# Geothermal Surface manifestation mapping in South-Western Tanzania

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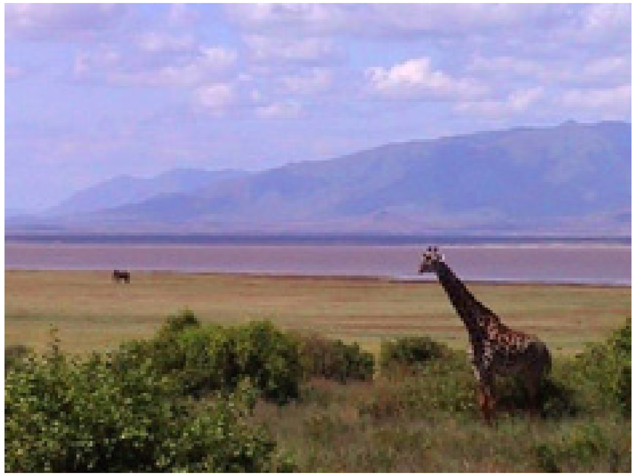
# UNITED REPUBLIC OF TANZANIA

- **Location:** East Africa lat. 1°S to 11°45´ S and long. 29° 21´E to 40° 29´ E
- **Population:** 34.6 M(2002)
- **Size**: 945,087 $Km^2$
- Percapita energy consumption 0.7 ToE (tonne of oil equivalent)

# UNITED REPUBLIC OF TANZANIA



Physical features

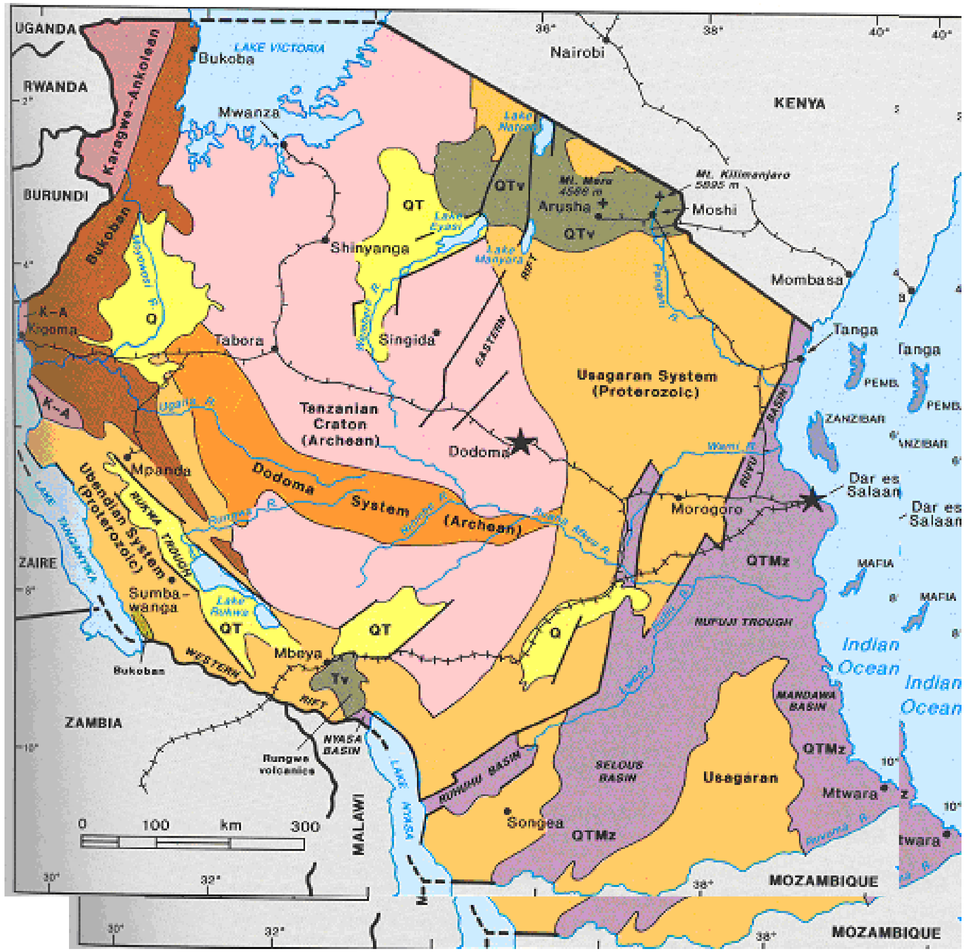
-A land of plenty from wildlife, forests products, minerals (gold, tanzanite, emerald and diamonds etc) gas, solar, Wind and geothermal;

- with African's highest mountain (Kilimanjaro) at 5,895m and lowest point (lake Tanganyika) at 358m below sea level

- Spectacular lakes;

Tanganyika, Nyasa, Natron, Manyara and Eyasi in the East African Rift valley, bounded by fault scarps

# General geology




Dominated by a large mineralized Precambrian craton with formations of >2 bil yrs old, rimmed by Proterozoic crystalline rocks.

Younger sediments and volcanoclastics of recent, occupy the rifted graben, coastal plains and inland basins

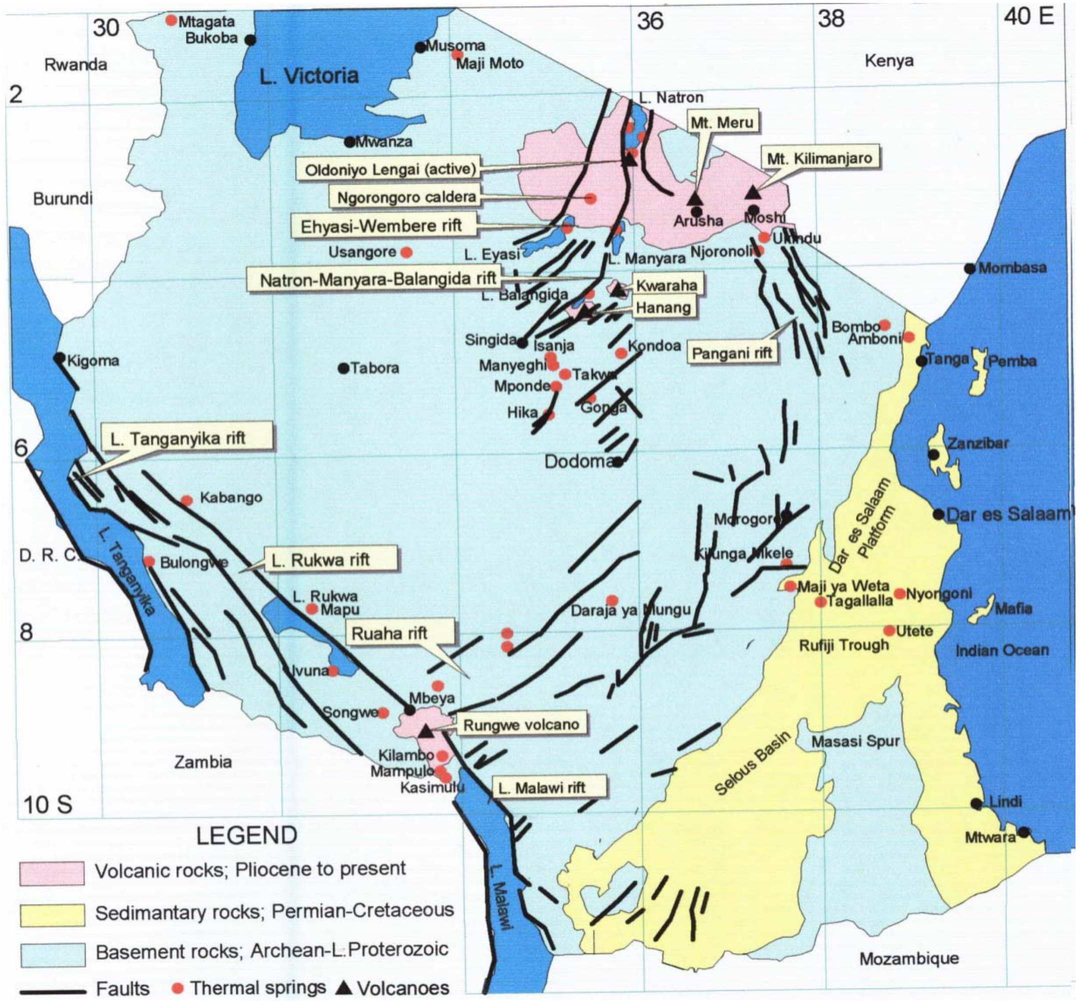
# Electricity

| | |
|---|---|
| Generating capacity (2006): 1018 MW | |
| 72.3% owned and operated by TANESCO | |
| Hydro | 561 MW |
| Natural gas | 182 MW |
| Diezel IPP | 100 MW |
| Isolated 10 towns (decentralized) | 55.5 MW |
| Other IPPs | 41.5 MW |
| Imported (Zambia and Uganda) | 13 MW |
| Comsumption: | 46 kWh/capita per annum |
| Access to electricity | 11.5 % of population |
| Rural population access to electricity | 2% |
| Geothermal | - |

# Geothermal sites in Tanzania

**the studied area and the selected GEOTHERMAL project region**

There are more than 15 locations, with more than 50 hot springs of temp > 40°C;
- Some are found over and near the active rift segments within Quarternary volcanism and in Pre-cambrian craton



# Potential locations

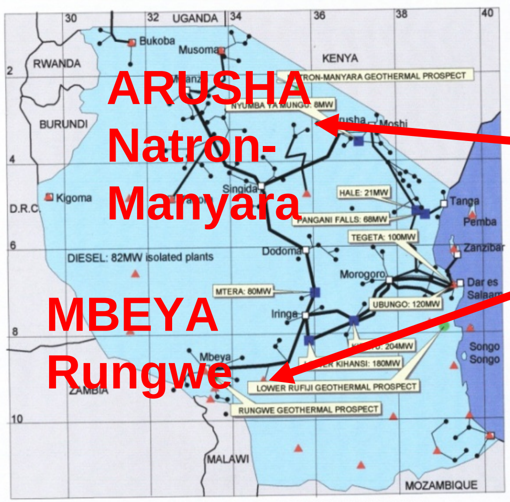



Fig.1. THE EXISTING POWER SUPPLY SYSTEM IN TANZANIA AND LOCATION OF PROPOSED GEOTHERMAL PROJECT SITES

LEGEND

Power transmission lines: 220 kV, 132kV, and 66 & 33 kV

Power plants: Hydro, Thermal (Gas turbine plants at Ubungo, diesel elsewhere)

Major cities and towns, other towns

Proposed geothermal exploration and development locations

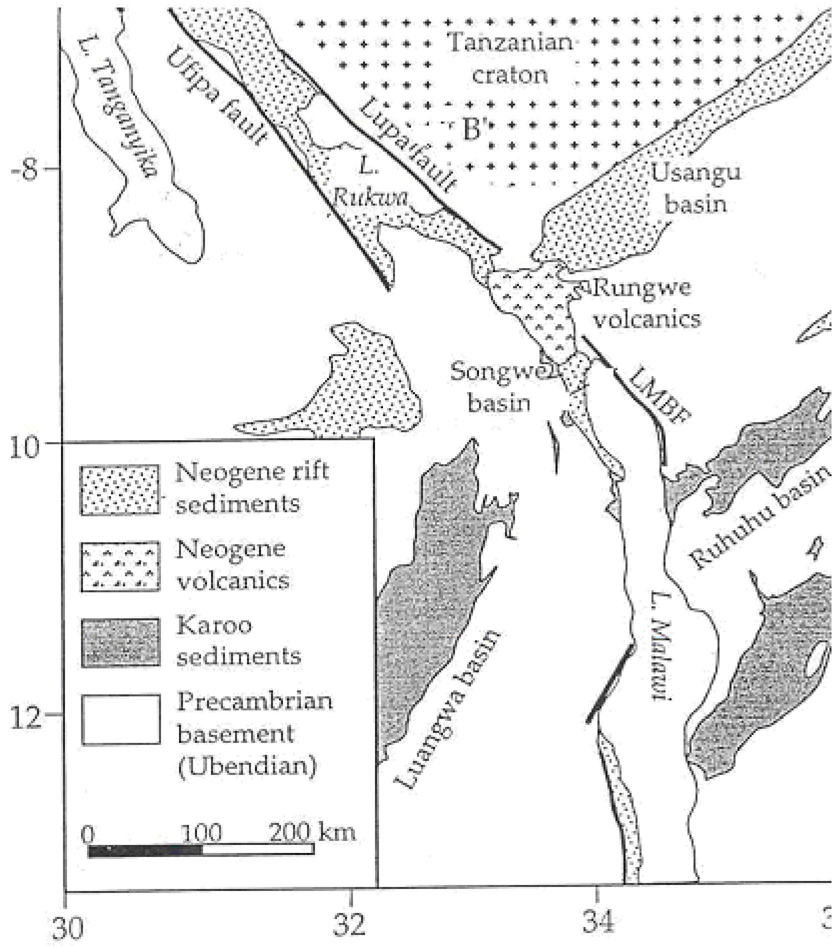
**LOCATION OF MOST POTENTIAL GEOTHERMAL SITES IN TANZANIA**

**Estimated Potential 560 MWe (1981)**

# Mapping surface manifestations in South western Tanzania,

- Geothermal mapping of surface manifestations, which includes structural mapping and hydrothermal mapping was carried out in the four geothermal prospects of South-western Tanzania namely Songwe, Mapulo-Kasimulo, Rungwe and Lake Ngozi area.

# Fig 1: Simplified geological map showing the triple junction, location of the study area, in the Rift valley



# Field work

- Springs in the three different prospects were mapped (Fig.3.1, 3.2 and 3.3)
- different parameters such as temperature, flow rate, altered rock, mud pools, sulphur, artesian springs and structure setting of the springs were observed and recorded.
- Water samples were collected

# Field sketch map 1

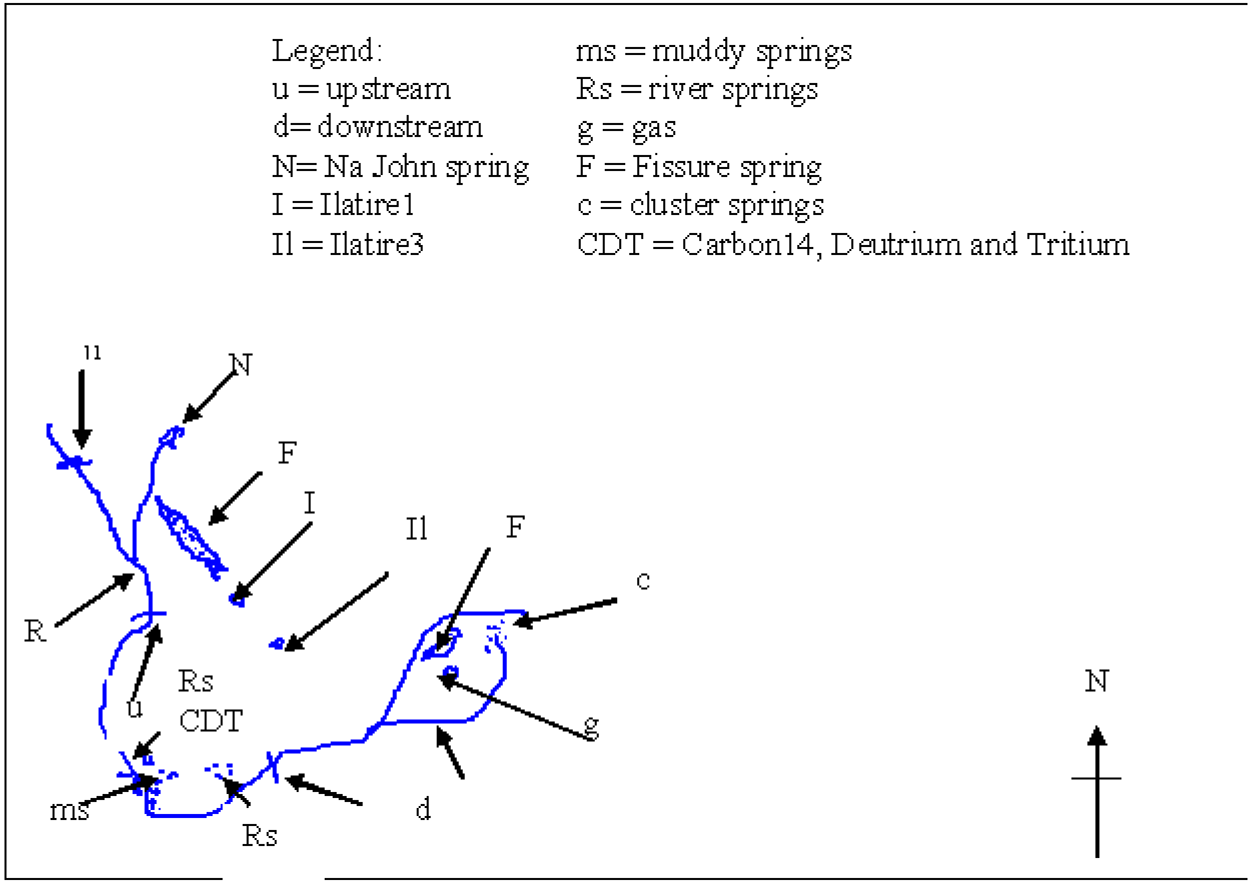



**Fig. 3. 1: Sketch map of Songwe valley sampling locations**

# Field Sketch Map 2

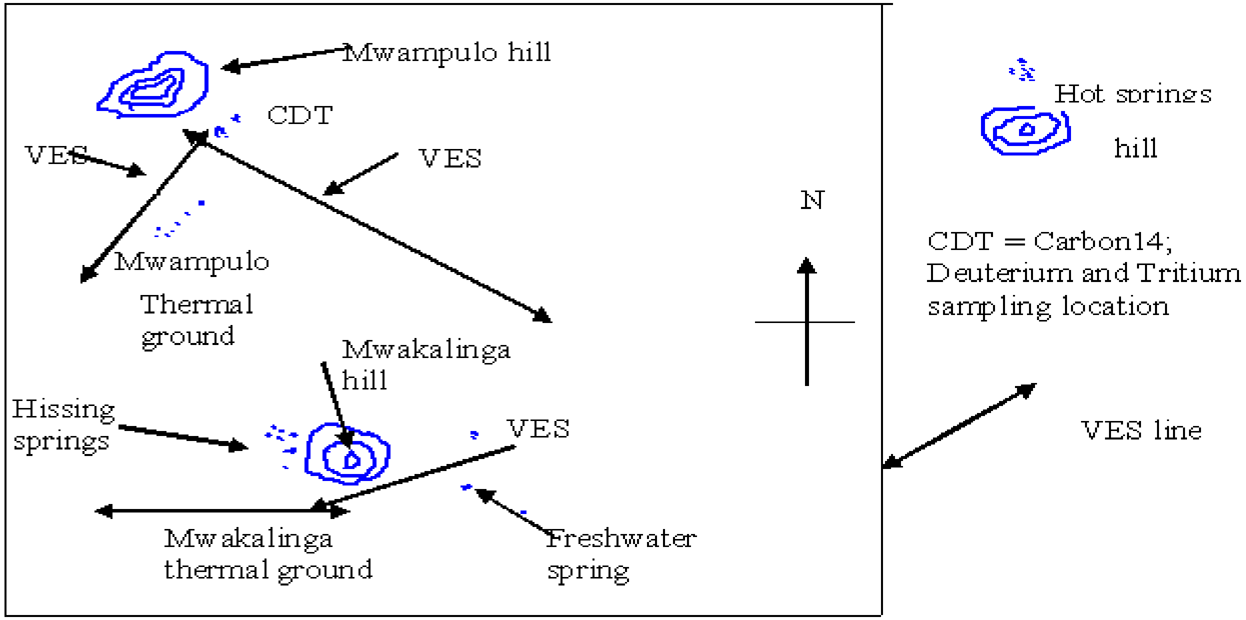



**Fig. 3.2: Kyela showing the Mampulo and Mwakalinga thermal grounds**

# Field SketchMap 3

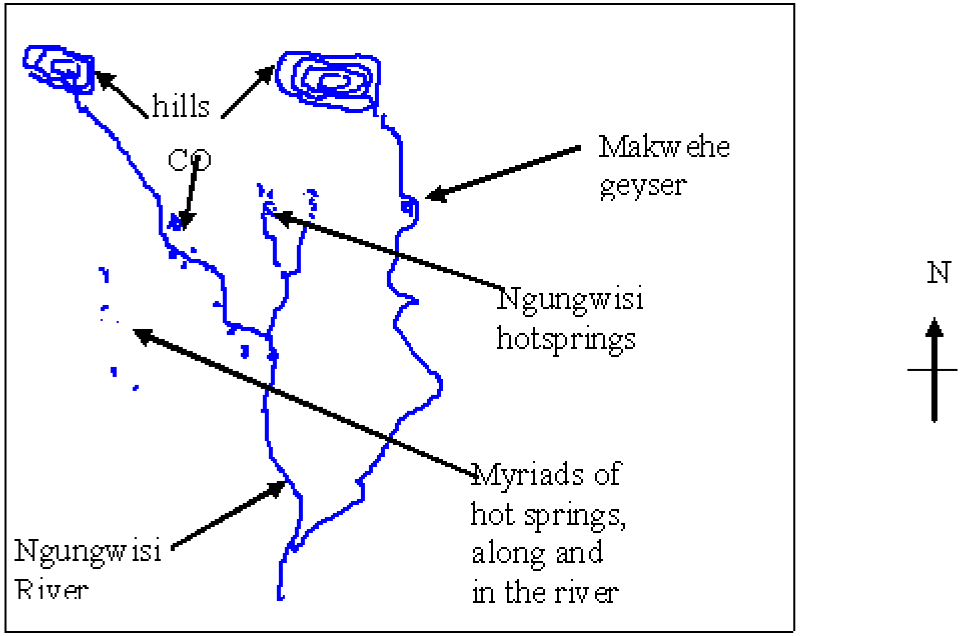



**Fig. 3.3: Rungwe hot springs**

## Surface spring maximum temperatures encutered

- Rungwe 98$^oC$ at Makwehe geyser
- Ngugwisi river springs 86$^oC$
- Songwe springs and Malonde 85$^oC$
- Mampulo and Kasimulo 65$^oC$
- Lake Ngozi 65$^oC$

# Surface manifestation

*Plate 4.1: Songwe-Bwana Hutu hot ground*

# Vegetation zonation

***Plate 4.2: Mampulo hot ground showing vegetation zonation***

# Fracture spring

***Plate 4.3: A fracture controlled spring, steam rising along the fracture from the boiling water within***

# Intermittent discharge; geysers

***Plate 4.4: Makwehe-Rungwe geysers with steam rising at the top left corner of the photograph***

# Water type

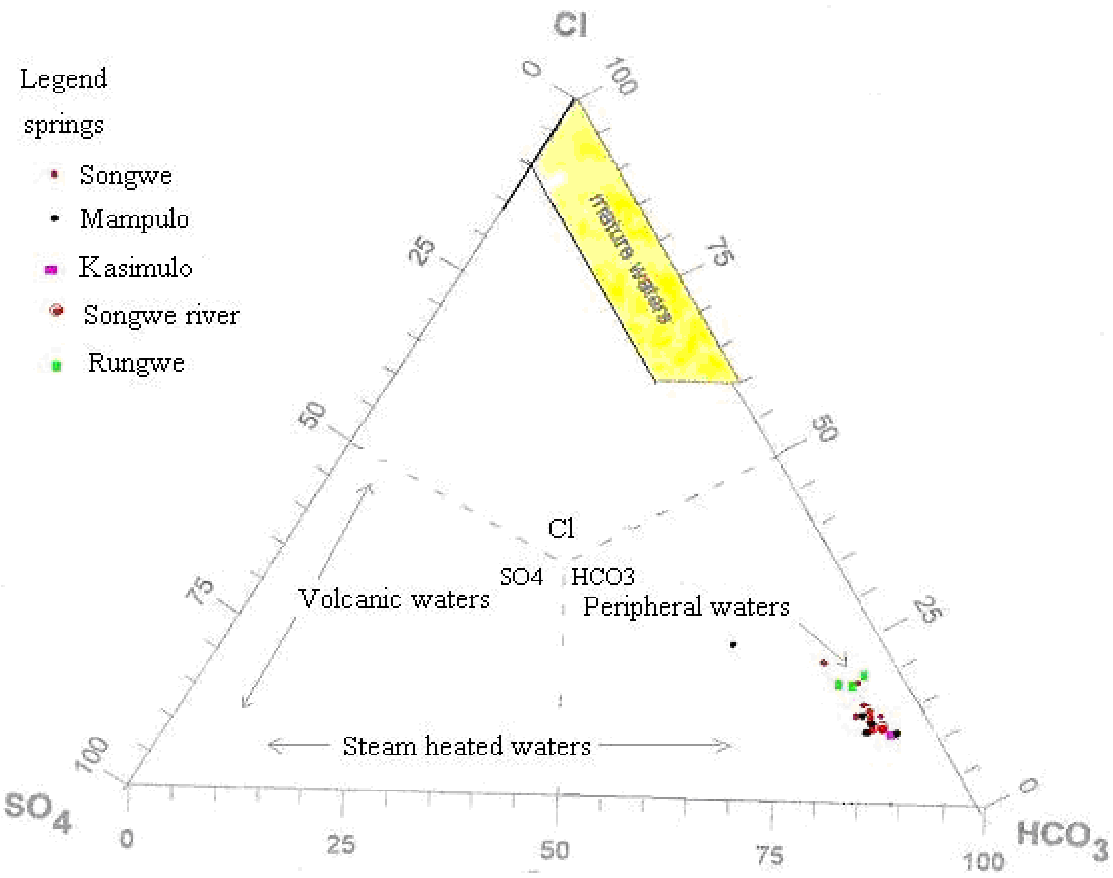



**Fig.4.1 Classification of water type by Cl-HCO3-SO4 ternary diagram**

Fluid mineral equilibria and subsurface temperatures

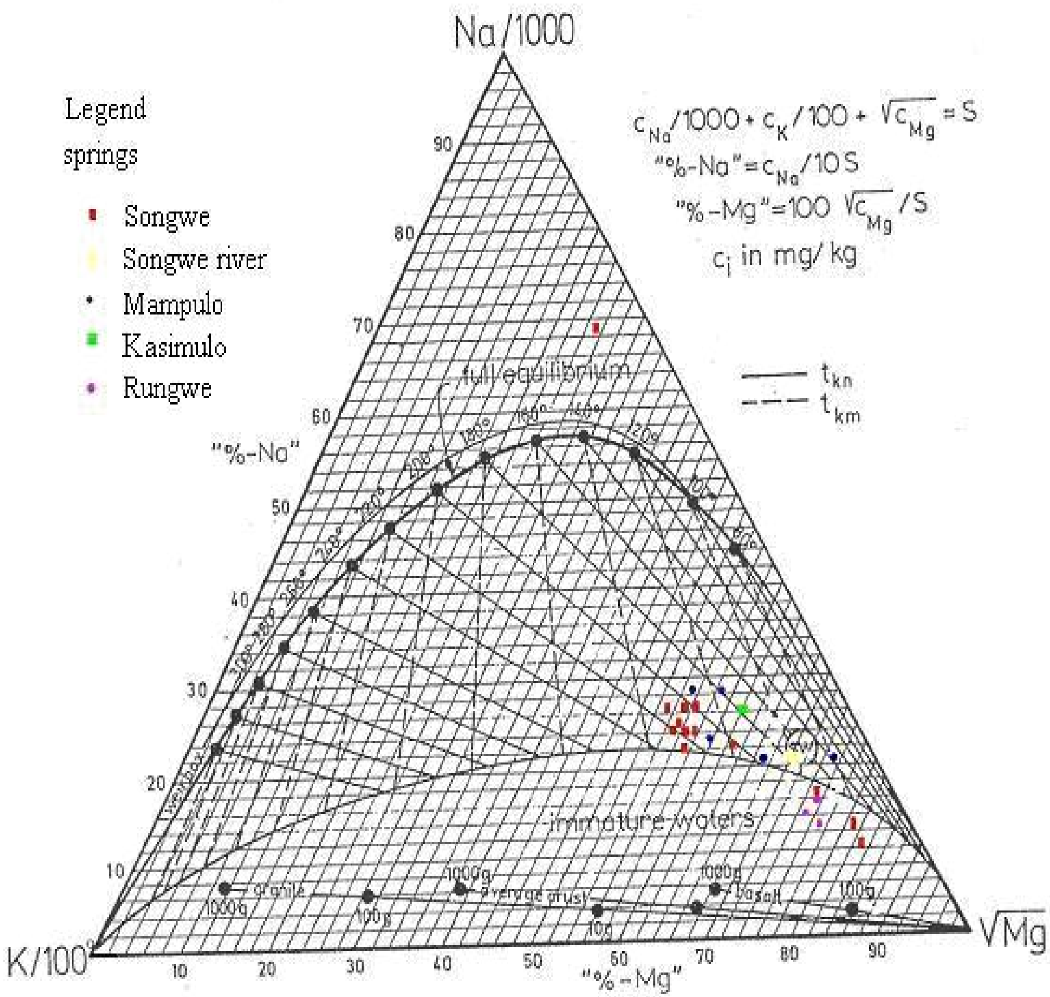



**Fig. 2: The (Na+- K+-(Mg+2)1/2) ternary diagram for Dec. 2002**

# Tkn temperatures from the ternary

The temperature given by tkn in the diagram were around

- 220$^{o}$C Rungwe;
- 210$^{o}$C Songwe;
- 209$^{o}$C Mampulo and
- 180$^{o}$C Kasumulo

## Heat stored, Potential stored heat and the Power potential of the prospect

- From the literature it was reported that the prospect have a temperature of 270$^o$C (SWECO-VIRKIR, 1978),
- therefore this was used as the maximum temperature in the calculation of a rough estimate of heat stored
- in rocks, fluid, vapor and condensate;
- potential stored heat and
- power potential of the prospect:

# Potential usable heat

- Potential usable heat = Q/ + Qv + Qc
- = 0.27 x 1018J + 0.014 x 1018J + 2.24 x 1018 J
- = **2.52 x 1018J.**

$$P(MWe) = \left[\frac{Potential\ usable\ heat * recovery\ factor * efficient\ conversion\ factor}{Lifetime\ (yr) * days(per\ year) * hours(per\ day) * seconds(per(hour))}\right] \ldots\ldots\ldots\ldots\ldots(4.9)$$

# The Songwe prospect Power Potential

- The assumption was made that
- the resource have a life span of 25 yrs,
- a recoverable factor of 0.25 and
- an efficient conversion factor of 0.162.

# Songwe prospect Power Potential

$$P(MWe) = \left[ \frac{Potential\ usable\ heat * recovery\ factor * efficient\ conversion\ factor}{Lifetime\ (yr) * days\ (per\ year) * hours\ (per\ day) * seconds\ (per\ (hour))} \right] \ldots\ldots\ldots\ldots\ (4.2)$$

$$P(MWe) = \left[ \frac{2.52\ x\ 10^{18}\ x\ 0.25\ x\ 0.162}{25\ x\ 365\ x\ 24\ x\ 3600} \right] = 1.07\ x\ 10^{8}\ (J/s)$$

= 107 x 106 (J/s) = **107 MWe**

# Conclusion and Reccomandation

- From these preliminary studies of surface manifestations it shows that the South-Western Tanzania prospects have a prospective geothermal potential with surface maximum temperature range of $65^oC$-$98^oC$
- Subsurface temperatures maximum ranging between $180^oC$-$220^oC$ (tkn)
- An estimated power potential of the Songwe prospect is about 107 MWe.
- It is recommended that further work for developing the resource should be taken into consideration.

# What Next?

- So far, the highest potential prospect for geothermal power exploration is at the south-western Tanzania (the Rungwe volcanics and Songwe/Rukwa basin)
- The study to identify exploratory drilling sites need a detailed exploration plan, intergrating geological, geophysical (TEM, MT, Gravity), fluid chemistry, isotopes and gases
- Training in different kinds of geothermal displines to build geothermal human resources capacity
- Move to appraisal studies and field development for more promising sites
- Create awareness on geothermal
- Conduct nationa-wide geothermal resource assessment for production of a national geothermal resource map
- Facilitate international cooperation in geothermal development.

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