

# PRELIMINARY GEOCHEMICAL INVESTIGATION OF THE GEOTHERMAL AREAS OF UGANDA OTHER THAN KATWE, BURUNGA AND KIBIRO

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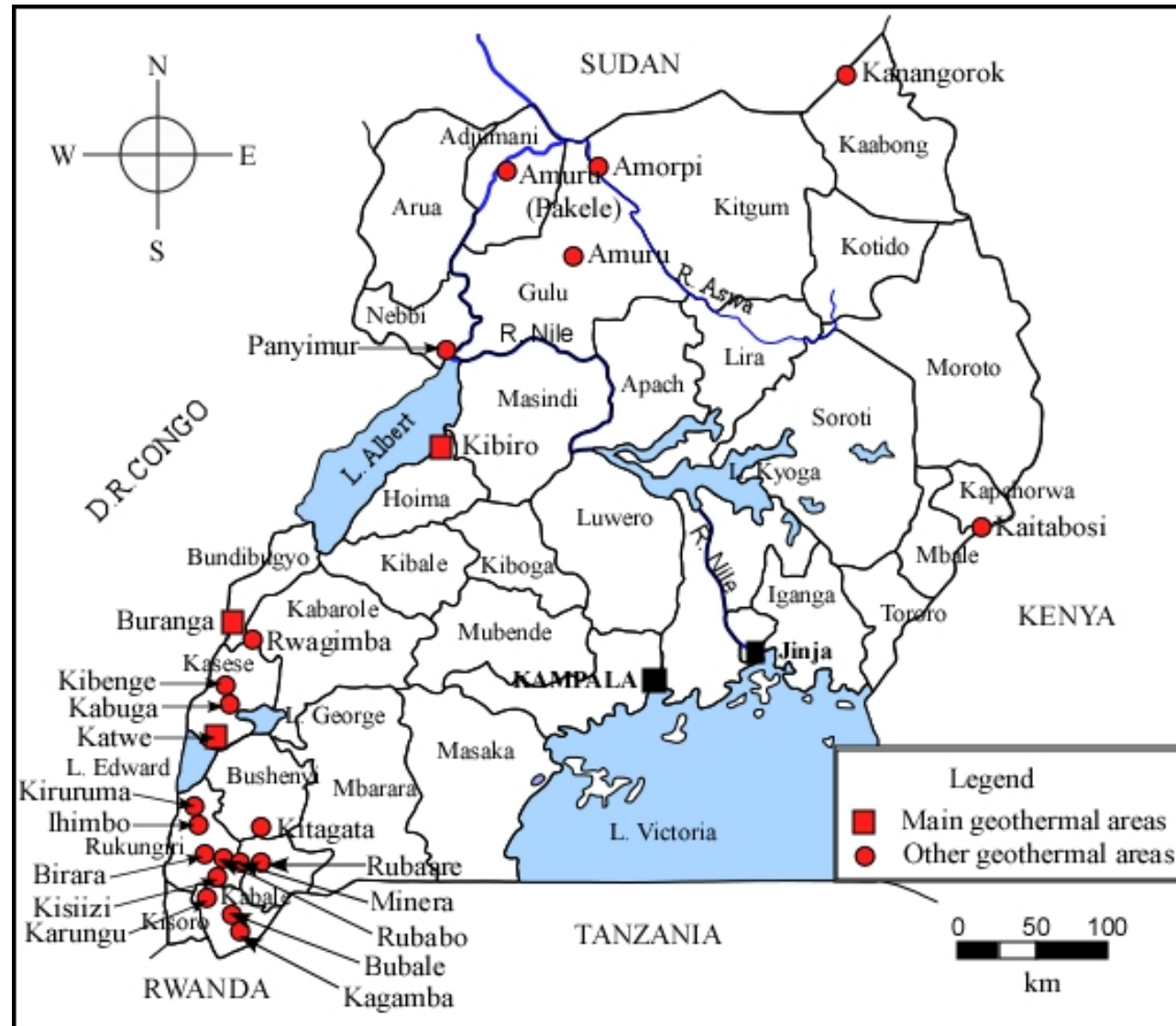
# *Outline*

- Objective of the study
- Study areas
- Previous studies
- Sampling and analysis
- Isotope results
- Chemical composition
- Geothermometer temperatures
- Conclusions and recommendations

## *Geothermal: Objective of the study*

- To develop geothermal energy to complement hydro and other sources of power to meet the country's energy demand and in particular rural areas far away from the present grid.
- To select more areas for cascaded geothermal exploration and development.

## Study areas: Uganda geothermal areas



## *Previous studies*

- Wayland 1935: 10 spring areas apart from Katwe, Buranga and Kibiro.
- Sharma 1971: 15 springs
- Bahati 1995, 1996: Karungu, Bubale, Kagamba, Kisiizi, Minera, Rubabo, Birara, Ihimbo and Kiruruma. Found Rubabo, Minera, Birara and Ihimbo promising. Geothermometer temperatures  $> 100^{\circ}\text{C}$
- Bahati et. al. 2005: 23 geothermal areas apart from Katwe, Buranga and Kibiro (Current results).

## *Sampling and analysis*

- Description of study areas: Geochemical team, MEMD
- Sample collection and field laboratory analysis: Geochemical team, MEMD
- Chemical analysis: GNS Science, Wairakei Analytical Laboratory, New Zealand
- Interpretation: ÍSOR, Iceland GeoSurvey

## *Uganda geothermal areas (other areas)*

### Grouping of the geothermal areas

- Group I, Southwest: Karungu, Bubale, Kagamba
- Group II, Southwest: Kisiizi, Minera, Rubabo, Birara, Rubaare.
- Group II, South of Katwe-Kikorongo: Ihimbo, Kururuma, Kanyinabarongo, Kitagata.
- Group IV, West: Kabuga, Kabenge, Ndugutu, Rwimi, Rwagimba.
- Group V, Northwest : Panyimur, Amuru, Amuru (Pakele).
- Group VI, Northeast: Kanangorok and Kaitabosi.

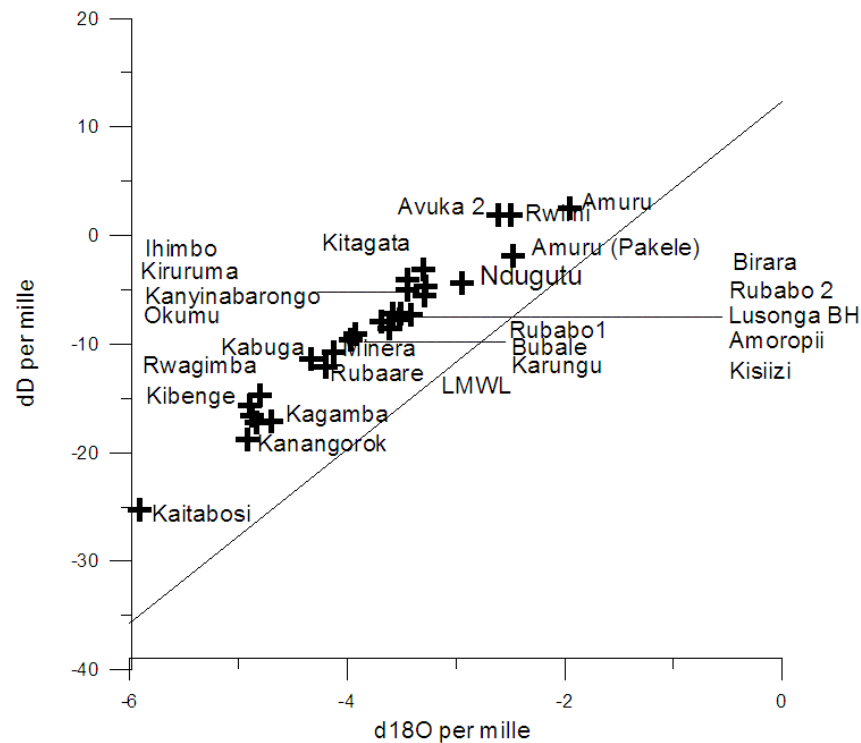
## *Current utilization*



- Spas
- Watering animals
- Salt production
- Only direct use in a Kisiizi hospital, Rukungiri district, Southwest Uganda.



# Isotope studies



Deuterium and Oxygen-18 isotope ratios

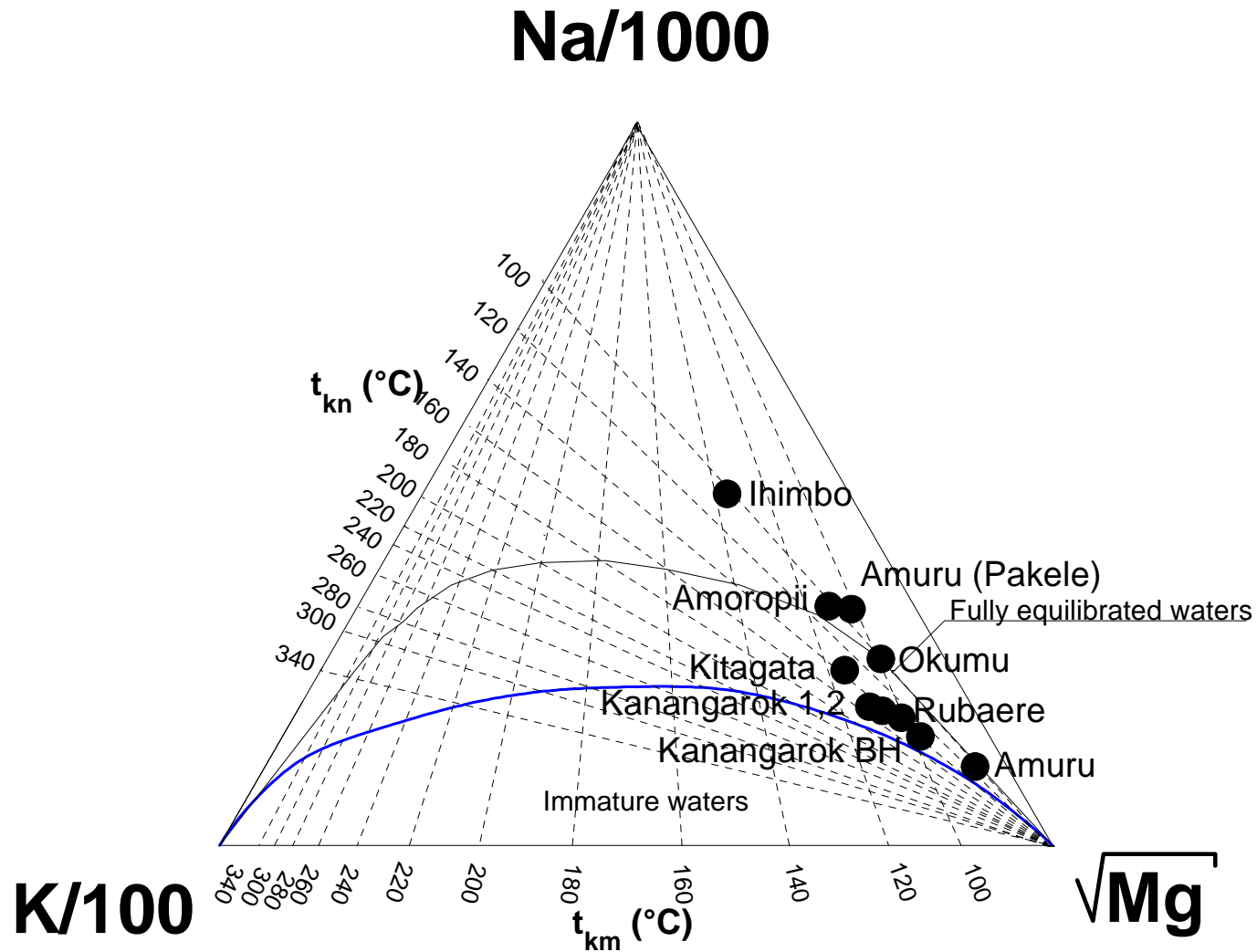
- Compared to GNIP (1999) LMWL deuterium excess for all samples
- Meteoric water precipitated when air moisture was less than today or a new LMWL needs to be established for the Western Uganda.
- Permeability is probably high with no indications of oxygen shift.

## *Deuterium and Oxygen-18 isotope ratios*

### *Individual areas*

- Kaitabosi: High altitude reflected
- Kanangarok, Kagamba, Kibenge, Rwagimba: Recharged from high elevations
- Rubaare, Kabuga, Minera, Karungu, Bubale, Rubabo, Kisiizi, Birara, Kanyinabarongo, Kiruruma, Ihimbo, Kitagata, Okumu and Amoropii: Recharged from moderate elevations considerably above the local one
- Amuru and Amuru (Pakele): Possibly local recharge
- Ndugutu, Rwimi and Avuka 2: Local, probably partly evaporated, e.g. from a lakewater component

# Na-K-Mg diagram for selected samples



*Group I and II: SW-Uganda. Measured and geothermometer temperatures and Mg concentrations (mg/l)*

Location	Measured temp. °C	Quartz temp. °C	Chalcedony temp. °C	Na/K temp. °C	Mg
Kagamba	35	73.9	41.8	338.9	44
Karungu	65	101.1	70.7	153.9	3.8
Bubale	34	62.6	30.3	194.7	38
Kisiizi	30.1	58.6	26.4	n.a	18.9
<b>Rubaare</b>	<b>54</b>	<b>138.8</b>	<b>112.1</b>	<b>134.6</b>	<b>1.4</b>
<b>Minera</b>	<b>58</b>	<b>126.8</b>	<b>98.8</b>	<b>128.1</b>	<b>22</b>
<b>Rubabo 1</b>	<b>58</b>	<b>125</b>	<b>96.9</b>	<b>136.2</b>	<b>8.3</b>
<b>Rubabo 2</b>	<b>60</b>	<b>123.2</b>	<b>94.9</b>	<b>137</b>	<b>8.3</b>
<b>Birara</b>	<b>63</b>	<b>136.1</b>	<b>109.1</b>	<b>155.8</b>	<b>10.5</b>

*Group II and IV:SW and West Uganda.  
Measured and geothermometer  
temperatures and Mg concentrations (mg/l)*

Location	Measured temp. °C	Quartz temp. °C	Chalcedony temp. °C	Na/K temp. °C	Mg
<b>Kitagata</b>	<b>66</b>	<b>120.1</b>	<b>91.4</b>	<b>136.1</b>	<b>0.28</b>
<b>Ihimbo</b>	<b>70</b>	<b>83.8</b>	<b>52.2</b>	<b>96</b>	<b>0.02</b>
Kanyinabarongo	38	85	53.4	136.4	4.5
Kiruruma	36	108.2	78.4	183.9	2.9
Kabuga	42	104	73.8	100.2	13.2
Kibenge	48	97.5	66.8	121.6	6.5
Ndugutu	22	79.7	47.9	141.3	11.2
Rwimi	24	133.2	105.9	250.3	191
Rwagimba	69.2	114.3	85	93.1	5.1

*NW and E Uganda. Measured and geothermometer temperatures and Mg concentrations (mg/l)*

Location	Measured temp. °C	Quartz temp. °C	Chalcedony temp. °C	Na/K temp. °C	Mg
<b>Avuka-2</b>	<b>35</b>	<b>104.6</b>	<b>74.5</b>	<b>139.6</b>	<b>3.1</b>
<b>Okumu</b>	<b>45</b>	<b>112.9</b>	<b>83.6</b>	<b>95.4</b>	<b>0.68</b>
<b>Amoropii</b>	<b>58</b>	<b>111.3</b>	<b>81.8</b>	<b>98.5</b>	<b>0.36</b>
Amuru	48	114	84.7	106.8	0.76
Amuru (Pakele)	49	78.7	46.7	82.5	0.04
Kaitabosi	48	26.9	-3.1	93.7	0.014
<b>Kanangarok 1</b>	<b>60</b>	<b>138.4</b>	<b>111.6</b>	<b>139.4</b>	<b>2.7</b>
<b>Kanangarok 2</b>	<b>42</b>	<b>145</b>	<b>119</b>	<b>146</b>	<b>1.5</b>
<b>Kanangarok BH</b>	<b>38</b>	<b>144.9</b>	<b>118.9</b>	<b>153.2</b>	<b>1.5</b>

## *Most promising areas based on subsurface temperature and volcanic characteristics*

Location	Measured temp. °C	Presence of Hydrogen sulphide	Average subsurface temp. °C
Rubaare	54	0	137
Kitagata	67	0	128
Kanangarok	60	0	145
Panyimur	58	5.61	105
Ihimbo	70	0.92	90
Birara	63	0	146
Rubabo	60	0	130
Minera	58	0	127

## *Conclusions and recommendations*

- Rubaare, Kitagata and Kanangorok areas are most promising and investigations for binary power production could be started if there is a market for electricity in the areas.
- Panyimur and Ihimbo have lower predicted subsurface temperatures but contain H<sub>2</sub>S suggesting a possibly hotter fluid and further studies are warranted.
- Birara, Rubabo and Minera have consistent geothermometer temperatures despite having high Mg concentrations. Further exploration warranted.



## *Conclusions and recommendations*

- Karungu: Predicted subsurface temperatures do not agree (100-155°C); but has high surface temperature (65°C), extensive coverage of surface manifestations (hot springs) and Mg not excessively high and therefore need further investigation.
- Kabuga, Kibenge, Rwagimba, Amuru, Amuru (Pakele) areas have lower subsurface temperatures but also need to be investigated for binary production and/or other uses.
- Kagamba, Bubale, Kanyinabarongo, Kiruruma, Kisiizi, Ndugutu, Rwimi, and Kaitabiosi do not seem promising for electricity production from the results of the just concluded study, but could be used for spas and other uses.



Thank You