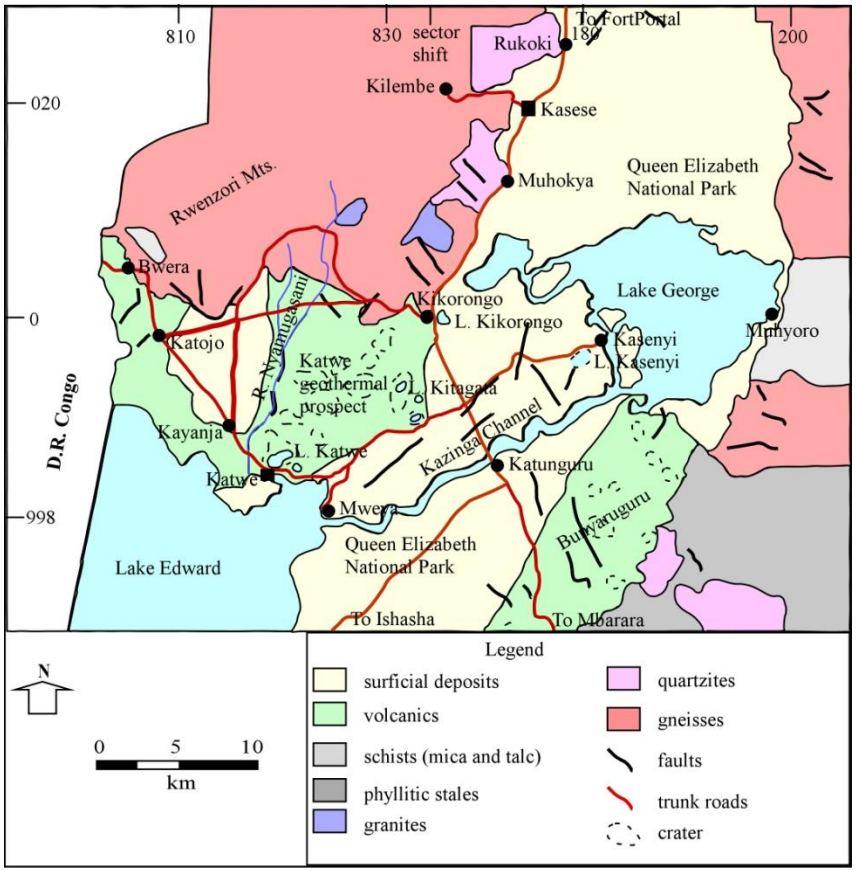
Geothermal Development in Uganda

- The strategic objective is to develop geothermal energy to complement hydro and other sources of power to meet the energy demand of rural areas in sound environment.

Location of geothermal resources



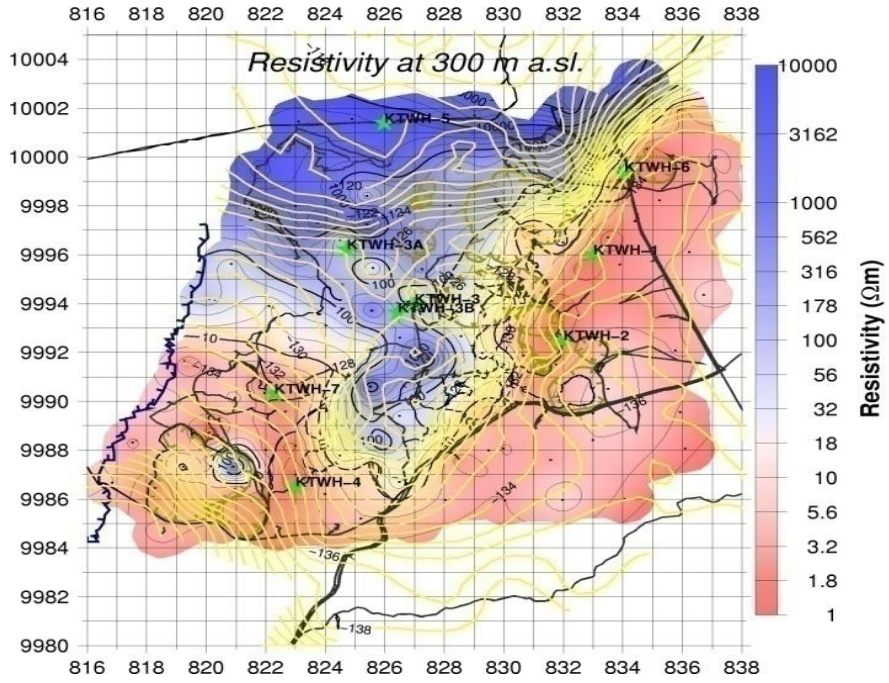
Results of recent investigations: Katwe Geology



- The Geology is dominated by explosion craters, ejected pyroclastics, tuffs with abundant granite and gneissic rocks from basement.
- Lava flows in L. Kitagata and Kyemengo craters.
- Extinct hydrothermal deposits in and around L. Katwe and L. Kikorongo.
- Surficial deposits (Rift valley sediments).
- Gneisses in the Rwenzori Mountains

Results of recent investigations: Katwe

- Subsurface temperatures of 140-200°C have been predicted by geothermometry.
- Low resisitivity Anomalous Areas mapped by geophysics.
- Drilling of shallow boreholes (200 – 300m) at selected sites.
- Temperature gradient drilling and measurements at Katwe (13 - 36°C/km) suggest geothermal reservoirs that are either deep seated or offset from the drilled areas.

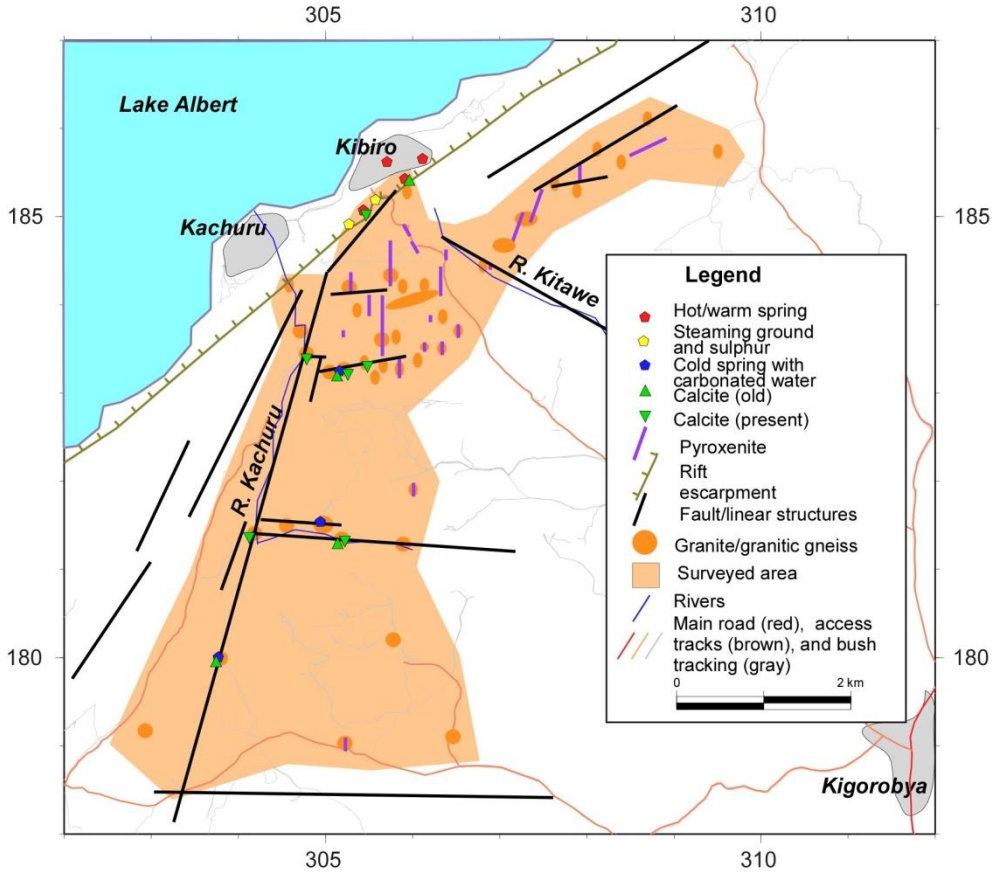


Katwe resistivity anomalous areas

Results of recent investigations: Katwe

- Very recent work published on the Rwenzori Mountains and surrounding areas suggest:
  - Melt zone at 15 km depth east of Katwe also shown by MT Surveys.
  - Passive seismic show anomalous areas pointing to shallow magma under the Rwenzori Mountains and South of Lake George (East of Katwe).
- Aeromagnetic surveys of 1983 detected some magnetic anomalous areas under Lake Edward that were interpreted to be magmatic bodies.
- The two observations need to be investigated further as we look for geothermal reservoirs in the Katwe – Kikorongo geothermal prospect.

Results of recent investigations: Kibiro Geology



- East of the escarpment the geology is dominated by the ancient crystalline basement (granite and gneisses), block faulted, extensive deposition of travertine.
- West of the escarpment; - Rift Valley sediments of up to 4-5 km thick.

Results of recent investigations: Kibiro

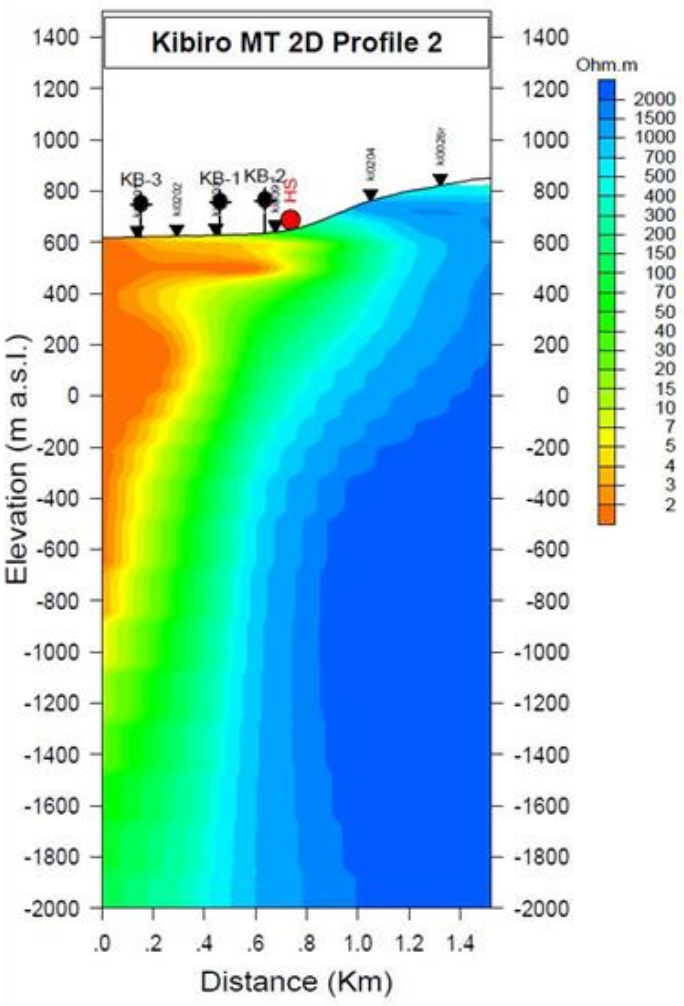
- Subsurface temperatures150-250^{o}C predicted by geothermometry and mixing models.
- Salinity up to 4,000 – 5,000 ppm.
- Geothermal water has a cold water component and hydrocarbons.
- The fluid is depleted in sulphate suggesting interaction of sulphate with hydrocarbons to produce hydrogen sulphide.
- Recharge is from high ground in Mukihani-Waisembe Ridge.

Results of recent investigations: Kibiro

Results of MT Surveys:

- All the cross-sections show the clay alteration deepening towards the lake but vary to the extent that they indicate a clay apron that might overlie a thermal aquifer.

- Low resistivity sediments in yellow-red, high resistivity Pre-Cambrian is blue.

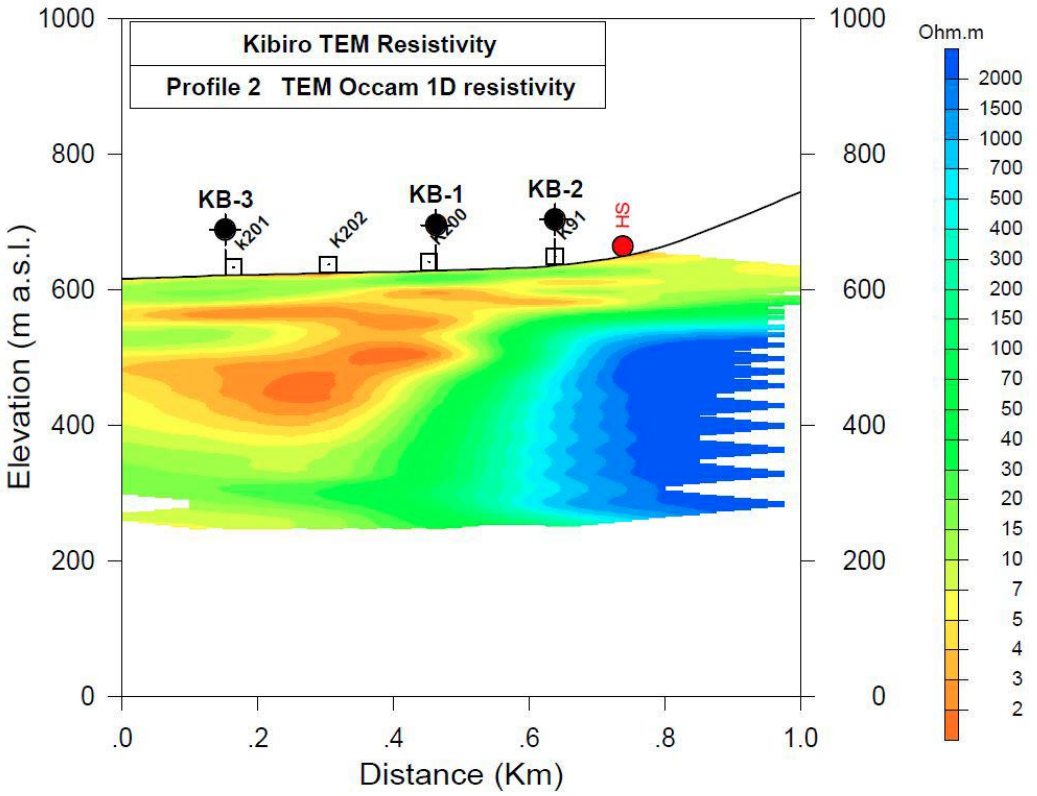


Results of recent investigations: Kibiro

Results of TEM surveys:

- The objective of using Transient Electromagnetics (TEM) was to identify a relatively shallow onshore capped aquifer that might host a >150°C geothermal aquifer that could be tested at low cost, and to collect a telluric shift in the MT. As shown in Figure, a cap exists, although it appears to be thicker and less distinctly layered than the MT inversion suggested.

- The clay zone (yellow-red) is interpreted as capping a more resistive and therefore possibly permeable hot aquifer or reservoir.



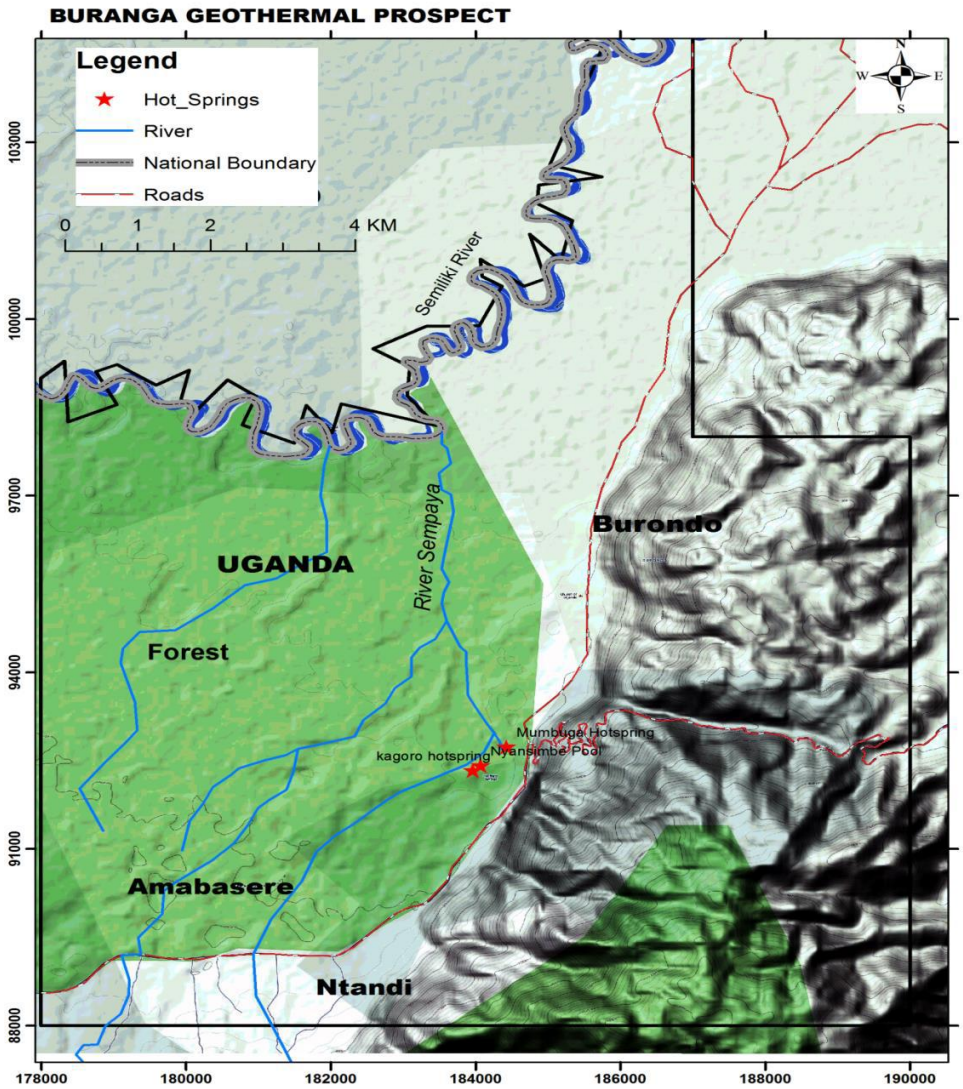
Results of recent investigations: Kibiro

Recommendations

Targeting a deep geothermal reservoir at >230°C is not recommended but a two stage approach is recommended as follows:

- Drill shallow wells (about 200 to 300 m depth) to explore the possibility that a shallow aquifer exists, as hinted by the resistivity (MT/TEM) data.
- If the well can be produced with air lift or similar means, check its chemistry.
- If it shows more definitive indications of being over 230°C, then consider options to target the deeper system, possibly by directional drilling offshore.
- If the temperatures are closer to 140 to 150°C, then design a low temperature exploration plan for the discovered resource.

Results of recent investigations: Buranga

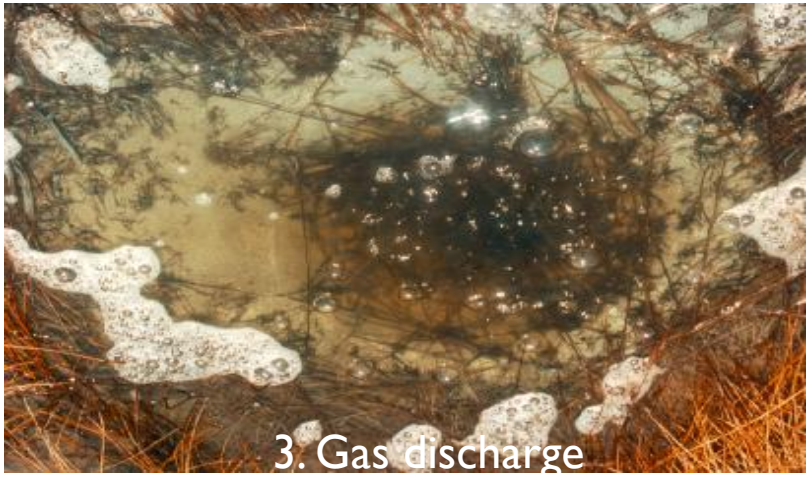


- Located at the foot of the Rwenzori Mountains.
- Sedimentary environment.
- No evidence of volcanism but highly tectonically active.
- Most impressive geothermal manifestations in the whole Western Branch of the EARS.
- Surface temp. 98°C.

Results of recent investigations: Buranga Surface manifestations


1. Boiling hot springs


2. Close to boiling


3. Gas discharge

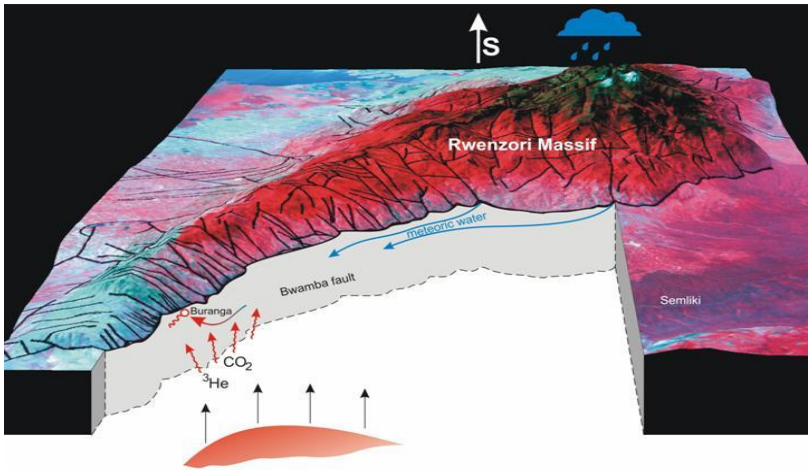

4. Geothermal grass

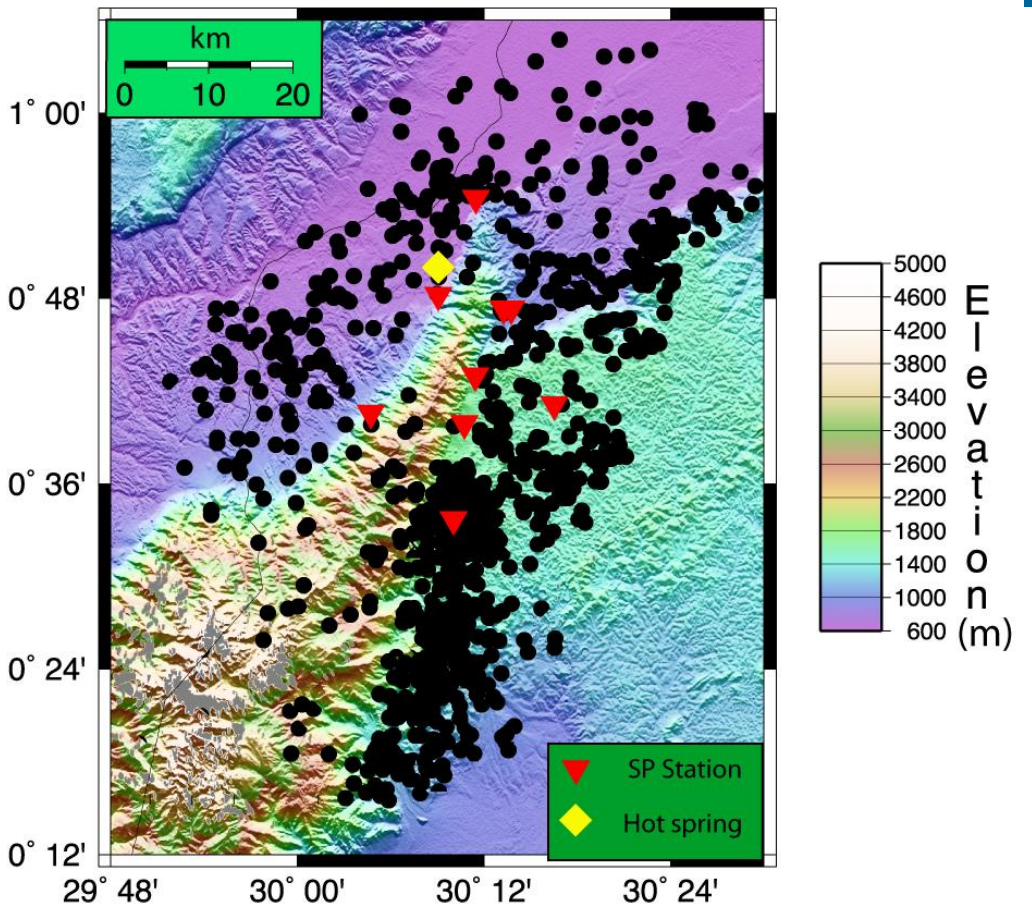
Results of recent investigations: Buranga

- Subsurface temperatures of 120-150°C have been predicted by geothermometry.
- Fluids with neutral pH (7-8).
- Salinity 14,000-15,000 mg/kg TDS.
- Isotope geothermometry gives 200°C.
- The source of sulphate: sulphate reach minerals or rock.
- Recharge is from high ground in the Rwenzori Mountains.

Results of recent investigations: Buranga

- Micro-seismic surveys have located a subsurface anomaly within the vicinity of the thermal activity at Buranga and could be the sources heat for the area.



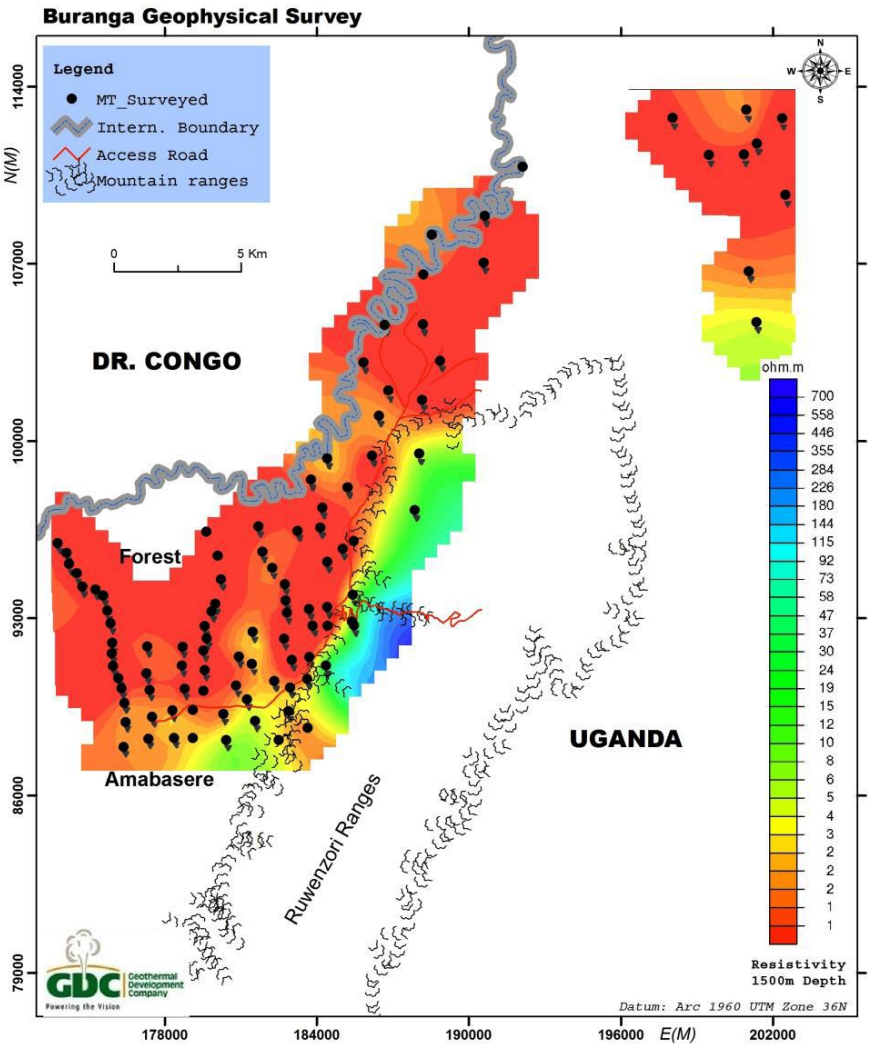


Buranga conceptual model (BGR 2007)

Results of recent investigations: Buranga

MT/TEM surveys

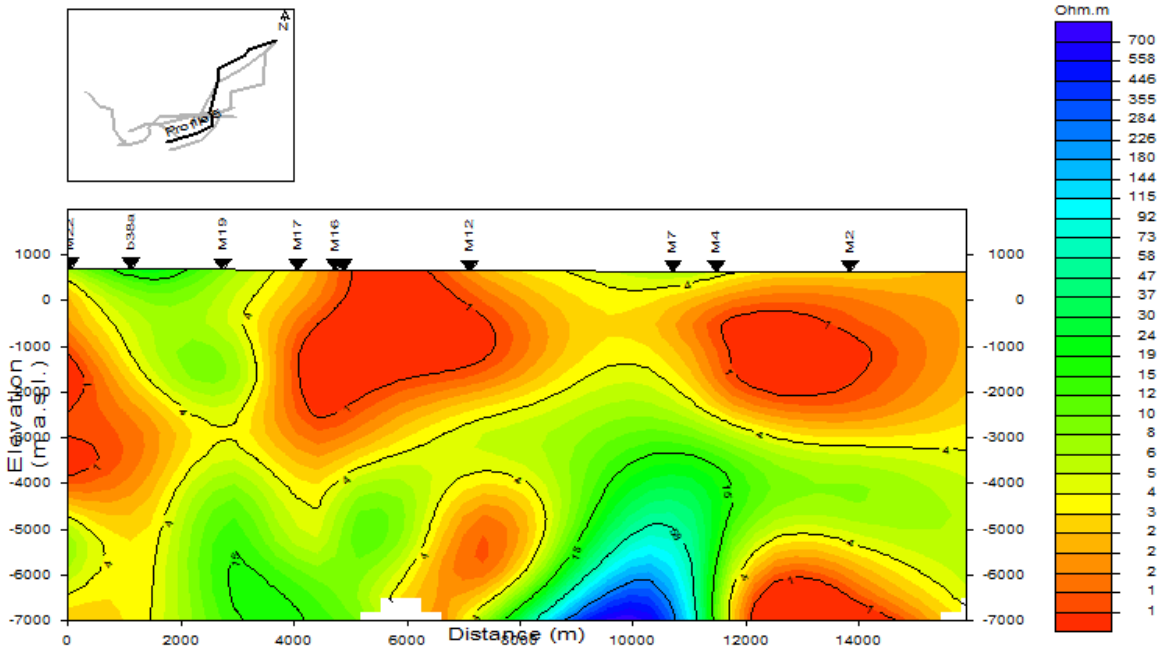
- The sedimentary basin highly conductive due to the clay type minerals which are consolidated in the sediments.
- The conductive layers have been mapped and can go deep up to 3000 m b.s.l and beyond.
- The Figure shows a 2D resistivity map at 1500 m b.s.l.
- The conductive anomalous area is more prominent in the NNE – SSW direction implying that it is possibly controlled by the Bwamba fault.



Results of recent investigations: Buranga

Cross-section through the MT anomalies:

- Low resistivity layer close to the surface underlain by a high resistive layer.
- The low resistive layer could represent a cap lock made by highly conductive clay minerals.
- Beneath would lie a geothermal reservoir which is expected to be highly resistive.
- The model looks ambiguous because only a few soundings were done in the area and therefore a need to collect more data at a close spacing.



On going programmes: Preliminary investigation of the Panyimur prospect

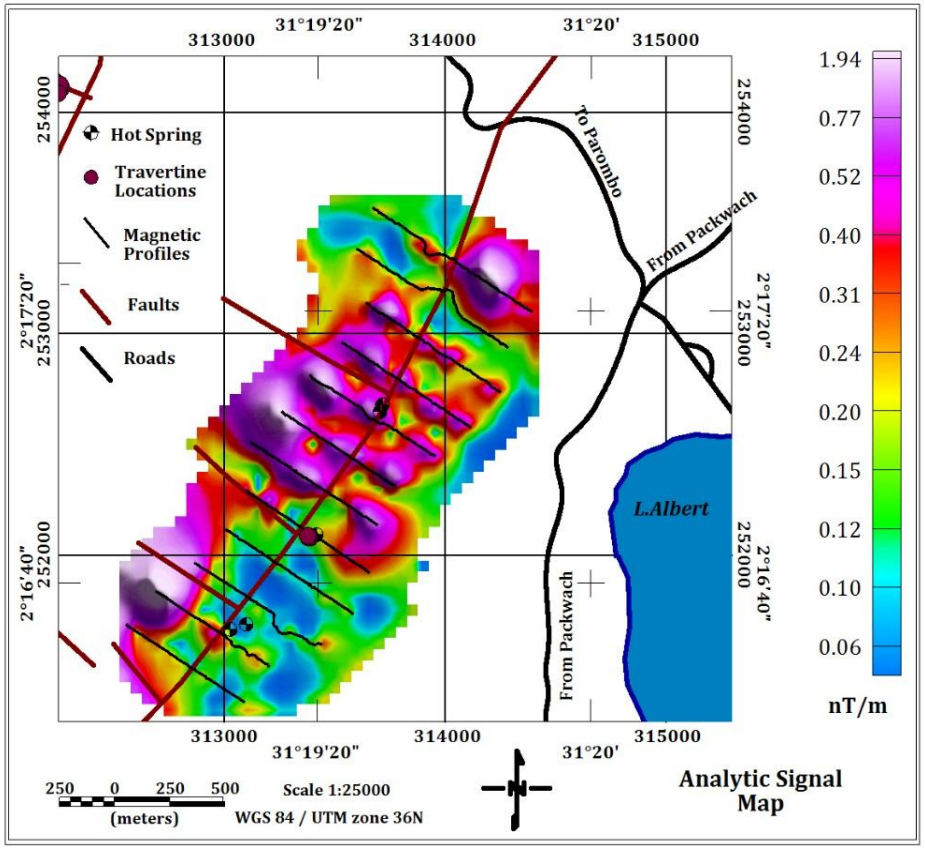
- Panyimur geothermal area is located on topographic map sheet 29/2 (Pakwach), Nebbi district.
- Geothermal manifestations are hot springs namely Amoropii, Okumu and Avuka with surface temperatures of 60, 47, and 45°C respectively.
- Other surface manifestations are altered ground, geothermal grass and shrub trees.
- High levels of hydrogen sulphide gas (10 – 12 ppm) suggest a high temperature geothermal system.

Detailed investigations of the Panyimur prospect

- Started investigating the Panyimur geothermal area is in October 2011.
- We have carried out detailed Geology, Geochemistry and Hydrology.
- We have carried out Geophysical measurements (gravity and magnetics).
- MT and TEM geophysical surveys are scheduled to start in July 2016.

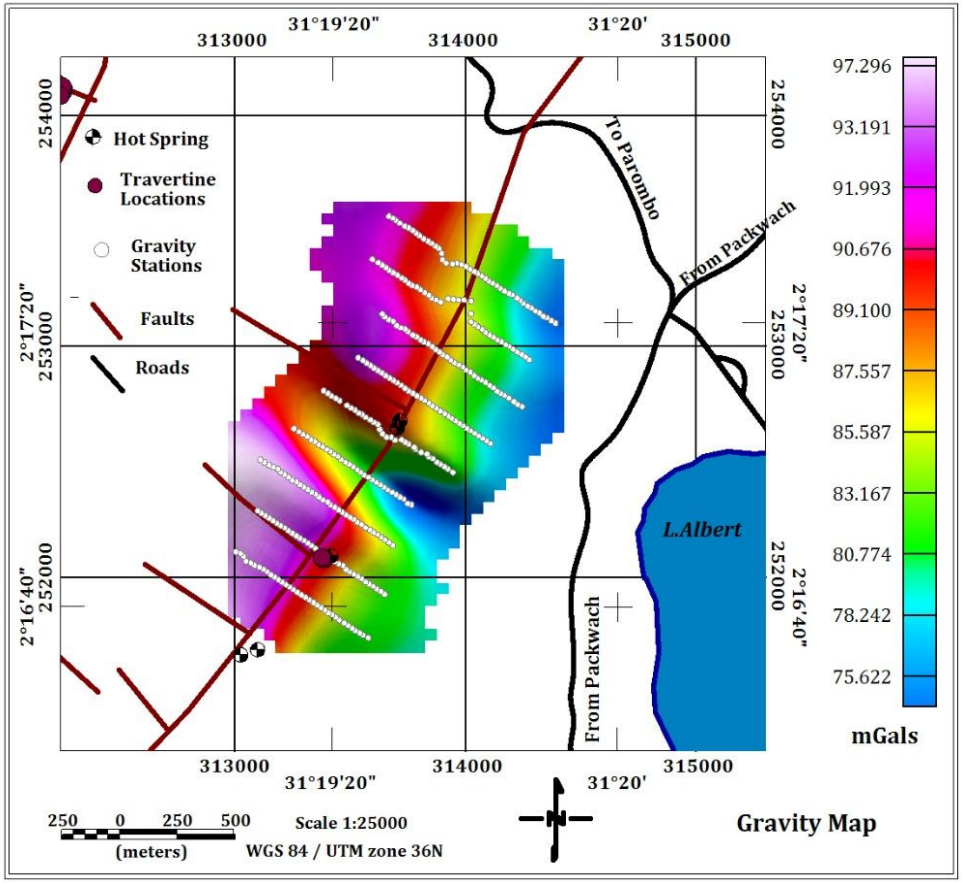
Panyimur: Magnetic surveys

Results of Geophysical Surveys: Magnetics



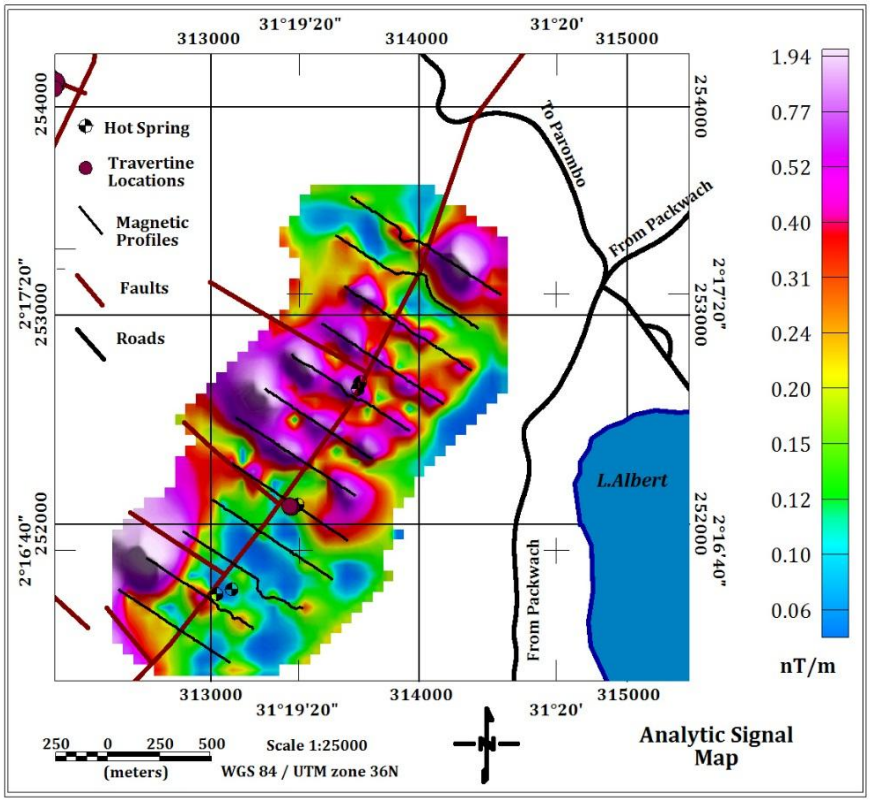
Panyimur: Gravity surveys

Results of Geophysical Surveys: Gravity

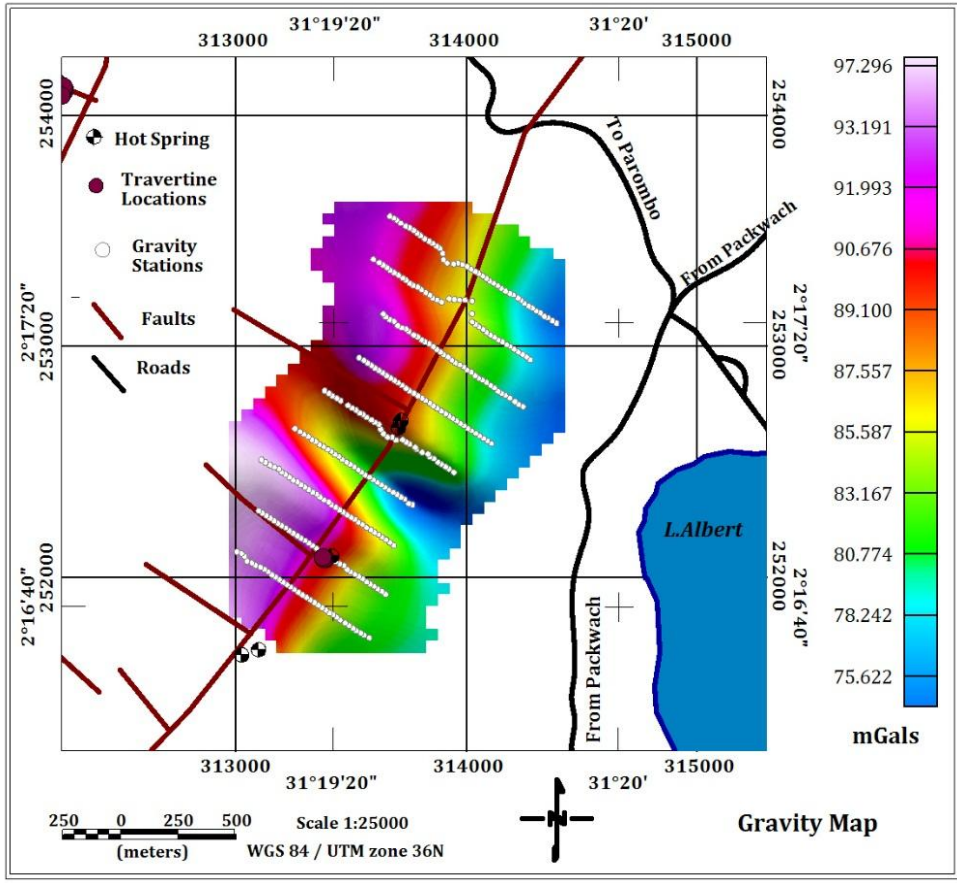


Panyimur: Comparison between Magnetics and Gravity surveys

Both Gravity and Magnetic data show possible geothermal signatures. Magmatic intrusions have high density hence Gravity -High and heat demagnetises the rocks hence low magnetic anomaly for geothermal is detected as magnetic -Low.



MAGNETICS



GRAVITY

Status of Licensing geothermal areas

S/No	Area	License Holder	EL	Date of Issue	Date of Expiry	Comments
1.	Katwe-Kikorongo	Cozumel Energy (U) Limited	EL 0705	29/11/2010	28/11/2015	Under renewal
2.	Katwe-Bunyampaka	AAE Systems Inc.	EL 1377	19/09/2014	18/09/2017	Active
3.	Bunyaruguru	Spencon (U) Ltd.	EL 1283	05/02/2014	04/02/2017	Active
4.	Buranga	Gids Consult Ltd.	EL 0725	10/02/2011	08/02/2016	Active
5.	Buranga	Kapex Ltd	EL 1456	13/03/2015	12/03/2018	Active
6.	Ntoroko	Kapex Ltd	EL 1455	12/03/2015	11/03/2018	Active
7.	Ntoroko	Kapex Ltd	EL 1395	14/11/2014	13/11/2017	Active
8.	Kanangorok	FCN Energy Limited	EL 1142	23/05/2013	22/05/2016	Expired

Challenges

- Inadequate Policy and Legal framework.
- Inadequate data on the geothermal resources.
- Inadequate resources for exploration and feasibility study.
- Capacity building:
  - Inadequate trained personnel to carryout exploration and development of the geothermal resources.
  - Inadequate equipment.

Strategies to address the challenges

- **Institution Framework**: Creation of a Geothermal Department to handle activities regarding geothermal development.
- **Policy and regulatory framework**: Review the existing policy and legal framework, and put in place a new geothermal policy and legislation to focus on geothermal energy development.
- **Financing of the Geothermal power projects**: Government to provide funding for geothermal exploration and development.
- **Feed-in tariffs:** Government to establish Feed-in tariffs to create a predictable business environment for renewable energy projects and geothermal in particular.

Conclusions and recommendations

- Potential for geothermal development.
- Government commitment to develop geothermal resources.
- Subsurface temperatures in the range of 100 - 250˚C suitable for power generation and use in industry and agriculture.
- Fast track the Formulation of Geothermal Policy and Legislation.
- Need to finalize surface studies in four areas Katwe, Buranga, Kibiro and Panyimur and select suitable areas for the feasibility study.
- Detailed studies of other geothermal areas in Uganda.
- Capacity building (manpower and equipment).

Uganda geothermal in pictures