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PROGRESS REPORT ON GEOTHERMAL RECONNAISANCE SURVEY OF UGANDA

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INTRODUCTION

The report is compilation of all known geothermal features in Uganda. It is a result of the national geothermal reconnaissance survey funded by ICEIDA-World Bank Power IV. The aim of the investigation was to identify specific prospects and assign them priorities for more detailed investigations in future. All known geothermal prospects in Uganda will be assessed and ranked. Field work included measurements of ph, conductivity, total dissolved solids, flow rate and surface temperature. Particular attention was paid on hydrology, thermal activity and heat flow of the thermal springs. Samples of surface manifestations like hot springs, gases, hydrothermal alteration minerals and hydrothermal deposits were collected for mineralogical, isotopic and chemical analysis. Most of the hot springs are genetically linked to the western rift valley tectonics and alkaline volcanism. The inventory is not exhaustive but it has been supplemented with available literature.

GEOTHERMAL PROSPETS

NEBBI DISTRICT

Panyimur hot springs (29/2 Pakwach).

Panyimur hot springs are located on escarpment front just near the shores of Lake Albert, in Panyimur sub-county, Nebbi district. Pallock (1967) refers to them as Amoropi hot springs in West Nile. Pallock (1967) describes thermal water as cloudy, odorless with a saline taste. Total dissolved solids are reported between 969-1000 ppm, implying a fresh to slightly saline water. The water is Sodium chloride type. Other surface manifestations reported include sodium chloride, sulphurous algae and gaseous emissions (CO_2, H_2S). Fractured crystalline basement rocks such as coarse hornblende gneiss, coarse hornblende garnet rock, talcose rock and a pegmatitic vein are all reported in a gorge above the hot springs. A foliation / basement schistose trend NNE-SSW. Others schistose trend almost NE, parallel to the local major faults.

At Avuka, water is clear with a surface temperature between 48-58^{o}C. Feeble gas bubbling was noted as well as gypsum flakes. A flow rate of 1.7 l/sec and pH of 7.5 were measured. The hot springs are aligned in a northwest direction possibly controlled by the major normal boundary rift fault. It is anticipated that the springs rise at or close to the fault.

At Okumu (Wankado west), south of Avuka, a warm springs discharges, with a surface temperature of 45^{o}C. Other surface thermal manifestations included inactive travertine moulds (old spring deposits) as high as 3 meters above the hot springs. The springs have thus previously been active at high level than today. The extent of travertine appears un proportionate relative to current rate of spring overflow. South of Avuka warm springs, another warm springs (Avuka-A) was noted. This was characterized by thermophyllic plants in a swamp. Here intermittent gas bubbling was noted with a surface temperature of about 44^{o}C. Clear to milky water issues along a line of a major NE-SW fault separating Precambrian basement rocks on the west from quaternary sediments.

Southwards, again, another discharging warm spring Avuka-B was issuing clear water at a temperature of 35°C. Rocks in the area included crystalline basement rocks (coarse jointed granite-gneiss outcrops on the west) and Pleistocene sediments on the east of the rift fault boundary. According to table 1 below, they are chloride waters.

Table 1: Chemical analysis of Amoropi hot spring waters by Pallock (1967)

Component	Sample 1 (ppm)	Sample 2 (ppm)
Cl^-	465.5	466.5
SO_4^{-2}	34.2	28.0
HCO_3^-	78.55	13.4
PO_4	Nil	Nil
NO_3	Nil	1
SiO_4	95	100
CO_3^{-2}	91.9	49.0
Ca^{2+}	Nil	2.3
Mg^{2+}	1.95	1.95
Fe	Nil	Nil
Na^+	352	336
K^+	10	9.2

KABONGO DISTRICT

Kanangarok hot springs (sheet 9/1).
Kanangarok hot springs are located in Kabong district. This area is located 9 km due south of Mt. Lotuke and near the Uganda-Sudan border (33°48'E, 4°01'N). Wayland (1935) describes this hot spring as a non-mineral spring. It is reported to have a weak discharge with a surface temperature between 42-60°C. A siliceous rock is reported in the area as well as a pink-grained limestone. The hot water is reported to issue from **fractured granitic gneiss** (Precambrian basement rocks).

A basement schistose, trends NW to NNW and Pallock (1958) reported a reaction pH of 8.5 and a TDS of about 1114 ppm (implying slightly saline water). The water is reported to be clear, odorless and tasteless. Previous analyses are indicated below. Other surface manifestations reported by Dixon et al (1967) include gaseous emissions (H_2S). Kanangarok hot spring waters are intermediate, a mixture of bicarbonate and low chloride high sulphate waters. Magnesium values ranging from 6.5-13ppm may indicate mixing with surface derived meteoric waters to produce high Mg content hybrids.

An under-saturated dyke rock is reported 0.8 km NE of Kanangarok hot springs while a basement carbonate rock is reported 1.6 km NE of the springs (lab report 24089, 1964). Syenite rocks are also reported to occur within the region. Fossil thermal features are reported to the east of Mt. Lotuke.

Table 2: Chemical analysis of Kanangarok hot spring waters (Pallock, 1958, 1964).

Component	Sample 1 (ppm)	Sample 2 (ppm)
Cl^-	105.2	47
SO_4^{-2}	353.4	334
HCO_3^-	321.5	441
CO_3^{-2}	44.9	*
Ca^{2+}	15.7	18
Mg^{2+}	6.5	13
K^+	*	48
Na^+	*	320
pH	8.5	5.5

SIRONKO DISTRICT

Suam warm springs (sheet 74/3, Elgony).
A saline spring is known to occur close to the summit of Mt. Elgon, on the rim of a caldera, Sironko District, on the Uganda-Kenyan border. Suam thermal area can be assessed through Budadiri-Masowali trading center. The Journey takes a minimum of four days. Warm water issues with a temperature between 45-48°C, from fine-grained volcanic basaltic agglomerates and tuffs (Miocene-Pliocene). These volcanic rocks are older than the western volcanic rocks. The water is clear, with a slight taste and odorless. A TDS of about 819 ppm is reported, implying fresh to slightly saline water. Hydrogen sulphide is reported in the area. Other surface manifestation includes thermophyllic grass near the springs. Possibly the spring area is a junction of a presumed E-W to ENE-WSW trending fault and the circular fracture of the caldera. Ph was measured and found to be 10.

Table 3: Chemical analyses of Suam hot springs

Component	Sample 1 (ppm)
Cl^-	49
SO_4^{-2}	57
HCO_3^-	321

RUKUNGIRI DISTRICT

Birara hot springs (sheet 85/3)
Ngulukiro hot spring is likely to be the same spring recorded as Birara hot spring. U_3O_8 is reported at about 5 µg per litter in the water and tufa deposits are associated with this spring. Reference is made on laboratory report 20710 (1959). Birara hot springs issue fresh clear water on both banks of Birara river gorge. Intermittent gas bubbling was noticed, in places more vigorous. River Birara gorge is likely to be a fault through mica schists grading into gneiss. These rocks look ferruginous in places and micaceous. A maximum temperature of 63°C was recorded. More thermal seepages occur along the river, and more are reported down stream (about 3 km).

Rubabo hot springs (sheet 84/2)
Rubabo hot spring issue from a fractured crystalline basement (jointed and fractured granite gneiss) rock, along the deeply incised Minera river gorge, some 20 km from the rift valley. The temperature ranges from 58°C to 60°C. The thermal water is clear and fresh issuing at less than 4.1 l/sec. intermittent gas seeps were noticed from nearly vertical joint sets (N-S). Another joint set was recorded as 110°/60°SW. The flow was fracture controlled in crystalline basement rocks. Near by is limestone deposit in a swamp. A pH of 7.14 and a flow rate of 1.7 l/sec were recorded on a second thermal spring.

Minera hot springs (Rwasamaire, 85/3)
Several points of fossil thermal features could be noticed around the hot springs, including geothermal grass. It is about 25 km from the edge of the rift valley. According to table below, Minera hot springs are slightly saline (dissolved constituents 1638 ppm). High magnesium content (29 ppm) might indicate mixing with surface derived meteoric waters and possibly these are immature bicarbonate waters. Minera hot springs issue clear water with moderate gas bubbling at some points. Gas seeps were noticed along the river in a distance of 20 m downstream. Water issues from **fractured crystalline basement rock** (granite gneiss rock, with quartzite bands of Karagwe-Ankolean system), jointed with different sets. A flow rate of 4.1l/sec and a temperature of 57°C were recorded. A 2 m diameter pool was noticed with a pH of 6.88-7.5. A thermal spring called Nyakibare is reported near Minera.

Table: Chemical analysis of Minera hot spring waters (Lab 25339, 1968)

Component	Sample 1 (ppm)	Sample 2 (ppm)
Cl^-	180	186
SO_4^{-2}	361.7	373
HCO_3^-	868.1	880
Ca^{2+}	68	67
Mg^{2+}	25.1	29.4
Na^+	475	460
K^+	32.7	24.3
TDS	1638	-

Kisizi warm spring (Rukungiri 84/4)
Kisizi thermal springs are issuing clear warm water of about 30°C. They are located about 25 km from the rift. A pH was measured to be 7.44. Fractured silicified quartzitic rocks and granite gneiss of Karagwe-Ankolean system, underlies the area. Several warm springs occur in the area currently used by Kisizi hospital for direct use application. Possibly thermal springs are controlled by fractures with an average flow of about 0.5 l/sec. Water is characterised by high bicarbonate contents and exhibit higher than equilibrium Mg values. Travertine is reported at Nyarusanje in Kisizi.

Table 1: Chemistry of Kisizi thermal springs

Component	Sample 1 (ppm)
Cl^-	8
SO_4^{-2}	16.5
HCO_3^-	179.7
Ca^{2+}	30.7
Mg^{2+}	20.7
K^+	4.4
TDS	200

KANUNGU DISTRICT

Kiruruma warm spring (sheet 84/4)
Kiruruma thermal spring is located 10 km on Kihihi – Katunguru road on banks of River Kiruruma. It is 50 m from river issuing at about 36°C from unconsolidated rift Pleistocene sediments (conglomerates, sands, silts and clays). These warm springs issue clear fresh water, with intermittent gas bubbling. The sediments are ferruginised in some places according to observable rusty stains. Thermal springs are located at or near a fault plane. A flow rate of about 1 l/sec was recorded. A pH

was measured at 7.09. A pool of about 4 m in diameter exists in the area. Neither thermal alteration features nor hydrothermal deposits were noticed.

Ihimbo hot spring (Ruhinda sheet 84/2).
Ihimbo thermal springs are located in Ihimbo forest, rising close to a tributary of Ihimbo River. It is anticipated to be located on or close to the presumed major boundary step rift fault, at the escarpment front. The springs are issuing from tertiary rift sediments (conglomerates, clays, silts and sands). The grains and pebbles of quartz are rounded to sub angular and the beds appear to contain iron oxide deposited from infiltration solutions, which give the beds their rusty brown color. A temperature of 69-70°C and a discharge of 8.3 l/sec were recorded, covering a distance of approximately 500m. Intermittent gas bubbling was noticed. The thermal springs are aligned in an approximately North-South direction possibly related to the major normal boundary rift fault. A pH of 9.2 was recorded and travertine was noted (Sharma, 1971). The thermal water is reported to be immature. A pool of warm water measuring 10 m x 5 m was constructed in the area.

Table: Ihimbo hot spring chemical results

Component	Sample 1 (ppm)
Cl^-	73.0
SO_4^{-2}	205
HCO_3^-	81.2
CO_3^{-2}	16.7
Ca^{2+}	Nil
Mg^{2+}	Nil
Na^+	182
K^+	5

Kanyinabalongo warm spring (sheet 84/2)
Kanyinabalongo warm spring is located in Bwambala sub-county, Ruzumbura County in Rukungiri District. Kanyinabalongo thermal springs are located within the vicinity of Ihimbo hot spring. They were also issuing from a pebbly clay (Pleistocene sediments) environment. More warm springs are reported in the area. A surface water temperature was found to be 38°C with a flow of about 4 liters per sec. This spring is north of Ihimbo hot spring, aligned in North-South direction. A pool of about 4 meters in diameter was used by locals for its therapeutic values. These thermal springs seem related to the escarpment front boundary normal fault.

KABALE DISTRICT

Kagambanengo warm springs (sheet 93/4).
The warm spring is located on Kabale – Katuna road. Clear fresh water is seeping under a pool of water (15m x 30m). The area is swampy with molds of travertine ascribed to the past activity of the thermal water. No outcrop was seen around but floats of ferrugnised phyllites / slates and quartzite were noticed. Just about 50 km across the road, ferrugnised quartzite is quarried for aggregates. A fault is inferred in the area and possibly may be the one influencing the location of the warm springs. Water issues at about 38°C with intermittent gas bubbling. Ph was measured around 7.49.

Karungu hot spring (Rubanda sheet 93/2).
Karungu thermal springs are located in Rubanda County, Kabale District, about 11 km NNE from Ruhuhuma vent. About 12 springs are reported to issue from the bed

of Ishasha river (trending E-W) from two sets of very narrow cracks, one coinciding with the bedding plane and the other with a joint plane, which run at an angle to the bedding plane. The area is underlain by hard ferruginised Karagwe-Ankolean phyllites / slates, jointed and bedded (trending North and dipping East). Some joints were nearly vertical. A faulted plane is inferred along river Ishasha gorge. Water is clear and fresh, issuing at 54°C-65°C. Intermittent gas bubbling was observed and water had a pH of 7.49. The nearest volcanic rocks is at Kitunga lava flow some 30 km away.

Bubare (Kizuguta) warm spring (Sheet 93/2)
The area is underlain by ferruginous phyllites and slates of Karagwe-Ankolean system. The thermal springs are located on Kabale-Kisoro road (about 4.8 km from Kabale). Clear water is issuing at 34°C with a pH of 6.29. Intermittent gas bubbling was noticed in a pool of warm water (10m x 5 m). A few tens of meters is another small warm spring issuing at 28°C forming a pool of warm water (1m x 1m). A flow rate of 1.7 liters per second is reported.

NTUNGAMO DISTRICT

Rubaare hot spring (sheet 85/3)
The hot spring is located Rugalama sub county, Rushenyi county in Ntungamo District. A pool of about 15 m diameter was noticed around Kakono swamp, west of Lake Nyabikoko (Karenge). The water was clear and inactive fossil travertine (older spring deposits) was noted at high elevation, in a distance of more than 200m. The springs have thus been active at a higher level than today. The current extent of travertine appears disproportionately large relative to the current rate of spring overflow. Water is issuing from fractured quartz rich pegmatite granitoid rock, with muscovite sheets and tourmaline. Surface water temperature was measured at 55°C with a flow of about 2 l/sec. Another hot spring with a pool of about 1m was observed aligned with the former. Some sort of structural control is inferred.

BUSHENYI DISTRICT

Kitagata hot springs (Bushenyi 85/1)
Kitagata is located in Kitagata sub county, Shema County in Bushenyi District. Water issues from banded fractured biotitic granitic gneiss, which is jointed (four sets), in the broad Rwabanjori valley. Gas bubbles were issuing intermittently. Temperature was found to be 67°C while the pH was found to be 7.5. The hot spring have a discharge rate of 4.1 l/sec. Striations were noted on the gneiss, an indication of a possible fault in this area, trending approximately N-S. E-W foliation trends were observed and N-S almost vertical joints were measured. A pool of water (7m x 10m) occurs in the area. Some iron oxide mineralisation was observed. About 300m away is another hot spring (Omugabe pool), discharging at 2.8 l/sec. This also issues from granite gneiss forming a pool of about 9m. Again intermittent gas bubbling was noticed. The thermal water is clear and fresh. White oolitic spring deposits were noticed on the gneiss surface and along fracture planes. It reacted slowly with acid. The water is reported to be immature and the high B/Cl ratio in Kitagata thermal waters precludes involvement of saline fluids in this hydrology system.

KASESE DISTRICT

Katwe warm spring (Katwe sheet 75/2)

Several warm springs occur in the Katwe explosion crater. Surface manifestation in the explosion crater includes several travertine moulds, some extending about 10 meter high, gaseous emission, thermophyllic grass and warm water. The thermal area is underlain by phreo-magamatic (laid down under water) rocks including volcanic ash (sub aqueous volcanic rocks), resting on fractured crystalline basement rocks. Metamorphic and granitic rocks form the "basement" while volcanic and volcanic derived sedimentary rocks form the cover. A saline crater lake exists in the area, possibly underlain by an evaporite. One thermal spring measured had a temperature of 32°C. The water is very saline to almost briny. Hydrogen sulphide is reported at 900 ppm while the pH was found to be 8.5. The lowest B/Cl value of Katwe water (briny) indicates a comparatively high influence of saline fluids in the hydrology of system.

Lake Kitagata hot spring (sheet 75/2 Katwe)
Lake Kitagata thermal spring is located in Lake Kitagata explosion crater, about 13km NE of Lake Katwe explosion crater. Clear hot water issues from a rim of the lake Kitagata explosion crater. Geothermal surface manifestations include thermophyllic grass around the crater rim, gaseous emissions (faint odor of hydrogen sulphide) and hot water issuing at about 58°C. Salt crusts are noted around the hot springs, possibly sodium sulphate. It is reported that there are many unseen small seeps that discharge directly into the saline Crater Lake. The pH was found to be 9. Volcanic tuffs, bombs and agglomerates underlie the area. Bombs of gneiss rocks and other ultra basic rocks can be seen in the area. A cover of volcanic rocks rests on a basement of metamorphic and granitic rocks. Lake Kitagata hot water is very saline (dissolved constituents 20360 ppm) and has a conductivity of 29 ms/cm.

Muhokya warm spring (66/3)
Muhokya warm spring is sometimes referred to as Kabuga warm spring. The water is clear and some intermittent gas bubbling was noticed. A temperature of 41-42°C was measured. The pH was found to be 7.42 with a flow rate of 0.3l/sec. There is no rock exposure but the spring is likely to issue from the flanks of Rwenzori Mountain under alluvial and pediment gravel materials, according to surface geology. Conductivity was measured at 3.5ms/cm. It is likely that this thermal spring is controlled by the major Rwenzori fault.

Kibenge warm spring (sheet 66/1)
Kibenge thermal spring is located on Kasese – Kilembe road, just after the junction to Marigherita Hotel, on the right. It is located in eucalyptus plantation, possibly underlain by alluvial and pediment gravels overlying fractured Precambrian basement rocks (gneiss, amphibolites, quartzite and schist). Local people use a pool (of 7 m diameter) for therapeutic purposes. It issues clear water with a temperature of about 45°C and with intermittent gas bubbling. A pH of about 7.5 and conductivity of 3.6 ms/cm were recorded. It is likely to be related to a major Rwenzori fault.

Bugoye cold spring (sheet 66/1).
To access Bugoye cold spring, you branch of at Bugoye trading center and turn to the left towards Kindigiri (Ndugutu cell). The cold springs, located west of Sebwe River, flow into river Sebwe. Geothermal grass and fossil travertine terraces upon

basement rocks, characterize the thermal area. The current extent of the travertine complexes is disproportionately large relative to the current rate of spring overflow. The water is described as moderate to very saline and was difficult to filter. It occurs in a distance of about 50 meter. A temperature of was found to be between 21-22°C and a flow rate of about 0.1 l/sec was estimated. Surface geology revealed that the area is underlain by fractured quartzite, phyllitic schist and granite gneiss covered by travertine molds. Feeble gas bubbling (H_2S, CO_2) was noticed in the highest point terrace.

KABAROLE DISTRICT

Rwimi warm spring (Sheet 66/1)
Rwimi thermal area is located at Mirambi near Rwimi trading center. Efferscence of dissolved carbon dioxide is characteristic of Rwimi warm springs. Clear to cloudy water is issuing under a pool of cold to warm water (2.5 m in diameter). There is vigorous gas bubbling (ebullition caused by CO_2 discharge) and pH was measured at 7.09. The hot-spring deposit consists almost entirely of travertine, about 1.5 m high at one spot. Water is issuing at between 24-25°C. This is really gassy cold water. The area is swampy with no rock outcrop. Surface geology reveals limestone nodules in the vicinity. Iron oxide stains are visible. Conductivity was measured at 3.8 ms/cm. Rwimi thermal area is possibly related to mountain front faults or ragged front fractures. A magma chamber might be the reasonable source of huge quantities of carbon dioxide discharging at Rwimi but it might as well be a low temperature non volcanic travertine depositing system.

Rwagimba hot spring (sheet 66/1)
Rwagimba thermal spring issues clear water. Surface geothermal manifestation in the area includes travertine moulds (not pervasive), intermittent feeble gaseous emission (H_2S) and hot water with a temperature ranging from 40 (warm springs) to about 69°C (hot springs). The area is underlain by fractured crystalline basement rocks (undifferentiated granite gneiss), along river Rwimi gorge, flowing into Mubuku river gorge. The pH was found to be 8.5 while the flow rate is estimated at 3.3 l/sec. The water is described as slightly to moderately saline. More seepage was noticed down stream in a distance of 30 m. The river gorge seems to be a fault line structurally controlling the hot water flow. There is evidence of ferruginisation in the rocks, in form of yellowish brown (reddish iron) stains. It is reported that discharging springs occur in a distance 1 km, discharging from both sides of the River. Four major discharging thermal springs are recorded.

ARUA DISTRICT

Aiwa warm spring (sheet 12/1)
A warm spring was reported with a surface temperature of about 31°C. It is located near Aiwa hill with a pH of 7 and a flow rate of about 5 l/sec. The discharging spring emerges at the edge of the rift fault, and is reported to be associated with the rift fault. The water is reported to discharge through the joint plane of granite gneiss. The water is characterized by high bicarbonate contents, issuing at a flow rate of about 5 l/sec.

GULU DISTRICT

Keyo Amuro hot springs (sheet 21/1)
Keyo Amuro thermal springs are reported to be discharging at about 2.5 l/sec with a surface discharge temperature of about 49.5°C. A pH of about 6.5 is reported. The area is reportedly underlain by fractured crystalline basement rocks (biotitic granite gneiss, amphibolites and schist). Geothermal surface manifestations include travertine moulds and gaseous emissions. Foliations trending NNE-SSW are reported together with joints trending NE-SW in quartzite.

Keyo hot springs (sheet 22/3)
Keyo hot spring is reported to discharge at 0.4 l/sec and has a surface discharge at about 49.5°C. Geothermal surface manifestations include travertine moulds and gaseous emissions. The area is reportedly underlain by fractured crystalline basement rocks (granite gneiss). A pH of about 6.5 is reported. The is intermittent gas bubbling with no visible rock outcrops.

Koich warm spring (sheet 22/3)
Koich hot spring has discharge rate of about 1.7 l/sec and surface discharge temperature of about 33°C. This thermal spring is described as intermittent, characterized by intervals of discharge that alternate with intervals of no discharge.

ADJUMANI DISTRICT

Pakele (Amuru) hot spring (sheet 13/4)
Active hot springs occur at Amuru-Paloga village, in Pakele sub-county, Adjumani District. It is reported to issue with a discharging temperature between 46 (warm spring) to51°C (hot spring). A Ph is reported between 9.3-9.6. Intermittent gas bubbling is reported from three thermal springs in the area. One of the discharging springs is reported to be milky. It is not clear whether it is due to human contamination or that it is natural state. Conductivity is reported to be about 490us/cm.

HOIMA DISTRICT

Kibiro hot springs (sheet 38/4)
Kibiro hot and warm springs are located on escarpment front, just on the shores of Lake Albert. The thermal water is moderately saline issuing at about 84°C. Escarpment front alluvial fans, coalescing to form pediments are found in the area. These are several hundred of feet thick extending several miles along the escarpment front. Saltpans are located just near the springs indicating a possible existence of an evaporate deposit underneath. Gypsum flakes, elemental sulphur, sodium chloride are all thermal features characterizing the area. The thermophyllic grass is evident in the area. Hydrothermal alteration features extend for about 1 km southwards. Fossil vents can be observed along the escarpment front about 1 km south of the active hot springs. The current extent of hydrothermal features appears disproportionately large relative to the current rate of spring overflow. Inactive fossil features appear at higher level than the hot springs. The springs have thus been active at higher level than today. Discharge rate is estimated at about 13.6 l/sec. Calcite deposits are evident in the crystalline basement rocks on the escarpment. The water is actively depositing on the crystalline rocks and in fractures. These have been found to be related to geothermal activity. Hydrogen sulphide was detected at the escarpment in basement rocks. A geophysical anomaly

has been identified in the crystalline basement rock and temperature gradient wells are to be drilled. Fractured crystalline granitic and metamorphic rocks are of very low permeability, and any migration pathway would be along weathered fractures and fault (providing bulk permeability).

BUNDIBUGYO DISTRICT

Buranga hot springs (sheet 56/1)
Three major thermal springs are observed at Buranga; these include Mumbuga, Nyansimbe pool and Kagoro. The mountain front alluvial fans include gravels of granites, gneiss, amphibolites, schists and quartzite. Secondary calcite and chalcedonic silica are reported. Angular pebbles are embedded in a fine-grained matrix.

One core was analyzed and consisted of principally Quartz, feldspars (albite, orthoclase, microcline, oligoclase). Accessory minerals included chloritised amphibole and pale mica showing alteration to magnetite. Travertine analysis has pointed to a magmatic heat of carbon dioxide. Recharge is from mountain Rwenzori, according to isotope geochemistry. Crystalline fracture systems control convective circulation of meteoric water. The 7360 km^2 of snowy mountainous area drains into Rwenzori thermal springs, serving as a huge scale recharging system. The difference in altitude between the recharge area and the discharge areas provides a positive driving force (pressure drive). Water from rain or snow seeps underground, through cleaved rocks and circulates downwards. The rugged front of Rwenzori reveal faults, which have cleaved the up arched block.

The Thermal water from the borehole was described as very saline with dissolved constituents of 18,690 ppm (Borehole No.3).

At Mumbuga, thermal water is continuously spouting from a travertine terrace. Artesian discharge of hot water produces spouting hot springs (spouters) in a valley which drains a liquid dominated system. Several thermal springs, tiny mud pools and numerous small vents are scattered in the swampy area. Small vents have a quite discharge and self-sealing has resulted in migration of these activities. Temperature measurements range from 40 (warm springs) to 94^{o}C (hot spring, almost boiling). Other surface manifestation thermal features include intermittent gaseous emissions, hydrothermal alteration features and hydrothermal deposits. The springs are located about 300 m away from the Rwenzori mountain front. The area seems to be underlain by alluvial fans, several hundred feet thick and several miles along basin margin. A pH of 8.5 is recorded from Mumbuga thermal water, with an estimated flow of about 8 l/sec.

Nyansimbe hot pool is south of Mumbuga thermal area and has an impressive appearance of a large steam cloud. It has a diameter of about 30 meters covered by a crust of travertine. It is reported to have a depth of 4.5 meters, the base of which is twice the top. Reported surface temperatures range from 76-94^{o}C. It is estimated to have a discharge flow of 16.6 l/sec and a Ph of 9. The pool is steaming and dangerous to sample. Thermal manifestation features include gaseous emission, steaming pools, hydrothermal deposits and thermophyllic grass. The water is also very saline. It appears there are seepages under the hot pool and heat transfer involves mainly evaporation at the exposed water surface and direct heat discharge.

Hydrothermal eruption might have been responsible for the crater forming the pool. This has to be proved by identifying hydrothermal breccias at the crater rims.

Kagoro thermal area is the most southerly of the three thermal areas in Buranga. It is characterized by conical travertine molds (1m high), intermittent gaseous emissions in an area of 30m^2. Some hot springs are on top of travertine mound with little surface run off. A discharge rate of about 4 l/sec is estimated with a maximum temperature of about 80^{o}C. Like other two thermal areas, Kagoro thermal area is underlain by fluvial materials (alluvial fans gravels and conglomerates), very close to the Rwenzori mountain front. Surface geology and drilling of three holes in an area has confirmed this. The water is very saline, and like Mumbuga and Nyansimbe, all the water is genetically correlated to Rwenzori thermal springs, chemically. Conduits of circulating thermal water are likely to be basement faults and fractures. A large still-hot magma chamber must underlie the Rwenzori area to account for the heat flow and some of the mineral constituents of the hot-spring system.

About three well-defined fault systems are recognized in the area. A Northeast trending major fault striking parallel bounding the Rwenzori block and cleaving faults cross cutting it (NW-SE, E-W). Others strike nearly north. A fault scarp is well exposed near the thermal area. These faults are presumed to provide structural control of the hot-water system.

KAMWENGE DISTRICT

Dwemkorebe warm spring (sheet 66/2)
Dwemkorebe thermal spring issues from Dwemkorebe River gorge a tributary of the Dura River. The thermal spring rises close to the margin of the Pleistocene rocks of Kaiso series, on or close to the presumed line of the rift faulting. Fractured crystalline basement rocks might play a role in thermal water migration. Thermal surface manifestation features include travertine mound deposits, warm water and gaseous emissions. Dwemkorebe warm springs might be a toe of an outflow.

Other Geothermal features
Older fossil thermal spring deposits are reported around Rwenzori nose. These include inactive travertine mound deposits. On the western side, inactive surface manifestation (hydrothermal alteration feature) were observed on the mountain front, northeast of Buranga hot springs. Older fossil thermal spring deposits are reported at Lake Saka, Kasekere, Nyabusozi and other explosion crater lakes around Fort Portal. Similar deposits are reported around north of Kikorongo crater, Kasenyi, Nyamunuka, and Busanga. More old travertine is reported in Mubuku and Rwimi river gorges. An extinct thermal spring is reported around Mbarara (Kikagata, sheet 86/1), at Nyambuga NNW along a truck to Isunga. This thermal spring used to issue from a fractured basement complex rock, some 20 km away from the edge of the rift. Other areas include Nyakagezi hot springs, Murambo, Ihanga (steam ground) and Rutoam, reported on Kigezi tourist map. Palabek hot springs are reported in Kitgum District. Gaseous emissions are reported at Mulyambuzi near Fort Portal, where gas diffuse in the ground. Lack of vegetation and dead animals in depressions confirm such diffuse discharges.