アフリカ地熱開発に係る
現状確認調査
報告書
（別冊資料）

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アフリカ地熱開発に係る現状確認調査
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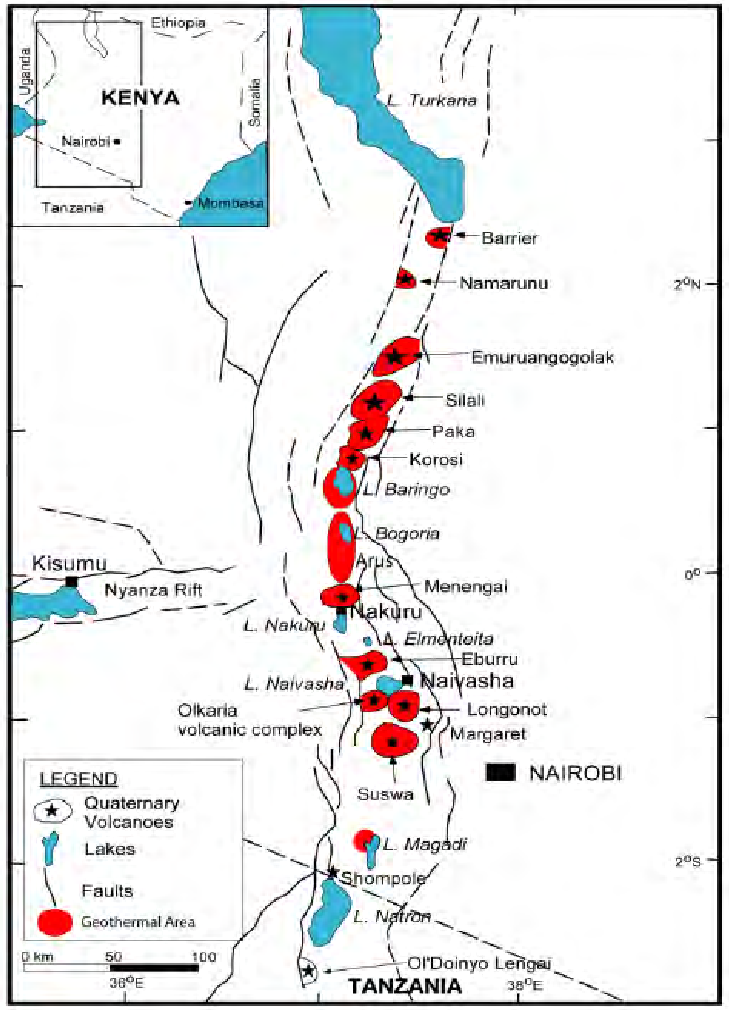
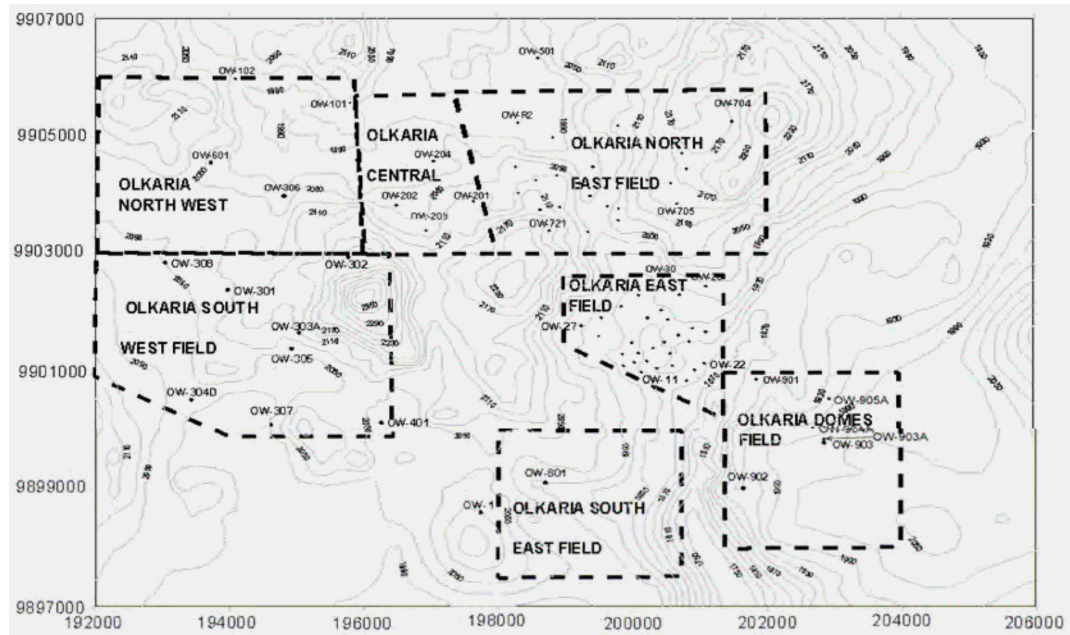
Field Name	Olkaria
Country	Kenya
Present Status	Currently, in Kenya, geothermal energy is being utilised in Olkaria field only. Three of the seven Olkaria sectors, namely Olkaria East field, Olkaria West field and Olkaria Northeast field are generating a total of 167 MWe. The resource is being utilized mainly for electric power generation (167 MWe) and direct uses (18 MWt). The proven geothermal resource at the greater Olkaria geothermal field is more than 450 MWe and accelerated development if envisaged in the near future.
Accessibility/Plant operation	The Olkaria I power plant is located in the Olkaria East field and has three turbo generating units each generating 15 MWe. The three units were commissioned in 1981, 1983 and 1985 respectively. Olkaria II is located in Olkaria northeast and the construction of 2 x 35 MWe Olkaria II geothermal power station started in September 2000 was completed November 2003. The construction of Olkaria II 3rd unit is expected to be commissioned in 2010. Olkaria III project is the first private geothermal power plant in Kenya. A 20-year Power Purchase Agreement (PPA) was awarded to Orpower 4 Inc. by Kenya Power and Lighting Company (KPLC) under a World Bank supervised international tender for the field development of up to 100 MWe. The first phase of the project included drilling of appraisal wells and construction of a 12 MWe pilot plant. The first 8 MWe was put on commercial operation on September 2000 and the other 4 MWe in December 2000. The appraisal and production drilling commenced in February 2000 and was completed by March 2003, after drilling a total of 9 wells (depth ranging between 1850-2750 m) and adequate steam was proved for total development of 48 MWe over the PPA period of 20 years. The 48 MWe p In addition, Oserian Development Company Ltd (ODLC) constructed a 2.0 MWe binary plant Ormat OEC in Olkaria Central to utilise fluid fr
Resource Characteristics Geology	Olkaria is characterized by numerous Quaternary volcanic centers, including a ring of volcanic domes on the east and south sides of the field area, which may represent a caldera boundary. The surface geology is dominated by rhyolitic lavas and pyroclastic rocks. Beneath this is a series of basalts, trachytes and pyroclastic units above the Proterozoic basement rock, which is composed of gneiss, schists and other metamorphic rocks belonging to the Mozambiquian group
Volcanic activity (heat source)	The temperature distributions at 0m asl suggest the likely location of heat sources (upflow of deep hot fluids) for the GOGA. Also it suggests the permeability structure and the possible lateral connections. Although it is difficult to define the position of heat sources, at least two deep upflow zones can be identified in the eastern side of the Olol Butot fault, one located in the NEPF and other comprising the EPF and the Domes. The analysis of the fluid geochemistry also suggests these two upflow zones. In addition, another upflow zone is identified for the WPF. The reliability of these assumptions will be discussed upon numerical simulation studies. Upflow zones are usually modeled as constant pressure and temperature boundaries or as mass and energy sources (or conductive heat sources). The former type is defined using constant pressure and temperature boundary blocks at the bottom most layer of the numerical model while the position and strength of the latter type of heat sources is defined by trial and error during the calibration process of the numerical model.
Geological Strucrure	Volcanic units are cut by numerous faults, some of which can be mapped on the evidence of aligned features such as hot ground, extrusion centers and craters. Notable among these are the Olol Butot and the Olkaria Faults. While the dominant fault direction is N-S, parallel to the rift trend, other faults have been inferred that trend NNW (such as the Gorge Farm Fault and the Suswa Lineament).
(Past Geological Studies included)	KenGen already carried out detailed scientific studies that included geology, geochemistry and .geophysics (MT/TEM, Schlumberger, and micro-seismic).
Geochemistry	Fumaroles are widespread over the greater field area, often associated with structures (faults or fractures and volcanic centers) visible at the surface, and represent discharge from the shallow two-phase part(s) of the system(s). The Domes area lacks fumarolic activity, probably due to a thick pile of impermeable pyroclastic rocks which acts as a seal. Fumarole chemistry across the field could be taken to indicate that a hot water reservoir underlies the whole geothermal field, and that there was no clear indication of significant later underground movement of boiled hot water. Muna (1993) concluded from soil gas (radon) and fumarole surveys that there may be a distinct upflow in the area between the Olol Butot lava flow (to the north), the Ol Njorowa Gorge (to the east) and the Olol Butot Fault (to the west), and the southmost edge of the ring structure to the south. It appears that the data presented do support this suspicion, but no deep drilling has been done in this area, named the South Olkaria Upflow Zone, which lies SSW of the EPF.
Work done so far	The data obtained from a selection of reports by KenGen and others include 119 water analyses and 61 gas analyses, many of which are presented by these reports as “averaged” or “best” data from selected wells which represent conditions prior to or early during field production. These selected data have been used as the basis for establishing and representing an overview of initial reservoir conditions in the five major production and exploration areas: Olkaria East (EPF or Olkaria I), Olkaria Northeast (NEPF or Olkaria II), Olkaria Central (OC), Olkaria West (WPF or Olkaria III) and Olkaria Domes (OD). In contrast, the larger part of the dataset has been used for more detailed well-by-well comparisons.
Geophysics	Data of All covering the Olkaria geothermal field and surroundings. - Bouguer gravity data (882 stations), - Aero-magnetic survey (75,495 stations), - Resistivity data at different depths of DC surveys (369 stations), and - Transient Electromagnetic (TEM) surveys (395 stations) Data in and around the Olkaria domes field - Power spectra data of a Magnetotelluric (MT) survey (80 stations)

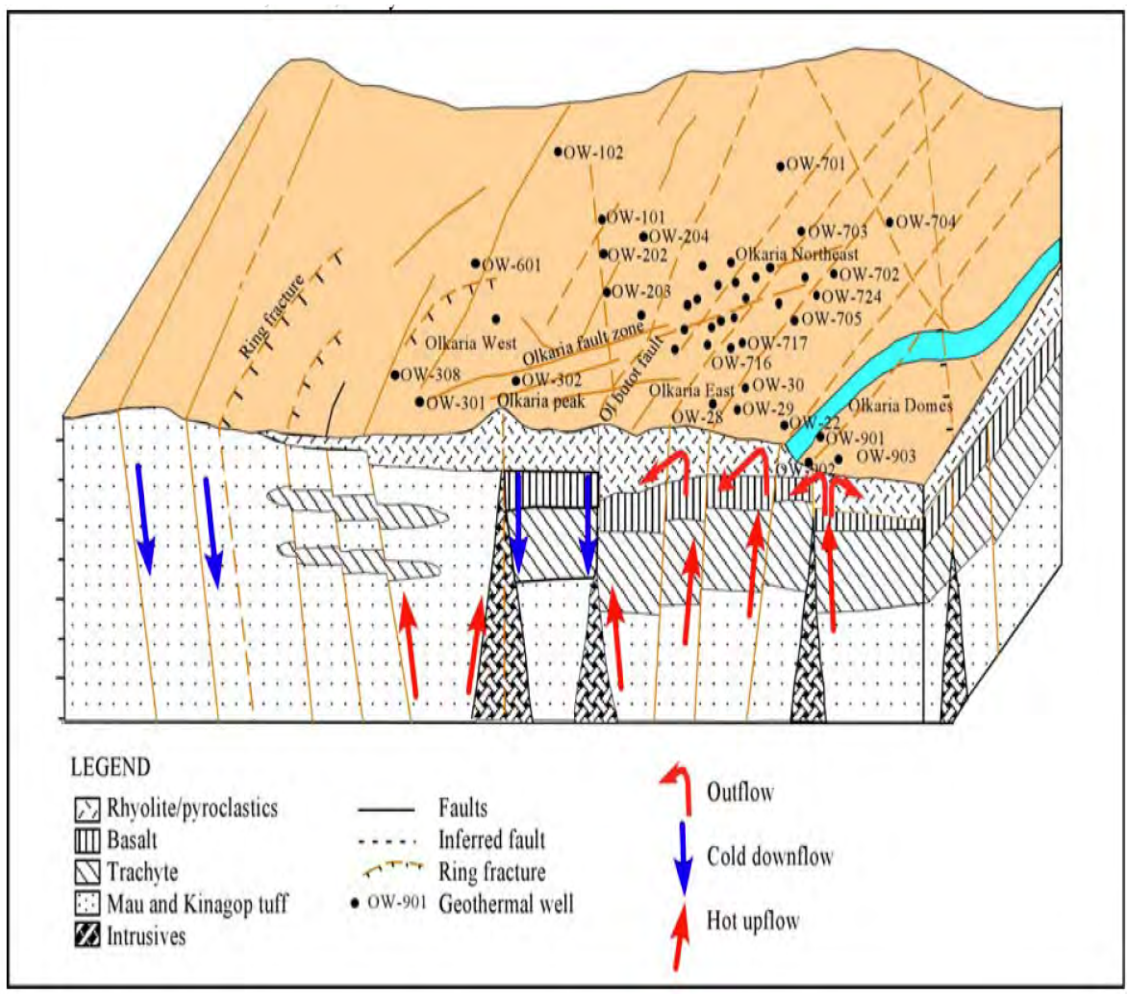


ケニア国内の地熱地域位置図



Olkaria地熱地域における鉱区図

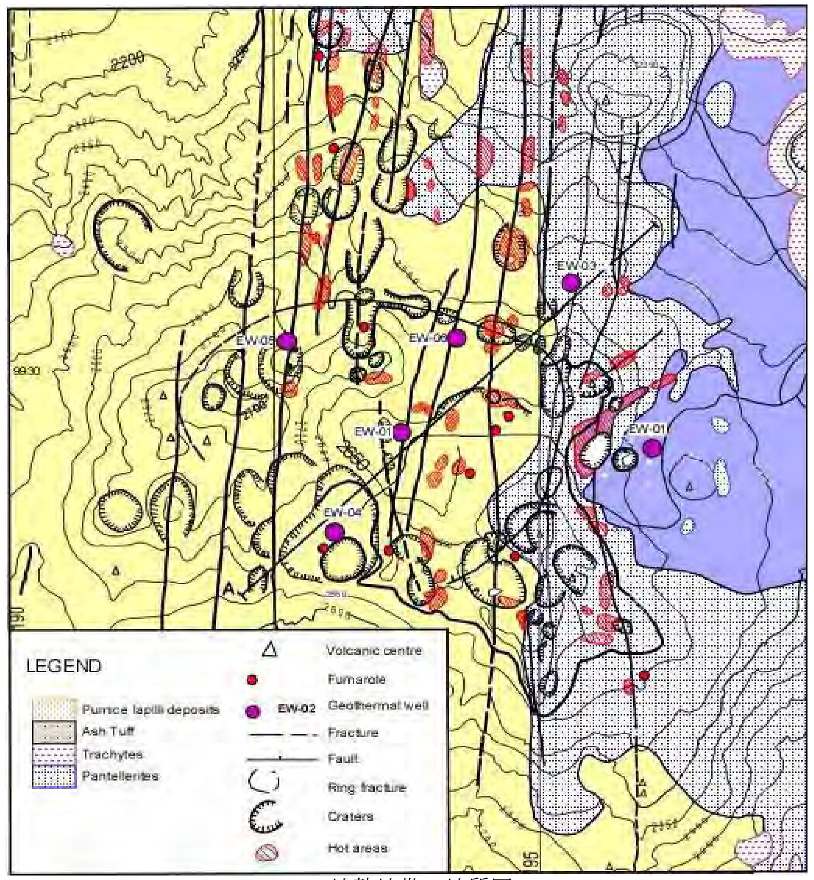
Gravity	**Aero Magnetic:** a NW-SE trending positive anomaly is recognized. This anomaly was interpreted as occurring in a demagnetized zone corresponding to the main heat source with a temperature above the Curie point at a depth of around 6km. Another positive anomaly trending NE-SW can also be seen as a reflection of Olkaria fault zone. This minor anomaly was interpreted as representing rocks demagnetized due to alteration by chemical and thermal processes at reservoir depth. In addition, a steep gradient zone of the relative intensity values trending roughly NNW-SSE can be seen extending from the eastern portion of the Olkaria northeast field to the east of the east production field. This tendency seems to indicate rapid changes in the magnetic properties of the subsurface rock, so the tendency is possibly indicative of a fault structure trending in a NNW-SSE direction. **Gravity**: gravity lineaments reflect fault structures, so these gravity lineaments detected in the filtered Bouguer anomaly maps possibly reflect fault-like structures in the Olkaria geothermal field. Moreover, the low Bouguer anomaly zone roughly distributed in the Olkaria fault zone is possibly indicative of a low-density zone caused by fracture and/or fissures in the zone. However, the possibility that these gravity
Resistivity	**TEM**: A remarkably low resistivity zone of less than 10ohm-m is widely distributed in the northern, central and southeastern portions of the Olkaria geothermal field. And the low anomaly zone has a very clear tendency to extend in a NNW-SSE direction. the widely distributed low resistivity zone detected in the resistivity maps at 1600m msl and 1400m msl probably reflects the areas where conductive clay products such as smectite and zeolite are abundant. The widely distributed low resistivity zone seems to be separated into two low anomalies. One low anomaly seems to be centered in the Olkaria northeast field and another low anomaly seems to be centered in the east production field. This fact may suggest that there are two separate up-flow zones in the Olkaria northeast field and the east production field. On the other hand, a relatively high resistivity zone of greater than 20ohm-m is widely distributed in the northeastern and eastern portions of the field. In between the low resistivity zone and the relatively high resistivity zone, a steep gradient of resistivity values trending roughly NNW-SSE is recognized. In addition, a relatively high resistivity zone located in and around Olkaria Peak could be due to a low de **MT**: The orientation of the low anomaly is similar to that of the low resistivity anomaly at shallow depths recognized in the resistivity maps o
Well Drilling	To date, more than 100 wells have been drilled in the Olkaria area. KenGen already has the abundant data of downhole pressure and temperature profiles of 82 wells with the flow test records of 55 wells, the production history of 47 wells, and the injection history of 8 wells.
Temperature Survey	The temperature distributions indicate that the whole GOGA can be considered divided into two main sectors; the western (OWPF) and eastern sides (NEPF, EPF, and the Domes). The separation is a low temperature region approximately coinciding with the Olol Butot fault. The general trend of the temperature contours of the eastern side seem stretch in NW-SE direction, which coincides with the direction of the inferred main geophysical. Thus, the eastern side should be considered basically as one geothermal system with the N-S structure separating the western and eastern sides a hydraulic boundary. The low temperature is in between two N-S trending structures, F2 and Olol Butot. The low temperature area detected from elevations of 1000m msl (and higher) at the northeastern portion of the NEPF, could be reflecting inflow of cooled water from the northeast. Pressure distributions show that the northern pressures are higher than those of southern pressures, which suggests that the natural trend of fluid flow is from north to south.
Well testing	Since results of spinner test are not available, a qualitative analysis was done on the shape of the temperature profiles of the several wells. Almost all wells showed a shallow feed zone and a deep feed zone.
Conceptual Model	There are two main geothermal systems separated by a N-S structure corresponding to faults F1, F2 and to Olol Butot. The eastern side is comprised by the NEPF, EPF and the Olkaria Domes and maybe the Olkaria Central too. The western side comprises the WPF, the Olkaria northwest and southwest. These systems seem to be heated by remaining magmatic intrusions beneath the GOGA. The eastern side may be primarily fed by meteoric deeply infiltrating from east escarpment of the rift valley into the Plateau Trachyte formation and migrating toward the west. This infiltrated meteoric water is heated by conductive heat changing its chemical characteristics to neutral chloride type by interacting with deep rocks. The western side might be receiving its primary deep recharge from meteoric water deeply infiltrating from the west escarpments of the rift valley. Geothermal surface manifestations such as fumaroles and hot springs are found along the border of the N-S hydrological barrier zone (between F1 fault and Olol Butot fault) and to the south of the GOGA. The temperature decreases toward this area, which is considered the main discharge zone.
Present Status of Development	Currently, in Kenya, geothermal energy is being utilised in Olkaria field only. Three of the seven Olkaria sectors namely Olkaria East field, Olkaria West field and Olkaria Northeast fieldare generating a total of 167 MWe. The resource is being utilized mainly for electric power generation (167 MWe) and direct uses (18 MWt). The proven geothermal resource at the greater Olkaria geothermal field is more than 450 MWe and accelerated development if envisaged in the near future.
Natrural/Social Environmental Condition	Hell Gate National Park/Maasai Village
Power Sector Situation	Installation of Sub-station at Olkaria-II Plant
Power Output Potential	
Resource Potential	1,000 MW (estimated): Olkaria I, II and III are already producing 209 MWe (by both Kengen and Or Power 4 Inc.).
Restrictted by National Park	Hell Gate National Park situated between Olkaria-I area and Olkaria-IV area
Restricted by Power Demand	None
Rank of Development Priority	OP: Operation stage
Potential (Expected) Developer	Operated by KenGen
Proposed Geothermal Development Plan	
Outline for Power Development	GDC is currently undertaking production drilling in Olkaria IV for a planned 140 MWe plant by 2012.
Possible or Recommended Multi-purpose Geothermal Heat Us	Already utilized the geothermal fluid in Oserian firm
Scope for Power development	
CO2 emmission Reduction ('000 tonne/year)	
Proposed Geothermal Development Schedule	KenGen is currently undertaking production drilling in Olkaria I for a planned 140 MWe plant by 2012.



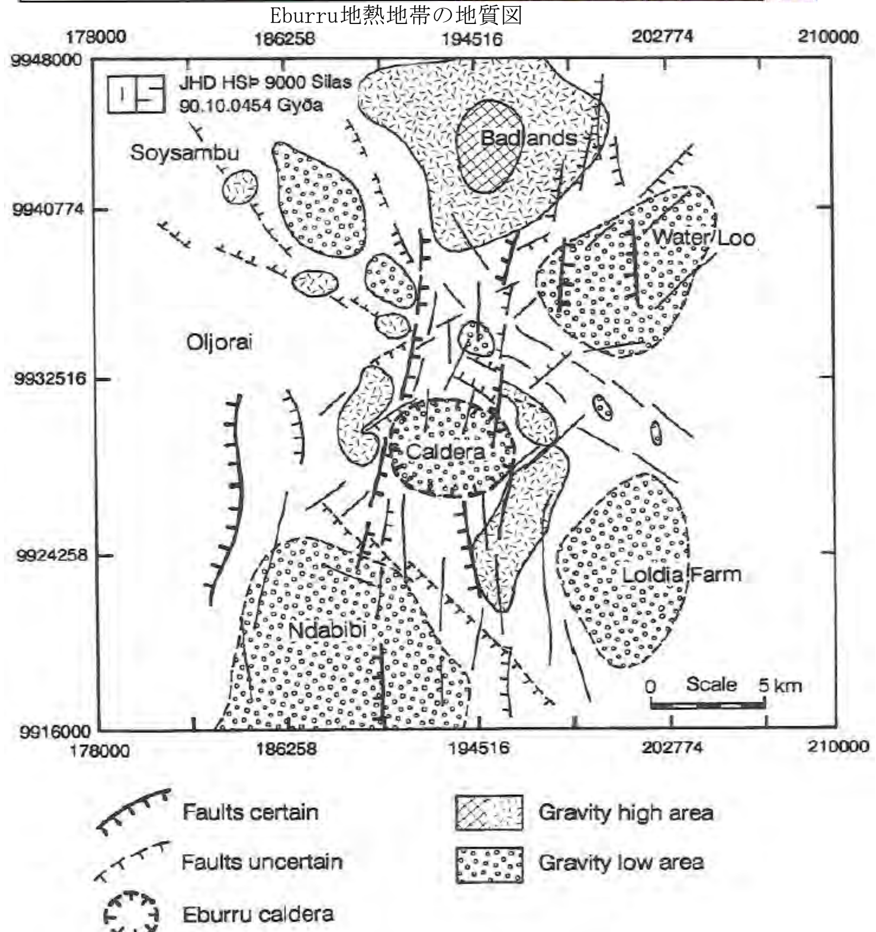
Olkaria地熱地域の地熱構造モデル

Direct-Use in Oserian Greenhouse utilizing Geothermal Heat

Field Name	Eburru
Country	Kenya
Province/Location	Eburru volcano is located about 50 km north of Olkaria geothermal field. Lake Elementaita is located about 20km north of Eburru.
Accessibility/Infrastructure	The Eburru area has a fairly well established infrasturucture and for this reason a 2.5 Mwe binary pilot plant is planned for comminsioning in 2010.
Resource Characteristics Geology	The Eburru volcanic complex is situated within the East Africa Rift Valley. It is part of a volcanic belt of peralkaline rocks trending in the NS that extends far to the south close to the Suswa volcanic complex. The Eburru volcanic complex extends towards the EW to the Mau escapement and it comprises two major volcanic centers with an elevation of more than 2,600 masl. The western volcanic center is older and is overlain by younger pyroclastics from the eastern volcanic centre. The top of the eastern volcanic center has numerous volcanic craters of various volcanic episodes. Some of these craters describe a ring structure, which is interpreted as a caldera. Others coincide with the NS trending faults. Eburru is characterized by highly evolved trachytic and rhyolitic lava compositions. These differ in detail from those of adjacent Longonot and Olkaria volcanic complexes.
Volcanic activity (heat source)	Eburru volcano is elongated perpendicular to the Gregory Rift NW of Lake Naivasha. The 2856-m-high, E-W-trending main edifice is eroded, but young partly vegetated rhyolitic domes occur on the east flank and are probably of Holocene age (Thompson and Dodson, 1963). Pleistocene phonolitic and trachytic lava flows are overlain by rhyolitic obsidian lava flows forming much of the northern and NE slopes of the main massif. A prominent late-Pleistocene rhyolitic lava flow from a SE-flank vents extends almost to Lake Naivasha. Extensive fumarolic activity occurs at cinder cones and craters constructed along dominantly N-S-trending faults cutting the massif.
Geological Structrure	In Eburru area, two major fault systems can be identified, i.e., the old Rift system trending in the NNW-SSE and the NS younger Rift floor faults. The NNW-SSE faults form the main rift valley escarpments. The Rift floor faults have a smaller throw and and form a shallow graben structure running in the N-S and which passes through the eastern volcanic center. These faults are numerous and in some cases occur at intervals of a few meters.
(Past Geological Studies included)	Thomson and Dodson (1963) carried out the first systematic work in Eburru in 1963 while they were describing the geology of the Naivasha area. They pointed out the age differences between the rift faults and the rift floor faults. Later on, in 1972 the UNDP executed a work that covered only the Eburru area with emphasis on geothermal activity. In 1983, JICA carried out a comprehensive study of geothermal activity and proposed the position of the heat source and defined the outflow area. KenGen carried out detailed surface studies between 1987-1990 that culminated in the drilling os six exploration wells in Eburru between 1989 and 1991.
Geochemistry	Discharge fluid chemistry from the wells indicates that the reservoir is non-boiling with high salinity brine and a high amount of non-condensable gases (NCG). Despite the almost similar geology, the chloride level of EW-1 (956 to 1,976ppm) is higher than the Olkaria average. As compared to olkaria, the reservoir permeability is moderate (KPC, 1990). The maximum discharge temperture was 285oC and the total output from the two wells that discharged (EW-1 & EW-6) is 29 MWt (ofwona, 1996).
Work done so far	In 1986, the Eburru geothermal field was classified as the next geothermal energy exploration target, then the Kenya Power Company (KPC) scientists carried out intense geological, geophysical and geochemical surveys. The results indicated that an area around the main crater area was the best target for exploratory drilling in the whole prospect. A soil and fumarolic survey was carried out in 1990 and in 1991 this was complemented with an additional downhole chemistry of the last five wells drilled.
Geophysics	Exploration drilling started in Eburru in 1988 and by 1990 four deep wells had were completed. The information recovered from this drilling together with some additional geophysical measurements were used to assess the resource potential and to identify further sites for exploration drilling. Two additional wells have been drilled and completed successfully, however the temperature recovery information reveals that only one of the drilled wells was prone to produce fluids.



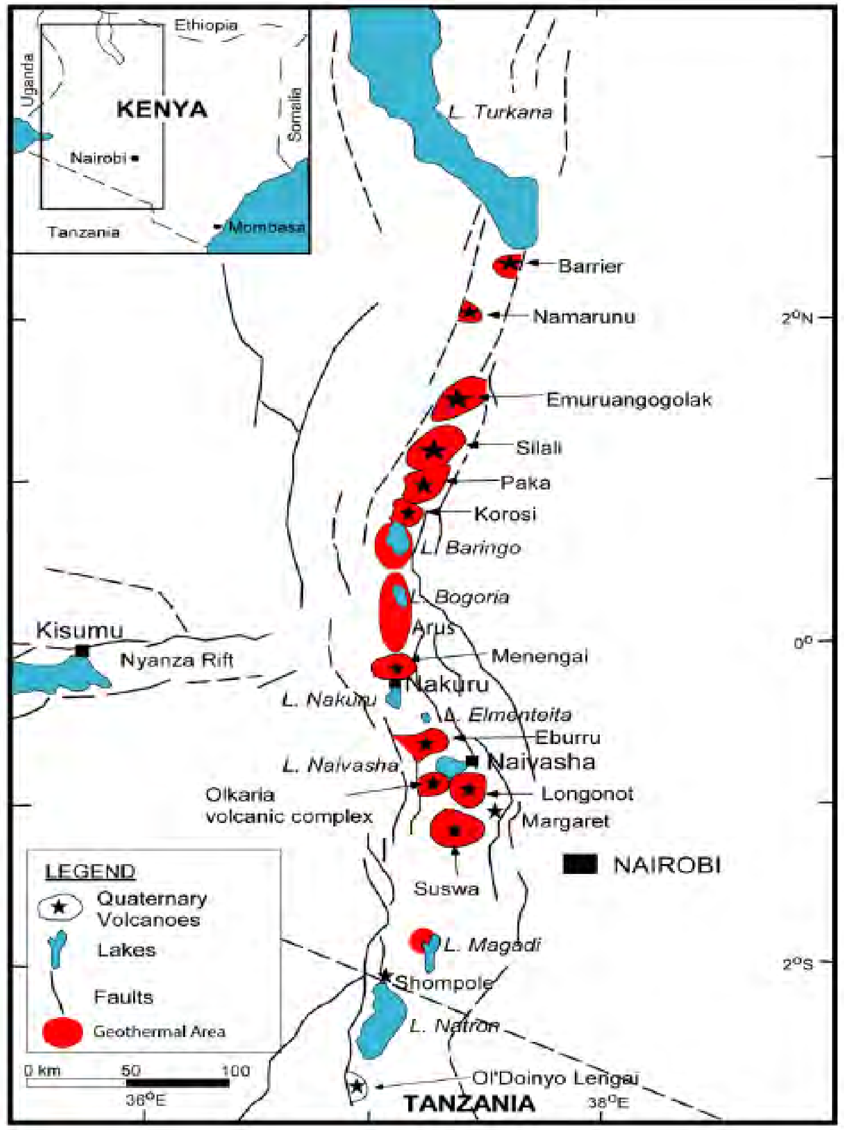
Eburru地熱地帯の地質図



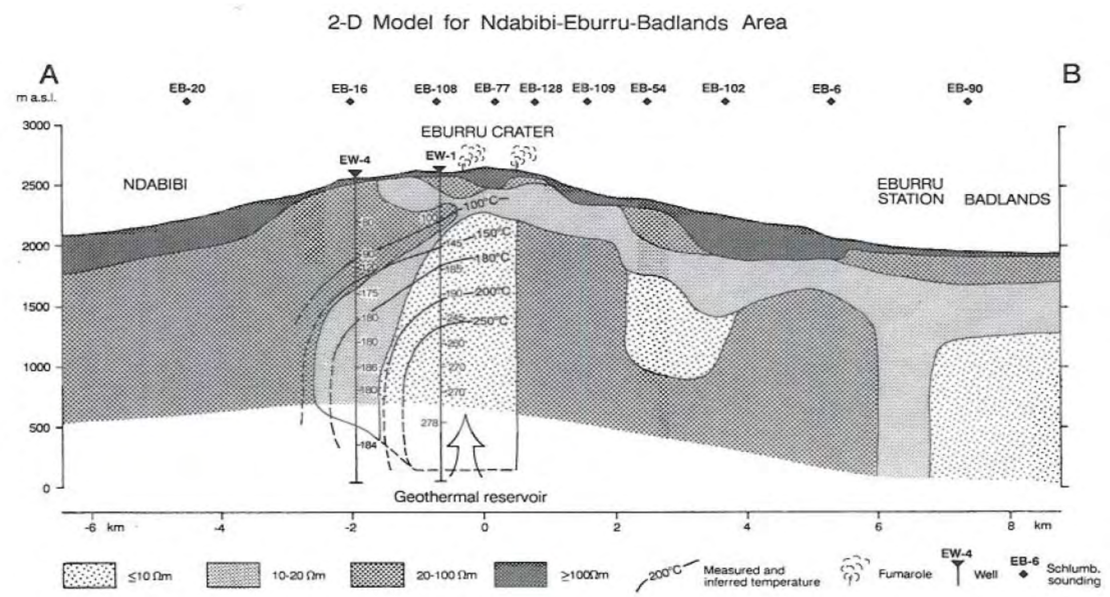
（資料）（Simiyu, 1990）

Eburru ブーゲー重力構造図

Gravity	The Eburru area has a complex gravity structrure. The results show a N-S axial high along a graben caused by dense intrusives along N-S fault zones and at major structural intersections within the area. Low frequency filtering delineates a mojor NE-SW negative anomaly modelled as a basin structure, at whose intersection with the N-S graben occurs the Eburru caldera. Within it, one well has been drilled with a 2.5 MWe production capacity. High frequency anomalies are related to vertical intrusives at shallow depths, occuring at fault junctions. Analysis of these anomalies has led to a proper definition of a NW-SE structural and resistivity disciontinuity, dividing the study area into two regions. This has also led to the confinement of the Eburru caldera boundaries. Fluid feed for the geothermal system is along vertical conduits and the heat coming from narrow intrusive bodies at fault junctions. Several intrusions exist at the intersectionsof the NW-SE structure and the N-S fault zone west of the Eburru volcano. (From Simiyu 1990)
Resistivity	The interpretation of Schlumberger data from Eburru identified two anomalous areas of low resistivity (<10 ohm-m) at 1,000masl. The first anomaly is in the Eburru crater area. The low resistivity seems to define an area of interpolated reservoir temperature of 200oC. The low resistivity above 1,800masl is caused by hydrothermal alteration of pyroclastics by acidic steam condensates and lateral outflows mainly to the northwest, northeast and sourht along fault lines. The low resistivity area has sharp boundaries. Outside this area the resistivity is higher (>30 ohm-m) due to low permeability and temperature which has been confirmed by exploration wells. The second anomaly is found in the Badlands in association with a gravity high and a magnetic low. The two areas are separated by high resistivity and an E-W structural discontinuity. MT suveys done in 2006 revealed that the Eburru area is able to support up to >60 MWe. The results from the exploration wells indicate that the field had experienced temperatures of over 300oC possibly due to localized intrusive.
Well Drilling	6 deep wells: Three wells, EW-01, EW-04, and EW-06 discharge geothermal fluid. Only EW-01 produced steam. Exploration drilling started in Eburru in 1988 and by 1990 four deep wells had were completed. Two additional wells have been drilled and completed successfully, however the temperature recovery information reveals that only one of the drilled wells was prone to produce fluids.
Temperature Survey	The maximum temperatures of EW-01 to EW-06 indicated 244, 131, 161, 185, 158 and 218 ℃ respectively.
Well testing	Discharge tests showed that at 6.0 bars the well produces 82t/h mass 21 t/h steam with enthalpy of 1150 kJ/kg equivalent to 2.3 MWe. The well produced fluids at 265 ℃ and at a thermodynamic state close to saturated conditions. Drawn down tests indicated relatively low transmissivity of 0.35 x 10-8 m3/pas if major production comes from well bottom. Shut in tests indicated much higher transmissivity (5.2 x 10-8 m3/pas) but is most likely exaggerated if by the internal flow which starts immediately after shut in, masking true temperature recovery as well. Maximum temperature is 276 ℃ at 1550-2100 m, but temperatures are near-boiling between 1000-1200 m.
Conceptual Model	The Eburru caldera is covered by pyroclastics (low density) of a thickness less than 500m and intruded by narrow volcanic bodies which may be related to a heat source. There exists a NW-SE buried graben structure that divides the Eburru massif from the Badlands area. On the contrary, there occurs a mojor low frequency NE-SW structure which may be related to the rift structure with the Eburru caldera occurring at its intersection with the N-S graben structure. Several intrusions exist at the intersections of the NW-SE structure and the N-S fault zone west of the Eburru volcano.
Present Status of Development	- Explored between 1989-1991 - 6 exploration wells were drilled - Estimated resource: 200 MWe (20-25 MWe in Eburru areas), - 2.5 Mwe binary pilot plant to be installed in 2010 by KenGen
Natrural/Social Environmental Condition	
Power Sector Situation	
Power Output Potential	
Resource Potential	Eburru-Badlands: 200MW (estimated), Reconnaissance and detailed surface exploration planned for 2011.
Restrictted by National Park	
Restricted by Power Demand	None
Rank of Development Priority	FS: Feasibility Study
Potential (Expected) Developer	GDC, KenGen, Private
Proposed Geothermal Development Plan	
Outline for Power Development	
Possible or Recommended Multi-purpose Geothermal Heat U	Supply of fresh water
Scope for Power development	
CO2 emmission Reduction ('000 tonne/year)	
Proposed Geothermal Development Schedule	



ケニア国内の地熱地域位置図

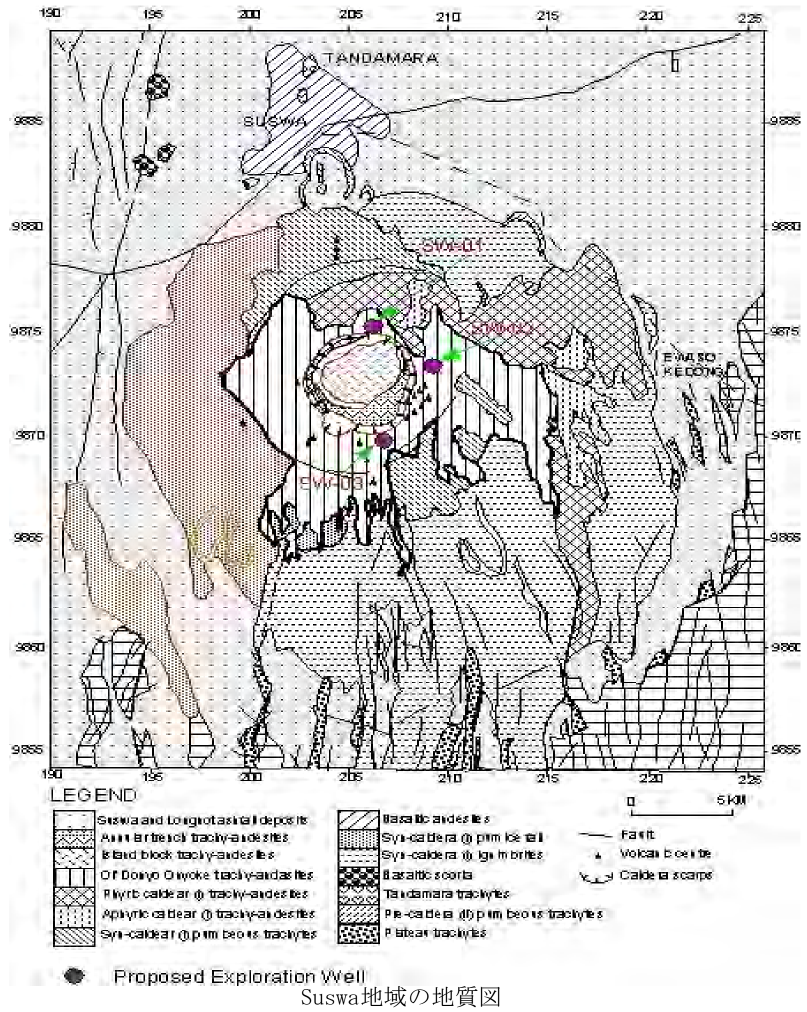


（資料）（Onacha, 1990）

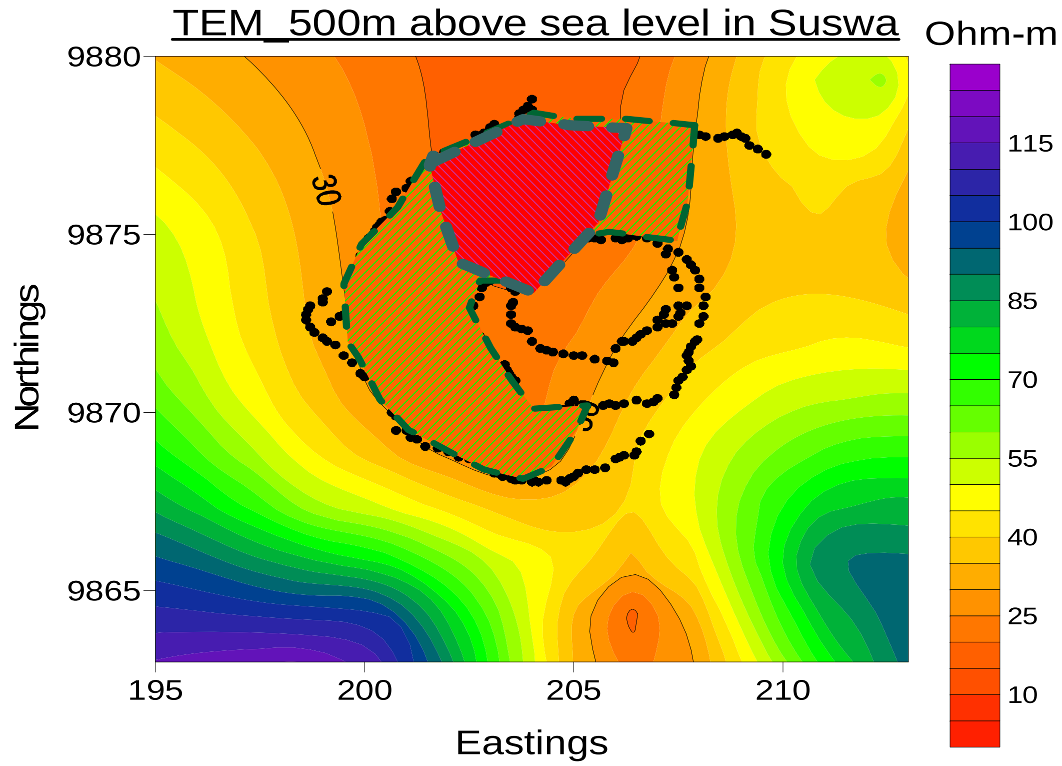
Ndabibi-Eburru-Badlands 地域の比抵抗断面図

別冊資料-1-3　Suswa地域（ケニア）の地熱資源状況（１）

Field Name	Suswa
Country	Kenya
Province/Location	Suswa is the southern-most caldera in the Kenyan Rift Valley. It contains a 12 x 8 km caldera with the rim at an altitude of 1890 m. Suswa is the closest active volcano to Nairobi, the capital of Kenya (50 km). 1.175 S, 36.35 E　Summit elevation 2356 m　Shield volcano
Accessibility	Suswa lies south of Longonot volcano and about 50 km WNW of the capital city of Nairobi.
Resource Characteristics Geology	Suswa Geothermal Prospect is associated with a central volcano with an outer and inner caldera. The inner caldera has a resurgent block in the middle, which has created a circular trench around the block. The outer caldera has a diameter of about 10 km and the inner caldera has a diameter of approximately 4 km. The mountain has a maximum height of 2356m above sea level with the caldera floor elevation of about 1900m. Geothermal surface manifestations occurring around the outer and inner caldera where near North South structures intersect the calderas, including the trough surrounding the island block make the volcano an attractive prospect for geothermal energy investigations.
Volcanic activity (heat source)	Suswa is the southern most Quaternary volcanoes in the central Kenya rift. Earlier investigations indicated that the latest magmatic activity in Suswa is estimated to have occurred about 200 years ago within the annular trench in the caldera (Torfason, 1987a; Torfason, 1987b; KPC, 1992). The phonolitic nature of the lava implies medium level magma chamber, which could provide a heat source for a geothermal system. NE-SW gravity high sitting directly on Suswa caldera suggesting a massive dense body, most likely to be a shallow magma chamber at depth of 8 km in to NE and 4 km below OlDoinyo Nyukie. This also coincides with a reverse (‘positive’) magnetic anomaly. This could be the heat source.
Geological Structrure	All the lava flood formations are heavily faulted trending N-S and NNW-SSE. There are acurate fault systems to the SE and SW which may be acting as up-flows from the reservoirs.
(Past Geological Studies included)	KenGen carried out detailed scientific studies that included geology, geochemistry and .geophysics (MT/TEM, Schlumberger, and micro-seismic).
Geochemistry	The presence of a degassing magmatic body is also indicated the presence of solfatara within the annular trench (Omenda, 1993). Low pH of fumarole condensate also suggests close proximity to magma bodies or upflow of a geothermal system (Halldor, 1987; Geotermica Italiana, 1987).
Work done so far	Geochemical studies were carried out on the fumaroles; and the waters from surface water points such as springs and rivers. These included major element chemical analyses on liquid phase samples; gas analyses on samples from fumaroles, isotopic determinations on all fluid sources in the area and soil survey have been done.
Geophysics	Interpretation of DC Schlumberger soundings was conducted by Geotermica Italiana in 1987. Subsequent analysis were added by KenGen geophysicists through MT/TEM and micro-seismic survey.
Gravity	A major NE-SW gravity high sitting directly on the Suswa Caldera with amplitude 250 g.u. and half wavelength of about 12.5 km in the caldera area. The anomaly appears to broaden and extend further south beyond the present area of investigation. The anomaly amplitude within the caldera is more pronounced to the south-west with its peak occurring slightly south of the Oldonyo Nyoike peak then decreases gently further south. Some small anomalies superimposed on the gravity high in the region of the Suswa caldera which could be related to shallow structural variations and geology within and around the caldera. Generally low gravity values towards the west and east.



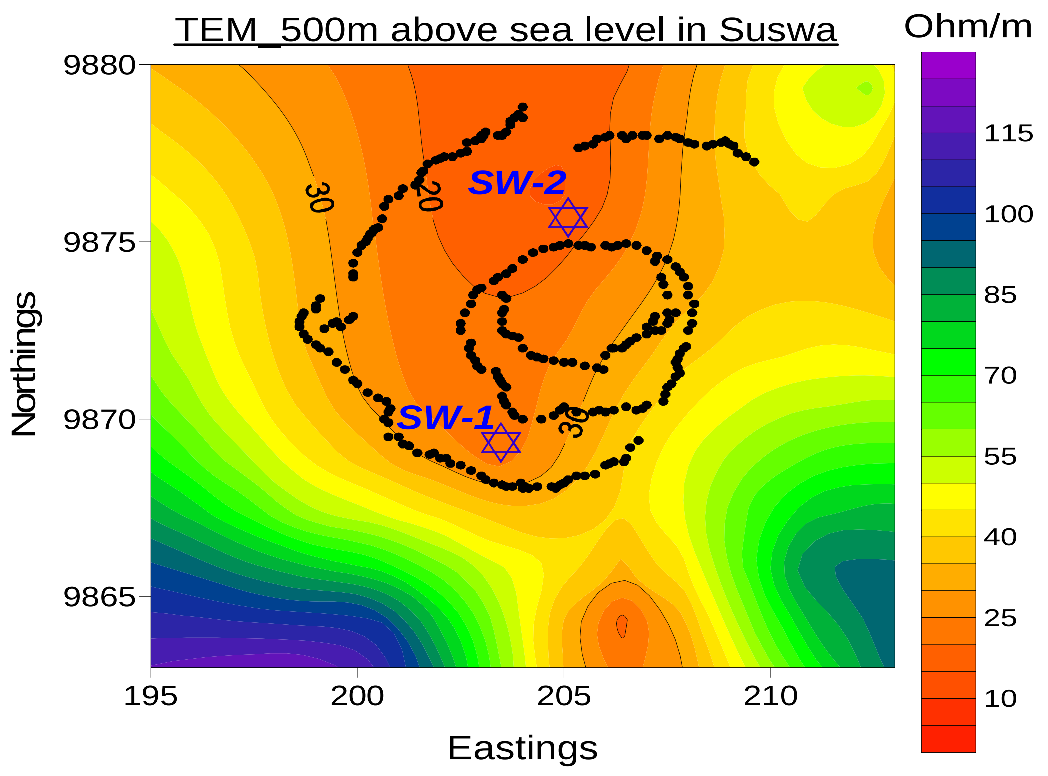
Suswa地域の地質図



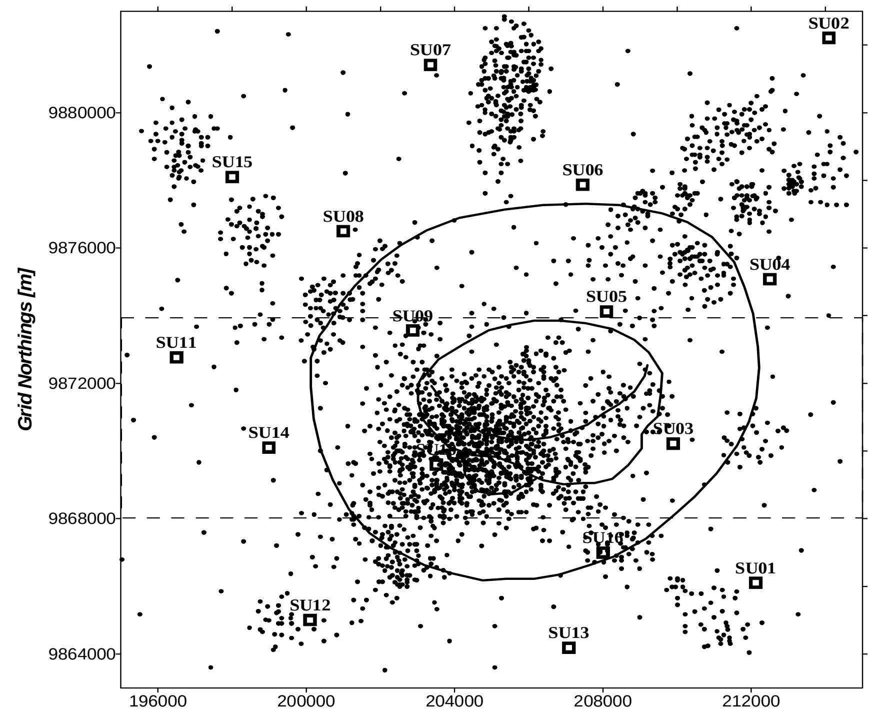
Suswa地域の地熱貯留層の広がり

別冊資料-1-3　Suswa地域（ケニア）の地熱資源状況（２）

Resistivity	Interpretation of DC Schlumberger soundings by Geotermica Italiana in 1987 identified 3 anomalous regions of low to intermediate resistivity. The first region was found on the western half of the outer caldera extending to the south and southwest. The second region was found on the eastern slopes of the mountain with a N-S linear trend. The third region was found to NW corner of the prospect area. The boundaries of these anomalies were not defined but appeared to cover large areas.
Well Drilling	
Temperature Survey	
Well testing	
Conceptual Model	The geothermal system developed prior to caldera collapse as hydrothermally altered lithics occur within the syn-caldera sequences. The geothermal system must have attained temperatures of more than 2500C as seen from the presence of hydrothermal epidote within the lithics. Gas geothermometry indicate that gases sampled in the prospec originated from sources having temperatures of more than 200oC. The size of the high potential area is not well defined but is probably within the caldera floor and to the south. Resistivity data indicated that the top of the geothermal reservoir in the caldera is deeper than 1000 masl. The prospect has a good recharge from both the west and east rift escarpments. Water table is probably lower than 300 m below the floor of the valley in the vicinity of Suswa or greater than 600 m below the caldera floor. Recharge could be mainly from western and eastern escarpments and hydraulic gradient from the north.
Present Status of Development	The existing investigations have inferred the presence of a geothermal resource in the Suswa prospect. However before exploratory drilling can commence there is need to carry out more detailed work (mainly involving MT resistivity and TEM) in western, southern and north-western parts of the caldera and if possible a few stations on the Central Island, areas that look promising from the analysis.
Natrural/Social Environmental Condition	
Power Sector Situation	
Power Output Potential	
Resource Potential	600MW (estimated): Detailed surface exploration has been done. Exploration drilling to commence 2011.
Restrictted by National Park	
Restricted by Power Demand	
Rank of Development Priority	
Potential (Expected) Developer	
Proposed Geothermal Development Plan	
Outline for Power Development	
Possible or Recommended Multi-purpose Geothermal Heat Use	
Scope for Power development	
CO2 emission Reduction ('000 tonne/year)	
Proposed Geothermal Development Schedule	
Location Map	
Other Figures	



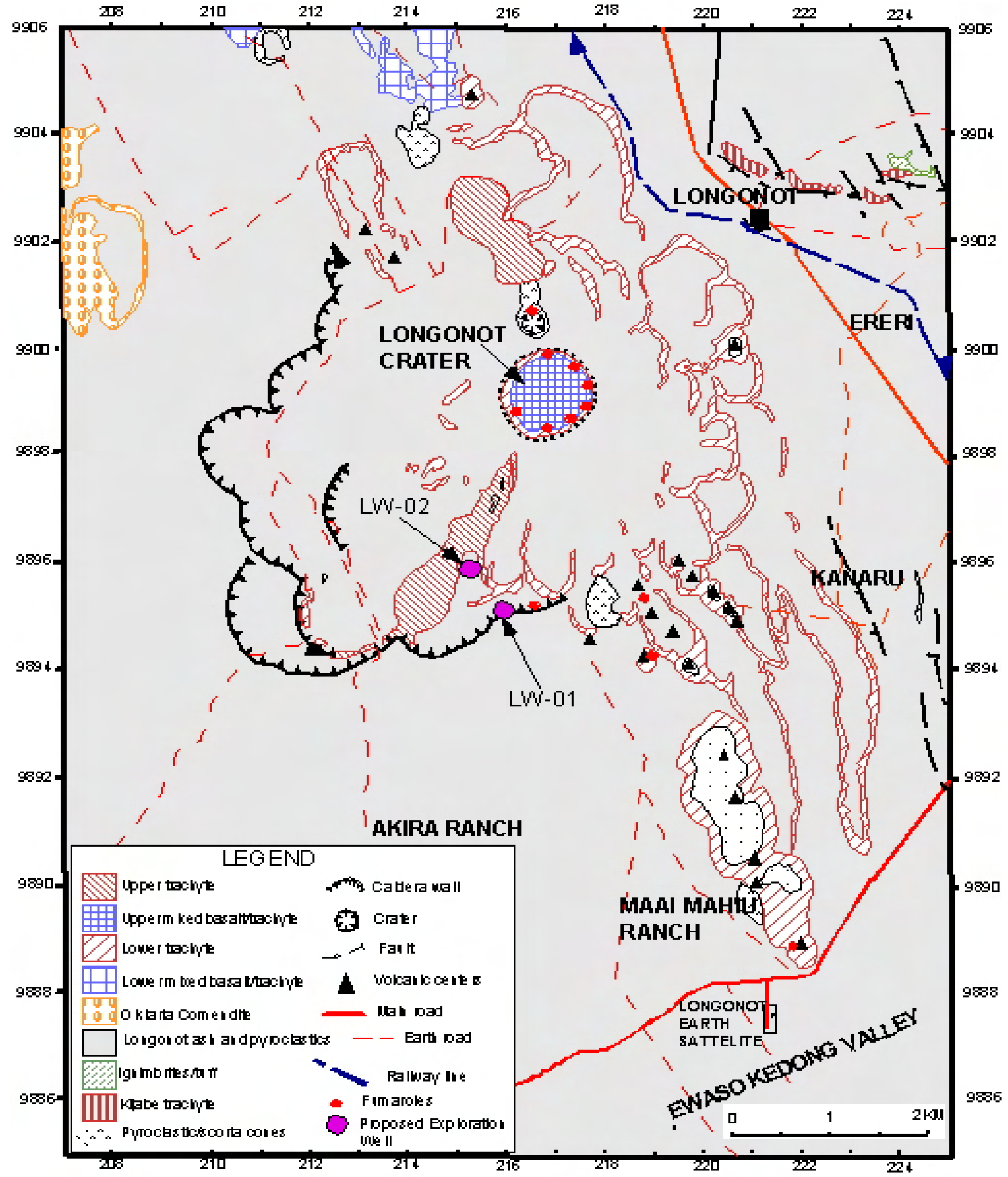
Suswa地域の調査井掘削候補地点



Suswa地域の震源分布図

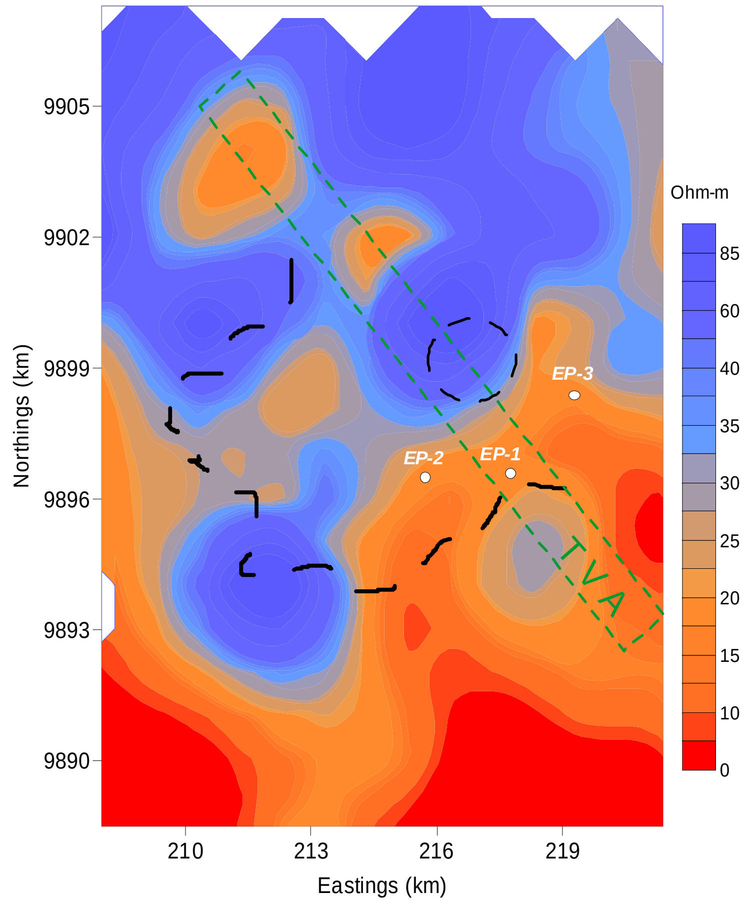
別冊資料-1-4　Longonoto地域（ケニア）の地熱資源状況（１）

Field Name	Longonoto
Country	Kenya
Province/Location	Latitudes 0o51' S and 1o02' S and longitudes 36o22' E and 36o32' E. Longonot Volcano Caldera is located east of Olkaria geothermal field on the floor of the rift valley.
Location	Longonot is one of the geothermal prospects with the Central Kenya Rift. The prospect is located on the Kenyan Rift Valley floor about 60 km southeast of Nairobi. It borders Olkaria volcanic complex to the west, Lake Naivasha to the north, Suswa volcano to the south and Kijabe hill to the east. Longonot volcano occupies an area of about 350 km2 and consists of a cone with a gentle slope to the south and attains a maximum height of 2776 masl. It rises about 1000 m high relative to Akira plains which lie to the southwest and 880 m high relative to Lake Naivasha to the north.
Resource Characteristics Geology	It consists of arcuate structures on the western and the southern parts which mark remnants of a caldera boundary. The area in and around Longonot is marked by active manifestations that occur in the form of fumaroles, altered grounds, warm grounds, sulphur deposition and silica deposition. Geological studies indicate that Longonot Volcano is a Quaternary volcano, which is a divergent zone where spreading occurs resulting to the thinning of the crust hence eruption of lavas and associated volcanic activities. Trachyte, mixed basalt/trachyte, ignimbrites, base surge, pumice fall and ashes are the rock types associated with the volcano.
Volcanic activity (heat source)	Development of the precursor of Longonot caldera started 800,000 years ago with the development of a broad shield volcano. Volcanism continued and culminated in the caldera collapse about 9,000 years ago. Subsequent volcanism occurred in the center of the caldera and resulted in the building of a trachytic massif and deposition of thick pumice deposits within the caldera and on the flanks. It is estimated that the most recent volcanism at Longonot occurred about 200 years ago within the summit crater and along a north-northwest trending volcano-tectonic axis. The geothermal potential of the area is associated with a shallow magma chamber that exists under the caldera and the summit crater. A heat source in the form of shallow intrusives is postulated to exist under the caldera and the summit crater. Xenoliths showing high alteration temperatures suggest hydromagmatic eruptions encountering geothermal aquifers with high temperatures.
Geological Structrure	The main structures in the area are tectono-volcanic axis, faults, caldera rims and lineaments. The general trend of the tectono volcanic axes is NNW-SSE and are marked by lava and pyroclastic cones which are aligned on the northern and the southern parts of the summit crater.
(Past Geological Studies included)	Many scientific investigations have been carried out in the area. But many of these were not specific to geothermal exploration. Under a UNDP, UK and Government of Kenya Technical Cooperation in the 1980s, extensive work was done on a geothermal resource assessment program of the Longonot-Suswa prospects. Further surface exploration work has been carried out in the mid of 2000's by KenGen on behalf of the Ministry.
Geochemistry	The Longonot geothermal prospect has positive indicators of a geothermal resource. Numerous manifestations occur within the summit crater and a few outside on volcanic centres to the south and on the southwestern caldera rim. They occur in form of fumaroles, altered grounds, warm grounds and sulphur and or silica deposition. Few manifestations are exposed in the area due to the thick pyroclastic cover. The few indicators include low-pressured fumaroles with a few exceptions located inside the Longonot summit crater. Geochemical survey conducted involved fumarole sampling and soil gas survey with emphasis on carbon dioxide (CO2) and radon (Rn-222) gas compositions. Reservoir temperatures estimated using the gas geo-thermometers indicate a resource with geothermal fluids in excess of 3000C. These are conceived to be flowing from around the main summit crater towards the south and southwest.
Work done so far	A concerted effort was made in the 1980s to collect geochemical data. The Longonot area has limited surface activity that makes it difficult to explore using geochemical methods.
Geophysics	A sizable amount of geophysics data using the gravity, resistivity and micro-seismology techniques has been collected from the Longonot prospect. A detailed interpretation of geophysical data collected by KenGen was done in the mid of 2000's, aimed at evaluating the significance of the data for sitting deep exploration wells.
Gravity	Gravity low to the north of Longonot caldera including Kijabe Hill and the north-west of it Gravity high to the south-east Localised gravity high just north-west of Hyrax Corner Gravity low to the west corresponding to the outer Longonot caldera.

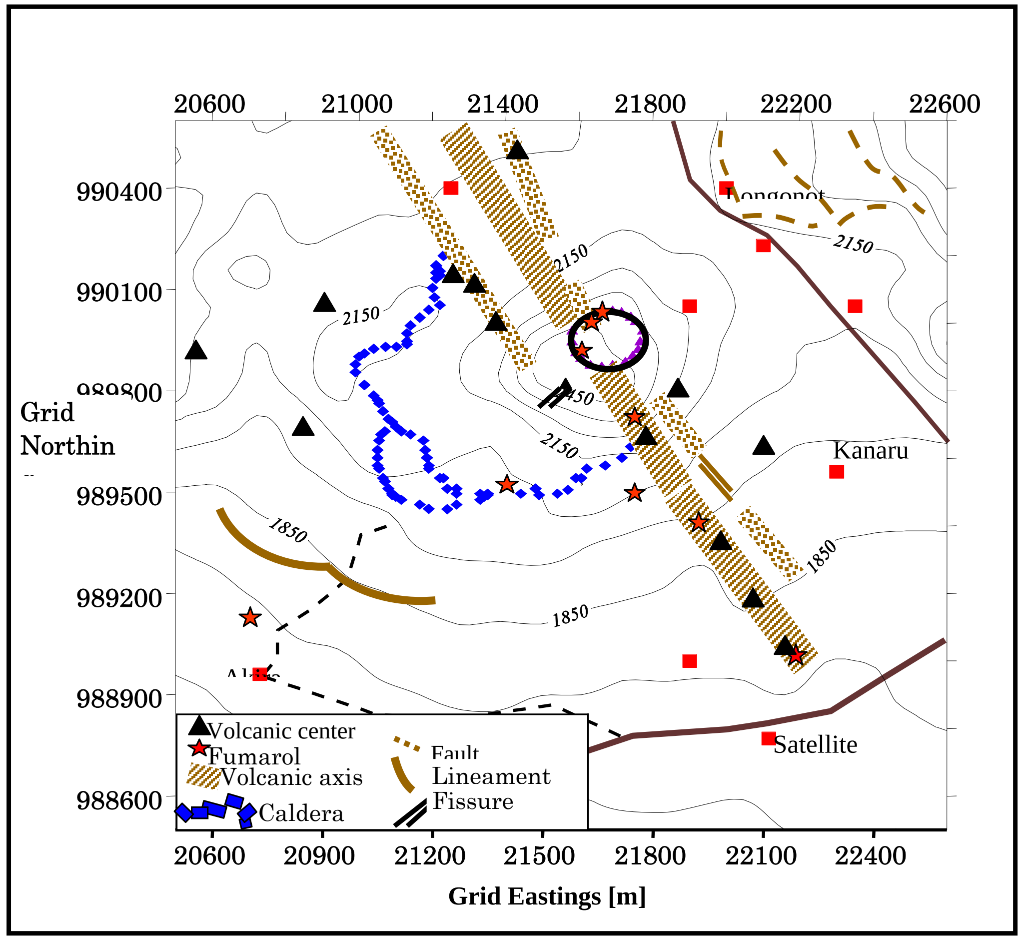


Longonot地域の地質図

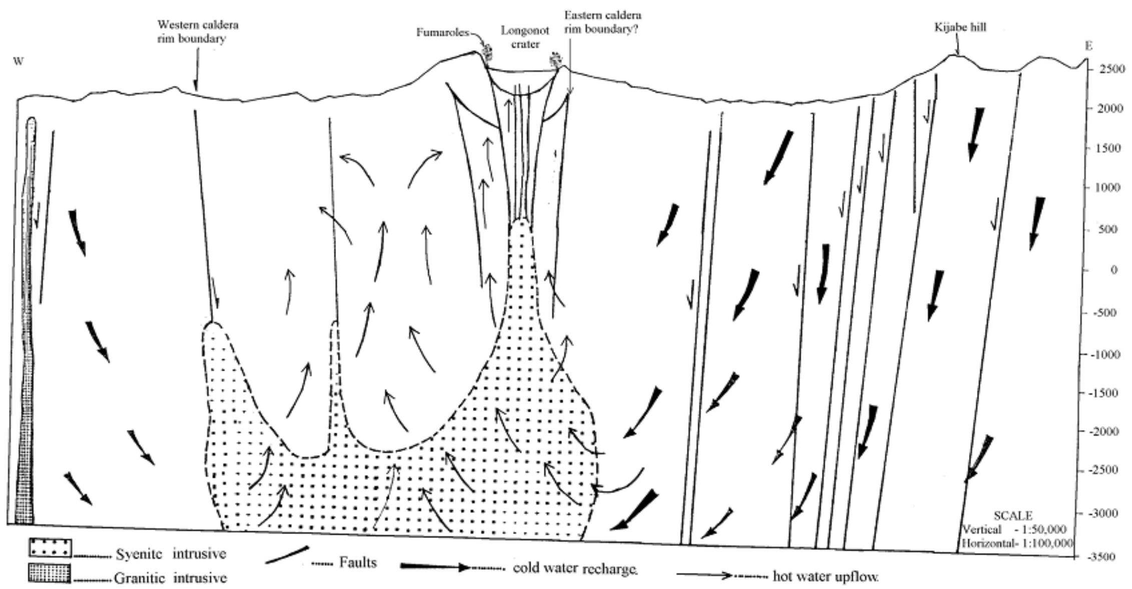
Resistivity	Two shallow low (<10 ohm-m) resistivity anomalies were mapped. Interpretation of the data suggests a deep low resistivity anomaly exists in the area. The first anomaly lies to the south and southeast of the Longonot summit but within the outer caldera and covers about 70 km². It is shallower to the south of Longonot but deepens to the north. The second anomaly is found around the Akira offices further south and covers about 30 km². The northern sector of the study area shows high (>20 ohm-m) resistivity. The low resistivity anomaly is attributed to higher subsurface temperature, higher degree of hydrothermal alteration and higher permeability. The areas of higher subsurface resistivity are attributed to lower temperatures, lower degree of hydrothermal alteration and a deeper heat source. The heat source is postulated to be shallower to the south of the crater and deeper to the north as shown by MT interpretation. Geophysics data has also mapped low resistivity areas that are coincident with regional NE and NW trending faults that cut across the rift floor through the geothermal prospect. Their interpretation is that these faults control flu
Well Drilling	None
Temperature Survey	
Well testing	
Conceptual Model	The prospect area is faulted though the faults are completely covered by the Quaternary lavas and pyroclastics from Longonot and adjacent volcanic centres. The area is most likely recharged by the flank faults from the eastern part which channel the fluids deep to the heat source. Another recharge is through the concealed rift floor faults that run in a NNW-SSE direction, that channel the fluids from the northern part of the field. The regional hydrologic flow of the area is southwards and therefore the recharge from the north via the faults is quite possible.
Present Status of Development	KenGen conducted surface exploration work of Longonot geothermal prospects in 1 998 that involved geological, geochemical, geophysical and environmental surveys (KenGen, 1998). The presence of hydrothermally-altered lithics indicates that the geothermal system under the volcano must have attained temperatures of more than 250℃. Resistivity studies indicate an anomaly on the southern slopes of Longonot crater. These results have been used to site the first exploration well south of the volcano bound by the caldera structure. Exploration wells are proposed in the area bound by the caldera rim where a heat source in form of intrusives is thought to be present, closer to the NW-SE Tectono-Volcanic Axis (TVA). The accessibility of the area is controlled to a large extend by the topography. The areas that are accessible and which are served by tracks include the eastern and the southeastern portions. Those areas that are poorly accessible and would involve quite some earth moving include the southern part of the summit crater and close to the steep edges of the crater. The difficult areas to access include the summit crater and its steep flanks and areas with lava flows exposed.
Natrural/Social Environmental Condition	
Power Sector Situation	
Power Output Potential	
Resource Potential	750MW (estimated): Detailed surface exploration have been done. Exploration drilling to commence mid-2010.



Longonot地域の標高1,300mにおけるTEM比抵抗異常図と掘削候補地点



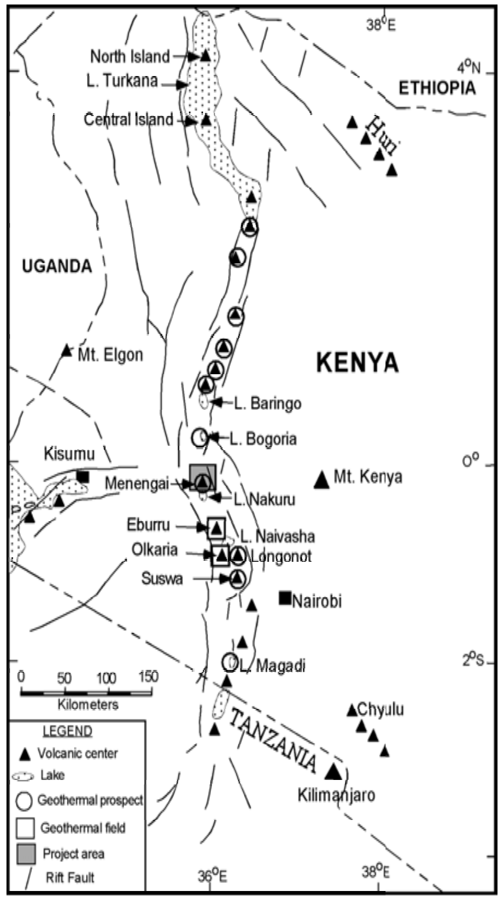
Longonot火山の構造図



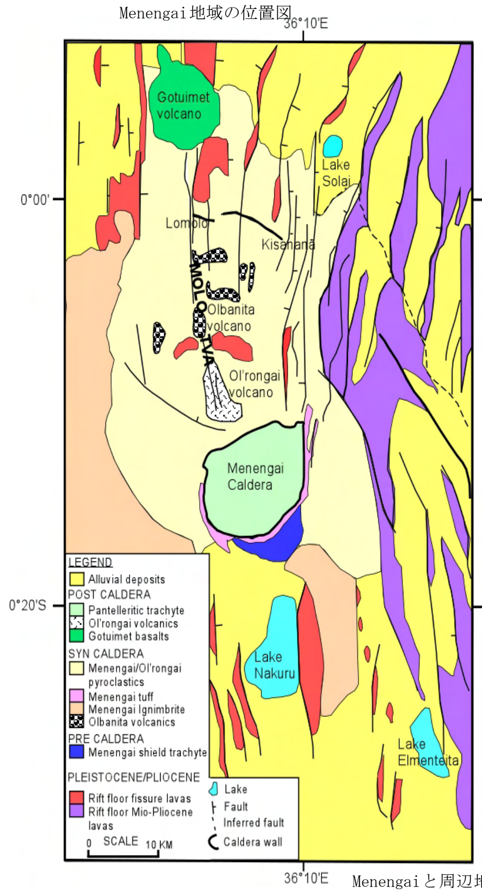
Longonot地域の流体流動モデル

別冊資料-1-5　Menengai地域（ケニア）の地熱資源状況（１）

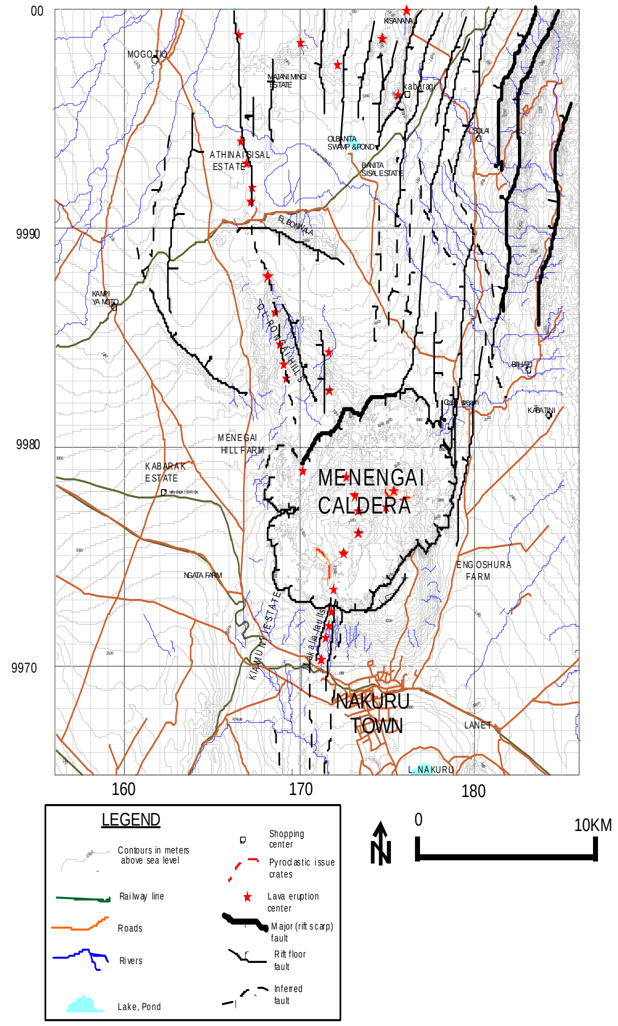
Field Name	Menengai
Country	Kenya
Province/Location	Parts of six (6) administrative divisions that include Nakuru Municipality, Bahati, Njoro and Rongai divisions of Nakuru district and parts of Mogotio and Kisanana divisions of Koibatek District.
Location	The Menengai Caldera Geothermal Prospect is bound by the UTM co-ordinates 157000 E to 185000 E and 9966000 N to 0 (Equator). The area encompasses Menengai volcano, Ol'rongai volcanic field, the Olbanita plains and parts of the Solai graben. The prospect area measures 29X30 km2 and extends from the immediate north of Nakuru Town in the south to Kisanana in the north.
Resource Characteristics	
Geology	Menengai Geothermal Prospect is located within an area characterized by a complex tectonic activity associated with the rift triple junction. This is a zone at which the failed rift arm of the Nyanza rift joins the main Kenya rift. The Kenya rift is characterized by extension tectonism where the E-W tensional forces resulted in block faulting, which include tilted blocks as evident in both the floor and scarps of the rift. Narrow scarps that show little effects of movements and have been eroded resulting in gentle scarps characterize the western margin. The eastern margins however depict wider belts, with sharp scarps implying recent active movements. This is further confirmed by the presence of a detachment fault (bounded by transcurrent faults) that runs for hundreds of kilometres. The rift trough is cut by numerous normal faults that clearly represent continued extensive tectonism under the rift floor. Two rift floor tectono-volcanic axes (TVA) that are important in controlling the geothermal system in study area include the Molo and the Solai TVA.
Volcanic activity (heat source)	The surface is covered by volcanic rocks mostly erupted from centres within the area. Most of the area around the caldera is covered by mainly pyroclastics erupted from centres associated with Menengai volcano. Young lava flows infilling the main caldera are post caldera in age. Older (Pleistocene) lavas mainly trachytic and phonolitic in composition are exposed in the northern parts and are overlain by eruptives from Menengai volcano. Some alluvial deposits are found in low-lying narrow grabens where they are deposited as thin reworked layers. One isolated exposure of diatomaceous bed was noted on the caldera floor, probably indicative of prehistoric climates and existence of shallow fresh lakes in this part of the rift. The Menengai caldera represents a collapse directly above a partially emptied magma chamber. The 88 km2 oval depression indicates a vast magmatic body underlying the volcano. The continued eruptions (intra and post-caldera) which include the fresh young lavas, suggest that the magma body could still be active.
Geological Structure	The location of Menengai prospect on the rift floor where the hydrogeologic regime comprises of recharge from the higher rift scarps and the intense rift floor fracture/faulting resulting from extensional tectonics of continental rifting, provide for a good structural set-up that allows water from the rift scarps to penetrate deep into the crust. The water then flows towards the hot magmatic intrusives under the rift floor and the normal faults provides for conduits for the hot fluids to percolate from depth into possible geothermal reservoirs at shallower depths. The regional Molo TVA may be such an important conduit of deep fluids thus an important geothermal controlling feature in the area
(Past Geological Studies included)	Inventory of hydrothermal features, geological mapping and Petrographic studies Petrochemical and XRD analysis of surface alteration minerals
Geochemistry	The geochemical survey in Menengai prospect conducted involved fumarole sampling and soil gas survey with emphasis on carbon dioxide (CO2) and radon (Rn-222) radioactivity in the soil air. The soil gas survey was conducted along traverse lines running E-W and were 1000 m apart while the sample points were taken at 500 m in areas with visible surface geothermal manifestations and wider apart in areas no manifestations.
Work done so far	Geochemical studies were carried out on the fumaroles; and the waters from surface water points such as springs and rivers. These included major element chemical analyses on liquid phase samples; gas analyses on samples from fumaroles, isotopic determinations on all fluid sources in the area and soil survey have been done.
Geophysics	Gravity and seismology data from studies of the Menengai area identified bodies postulated as magma chambers that could constitute the heat sources directly beneath the caldera (Simiyu and Keller, 1997, 2001). Resistivity investigations revealed anomalies in areas north of the caldera (Geotermica Italiana, 1987). On the basis of these previous surface exploration activities at Menengai geothermal prospect, three sites were proposed for exploration wells.
Gravity	Gravity data interpretation by KRISP (Simiyu and Keller, 1997) along a regional profile that runs across Menengai show gravity high with an amplitude of 40 mgal and an EW wavelength of 35 km. This anomaly was modelled as an intrusive body, about 13 km wide and coming to within 4 km depth below the surface. Mariita (2003) carried out a filtering analysis of the gravity data from the area and found out that when the filter wavelength passed is increased, wavelengths and amplitudes of the anomalies change implying deeper roots of the causative structures. The individual gravity highs of Ol'rongai and Olbanita volcanic centres and Menengai caldera merge giving the impression of a continuous gravity high along the Molo TVA.
Resistivity	KenGen in 1998 carried out a re-interpretation of all the resistivity data and their results confirmed the earlier findings by Geotermica Italiana (1987). A distinct low resistivity anomaly (<15 Ωm) occurs to the west of the Menengai crater and the western anomaly extends into the Ol'rongai estate to the NW of Menengai in the Solai-Kisanana area. At 1000 m.a.s.l. the three distinct areas previously identified by Geotermica Italiana are clearly seen.



Menengai地域の位置図

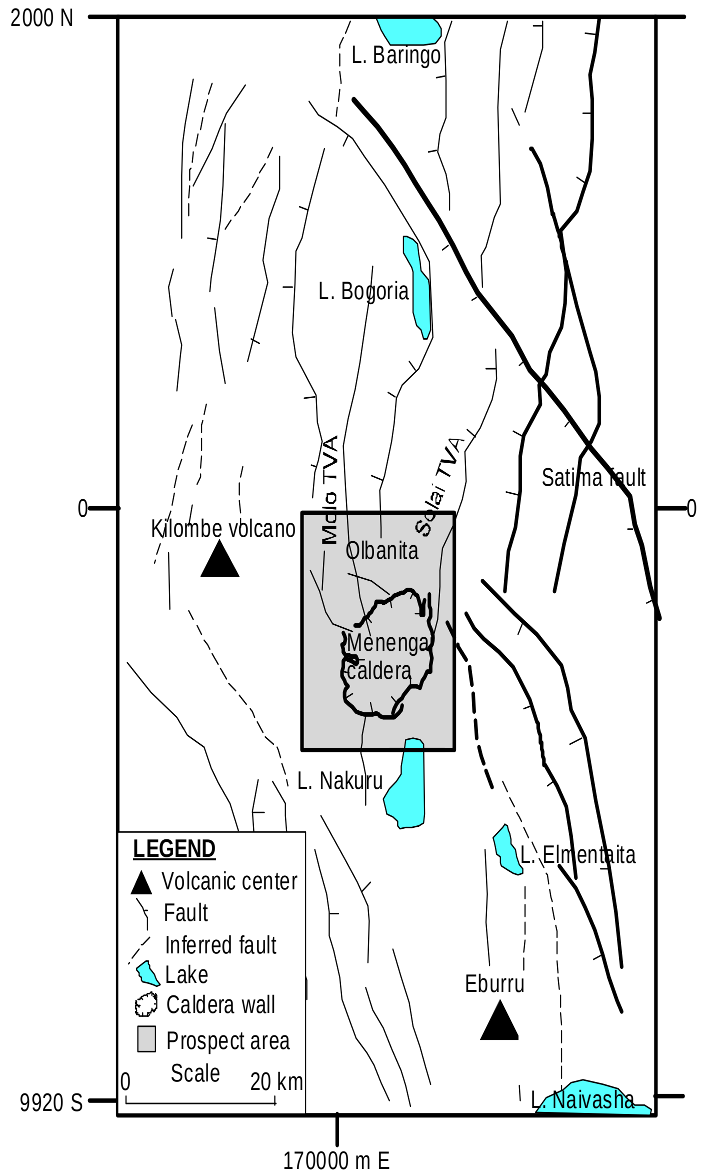


Menengaiと周辺地域の地質図

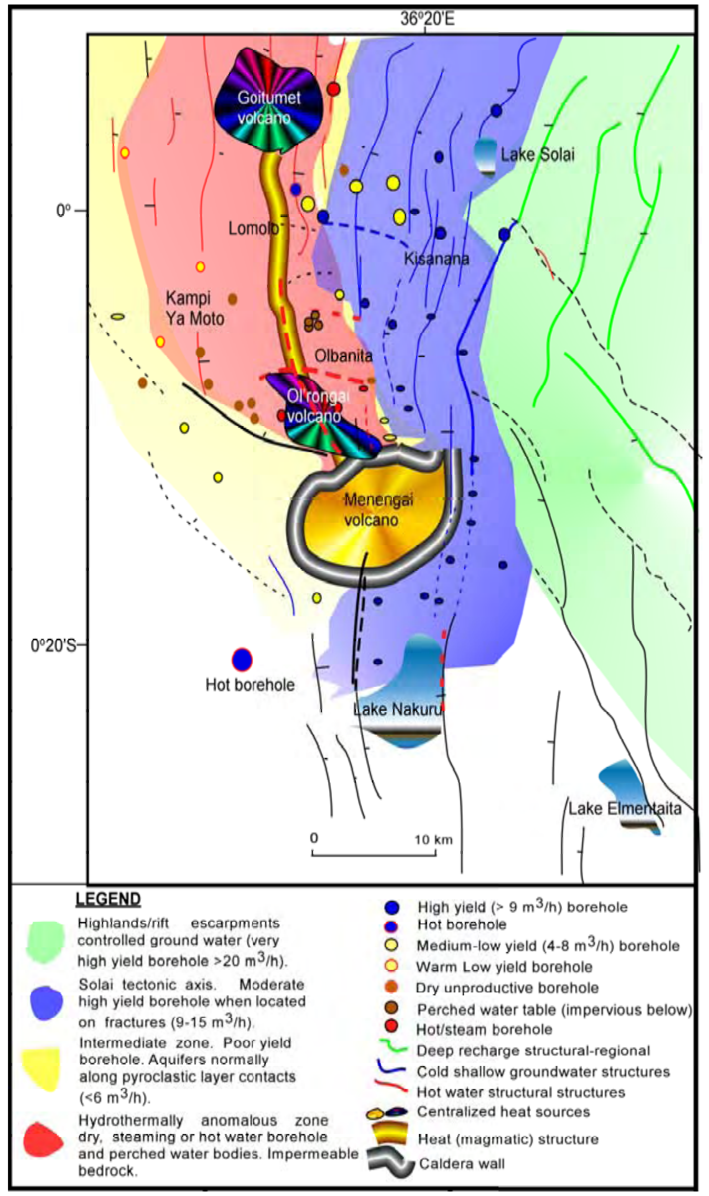


Menengai地域図

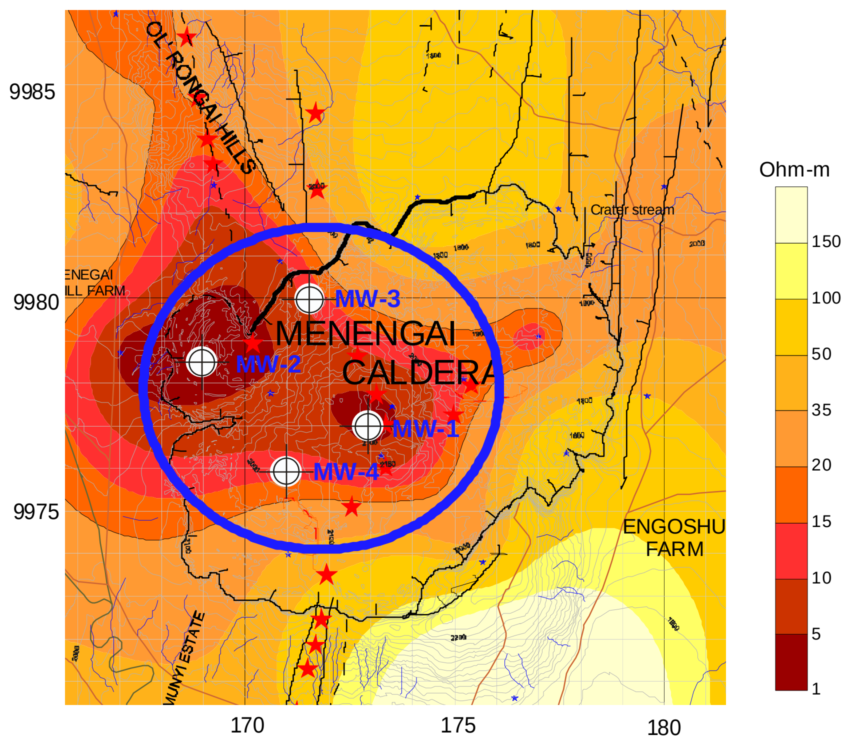
Well Drilling	None
Temperature Survey	
Well testing	
Conceptual Model	A high temperature geothermal system exists under Menengai caldera within the prospect. It is postulated that the geothermal reservoir is at temperatures of more than 250°C as inferred from gas geothermometry. It is envisaged that the reservoir is hosted within fractured trachytes and associated pyroclastics of the Menengai shield formation and flood trachytes of the Kenya rift floor The intense fracturing of the formations is likely to have created high permeability within the reservoir, however, it is expected that some regions could have effects of sealing by dyke intrusions. It is modelled that the reservoir primarily exists within but with extensions to the west and north of the caldera. The main upflow of the geothermal fluids is postulated to be around the centre of the caldera and extending mainly west and northwest of the caldera. Resistivity data indicates the eastern half of the caldera to have relatively less potential as evidenced by higher values. The top of the reservoir is to be expected to be between 500-1,000 m depth and outflows at shallow levels to the east, west and north. However, it is not clear yet whether some of the outflows c
Present Status of Development	Drilling of exploratory wells represents the final phase of any geothermal exploration programme and is the only means of confirming the characteristics and potential of a geothermal reservoir. Based on results of the present study, it is concluded that Menengai has a high potential that warrant further exploration by drilling deep geothermal wells. It is proposed that four exploratory wells; MW-1, MW-2, MW-3, and MW-4 be drilled. But before commencement of exploratory drilling, a full EIA study for the prospect area should be carried out . Whilst, the northern extent of the resource along the Molo and Solai TVA's requires further investigation as preliminary studies indicate possible existence of geothermal systems. The surface studies should also be extended northwards to include Arus-Lake Bogoria area.
Natural/Social Environmental Condition	
Power Sector Situation	
Power Output Potential	
Resource Potential	1200MW (estimated): Detailed surface exploration done. Exploration drilling to commence mid-2010.
Restricted by National Park	None
Restricted by Power Demand	
Rank of Development Priority	A
Potential (Expected) Developer	GDC (state-own company)
Proposed Geothermal Development Plan	
Outline for Power Development	The 840MWe power generations in Menengai prospect will be conducted in 6 phases (140MWe x 6 phases). The demand of electricity in Kenya is large, so a large scale power plant development as far as resource available is recommendable.
Possible or Recommended Multi-purpose Geothermal Heat Use	
Scope for Power development	
CO2 emmission Reduction ('000 tonne/year)	
Proposed Geothermal Development Schedule	
Location Map	
Other Figures	



Naivasha湖ーBaringo間のケニアリフトフロアの構造

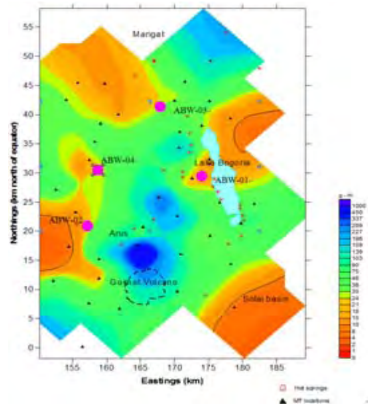


Menengai地域の流体流動構造

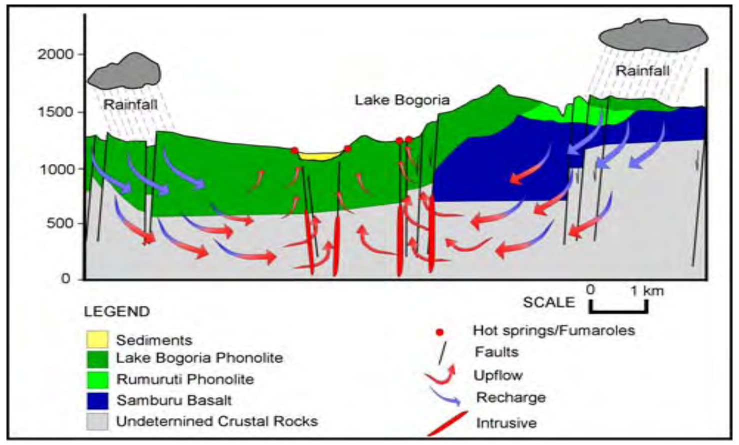


標高2,000mにおけるMT比抵抗図とMenengai地域の掘削候補地点

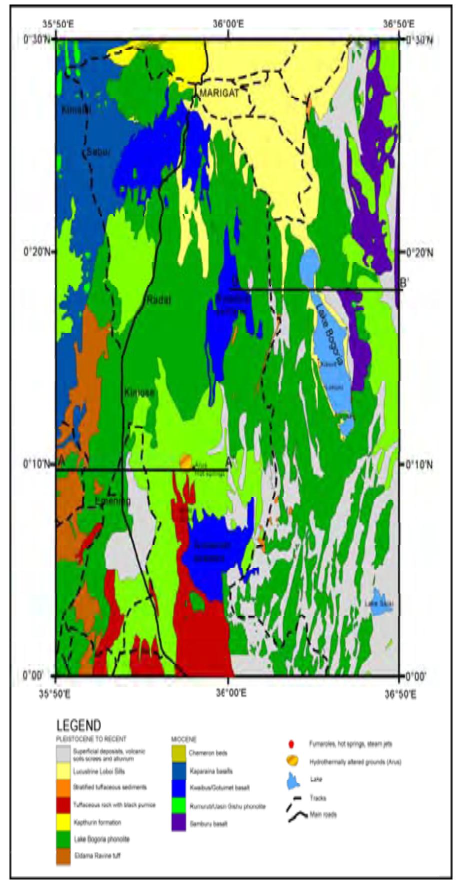
Field Name	Arus Bogoria
Country	Kenya
Province/Location	The area referred to as Arus and Lake Bogoria prospects is located within the Kenya Rift valley immediately south of Lake Baringo prospect and north of Menengai prospect. It is situated mainly within the Baringo and Koibatek Districts and also includes parts of Nakuru District. The area is bound by longitudes 35°50' and 36°10' E and latitudes 0°00' (Equator) 0°30' N and is approximately 2000 km².
Accessibility/Communication	The prospect area is well served by a network of both all weather to murram tracks and therefore is fairly accessible. Nakuru-Kabarnet tarmac road run across the prospect area near the western boundary from north to south. The seasonal tracks serve most of the area making it easily accessible, though with difficulty during the rainy seasons. Electric power and telephone service lines serve most of the farms, hotels and market centres that are in the area. GSM coverage appears intermittently within the prospect area.
Resource Characteristics Geology	The upper Plio-Pleistocene volcanism of the rift floor in the area between Arus and Lake Bogoria is characterized by large volumes of evolved lavas that consist mostly of peralkaline trachyte, trachyphonolite and phonolite. Small outcrops of basaltic lavas occur in isolated areas within the prospect. The northern sector is, however, dominated by fluvial and alluvial deposits.
Volcanic activity (heat source)	Major faults extended along the western side forming half graben bounded by monoclinic flexure on eastern side and development of major basaltic-trachytic shield volcanoes occurring. Major faults developed on the eastern side with the half graben changing into full graben accompanied by basalt-trachyte volcanism. The formation of the graben structure started about 5 million years ago and was followed by fissure eruptions in the axis of the rift to form flood lavas by about 2 million years ago. During the last 2 million years ago, volcanic activities become more intense within the axis of the rift. During this time, large shield volcanoes, most of which are geothermal prospects, developed in the axis of the rift. The volcanoes include Suswa, Longonot, Olkaria, Eburru, Menengai, Korosi, Paka, Silali, Emuruangogolak, and Barrier Complex. Other geothermal prospects, of which Arus and Lake Bogoria prospects are, occur between these central volcanoes (Omenda et al., 2001).
Geological Structrure	The main structural features in the Arus and Lake Bogoria areas include; the eastern rift flank, the rift proper, NW, NNE and N-S trending faults and fractures and the Marigat and Loboi lineaments. The most prominent of the NW trending faults is the line of Sattima-Aberdares and Marmanet Faults. Its complement to the north comprising the Lariak-North Arabel and other shorter minor faults forming a belt of discontinuous fractures. Progressively towards the northwest, both fault zones display an en echelon displacement to the west.
(Past Geological Studies included)	The first detailed geological mapping in the Kenya rift including Arus and Lake Bogoria area was done in the late 1960's by the Kenya Geological Survey. Geological work in the area with bias in geothermal exploration was carried out by Geotermica Italiana Srl (1987) in their Menengai-Bogoria reconnaissance report, but dwelt mainly on Menengai caldera. Further surface exploration work has been carried out in the mid of 2000's by KenGen on behalf of the Ministry.
Geochemistry	From the study done in the middle 2000's, geochemical exploration provides greater understanding of the location, nature and the origin of the thermal waters in a geothermal system. In addition, an insight into the recharge mechanism for the reservoir is envisaged. The information is fundamental for the assessment of the relative merits for future exploration and exploitation of a potential geothermal field. Geothermal surface activities in an area can be broadly classified into three types, which include: (i) Hot water in form of springs and mud pools, (ii) Steaming grounds, alteration zones and fumaroles and (iii) Non-manifestation areas where no surface expression of geothermal activity is observed.
Work done so far	Geochemical investigations of this area were carried out by Geotermica Italiana Srl, (1987) and Ministry of Energy (MOE) in 1985-1986 under the auspices of the United Nations Department for Technical Development (DTCD). The work by Geotermica Italiana covered the area from Menengai Caldera in the south to Lake Bogoria to the north. It involved sampling of water points and a few soil gas surveys targeting mainly carbon dioxide gas. High flows of discharging fluids were recorded around Lake Bogoria springs and temperature estimates using solute geothermometry from the springs and boreholes ranged from 145-190°C for borehole and spring water. Gas geothermometry gave temperatures between 209-214oC for the Arus steam jets using CH4/H2 and CO2-CH4-CO gas functions. In the middle of 2000's, geochemical surface exploration was programmed to take one hundred and eighty working days, it was estimated to be adequate to sample all the fumaroles, springs, boreholes, and expedite soil gas surveys in the study area. The work involved (i) Sampling of all boreholes and springs within the Arus-Lake Bogoria prospects, (ii) Fumarole gas sampling, steam condensates and soil gas survey targeting mainly Radon-22
Geophysics	Since the early 1970's both passive and active source seismic investigations were applied to understand the formation and structure of the Kenyan part of the East African rift valley. The United States Geological Survey carried out seismic studies at Lake Bogoria and Olkaria in 1972 and located earthquakes of magnitude 2 or less that were restricted mainly within the fields along fault zones (Hamilton and Muffler, 1972). In 1986/87 a micro-earthquake network was setup in the Lake Bogoria region in an area of bout 25 km diameter in the Molo graben, Ndoloita graben and Kamaachj horst comprising of 15 recording stations. Results from the survey appeared to suggest that most of the activity was associated with larger, older faults of the rift flanks rather than younger grid faults crossing cutting the rift. In the early 2000's, mMethods that were employed during exploration of Arus-Bogoriawere, Magneto telluric (MT) Transient Electromagnetic (TEM) and Gravity.



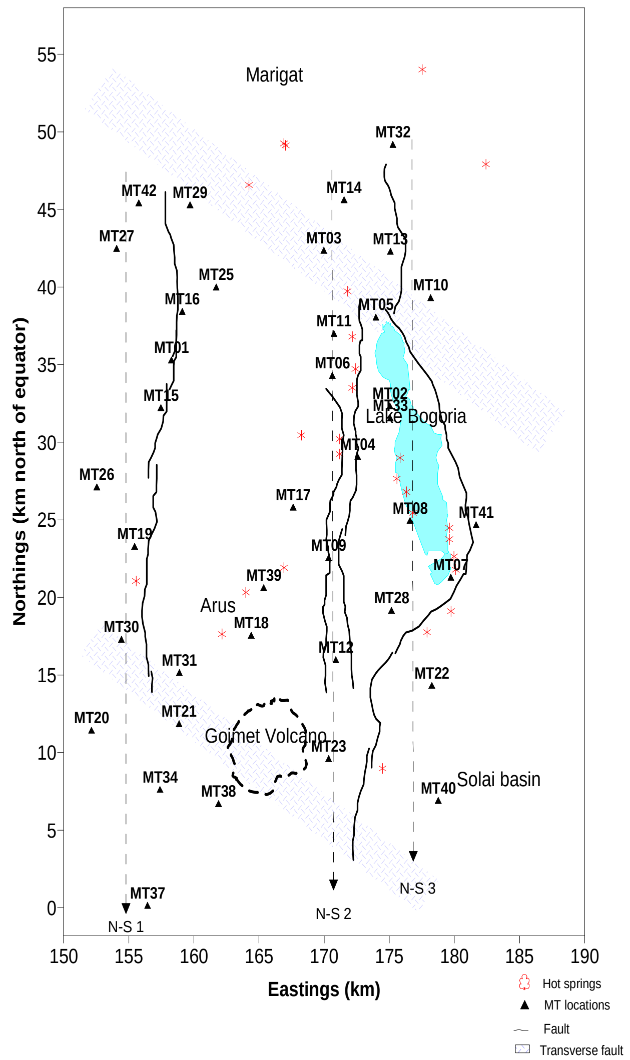
Location of Proposed Exploration Wells in Arus and Lake Bogoria prospect



Conceptualized Model of the Lake Bogoria Geothermal Prospect



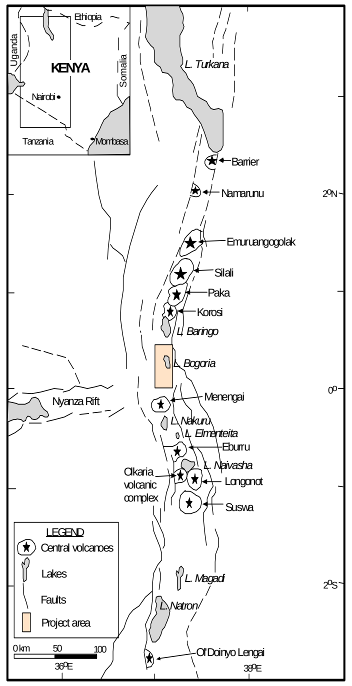
Geologic Map of the Arus-Bogoria Geothermal Prospect



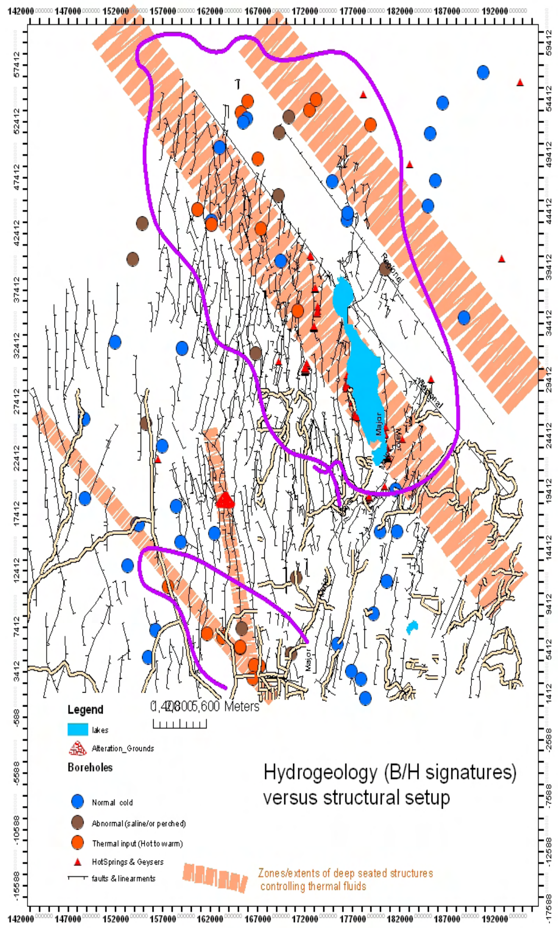
Location of MT soundings and interpreted profiles across the Arus-Bogoria region


Hot Spring at the western edge of Lake Bogoria

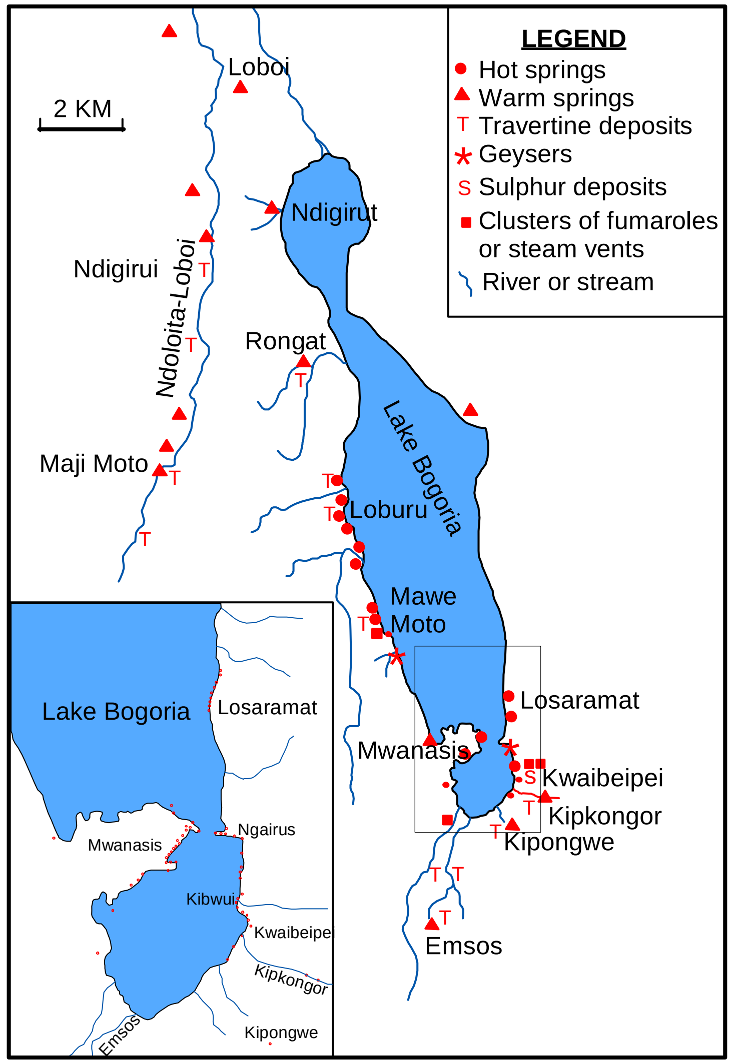
Gravity	The gravity measurements were carried out using Lacoste and Romberg gravimeter model G-767. One hundred twenty data points were collected in the Arus and Lake Bogoria prospect. These were merged with data collected by UNDP and earlier workers for better coverage. Various plot maps of gravity were prepared from the data set comprising of over 150 gravity stations using Bouguer density of ranging from 2.0 gcm-3 to 2.7 gcm-3 using Nettleton's method. It was found that to get the best fit for the region an average Bouguer density of 2.5 gcm-3 had to be used. Iso-maps maps were then prepared.
Resistivity	**TEM**: A total of 47 TEM soundings (Figure 3.3), covering an area of about 1575 km2, were carried out in the Arus-Bogoria prospect area using a central loop TEM array. The results are presented in this report by resistivity iso-maps at various heights above sea level. **MT**: An MT sounding is measured over a frequency range. The lower frequency penetrates deeper than higher frequencies. MT techniques acquire data in frequencies ranging from about 400 Hz to 0.0000129 Hz (a period of about 21.5 h), and are suitable for deeper investigations. Processing, analysis and interpretation of the MT data was carried out using the computer software WinGLink and the results presented by resistivity iso-maps at various elevations and cross-sections.
Well Drilling	
Temperature Survey	
Well testing	
Conceptual Model	Fault controlled geothermal systems exist in both Arus and Lake Bogoria geothermal prospects. The estimated reservoir temperatures predicted to be medium to high (180 - 248ºC) and are ideal for electricity generation as well as direct utilisation. The geothermal system around Lake Bogoria is possibly restricted to the regions around the Lake, more so the southern half. It is postulated that the geothermal system around the Lake involves deep-water circulation through the eastern and southeastern rift master faults. The main recharge path would be via the Sattima-Marmanet fault system. The water would then be heated by the general high geothermal gradient in the area and localized hot bodies possibly associated with deep-seated intrusives as manifested by the occurrence of dikes on the surface. The absence of a clear centralized heat source implies that the geothermal systems are small and restricted to the fault zones. It is also postulated that the system is of medium temperature. No clear cap rock can be described for the system near Lake Bogoria.
Present Status of Development	According to the recommendation of the Exploration study report prepared by KenGen in 2006, 6-exploration wells (>2,000 m) were selected to drill in the in the Arus-Lake Bogoria prospect to confirm and characterize the geothermal systems.
Natrural/Social Environmental Condition	
Power Sector Situation	
Power Output Potential Resource Potential Restrictted by National Park Restricted by Power Demand	 400MW (estimated): Reconnaissance and surface exploration has been done. detailed detailed surface exploration planned for 2010.
Rank of Development Priority	B
Potential (Expected) Developer	
Proposed Geothermal Development Plan Outline for Power Development	
Possible or Recommended Multi-purpose Geothermal Heat Use	Some of direct applications that can be utilized in the Arus and Lake Bogoria geothermal prospects include spa pools, greenhouse heating, agricultural produce drying and industrial processes. Most of these direct use applications utilize geothermal fluids in the low to moderate temperatures and the reservoir can be exploited by conventional water wells drilling rigs. The direct application currently available within the prospect area is a spa pool at Lake Bogoria Hotel. The water, which is at 38ºC is channeled directly into the swimming pool at one end and flows out at the other end.
Scope for Power development	
CO2 emmission Reduction ('000 tonne/year)	
Proposed Geothermal Development Schedule	
Location Map	
Other Figures	

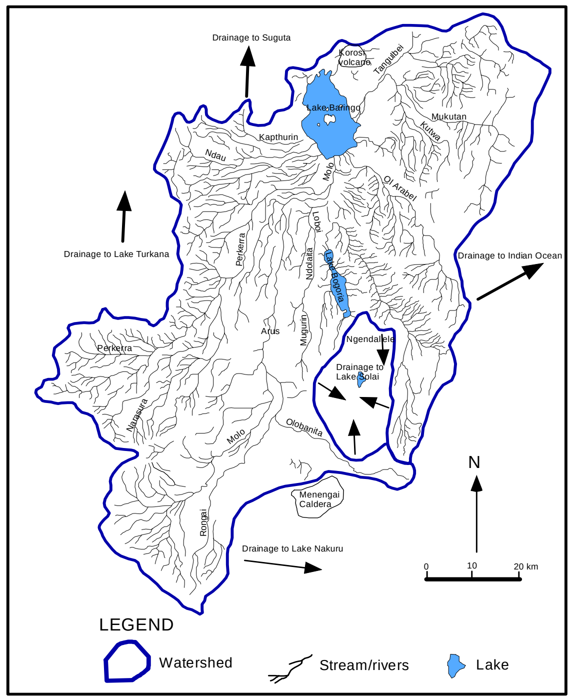


Map of the Kenya Rift showing the locations of major central volcanoes and the Arus and Lake Bogoria geothermal prospects

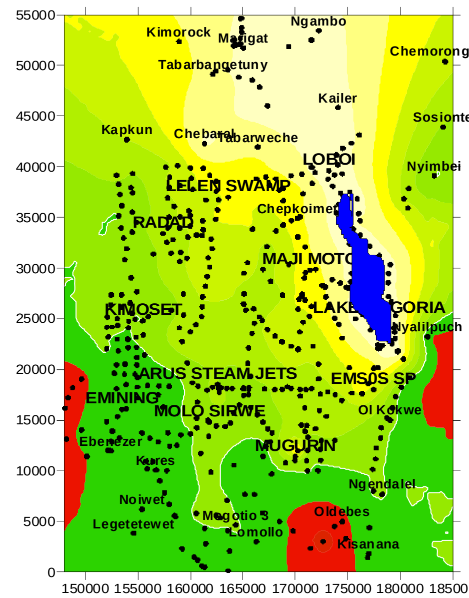


The Structural controls of the hydrogeology and hydrothermal activity in the Arus and Lake Bogoria prospect

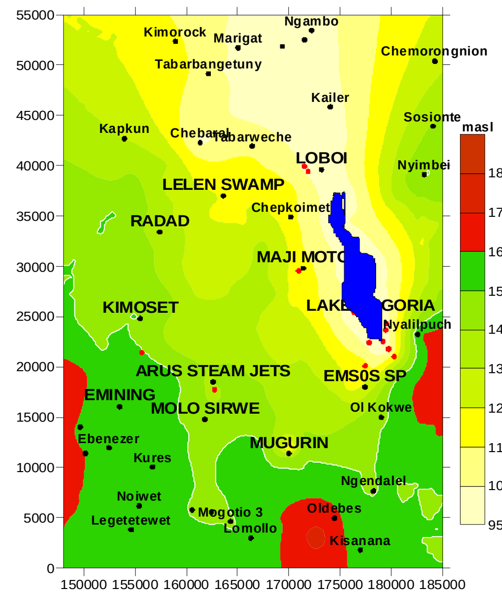




Map of the drainage system in the Arus and Lake Bogoria geothermal prospects



Arus-Lake Bogoria soil gas sampling points



Arus-Lake Bogoria prospects borehole and springs locations