



OVERVIEW OF GEOTHERMAL RESOURCE UTILIZATION AND POTENTIAL IN EAST AFRICAN RIFT SYSTEM

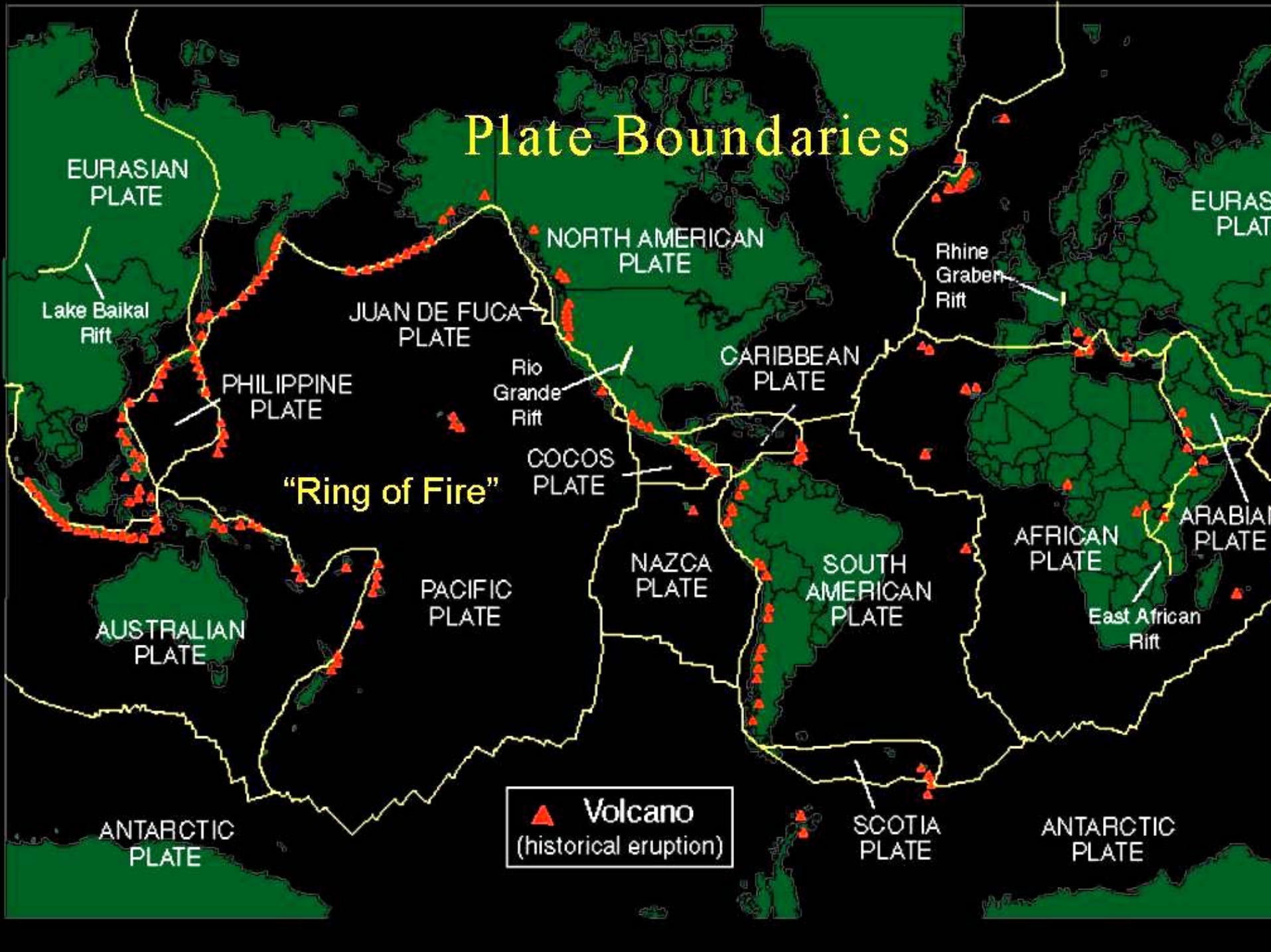
Meseret Teklemariam

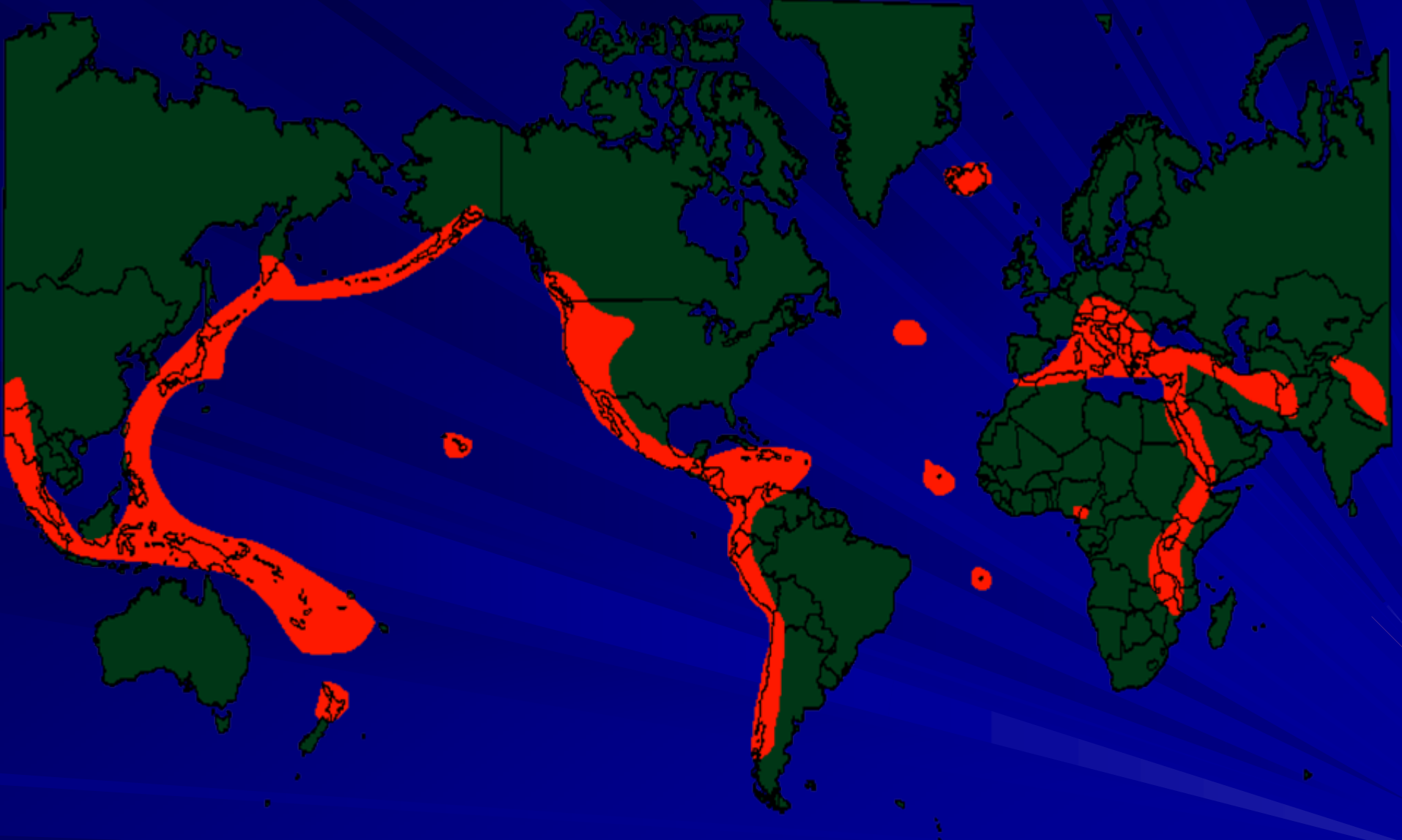


**The First International Conference on geothermal Energy
in the East African Rift Region
November 24-26, 2006
Addis Ababa, Ethiopia**



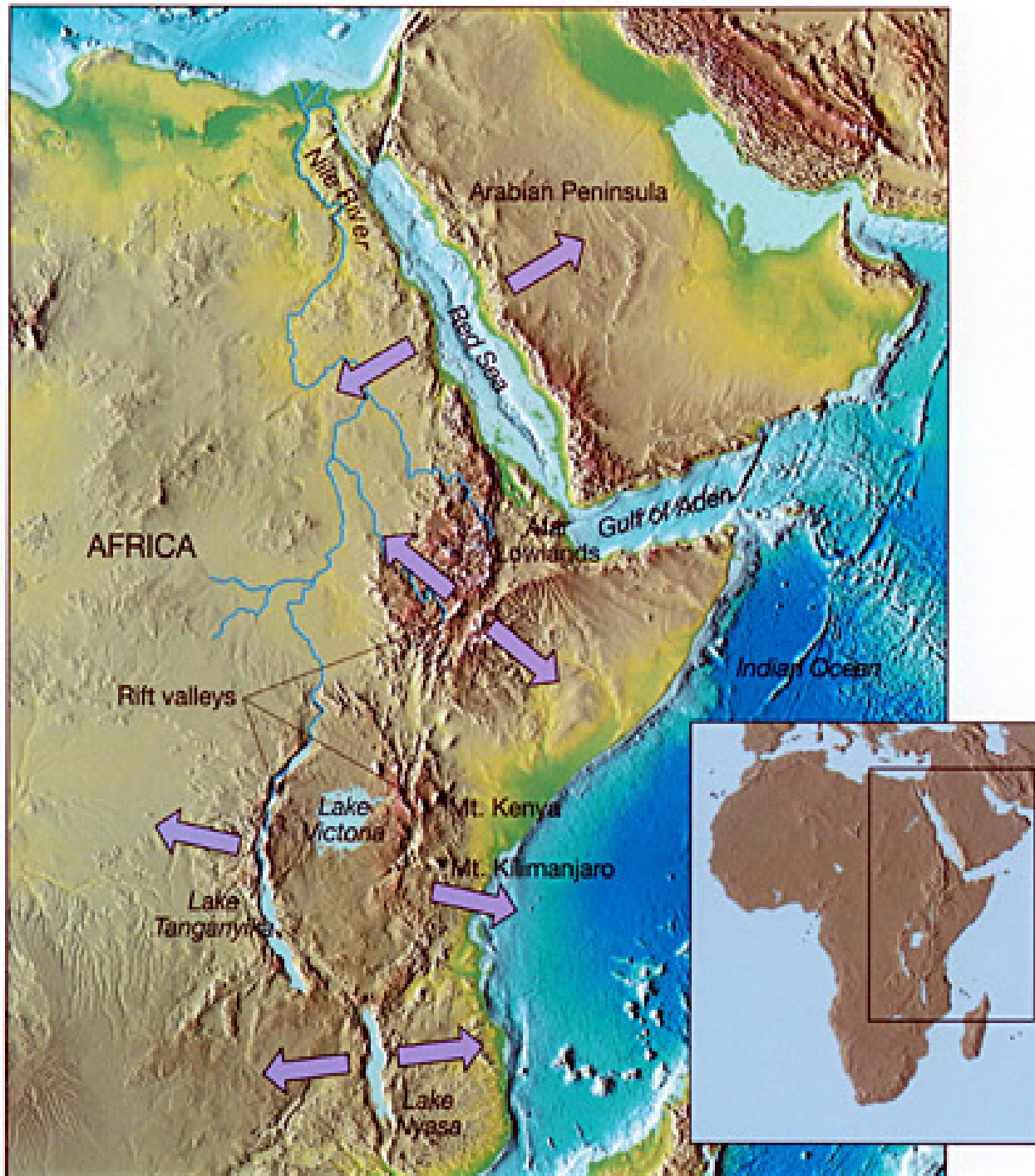
Plate Boundaries



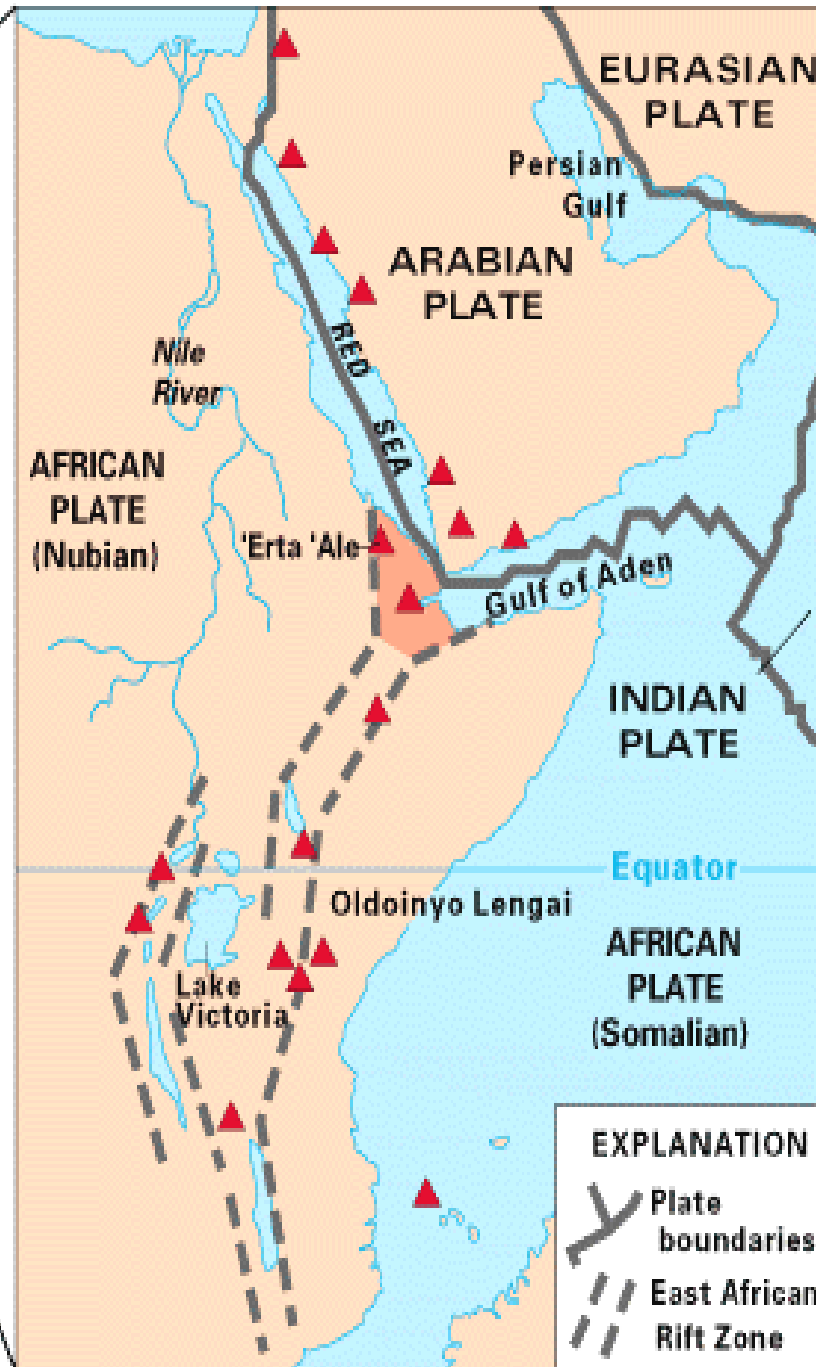


Hottest Known Geothermal Regions

THE EAST AFRICAN RIFT SYSTEM



THE EAST AFRICAN RIFT SYSTEM GEOTHERMAL POTENTIAL



THE EAST AFRICAN RIFT GEOTHERMAL POTENTIAL

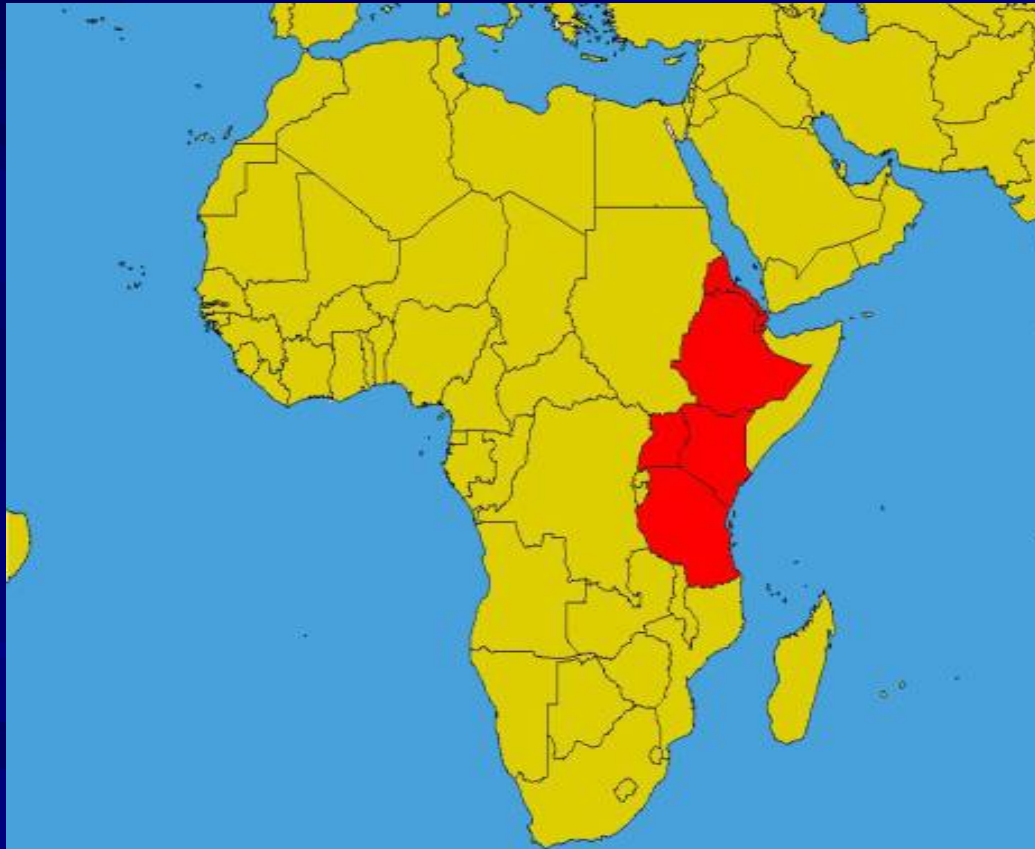
**E. G. R.P =
7000 MWe**



- **Most of the EA countries are dependent on TBF= 70- 90%: Causes Deforestation & Environmental degradation**
- **East African Countries are committed to investigate and further develop GE due to:**
 - **Strong growth in electricity demand in the countries**
 - **Hydro proven unreliable as a base load source due to Recent effects of drought**
 - **Volatile nature of petroleum fuels etc..**
- **RE sources (hydro, geothermal, solar) represent a small portion of TEP averaging 2%.**



African Countries Using Or Having Carried Out Research On Geothermal Resources



- Djibouti
- Eritrea
- Ethiopia*
- Kenya*
- Malawi
- Tanzania
- Uganda
- Zambia

*Plant installed

DJIBOUTI

**TIC= 85 Mwe
(Thermal)**

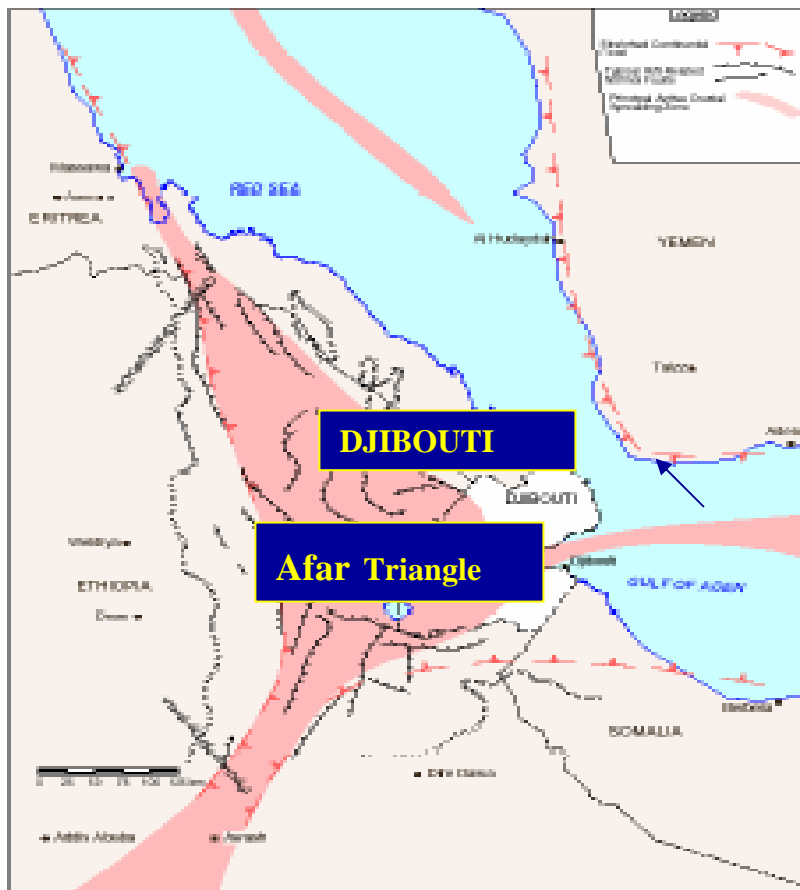


Figure 4.1.1. Afar Triangle and Asal Geothermal Area Regional Tectonic-Structural Relationship



GEOHERMAL PROSPECT AREAS OF THE REPUBLIC OF DJIBOUTI

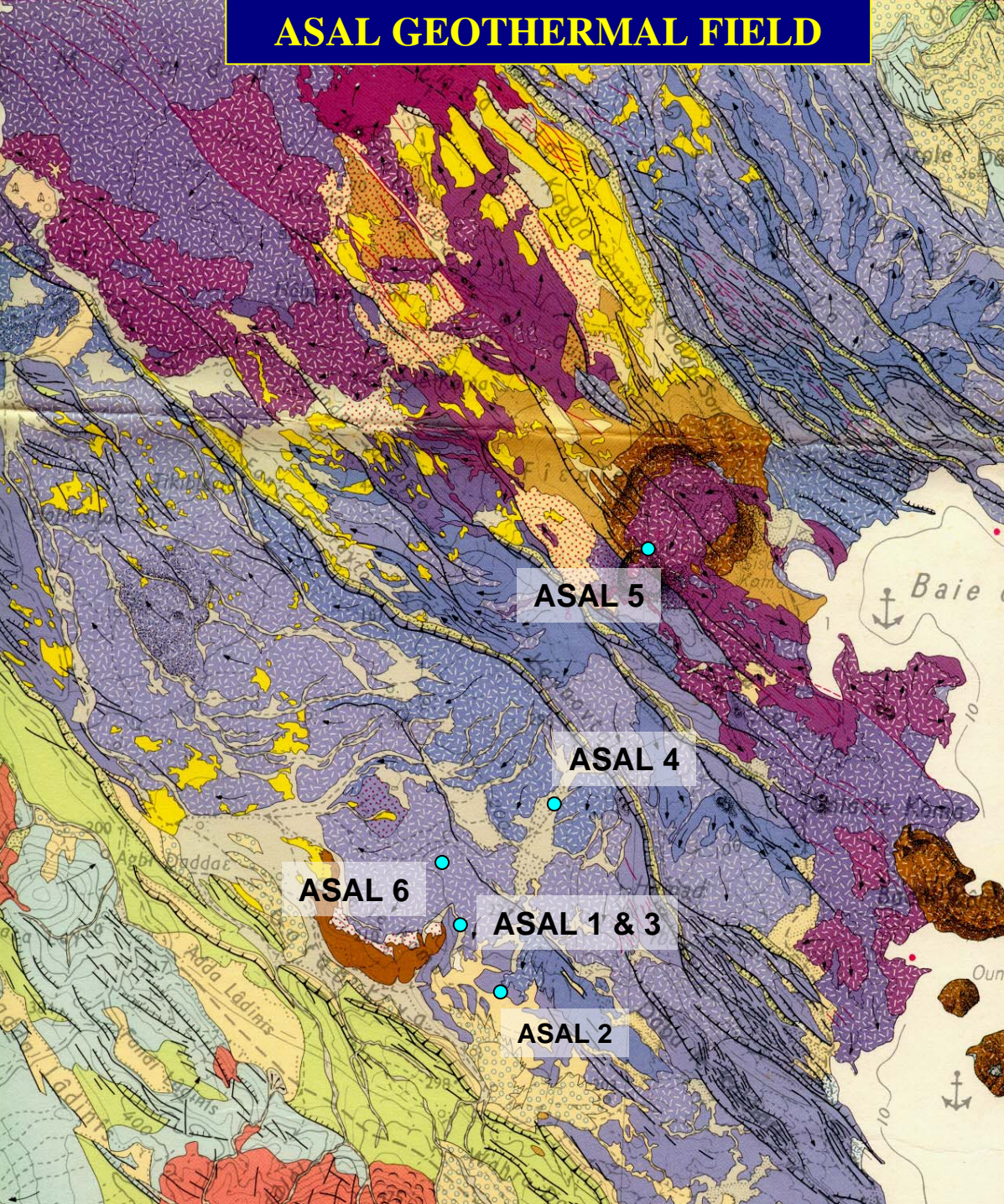


STATUS OF GEOTHERMAL EXPLORATION

- **Exp. Began in the Assal Area (1970-83) funded by French Govt.**
- **Geo-scientific studies including drilling of six wells in Assal**
- **Exp. in Hanle-Gaggade area (1984-92) funded by Ital Gov+ADB+OPIC+UNDP and WB**
- **Scaling and Corrosion Study of deep brines of the Assal area (1989) by the Icelandic company**
- **Devt. & Prod. of the deep Assal resource funded by Ita. Govt. and WB.**
- **With the support of USTDA, GDA completed a feasibility study for the devt. of 30 MW plant in the Lake Assal region**



ASAL GEOTHERMAL FIELD



MAIN AREAS OF FOCUS

PROPOSED GEOTHERMAL PROGRAM

- **Plan to drill additional wells and develop 30 MW Geothermal Plant in the Lake Assal Region**
- **Government of Djibouti is committed to diversify the primary energy resource particularly use of RE resources (Geothermal).**



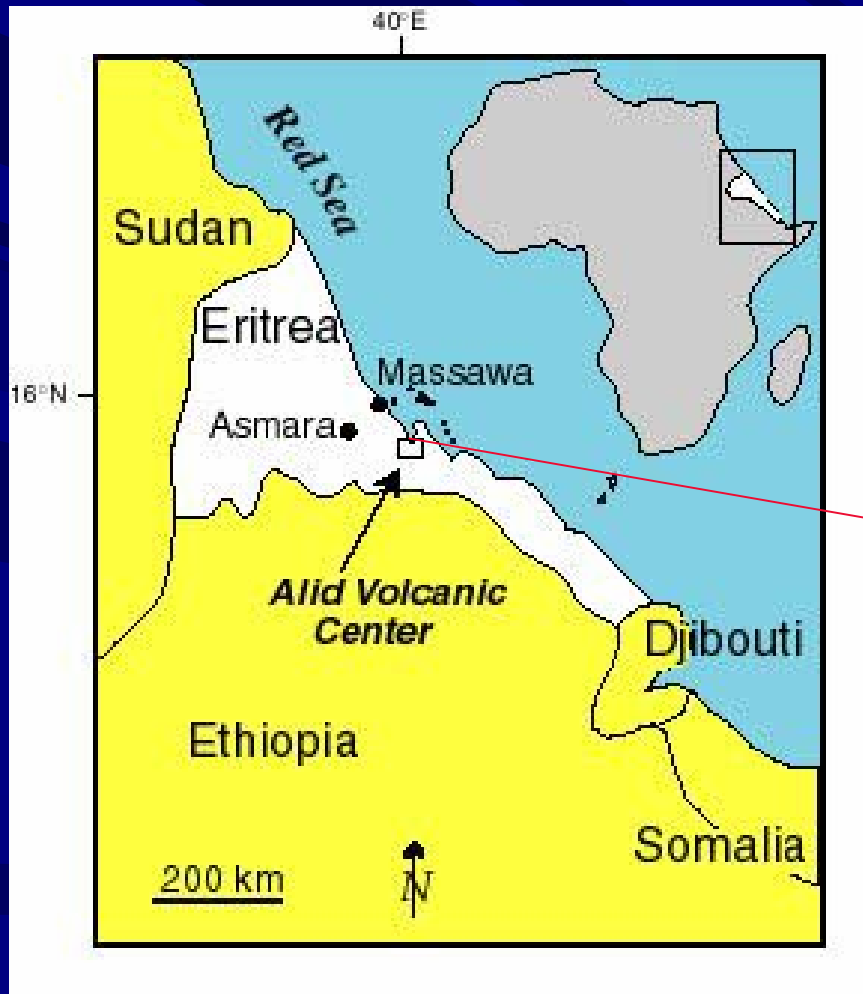
ERITREA



TIC= 130 MWe; Thermal

- **Asmara-Massawa HW Sp.**
- **Red Sea Coast**
- **Gulf of Zula**
- **Acfat Group**

MAIN AREAS OF FOCUS



SURFACE THERMAL MANIFESTATIONS IN ERITREA



Status of Geothermal Exploration

- **In 1973, UNDP identified significant Geothermal Resources.**
- **In 1995, USAID financed USGS to explore possible use of geothermal resources for power generation in Eritrea, and gave priority to Alid V.C.**
- **Geological and Geochemical including isotopes were carried out in the Alid Volcanic Area**
- **Results indicate-**
 - **Occurrence of magmatic chamber (heat source)**
 - **Gas geothermometer = $T > 250^{\circ}\text{C}$**
 - Presence of Fractured Permeability**
 - **Favourable for power generation**



PROPOSED GEOTHERMAL PROGRAM

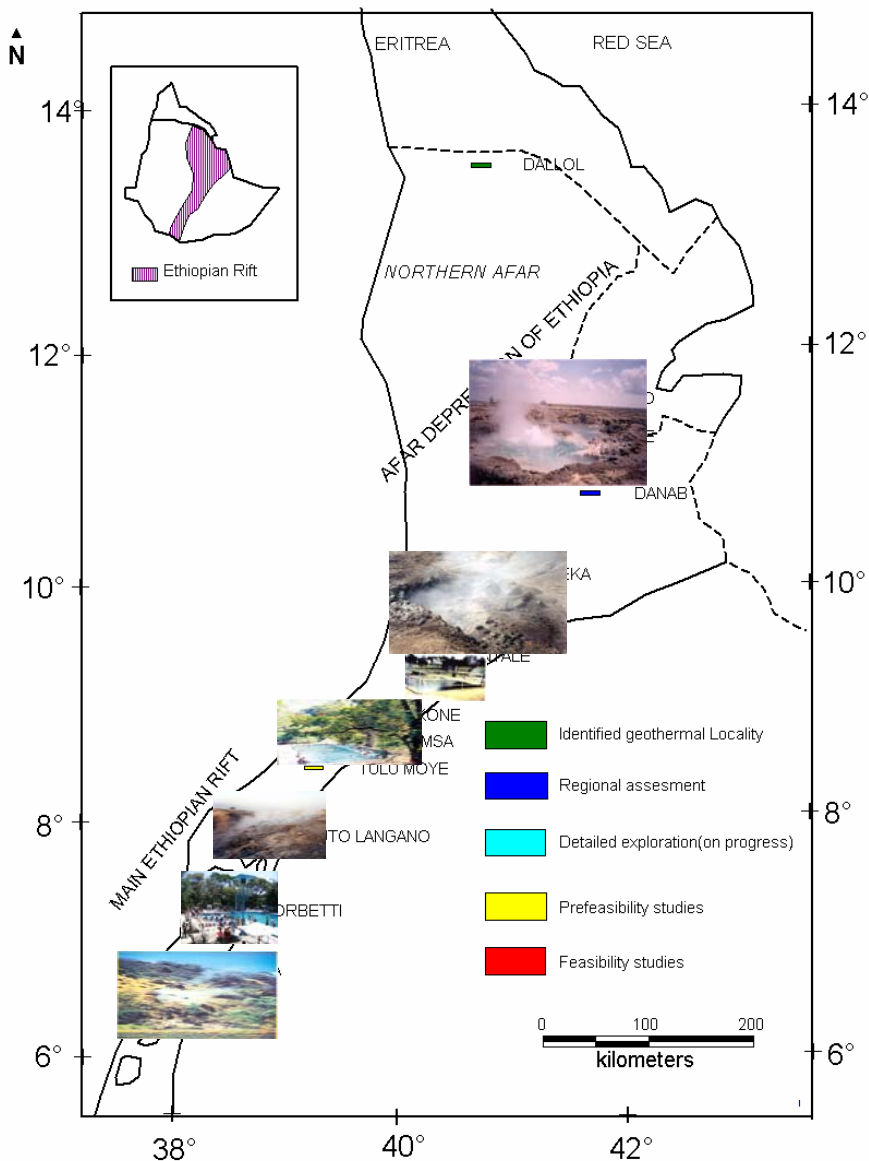
Further Exploration and Analysis in the Alid.V.Area These include:

- Upgrading of Geological, Geochemical and Geophysical information
- Selecting of target Areas for TG wells
- Exploratory drilling, well testing & installation of a pilot power plant at Alid.
- Reconnaissance Survey in the eastern lowlands of Eritrea.

ETHIOPIA



- Located in the H.of Africa
- Largest Geothermal Resources in Africa (E.G.P: > 1000 MWe)



- **Exploration began in 1969 (UNDP & EG)**
- **About 18 Geothermal Prospect areas were identified in the whole ERV (covers 13% of the country)**
- **Much larger are for direct uses (agriculture, agro-industry etc)**

LARGEST GEOTHERMAL RESOURCE IN AFRICA

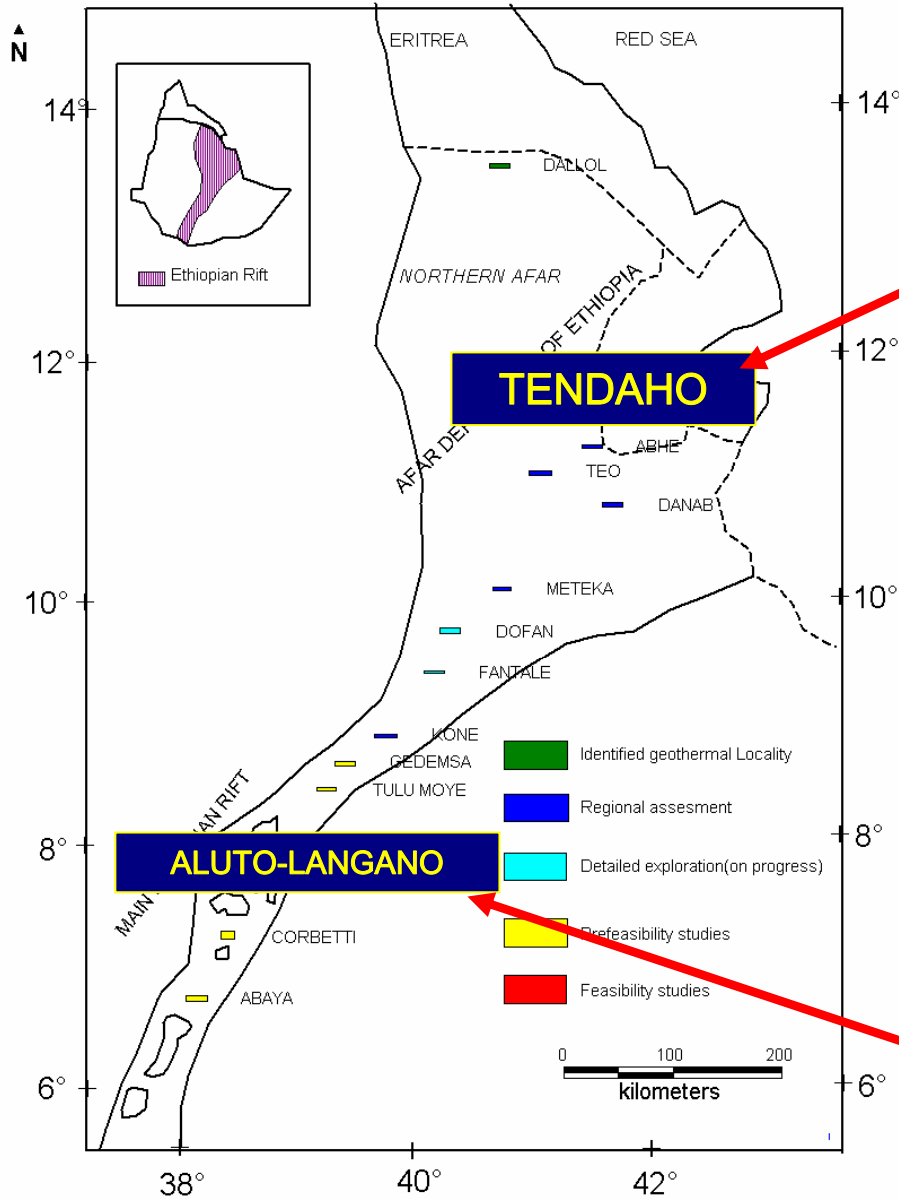


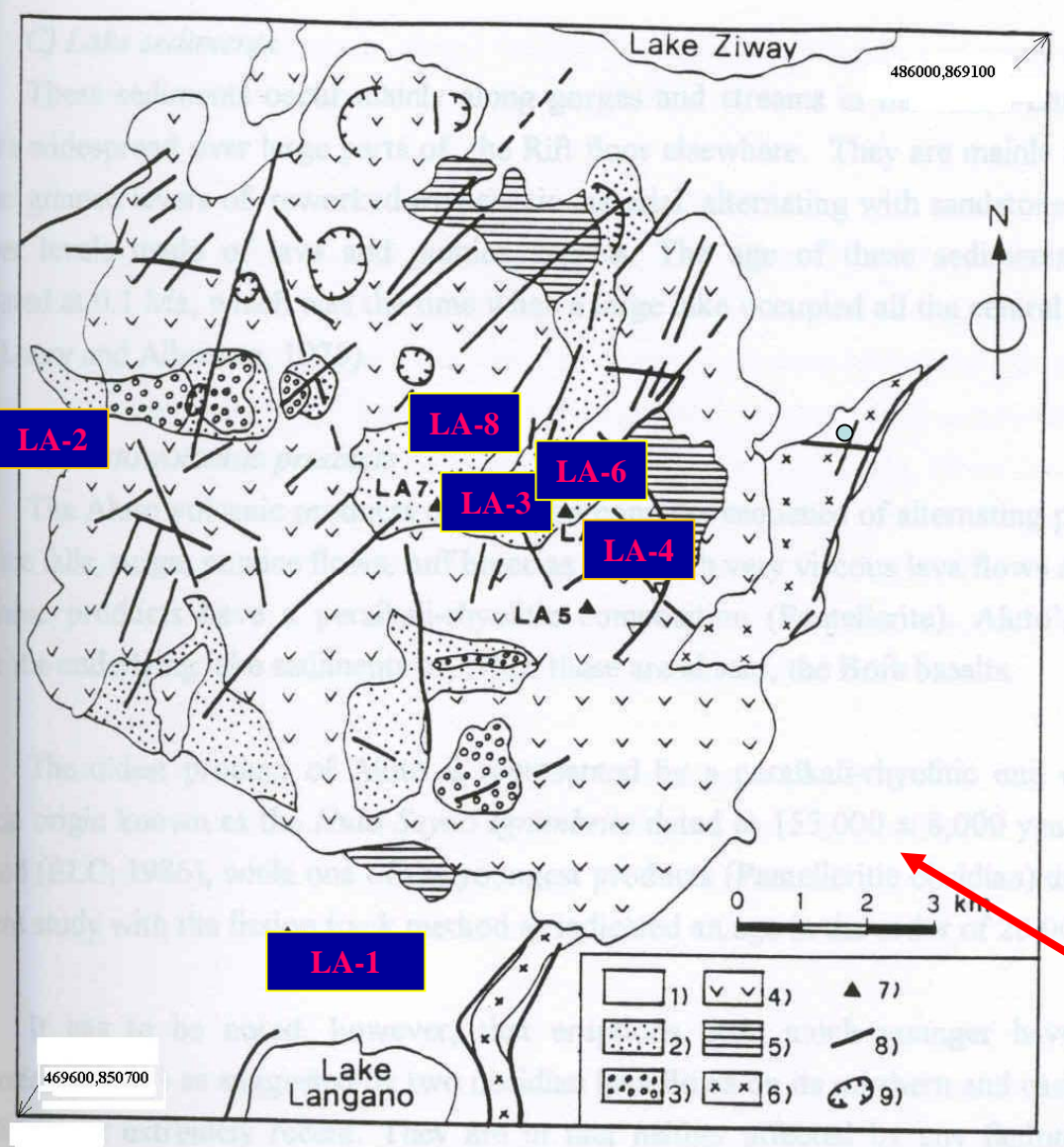
Fig.1 Location Map of the Geothermal Prospect Areas with in the Ethiopian Rift Valley



**ONLY TWO AREAS ARE
SUBJECTED TO DRILLING**

- **ALUTO-LANGANO (LD-AREA)
200 KM S. OF A.A**
- **TENDAHO (N.AFAR)- 650 KM
NE OF A.A**





- 8 Deep wells with maximum depth of 2.5 Km.

- Five wells are Potentially Productive with a Max. temperature of 350 °C

Simplified Geological Map of the Aluto-Langano Geothermal Area with Location of Deep Wells.



One of the Discharging Wells At Aluto, LA-6



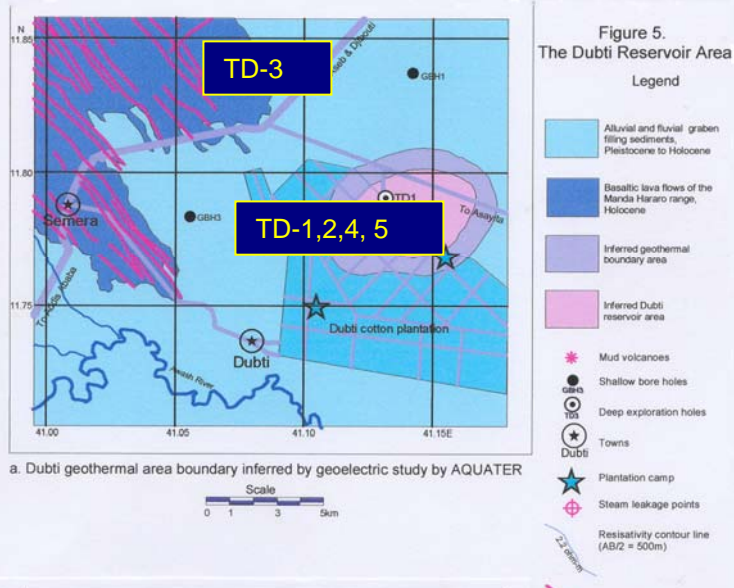
- **Estimated Capacity of the field = 30 MWe for 30 Years (Feasibility Study, 1986)**
- **In 1995, the field handed over to EEPCO for Development**

THE ALUTO-LANGANO PILOT POWER PLANT (BINARY)



A photograph of the Tendaho Geothermal Field in Ethiopia. The scene shows a rocky, barren landscape with a large, turbulent pool of light blue water. A powerful geyser is erupting from the center of the pool, sending a massive plume of white steam and water high into the air. The surrounding terrain is composed of dark, jagged volcanic rocks and sparse, low-lying vegetation. The sky is filled with large, white, fluffy clouds under a bright blue sky. A yellow rectangular box with a black border is superimposed over the center of the image, containing the text "TENDAHO GEOTHERMAL FIELD" in bold, yellow, sans-serif capital letters.

TENDAHO GEOTHERMAL FIELD



• **3 DEEP (2100 m) & 3 SHALLOW WELLS (500m)**

• **MAXIMUM TEMP = 260°C**

• **PRODUCTION TEST & GEOCHEMICAL MONITORING**

• **ITALIAN TECHNO ECONOMIC STUDY INDICATED SHALLOW PRODUCTIVE WELLS CAN POWER 3-5 MWe**

• **ESTIMATED CAPACITY OF THE FIELD FROM THE DEEP WELLS IS ABOUT 20 MWe.**



**One of the Discharging
wells, TD-5**

TENDAHO



PROSPECTS
AT
ADVANCED EXPLORATION STAGE

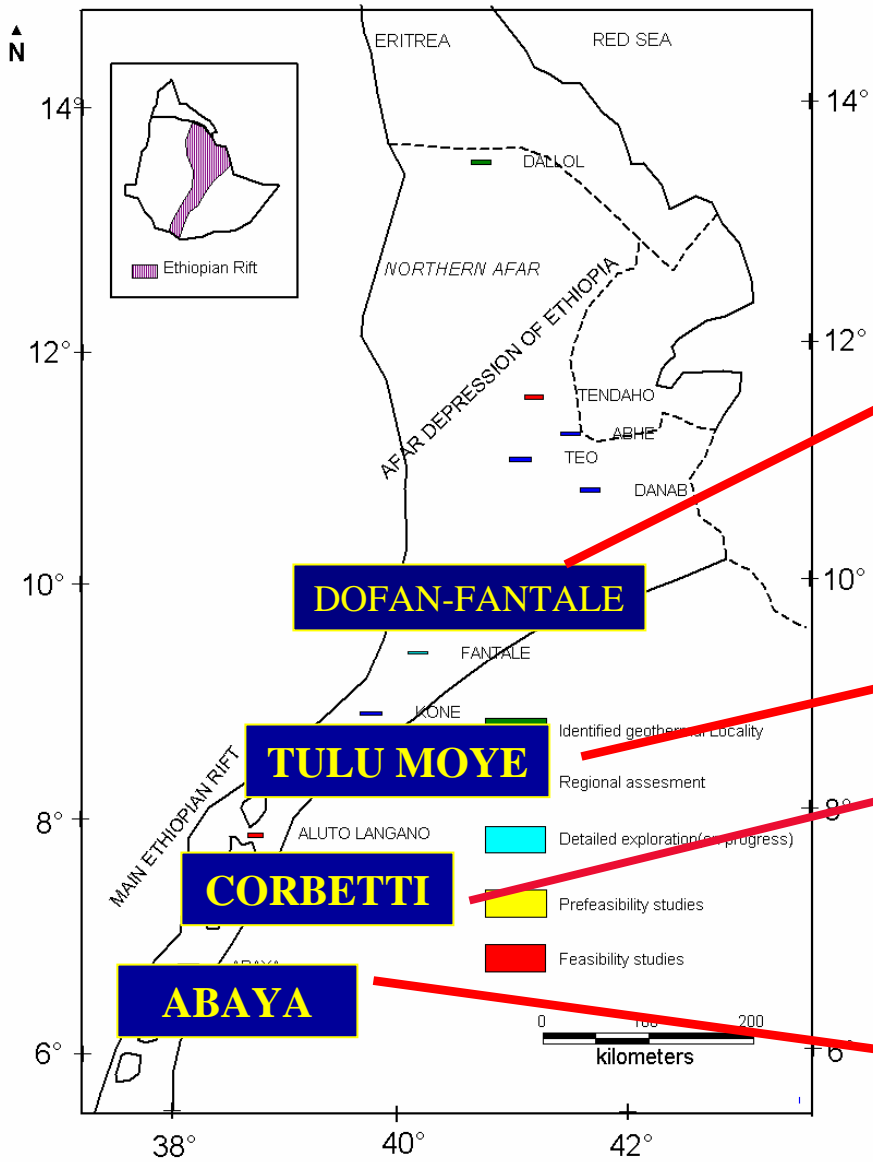


Fig.1 Location Map of the Geothermal Prospect Areas with in the Ethiopian Rift Valley

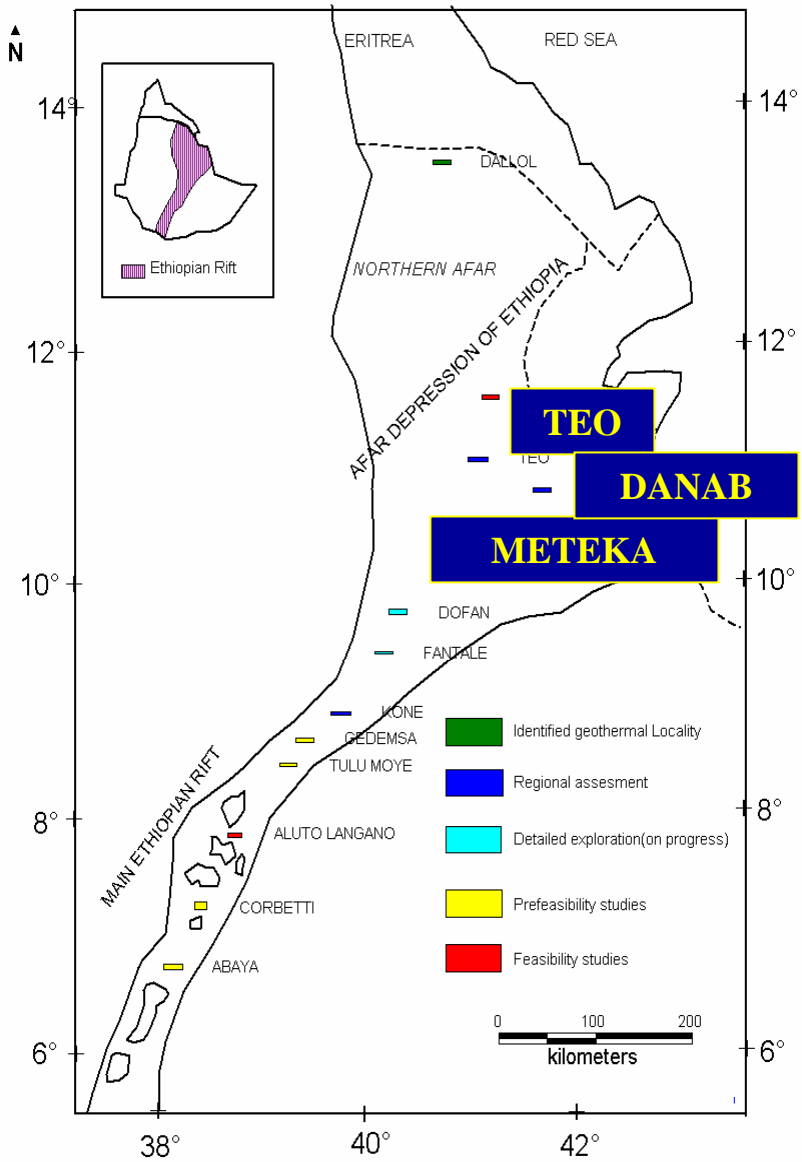


Fig.1 Location Map of the Geothermal Prospect Areas with in the Ethiopian Rift Valley



RECONNAISSANCE



CURRENT ACTIVITY

**RESERVOIR ENGINEERING &
GEOSCIENTIFIC STUDIES OF THE
TENDAHO GEOTHERMAL FIELD**



**REPORT COMPILATION OF THE
DETAILED GEOSCIENTIFIC STUDIES
OF THE DOFAN-FANTALE
GEOTHERMAL PROSPECT AREA**



**PROBLEM IDENTIFICATION AND
REHABILITATION OF THE ALUTO-
LANGANOGEOTHERMAL PILOT
POWER PLANT**



**DURING THE THREE DECADES THAT GEOTHERMAL RESOURCE
EXPLORATION WAS CARRIED OUT**

- **GOOD INFORMATION BASE**
- **GOOD DEGREE OF EXPLORATION
AND HUMAN CAPACITY**
- **BASIC INSTITUTIONAL AND
INFRASTRUCTURE HAVE DEVELOPED.**

FUTURE GEOTHERMAL PROGRAMME

- **FURTHER GEOSCIENTIFIC AND RESERVOIR ENGINEERING STUDIES (INCLUDING MT SURVEY BY “BGR”)**
- **FEASIBILITY STUDY (US-TDA) FOR INSTALLATION OF A PILOT PLANT OF 2-5 MWe AND FURTHER DEVELOP THE TENDAHO GEOTHERMAL FIELD**
- **REHABILITATION , FURTHER DEVELOPMENT AND EXPANSION OF ALUTO-LANGANO GEOTHERMAL FIELD**
- **RESOURCE ASSESMENT ON 5 SELECTED GPA & DETAILED STUDIES AND DEVT. AT THE TWO IDENTIFIED GEOTHERMAL PROSPECT AREAS.**



KENYA

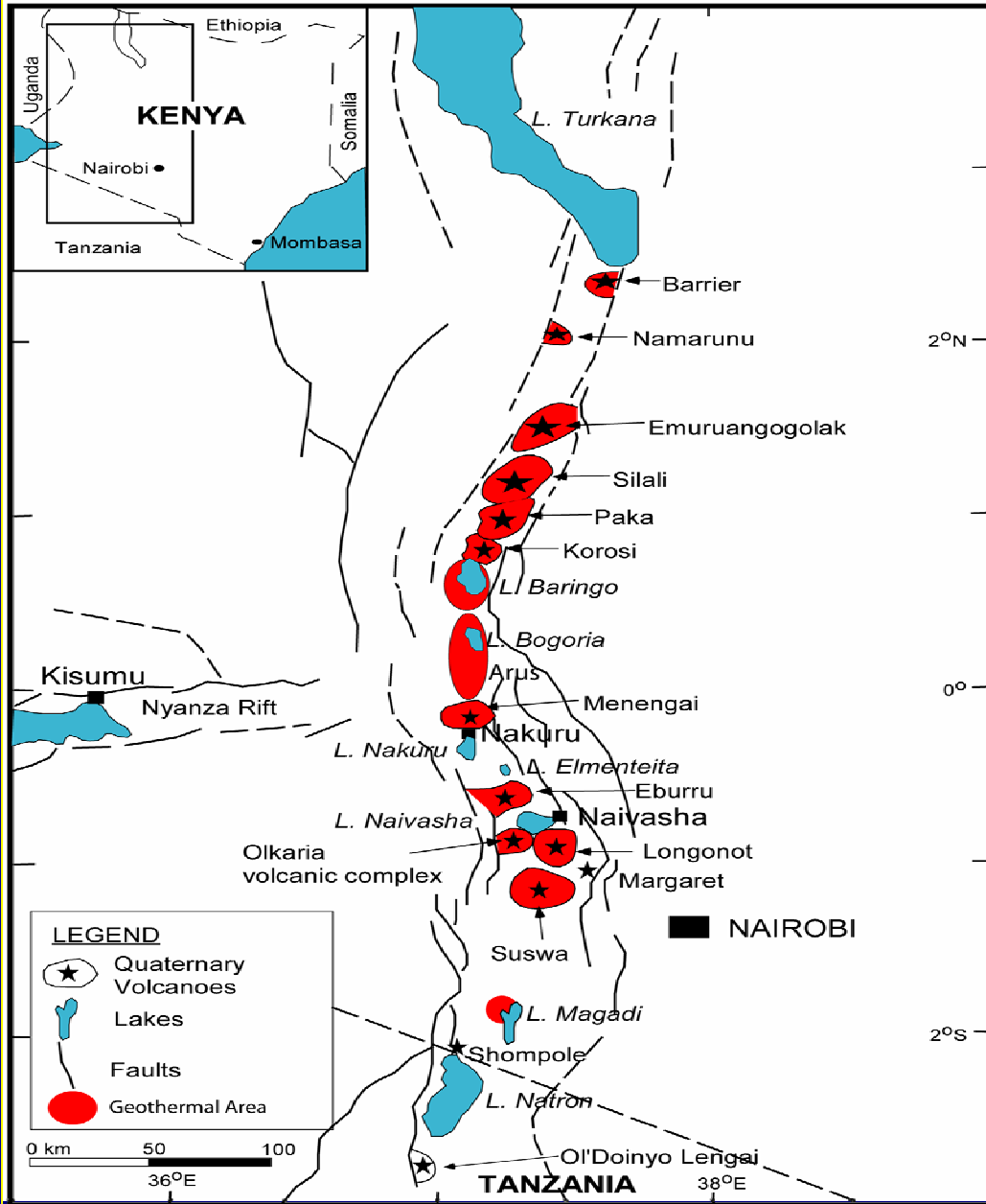


TIC= 1059 MWe

Thermal= 346 MWe

Hydro= 584 MWe

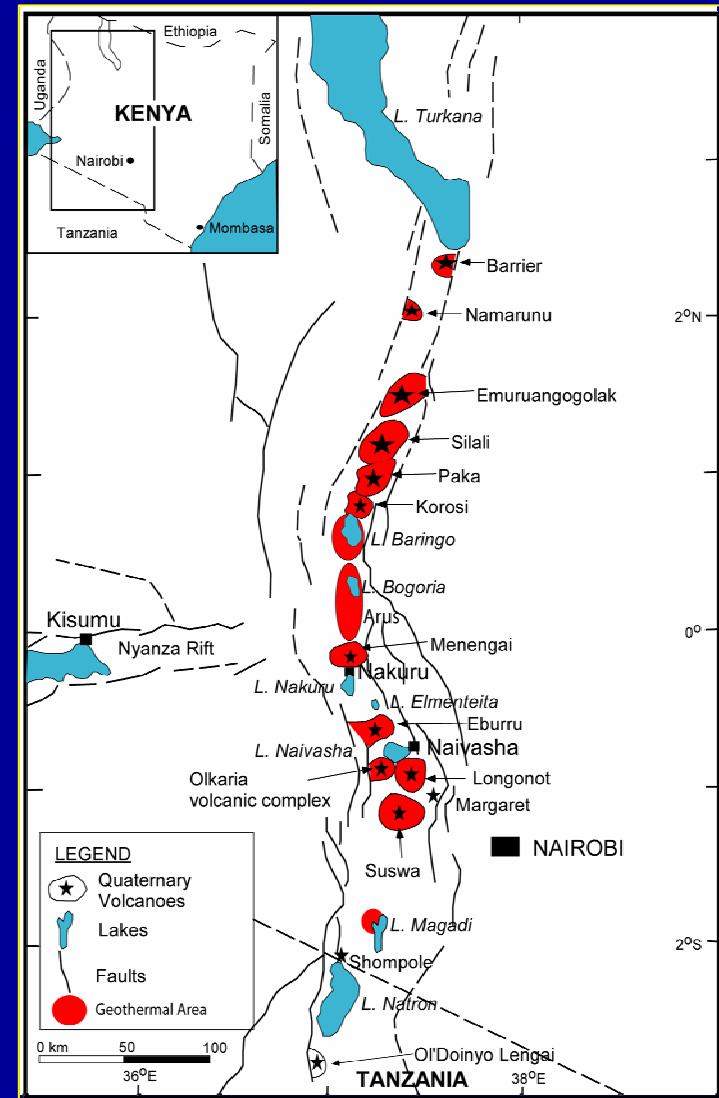
Geothermal= 129 MWe



**LOCATION OF GEOTHERMAL PROSPECTS
THE KENYAN RIFT**

STATUS OF GEOTHERMAL EXPLORATION

- Exploration started in Olkaria region in 1950's
- In 1970's More exp. Wells were drilled funded by UNDP and Kenya govt.
- Todate, a total of 105 wells were drilled in Kenya to depths ranging from 503m-2800m.
- Exploration ongoing at Lake Magadi, Longonot, Menengai and Suswa Sites.



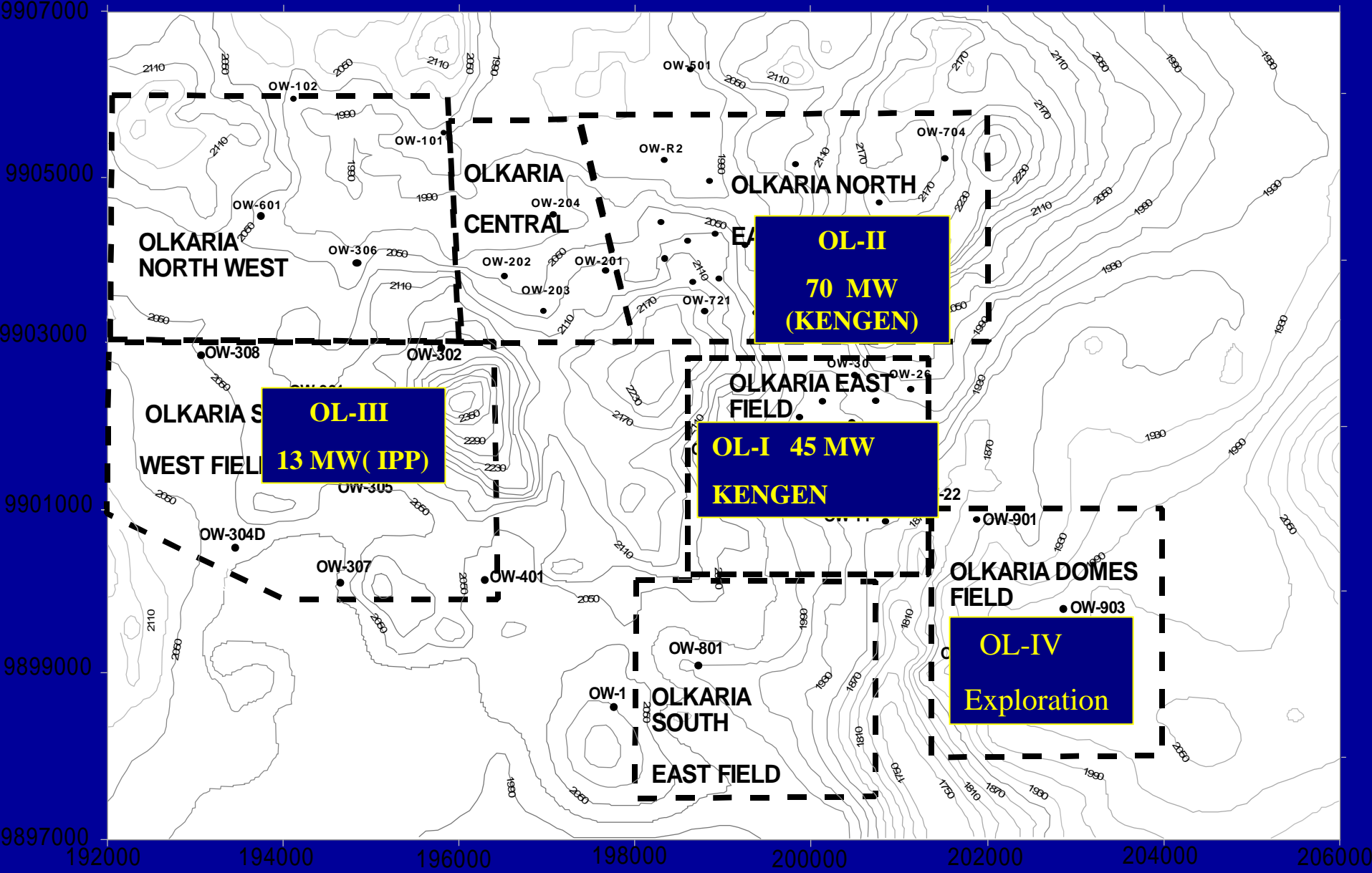
LOCATION OF GEOTHERMAL PROSPECTS THE KENYAN

RIFT

Kenya's use of Geothermal Energy

- **1ST African country to use Geothermal energy for E. power generation**
- **45 MW (Olkaria I plant) Operating in Hells Gate National Park since Early '80's > 98% Availability**
- **70 MW Power station (Olkaria II) owned by KENGEN was commissioned in 2003**
- **In 1997, Ormat International received a license to generate 64-100 MW in BOO agreement, 13 MW commissioned so far (Olkaria III)**
- **Olkaria IV (DOMES)- Exploartion with three Exploartion wells drilled. Further DEW drilling is under preparation**
- **Total installed capacity is about 129MW**

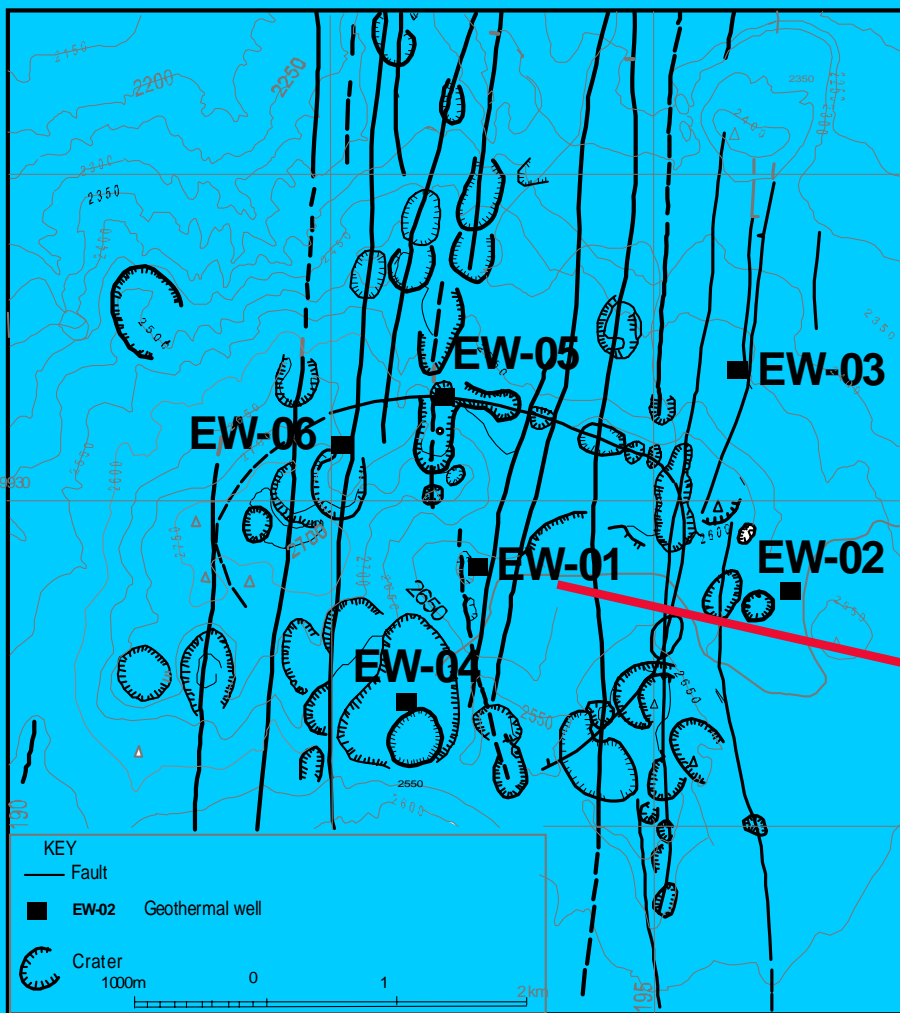




**The Greater Olkaria Geothermal Area,
Kenya**



OSERIAN-GREEN HOUSE



**Location of Geothermal Wells
in the Eburru Geothermal
Field, Kenya**

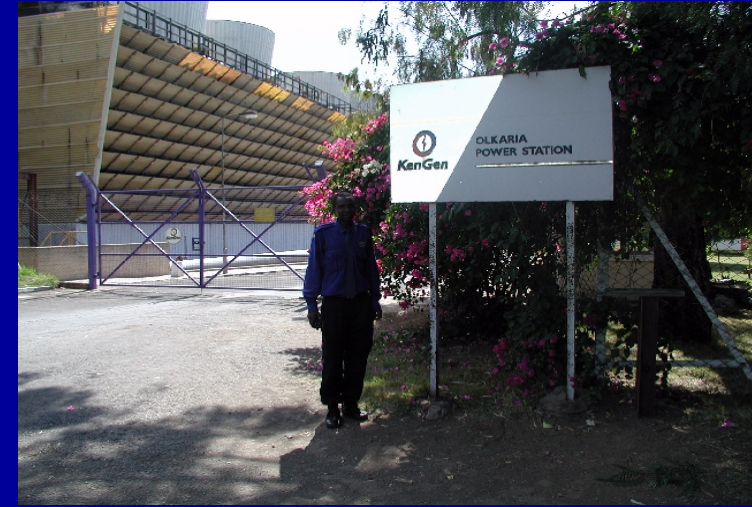
PROPOSED GEOTHERMAL PROGRAM

- **Appraisal drilling including six additional deep wells in south of Olkaria Domes (Olkaria IV)**
- **Addition of a 35 MW Unit in Olkaria II to take advantage of excess steam in Olkaria I & II**
- **Building a Geothermal Pilot plant at Eburru**
- **Plans for additional 576 MW by 2019**
- **GoK is planning to further explore and develop other geothermal prospects**

KENYA:

- **HAS ACQUIRED CONSIDERABLE EXPERTISE IN GEOTHERMAL RELATED EARTH SCIENCES AND ENGINEERING**

- **HAS LED TO A DEVELOPMENT OF THE INSTITUTIONAL STRUCTURE NECESSARY FOR GEOTHERMAL RESOURCE E,D & U.**



TANZANIA



TIC= 785 MWe

Hydro= 561 MWe (70%)

Thermal= 202 MWe

(30%)

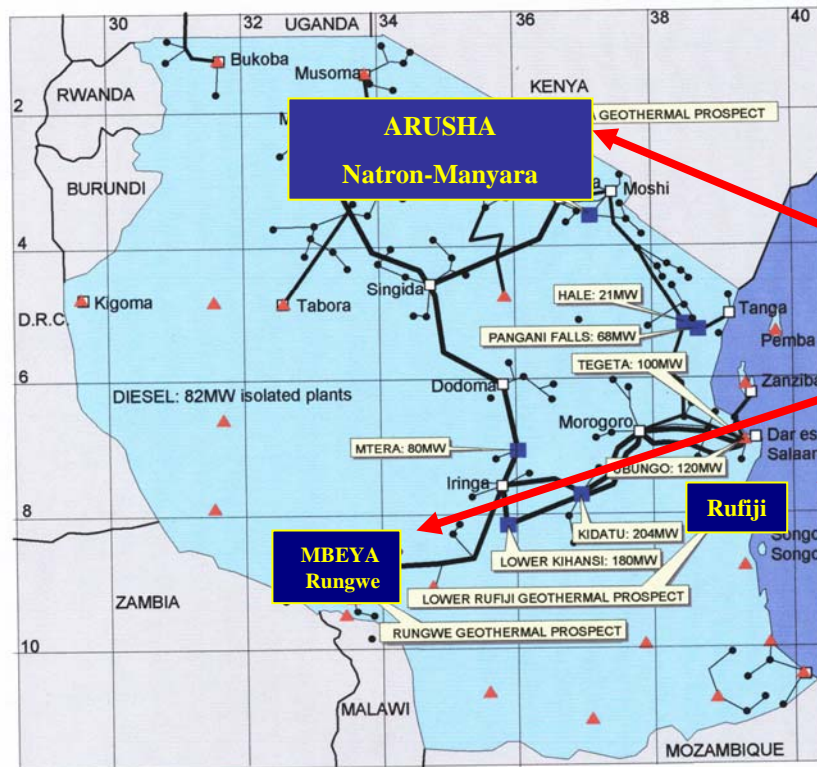


Fig.1. THE EXISTING POWER SUPPLY SYSTEM IN TANZANIA AND LOCATION OF PROPOSED GEOTHERMAL PROJECT SITES

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
PROPOSED
GEOTHERMAL PROJECT
SITES IN TANZANIA**

**E. G.R Potential
230-460 MWe**

STATUS OF GEOTHERMAL EXPLORATION

- **Geothermal Resource Exploration started between 1976-79 by Swedish Consult. Group in Collaboration with Virkir-Orkint of Iceland**
- **Two potential targets, Arusha & Mbeya region ,were Singled out for further Geothermal Exploration**
- **Detail Exploration in Mbeya region funded by UNDP in 1983**
- **FEC ,T. company, did exploration studies and research on the economic feasibility in Rufiji (Luhoi) region (1998-2002)**
- **Results indicate:
Existence of geothermal resources for power generation in Arusha, Mbeya and Luhoi area (T= 220-270°C).**

PROPOSED GEOTHERMAL PROGRAM

- **Further Exploration and Analysis of selected geothermal Prospects (Arusha & Mbeya)**
- **The company develop plans for a 6 MW G. power plant in Luhoi and looking for an international partner.**
- **The prospect is located 20 km from a MG and 90 Km from the National Power Grid**
- **Govt. is committed to participate in a private sector led initiative**

UGANDA

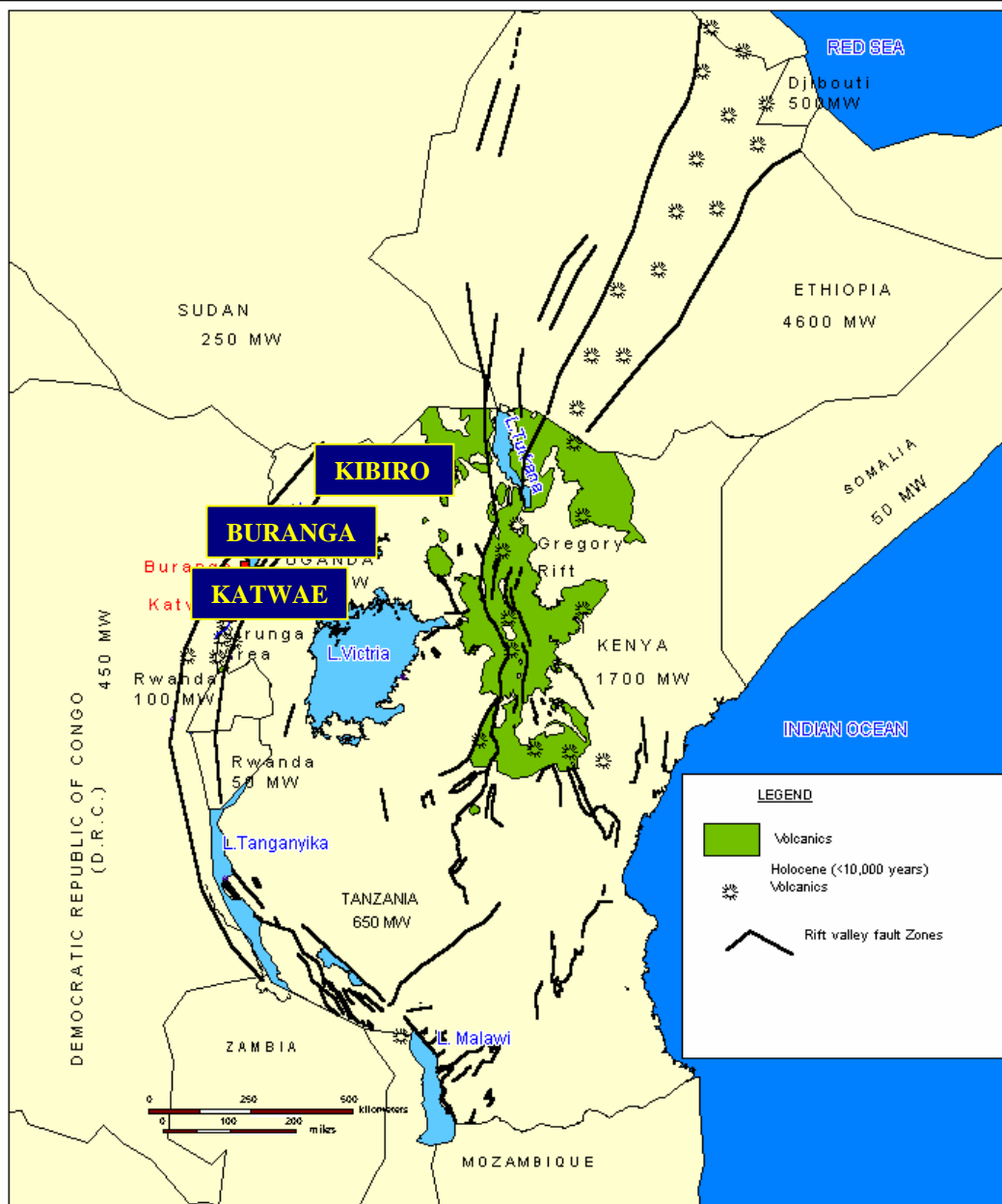


• Located in the western branch of the EAS

TIC= 300 MWe (hydro)
reduced to 135 MWe
(2006)

• E.R. Potential : 450
MWe

• Main Areas of Focus:
Western Part of Uganda



GEOHERMAL PROSPECT AREAS (UGANDA)

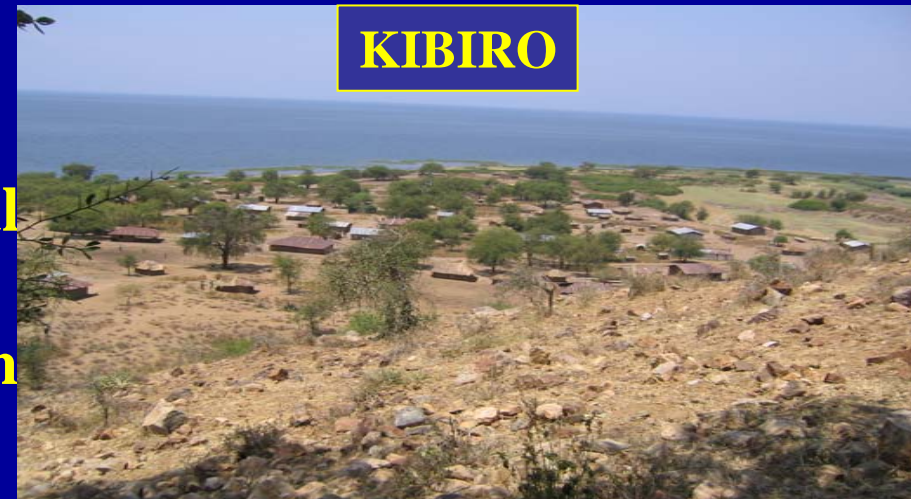
Figure 2: Location of the three main geothermal prospects of Uganda and the Estimated geothermal potential of East Africa.

STATUS OF GEOTHERMAL EXPLORATION

- **1st phase of Geoth. Exploration (GEP I) took place in 1993-94 with assistance from UNDP, OPEC and Govt. of Iceland**
- **Three Geothermal Areas were selected (Katwe, Buranga and Kibiro), all located on the W. branch of the EARS.**
- **ADB with UAERA conducted research at the katwe and Buranga fields**
- **ICEIDA financed geological and geophysical surveys at Kibiro & complete the work of UAERA.**
- **BGR is carrying out Microseismic survey at Buranga**
- **Drilling of TG wells (200-300m) is currently in progress at Katwe. 6 wells drilled at Kibiro.**
- **Govt. Provide Counterpart Support for successful Implementation**

PROPOSED GEOTHERMAL PROGRAM

- **Deep exploratory drilling at Kibiro & Katwe (is located 35 Km from the Terminus of a 132 KV transmission line).**
- **Feasibility study , if successful development of 30MW geothermal power plant by an IPP.**
- **Govt's policy framework is strongly private sector oriented for power generation**



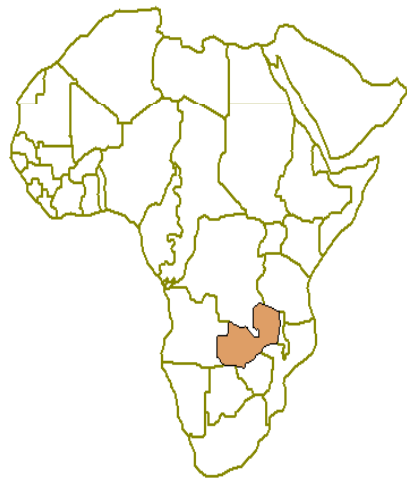
ZAMBIA



STATUS OF GEOTHERMAL EXPLORATION

- **Since 1950, ZGS examined various springs during routine R. mapping exercises**
- **In 1986, the ZGS together with I. company studied various HS and todate, development has been considered on two prospects (i) Kapsiya and (ii) Chinyunyu HS projects.**
- **Pilot Plant (nominal capacity of 200 kW) located in Kapsiya (Sumbu) was built with funding from the Ital. govt.**
- **The plant never became operational**
- **KENGEN- Refurbishing & carry out further studies for expansion**

Kapisya Prospect



chinyunyu

LOCATION MAP OF GEOTHERMAL PROSPECT AREAS IN ZAMBIA

PROPOSED GEOTHERMAL PROGRAM

- **Govt. of Zambia is exploring options for expansion of the Kapsiya geothermal field.**
- **Train local personnel in the maintenance & operation of the plant**
- **JICA with ZGS planning Construction of a geothermal power plant to provide electric power to the local community at chinyunyu Hs (50 km east of Lusaka)**

MAIN OBSERVATIONS

- **A substantial Potential of G. E. Resource exist within the African Continent (EARS)**
- **Geothermal resources are indigenous, reliable, environmental friendly & cost effective alternative energy resource.**
- **Devt. of Geothermal Resources are constrained by**
 - **Risks associated with resource E&D**
 - **Financial risks associated with investment in PD projects**
 - **Lack of appropriate investment and institutional settings in many EA countries**
- **Diversified use of energy augments energy supply from HP plants and improve the Generation Mix (Avoid vulnerability to drought and oil P. fluctuations)**

STRATEGIES FOR DEVELOPMENT

- **Establish long term conducive policies and incentives that attract private investment**
- **A Regional Network of Geothermal agencies should be set-up to ensure the promotion and use of geothermal expertise in the region**
- **Establish a Risk Guarantee fund for exploratory and appraisal drilling of projects in the region**
- **look for loans and grants from IO to finance the projects for further EX. & Development.**
- **Alternative is look for PS participation and financing from developers , investors, equipment suppliers and development banks.**



UPCOMING PROJECT

Multi and Bi-lateral Agreements

ARGEO

- Eastern African Regional Geothermal Programme
- P. Objective –Techn. Ass & RMF for exploration
- Kenya, Ethiopia, Djibouti, Eritrea, Uganda and Tanzania
- The project approved by the GEF Council in June, 2006.
- Executive and Implementing agents are: World bank and UNEP.



THE FIRST EAST AFRICAN RIFT GEOTHERMAL CONFERENCE-ARGeo-C1

**GEOHERMAL ENERGY: AN INDIGENOUS, ENVIRONMENTALLY BENIGN
& RENEWABLE ENERGY RESOURCE**

24 -29 NOVEMBER, 2006

UNITED NATIONS CONFERENCE CENTER

ADDIS ABEBA, ETHIOPIA

Organized by

Geological Survey of Ethiopia



EEPCO, EEA, EPA, EREPDC, IGA



THANK YOU