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# Development Cooperation and Geothermal Energy in East Africa

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## ABSTRACT

The Geothermal Exploration Project (GEP) carried out by the Icelandic International Development Agency (ICEIDA), which later merged with the Ministry for Foreign Affairs Iceland, with co-financing by the Nordic Development Fund (NDF), began in 2013 and finished in 2018. Support for geothermal development is defined as a priority in Iceland's Development Cooperation Strategy. The project was also carried out in collaboration with numerous international institutions, including the World Bank, UN Environment, Africa Union Commission and ÍSOR as a technical advisor. One of the cornerstones of the project was to assist the countries in the Rift Valley in East Africa in geothermal exploration and training with the aim to increase knowledge of the possibilities of these countries for utilizing their sustainable and clean resources. In addition to electricity production, direct use (e.g. food drying) is a viable option in many places. The project design in each country was based on demand and requests from countries on particular needs to be addressed.

## INTRODUCTION

Geothermal energy is found in various locations in East Africa, in particular within the countries of the Rift Valley. The energy is used for electricity production in two of these countries, Kenya where a substantial amount is produced (760 MWe) and in Ethiopia where much less is produced (7.3 MWe). Among other countries in East Africa which have geothermal energy resources to some extent are Eritrea, Djibouti, Tanzania, Malawi, Rwanda, Burundi and Uganda. In many of these countries, only low temperature resources are found. One of the main obstacles for further exploration and utilization of the resources, is limited technical know-how and capacities within local institutions. Electricity production by hydroelectrical power plants in East Africa has decreased in recent years because of drought. Therefore, the proportion of other energy resources within the energy mix has become increasingly important. Electricity remains as the key to development progress, education and increased quality of life. Geothermal, as an unexploited energy resource represents opportunities for enhancing development, economic progress and improving the living conditions for the poorest. Knowledge and technical skills of local institutions and experts is a key in this respect and ensures local ownership of development efforts.

In 2013, the Icelandic International Development Agency (ICEIDA, now Directorate for International Development Cooperation under the Icelandic Ministry for Foreign Affairs) and the Nordic Development Fund (NDF) started a programme aimed at assisting countries in East Africa to develop geothermal resources within the Great Rift Valley. Iceland GeoSurvey (ÍSOR) was a technical advisor to ICEIDA and NDF in all aspects of the programme. The programme, Geothermal Exploration Project (GEP), included geothermal surface exploration in several geothermal fields in Kenya, Tanzania, Djibouti, Eritrea and Ethiopia. Moreover, the project included technical assistance in other projects related to geothermal development in these countries as well as in Malawi and Rwanda (Figure 1), and regional training activities carried out in collaboration with UN Environment. Planning of project activities and emphasis in each country took aim of the status of knowledge and activities of other donors.

Geothermal utilization is in many respects a technically complicated task and future planning of early stage development involves many uncertainties. The GEP aimed at supporting the countries in taking the first steps in exploring geothermal potential of several fields and evaluate potentials for utilization of geothermal energy in the respective countries. Facilitating cooperation with countries to finalize the first steps of geothermal development was seen as essential for further work, reducing risk and providing the grounds for informed decisions on next steps.

Surface exploration studies were completed in several areas in Ethiopia, Kenya, Eritrea, Djibouti and Tanzania within the GEP. In addition, the GEP has supported projects at different stages of geothermal development in Rwanda, Burundi and Malawi. Several training courses have been held in these countries, as well as regionally, in the field of exploration, drilling and geothermal utilization to expand the knowledge base and skills of local specialists. Training activities were carried out in collaboration with the United Nations University – Geothermal Training Programme.

An external evaluation of the project carried out in 2019 found that the project had been relevant to the needs of East Africa countries, generated results to carry on with geothermal drilling and strengthened the countries' organisational and human resource capacities to further geothermal development.


**Figure 1. Countries (in orange color) where surface exploration studies and geothermal development programmes were supported by ICEIDA/NDF.**

**SURFACE EXPLORATION STUDIES AND CAPACITY BUILDING**

It is well known that the first phases of geothermal development (i.e. the surface exploration and exploration drilling) can be difficult to fund due to the high risks and limited information about the energy potential. Thus, funding surface exploration studies and assessing the power potential of a geothermal field is a major milestone. The following projects are listed as examples of surface exploration projects, including geology, geochemistry and geophysics, supported by the project:

- Lake Abhé geothermal prospect, Djibouti – Working with ODDEG (Office Djiboutien de Développement de l'Energie Geothermique) on surface exploration studies including geology, geochemistry and geophysics, resulting in a conceptual model of the area and drilling targets, see Figure 2. A short course on geothermal exploration was held at ODDEG's headquarters in Djibouti prior to the survey. Capacity building was a key factor. Three geothermal experts from ODDEG were invited to Iceland to work on data interpretation and conceptual modelling.
- Assal geothermal area, Djibouti – Working with ODDEG on geochemical sampling and analysis, and a review of previous exploration work, resulting in a conceptual model of the area, volumetric assessment and drilling targets.
- Suswa, Kenya – Working with GDC (Geothermal Development Company) and Efla Consulting Engineers in Iceland on reviewing previous exploration work and performing additional surface exploration studies including geology, geochemistry and geophysics, resulting in a conceptual model of the system and drilling targets. A workshop was held in Nairobi, Kenya at the end of the project organized by UN Environment, MFA and GDC. Capacity building was a key factor.
- Aluto Langano, Ethiopia - Working with GSE (Geological Survey of Ethiopia), ELC Electroconsult in Italy (ELC) and EEP (Ethiopian Electric Power), in collaboration with the World Bank, on carrying out surface exploration studies including geology, geochemistry and geophysics, resulting in a conceptual model of the area, volumetric assessment and drilling targets. Capacity building was a key factor.
- Alalobeda Tendaho, Ethiopia - Working with GSE, ELC and EEP in collaboration with the World Bank, on carrying out surface exploration studies including geology, geochemistry and geophysics, resulting in a conceptual model of the area, volumetric assessment and drilling targets, see Figure 3. Capacity building was a key factor.
- Meteka, Ethiopia - Working with GSE, ELC and EEP on carrying out surface exploration studies including geology, geochemistry and geophysics, resulting in a conceptual model of the area, volumetric assessment and drilling targets. Capacity building was a key factor.
- Luhoi, Tanzania – Working with TGDC (Tanzanian Geothermal Development Company) and ELC on carrying out surface exploration studies including geology, geochemistry and geophysics, resulting in a conceptual model of the area, volumetric assessment and drilling targets. Capacity building was a key factor.
- Kiejo-Mbaka, Tanzania - Working with TGDC and ELC on carrying out surface exploration studies, including geology, geochemistry and geophysics, resulting in a conceptual model of the area, volumetric assessment and drilling targets. Capacity building was a key factor. Prior to the surface exploration studies in Luhoi and Kiejo-Mbaka, a reconnaissance survey was carried out to identify geothermal fields that could be studied further, see Figure 4.
- Ngozi, Tanzania – Assistance to TGDC to finalize surface exploration studies and to write application to GRMF for exploration drilling and participation in writing a SESA report.
- Malawi – Review of country-wide reconnaissance study and surface exploration studies carried out by ELC for the Government of Malawi and the World Bank. Identification of future steps in geothermal development of the Chiweta field, see Figure 5.
- Alid, Eritrea, surface exploration and a short course in surface exploration carried out in collaboration with UN Environment.

Most of these projects included surface exploration studies covering geological, geochemical and geophysical studies. The main goal was to identify potential geothermal resources, evaluate its nature (e.g. size, temperature, permeability), assess the power potential of each field and identify drilling targets for exploration wells. All the exploration studies were carried out in collaboration between international and local experts. The studies were followed up with technical review meetings were the results were discussed and deliberated.

In addition to these surface exploration studies the GEP supported other activities, including programme supported ODDEG in Djibouti and TGDC in Tanzania to write applications for funding of further development of selected geothermal fields, supported the development of a Geothermal Centre of Excellence in Kenya, in collaboration with UN Environment, KenGen, GDC and Africa Union and the UNU-GTP. The project also supported GDC in Kenya to implement ISO 17025 in its geochemical laboratory.

The project also included efforts to explore the viability of geothermal direct uses in the context of East Africa. Importantly, this included collaboration with GDC in Kenya to install a pilot Geothermal Dryer for grain in Menengai.

**Figure 2. Setting up an MT station at Lake Abhé in Djibouti for resistivity surveying.**

**Figure 3. Setting up a seismic monitoring station in Alalobeda in Tendaho, Ethiopia for surface exploration studies.**

## CAPACITY BUILDING

Capacity building was one of the main goals of the programme and was considered vital to ensure local ownership and sustainability of project activities. To a large extent the capacity building goals were addressed through "on-the-job" training that was followed-up by lectures and training courses focusing on various aspects of surface exploration studies. Active participation of trainees was expected throughout each project, during preparation, field work, data handing, interpretation and conceptual modelling. Review meetings were held at the end of most projects with active participation of several geothermal experts. In addition to the hands-on practical training, specialized training courses were held to emphasize certain disciplines, such as chemical analysis and handling/interpretation of resistivity data.

Three groups of geothermal specialists were invited to Iceland to work with experts on different tasks. Three geoscientists from ODDEG in Djibouti visited ÍSOR to work on conceptual model of the Lake Abhé, two geochemists from GDC in Kenya visited

ÍSOR and Matís to study chemical analysis, data handing and practices according to ISO 17025 and nineteen geoscientists, engineers and technicians visited several Icelandic companies and institutions during a four-week training course in Iceland. During the training of the nineteen geoscientists, engineers and technicians from GDC, the trainees visited and worked with experts from ÍSOR, Matís, Mannvit, Verkís and Vatnaskil Engineering. At the end of the training, the trainees presented their work during the training.

ÍSOR carried out training focused on the following topics:

- Tracer and production properties
- Isotope analysis and Interpretation
- Laboratory procedures and laboratory standards
- Seismic analysis
- Well logging equipment and well logging techniques

Training focusing on laboratory procedures and laboratory standards were covered jointly by ÍSOR and Matís. ÍSOR was responsible for procedures related to analysis of geothermal liquid and gases whereas Matís was responsible for procedures related to the ISO 17025 laboratory standard.

Mannvit and Verkís carried out training focused on powerplants and steam gathering systems. Verkís carried out training focused on a feasibility study for a SPA facility in Menengai and Vatnaskil carried out training in gas dispersion modelling.

The trainees highlighted the importance of the close cooperation with the trainers and the usefulness of seeing and working with other experts in action. Furthermore, some of the trainees highlighted that they were challenged in many ways during the training, resulting in improved confidence, both personally and professionally.

Another important aspect to address the capacity building goals was through short courses in collaboration with UNU-GTP. From 2013-2017, 14 short courses were held by the UNU-GTP under the auspices of the project. The training activities abroad are an important aspect of UNU-GTP's operations, and complementary to the training in Iceland (Haraldsson, I.G., 2018: UNU-GTP training activities abroad 2006-2017). This training was to a large extent custom made, to suit the needs and projects requirements at hand in each country.

**Figure 4. A reconnaissance survey in Tanzania; surface exploration studies at the east side of Lake Natron.**

**Figure 5. Exploring geothermal in Chiweta, Malawi – geothermal fluid flow (80°C) is connected to a fracture, smell of sulfur and yellow sulfur alteration is seen on the surface.**

## CONCLUSIONS

At the end of the project, numerous surface exploration studies have been finalized and a clearer picture has been established in which countries there is geothermal potential for electricity production. Many projects are either underway for drilling or are well advanced in securing financing for drilling. In some cases, the results have been that no further action is warranted, which is considered as an important finding in itself. In addition to electricity production, direct use (e.g. food drying) has been explored and is now regarded as a viable option in many places.

The project has contributed to increased capacity with local institutions for surface explorations and further geothermal development. Number of geothermal specialists from East Africa have gained knowledge, experience and confidence to carry on with geothermal development in their countries and valuable connection between international and local experts have been established. Regional knowledge sharing has been encouraged and supported, the most important accomplishment is the contribution to the establishment of an African Geothermal Centre of Excellence in Kenya, which is now underway.

This project, along with several other programs by other donors that have been ongoing for the past seven years, has made important contributions to laying the ground to further geothermal development in East Africa in coming years. An external evaluation of the project carried out in 2019 found that the project had been relevant to the needs of East Africa countries, generated results to carry on with geothermal drilling and strengthened the countries' organizational and human resource capacities for geothermal development. In the coming years it will be essential to continue with efforts in this field and demonstrate that this important resource can be of critical use for the continent to further build its economic and human development.