GEOCHEMISTRY OF RWENZORI HOT SPRINGS

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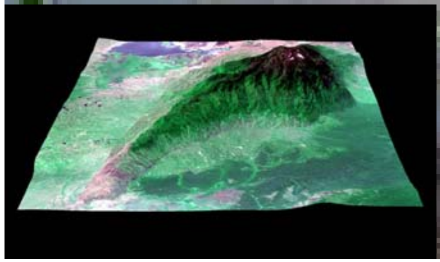
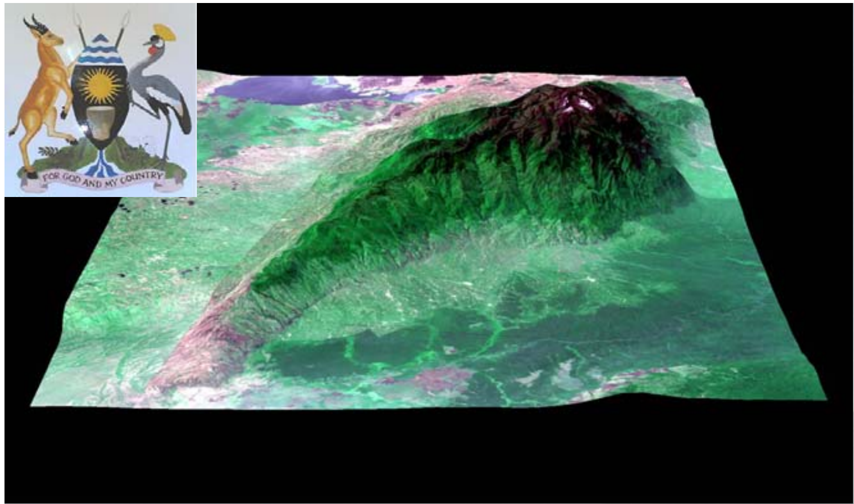
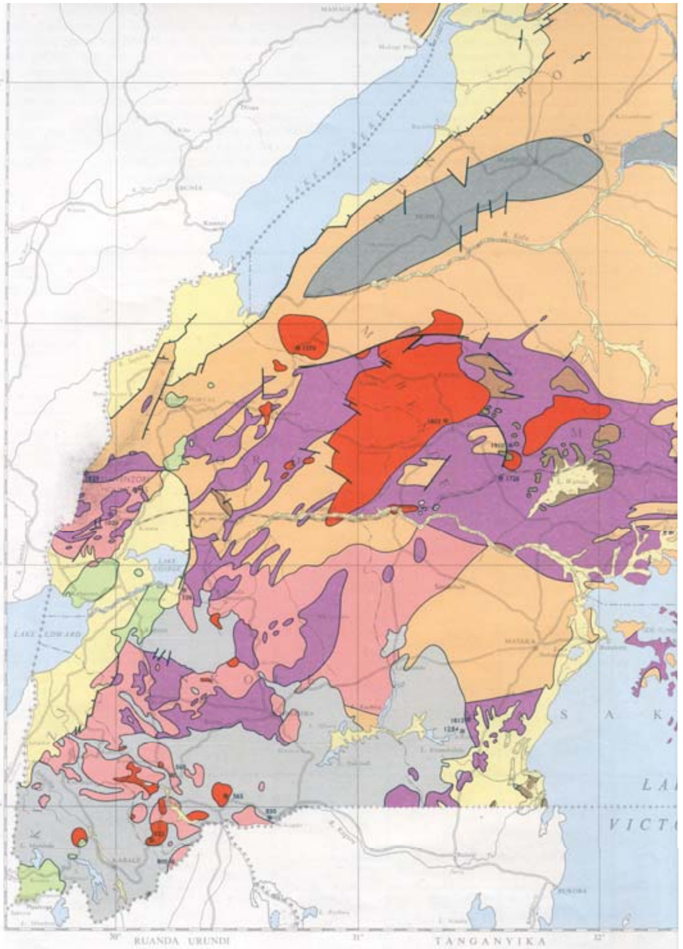


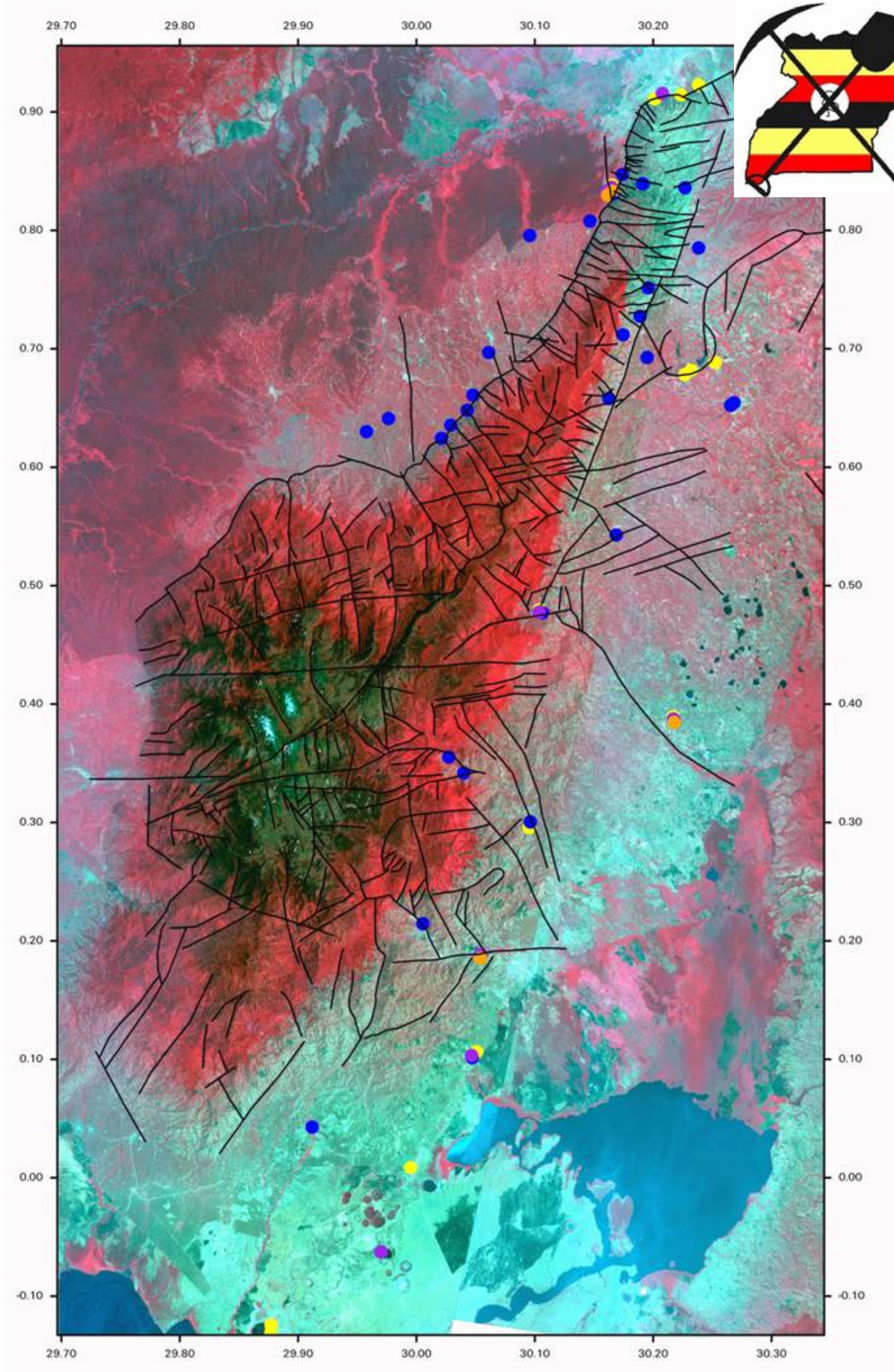


RWENZORI

- Length of 115Km
- Width of central dome 48 - 64 km
- Highest peak >5105m
- Snowy Mountain
- Lakes

Geology


CONGO
RUANDA URUNDI
TANGANYIKA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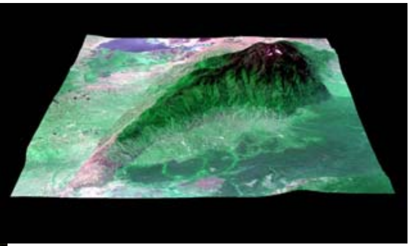


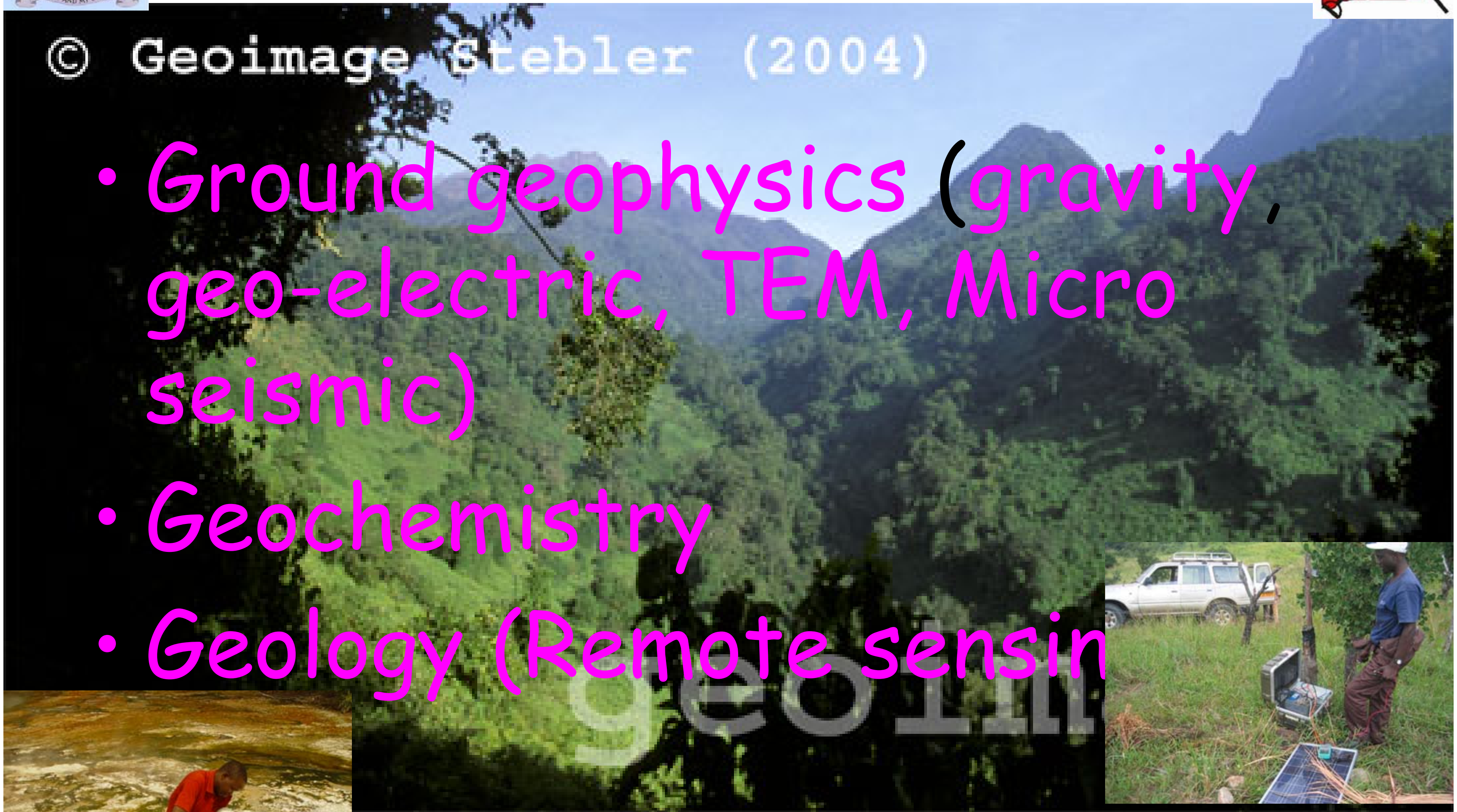
- Crystalline basement rocks (Precambrian)

  (amphibolite schist, amphibolites, diorite, diabase)
- Gneiss
- Schist,
- Quartzite,
- Granites

GEOTHERM

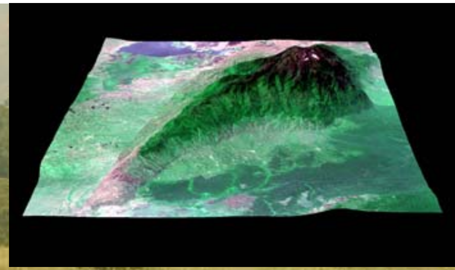
- BGR-DGSM
- DETAILED SURFACE ANALYSIS OF BURANGA

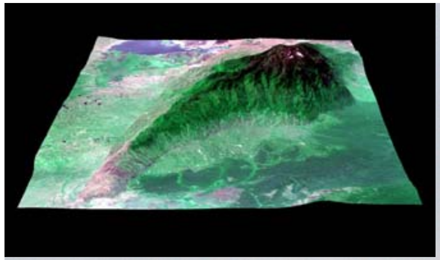
SCOPE OF WORK

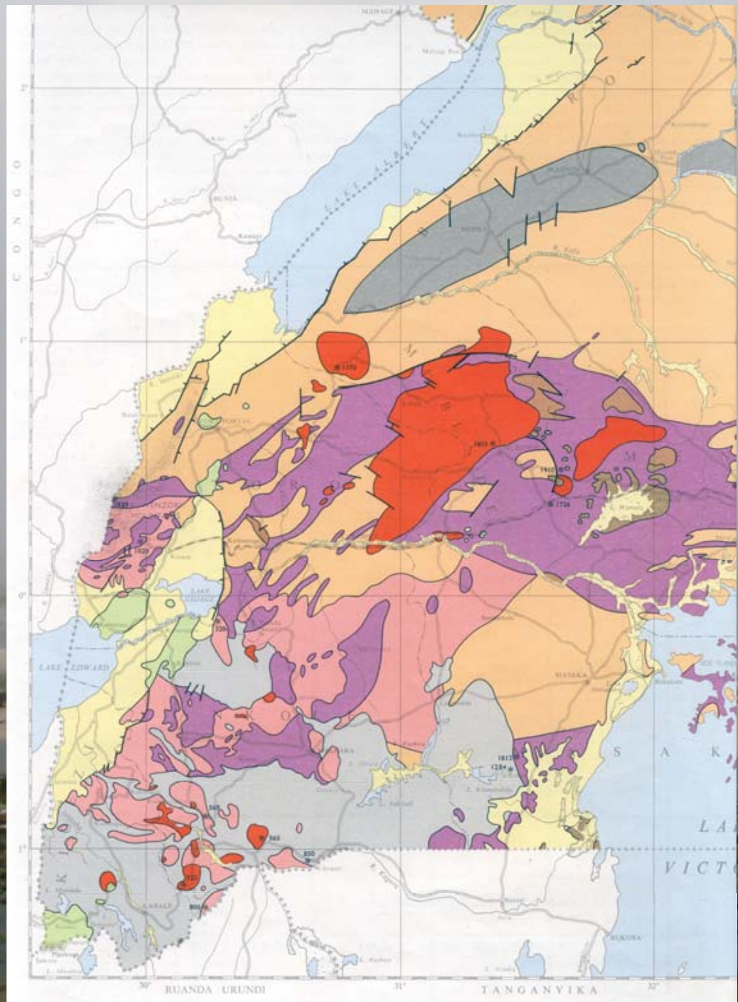


- Ground geophysics (gravity, geo-electric, TEM, Micro seismic)
- Geochemistry
- Geology (Remote sensin

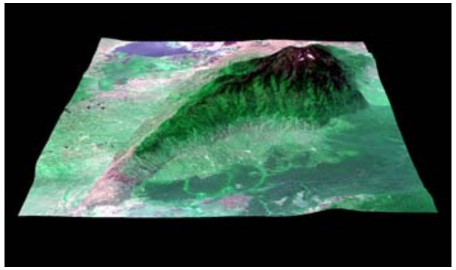
Contents

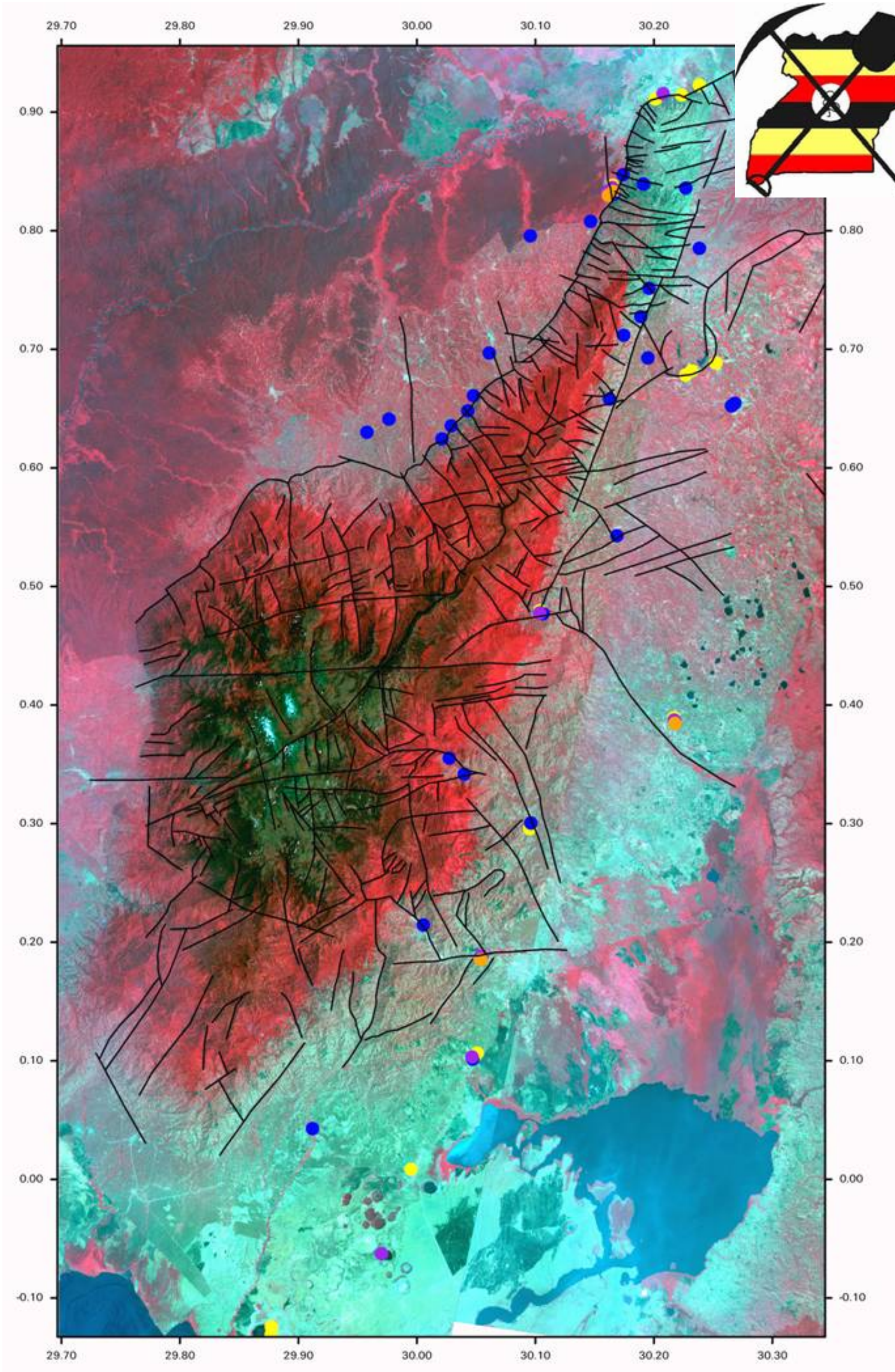






- Basement rocks
- Tertiary sediments
- faults
- Seismically active

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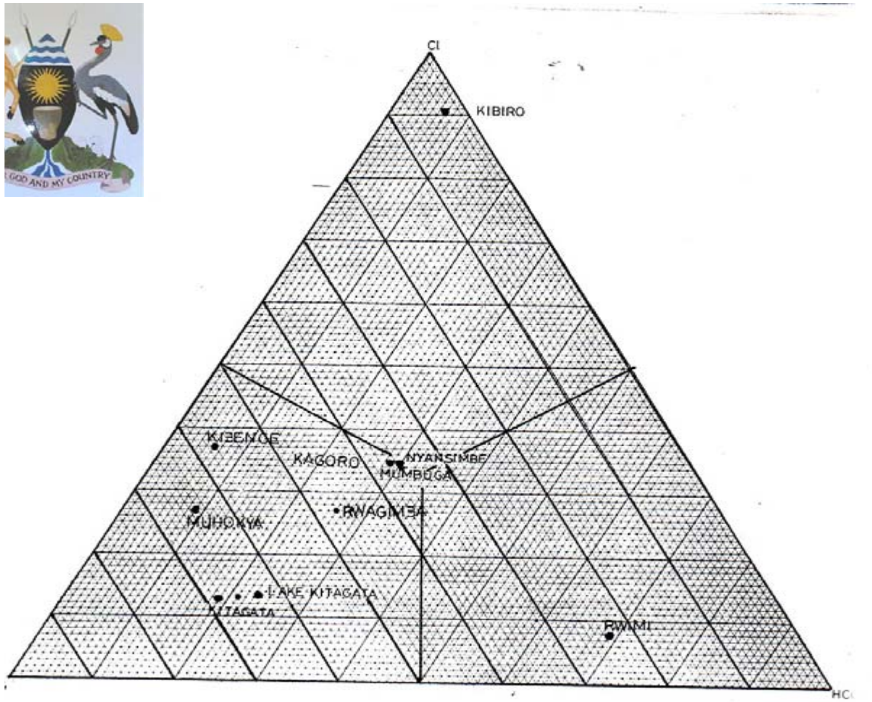
Surface Temperatures

- Buranga (95°C)
- Rwimi (25°C)
- Rwagimba (65°C)
- Bugoye (25°C)
- Kibege (45°C)
- Muhokya (41°C)
- Mubuku (41°C)

Surface manifestations




- Hot springs > 50°C
- Warm springs 26-50°C
- Hydrothermal deposits
- Gaseous emissions / bubbling pools
- Geothermal grass
- Hot pools
- Seepages


Cl
KIBIRO
KIBENGE
KAGORO
NYANSIMBE
MUMBUGA
MUHOKYA
RWAGIMBA
LAKE KITAGATA
KITAGATA
RWIMI
HC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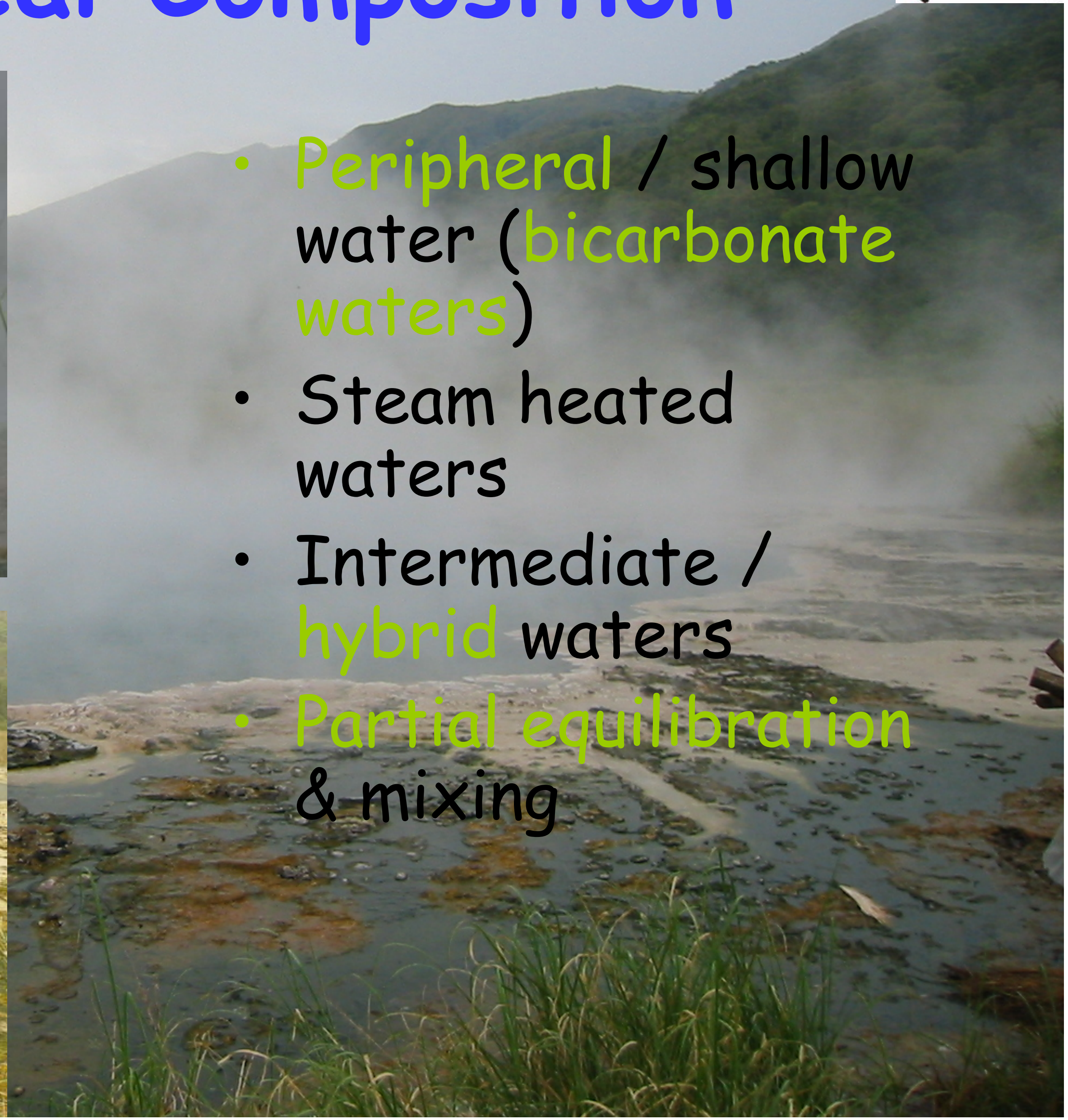
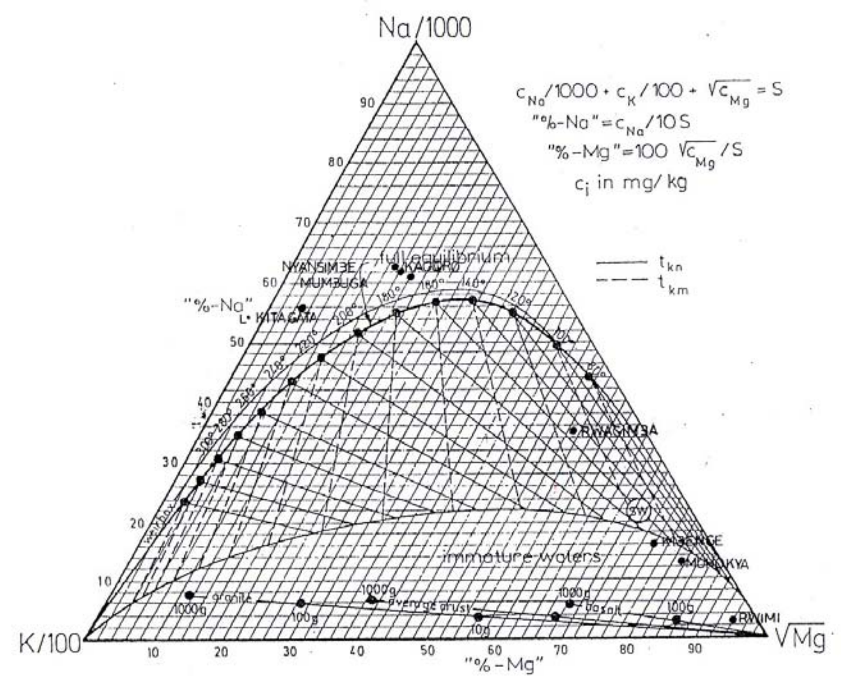
Chemical Composition



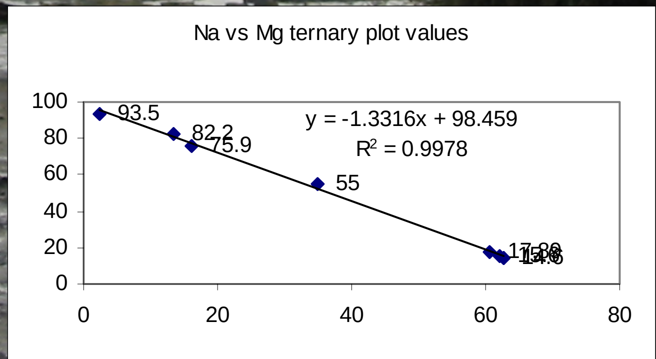
- Peripheral / shallow water (bicarbonate waters)
- Steam heated waters
- Intermediate / hybrid waters
- Partial equilibration & mixing

Geo-thermometry



Na Vs Mg

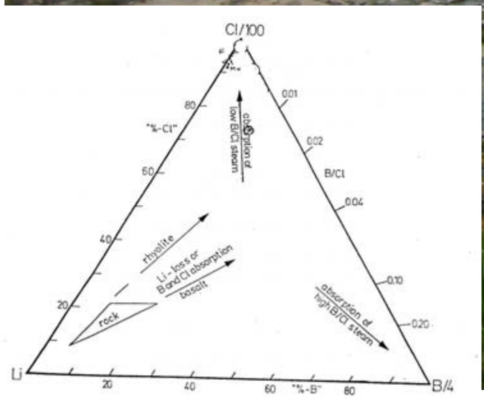
- R2=0.9978
- Very high correlation
- Genetic implication



Mg contents

- Influence of meteoric waters / surface derived water
- Immature waters (Rwimi, Kibenge & Muhokya)
- Genetic relationship
- Partial equilibration / mixing
- Boiling –high solute contents (Buranga)

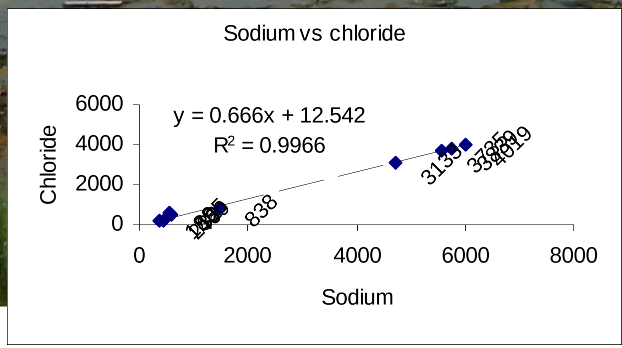
Li/Cl

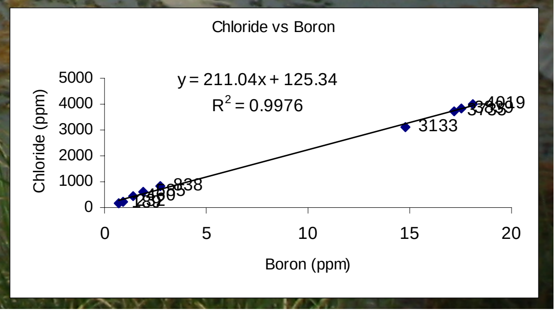


Cl/100
Li
B/4
"%-Cl"
"%-B"
B/Cl
0.01
0.02
0.04
0.10
0.20
80
60
40
20
absorption of low B/Cl steam
rhyolite
Li - loss or B and Cl absorption
basalt
rock
absorption of high B/Cl steam

Na vs. Cl

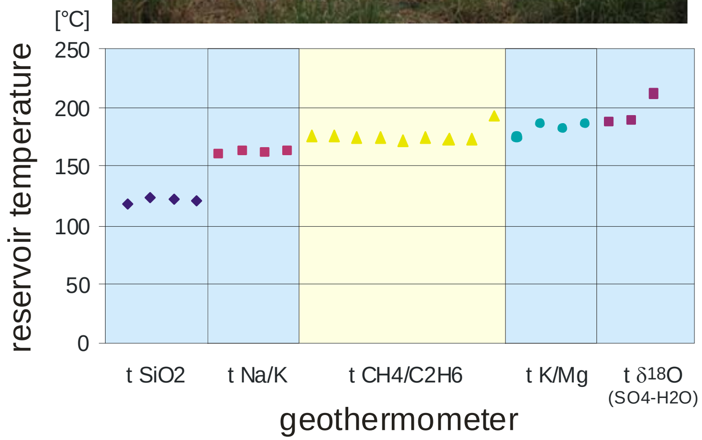
- R2=0.9966
- Very high + correlation
- Genetic implication





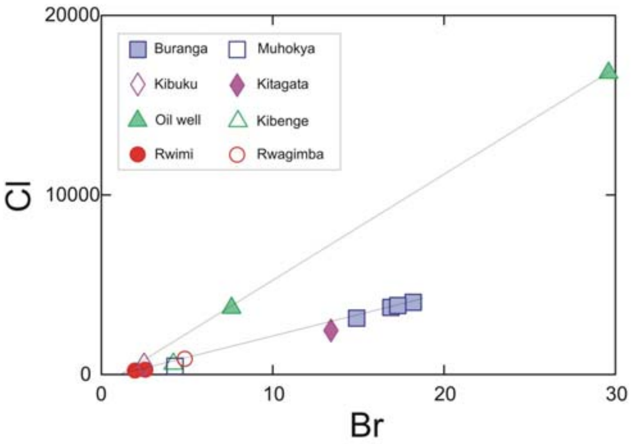
Chemical geothermometry

- Immature waters (Kibenge, Muhokya, Rwimi)
- Deposit travertine
- Not justified (not even partial equilibrium)
- Lower temp (~150oC) typical of environments created by the absorption of CO_2-rich vapors into groundwater at the periphery of a system.

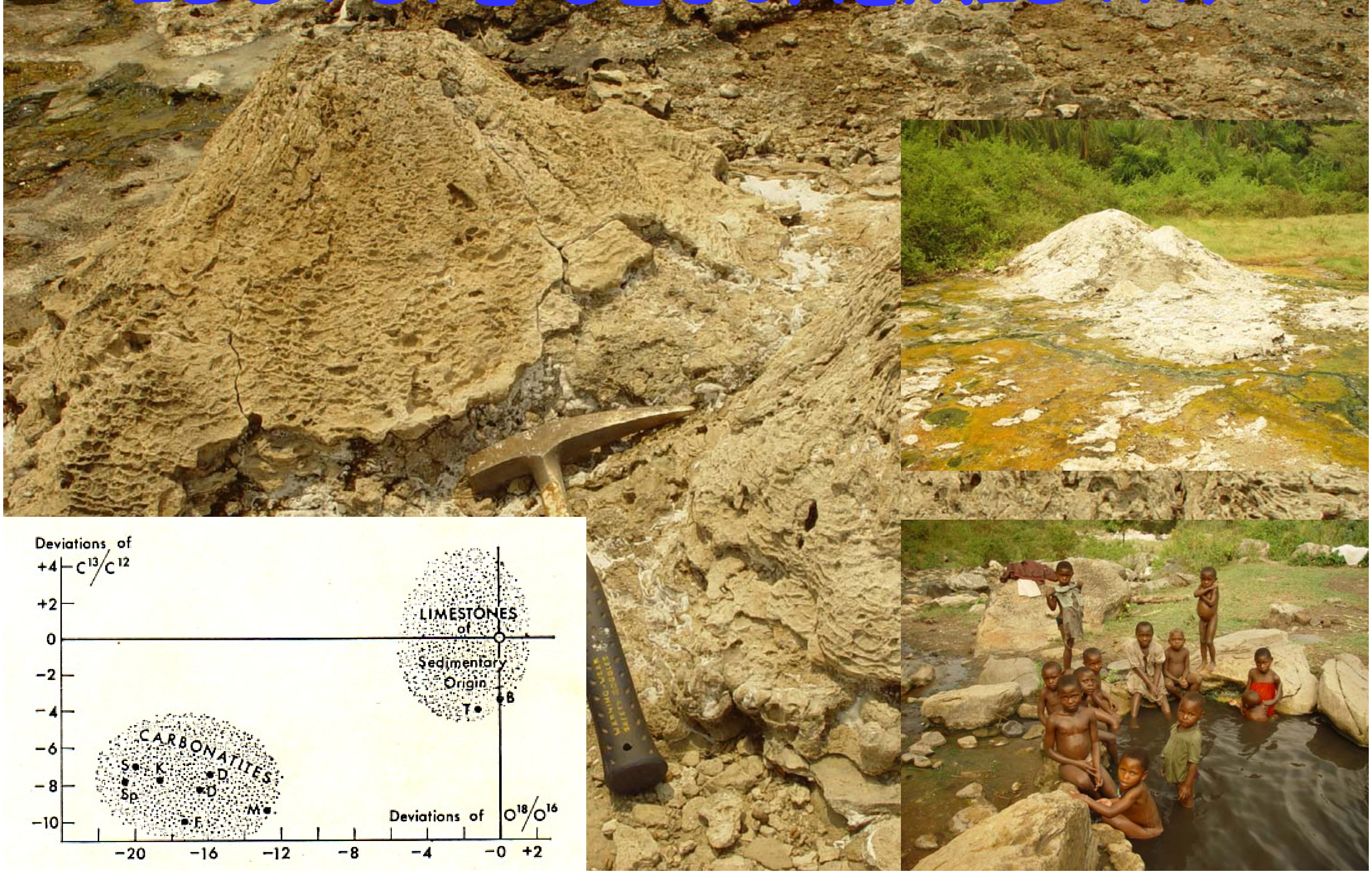


Salinity analysis

- The Br/Cl ratios fall in a range 0.00451 to 0.01120.
- Seawater (typically 0.00347) Cl=19000mg/l, Br=65mg/l.
- Silicate rock-water interaction / fluid inclusion leaching

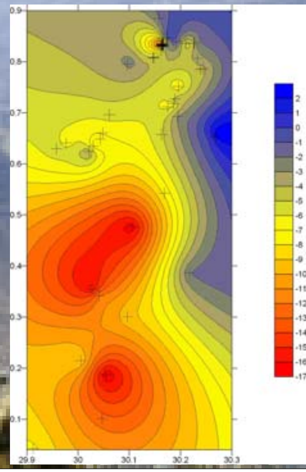


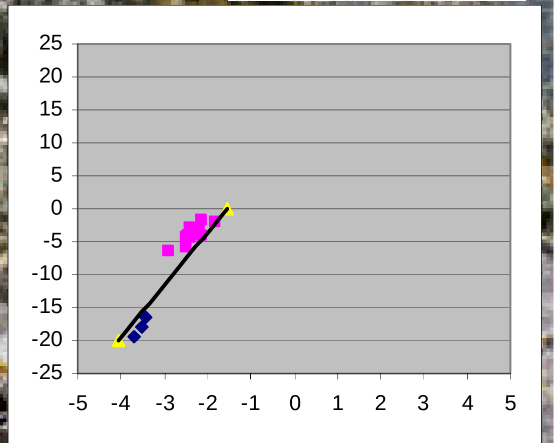
ISOTOPE GEOCHEMISTRY

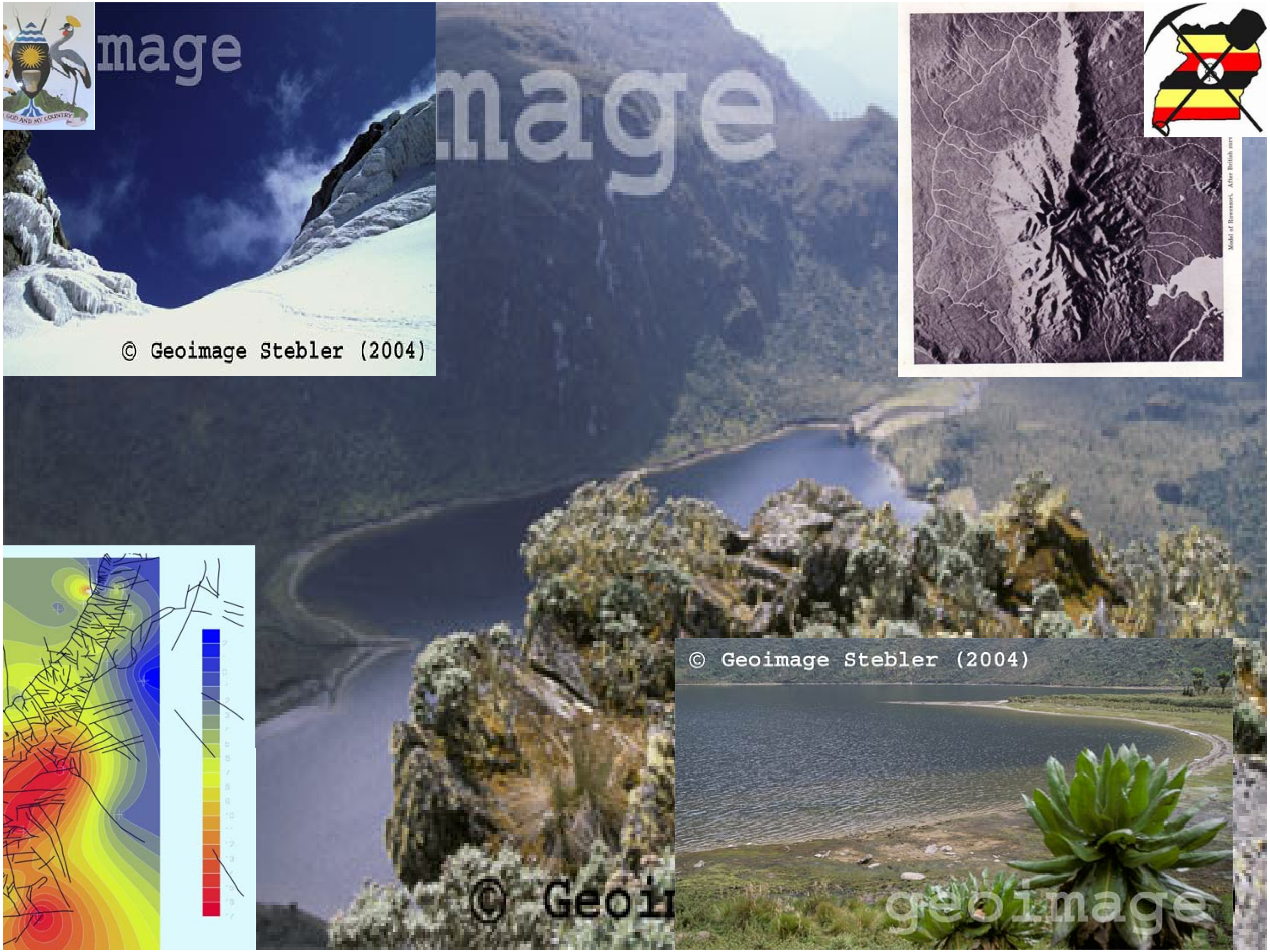


Isotope Geochemistry

- Recharge by local meteoric waters
- No major Oxygen-shift
- Isotopically lighter
- Higher altitude



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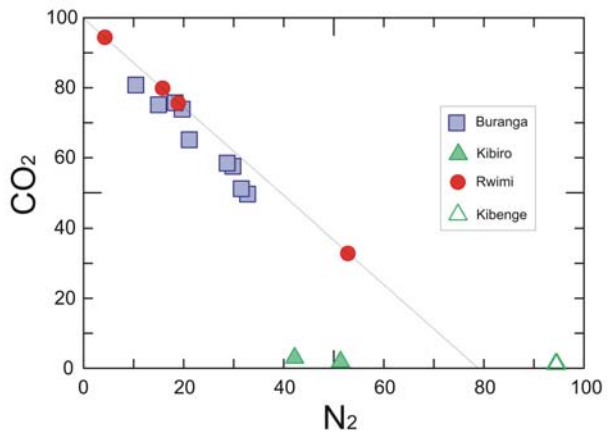
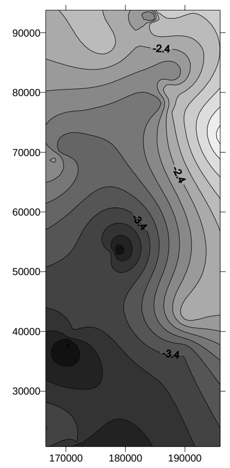
Gas geochemistry

- Greater meteoric ASW recharge (from Mt. Rwenzori, southern end)
- Greater heat conduction resulting low surface temperatures.



Oxygen-18 distribution

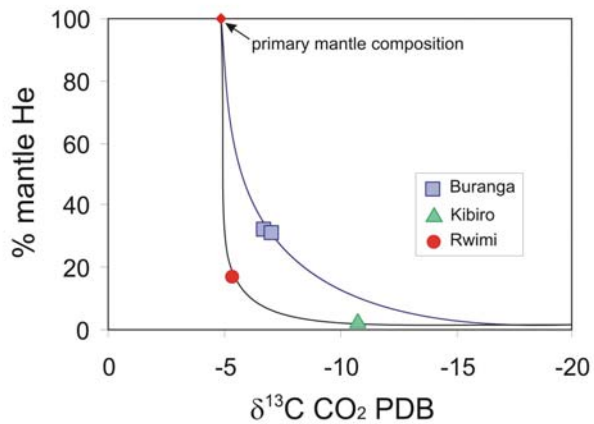
- Trend northwards
- More proximal to heat



Noble gas geochemistry

- R/Ra 1.5-2.8
- Rwimi 1.5
- Reduced influence of mantle helium

Location	Ne/He	$^{3}He/^{4}He \times 10^{-6}$	$^{4}He\_Nml$	R/ Ra
Mumbuga	0.002	3.80	3.00×10^{-2}	2.7
Mumbuga	0.002	3.75	7.00×10^{-2}	2.7
Kagoro	0.002	3.90	2.00×10^{-2}	2.8
Rwimi	0.002	2.10	5.00×10^{-4}	1.5
Kibiro	0.002	3.00	6.00×10^{-3}	2.1



Noble gas geochemistry

- mantle-derived helium (intrusion?)
- crustal contamination
- reduced influence (Rwimi)
- dilution by radiogenic helium (crustal)

δ13C in CO2

- -5.3 and -5.9‰, Rwimi
- deep magmatic fluids
- (-8 to -4‰; Allard and others 1977; Allard, 1979, Rollinson 1993
- MORB *(-8 to -5‰, Taylor et al, 1967, Deines. 1970*
- Buranga δ13C values -6.5 & -7.3‰,
- Kibenge δ13C values -19.8 & -20.5‰.

δ13C in CO2

- Breakdown of organic materials in sedimentary rocks

- 20‰ (Rollinson, 1993).

δ13C in CH_4

- Kibenge δ13C (PDB) in CH_4 are as low as - 22.6‰
- Buranga δ13C values clustering between between -52.7 to - 54.2‰ .
- Present evidence, primordial, decomposing sediment, or from reduction of magmatic carbon dioxide.

CH_4-CO_2

- (CH_4-CO_2) tend to get higher as you move northwards
- High meteoric recharge from the south
- greater flushing of S springs over time by meteoric water, possibly resulted in most gases having been swept from the south (Kibenge, CO_2 vol% 1.17, Methane vol%, 0.25).
- Rwimi & Buranga huge quantities.
- Less flushing by meteoric fluids in the north

HYDROGEN

- H2 must have undergone partial conversion to CH4 and NH3
- Not detectable (Kibenge, Rwimi, Mumbuga & Kagoro)
- Absorbed in O2-rich meteoric waters

Tritium

- No detectable tritium (Kibenge & Buranga)
- Large scale atmospheric testing of thermonuclear bombs (1952)
- Pre-bomb tritium values
- Isolated from direct contact with atmosphere

87Sr/86Sr

- Buranga (0.7195-0.7287).
- Granitic gneiss (crystalline basement rocks)

HYDROLOGY

- Meteoric recharge from Mt Rwenzori
- Cold water (high density)
- Hot water (low density)
- Crystalline rocks (fractures, faults)
- Convecting magma (heat)
- +Driving force (difference in altitude)
- Difference in density
- Gravitational recharge

AREA SELECTION

- Muhokya, Kibenge, Rwimi, Bugoye and Nyakalenjijo - very low temperatures and correspondingly very low discharge rates
- Marginal springs, lost much of their heat by conduction
- Temp of the rocks at the sweep base are not high, buoyancy forces are small which explains low surface discharge rates.
- Northwards, an in discharge rate and surface discharge temperatures are noticed reaching maximum at Buranga (95oC, and discharge rate greater than 17 l/sec).

AREA SELECTION

- Buranga hot-springs migratory channels are presumably surrounded by hot rocks (high heat flow zone, with little heat being lost by conduction, except very close to the surface).
- Buranga springs qualify to be more proximal to the up-flow zone

Conclusion

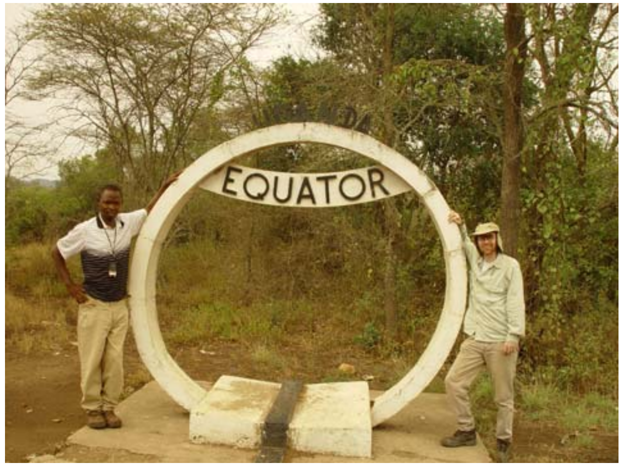
- Low SiO2 Levels reflect low temps
- Hybrid / intermediate waters
- Recharged from Mt. Renoirs
- Pre-bomb waters
- Hydrological connection / Genetically related (single hot water reservoir?)
- Marginal / periphery waters
- Magmatic heat source / crustal contamination

Conclusion

- Chloride salinity = Largely derived Silicate rock water interaction / fluid inclusion leaching
- Slightly to moderately saline (TDS)
- Recharge from south to the north (ASW)
- Buranga is more proximal to up-flow zone
- Fracture controlled reservoir
- Partial equilibration & mixing

Acknowledgment

- Federal Republic of Germany (BGR)
- Uganda Government (DGSM)



Thank you!!!!!