Proceedings, 10th African Rift Geothermal Conference
Dar es Sallam,Tanzania, 13-15 November 2024

FRENCH PROFESSIONALS AND RESEARCHERS DEVELOPING TAILORED TRAININGS FOR GEOTHERMAL STUDENTS, TRAINING OF TRAINERS AND DECISION MAKERS

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Key words: Skill development, Capacity building, Training of Trainers, geothermal resources

ABSTRACT

Over the last 50 years, France has been developing and operating more than 80 deep geothermal plants, in majority for district heating but also for power generation, and for the same period, the country has been training generations of students, researchers, engineers and public policy agents, and now intends to share its know-how worldwide, particularly in regions where geothermal energy presents favourable conditions yet untapped, as in the case of the East African Rift System (EARS). Geothermal systems located in active volcanic and tectonic are extremely varied and require a strong science-based approach, particularly at the early exploration stage. The link between industry and academic research is a must for ensuring the best chances of success. Witnessing the gap between the needs in skilled professionals for the geothermal industry, and the existing academic offer in terms of research and education, CY Paris-Cergy University (CYU) started a fruitful collaboration with Ethiopian universities, through the project "Ethiopia-France Focused Trainings for Geothermal" funded by the French "Ministry for Europe and Foreign Affairs". The aim of this project is to reinforce their curricula with trainings oriented toward geothermal exploration and geothermal energy production. Backed by the French Embassy in Ethiopia, a workshop was conducted at the end of 2023 and five universities were selected to participate to a brainstorming on "how to boost geothermal education in Ethiopia". During 2024, two sessions of training were conducted in Arba Minch and Addis Abeba, allowing to assess more accurately the needs of Ethiopian students, covering a wide range of topics such as exploration and energy production. Teaching and field training is delivered by researchers from CYU and two independent professionals (Geo2D and WGS) engaged in the EARS region. Closely after that, a training of trainers was carried out in France in June 2024, bringing Ethiopian University staff to visit several geothermal sites and follow specialized courses covered by French researchers in CYU and Université de Lorraine.

Following these initiatives, the consortium is planning to extend the training proposition to other universities of Ethiopia (Semera, Dire Dawa, Djijiga, Addis Abeba Science and Technology University) and if feasible in other countries of the EARS.The French geothermal association of professionals (AFPG), also aims to backing geothermal development world-wide through the national geothermal Plan recently launched by the French Government. Based on short-courses targeting decision makers and covering the whole geothermal value chain, AFPG will also support training programs -experience-based, addressing concrete geothermal project management -for-African experts by the end of 2024.As a whole, benefitting from French and EU support, academics and professionals of the geothermal sector are willing to share their experience, theoretical aspects as well as practical applications, with international stakeholders, particularly in Africa.

1. ABUNDANCE AND DIVERSITY OF GEOTHERMAL RESOURCES IN EAST AFRICA

East Africa hosts one of the few rift systems worldwide, including both continental and oceanic rifts, the East African Rift System (EARS).
This unique geological context is both the expression of an extensive dynamic, together with the raise of magmatic plumes, both resulting in magmatism & volcanism. One can distinguish two main branches of the East-African rift System: the western branch (also called the Albertine rift) and the eastern branch (called Kenya Rift System, RKS and Main Ethiopian Rift (MER). Those two branches have distinct geodynamical features: whereas the eastern branch is highly magmatic with active diking andvolcanoes in several countries, the western branch is essentially tectonic and mostly amagmatic. At the northern extremity of the EARS, the Afar depression presents different characteristics, with a process of ocean opening under progress, as the Red Sea-Gulf of Aden rift system passes through the continent where it meets the northern extremity of the EARS with spreading rates reaching 2cm/y, whereas it is from 1 to 7 mm/year from South to North along the Eastern Branch.

If one considers the heat flow simulations which were carried out in the EARS region the highest values are encountered along the Ethiopian segment of the rift and reach around 250mW/m² in Afar. Values above 200mW/m² are still observed in the Kenyan segment. In the western branch, values around 200mW/m² were also measured (Jones, 2020).
Geothermal resources have been proven to be abundant in the EARS, and numerous projects are blooming in all countries it crosses.
The diversity of geological environments being cross-cut by the rift, and the rifting process itself generate equally a large variety of geothermal play types, ranging from a-magmatic fault controlled low to medium thermal water up-flows, to steam dominated high temperature reservoirs in volcanic environments (Varet, 2022, 2024 these proceedings). The first one allows for Direct Uses Developments whereas the second allows for electricity production feeding the national grids (Omenda et al., 2020 & 2024 these proceedings). Also note that in the latter case, local developments should also take place as the geothermal resource – itself various with upflows and outflows - also allows for diversified, cascade uses at local level, as promoted by the “Geothermal Village” project initiated in 2014 (Varet et al, 2014; Mariita et al., 2016) and developed in the frame of the LEAP-RE EU-AU research program with demonstration sites being studied in 4 countries: Ethiopia, Kenya, Rwanda and Djibouti (Geraud et al. 2022; Varet et al. 2022)

The variety of geothermal play types and of socio-economic development necessitates for developers to master a variety of scientific expertise and know-how to be taken into account by the concerned education systems, particularly at University levels where teaching should directly link with research and developments (IRENA, 2020).

2. NEEDS IN MULTILATERAL JOINT RESEARCH AND TRAININGS FOR STUDENTS AND THEIR TRAINERS TO SUPPORT THE ACCESS TO ALL GEOTHERMAL RESOURCES

For successful geothermal developments, as in other applied fields, close collaboration between researchers and industrial actors is what leads to a better understanding of natural phenomena in the scope of their utilization. Academic research can help for spreading experiences and best practices, and creating the conditions for a sustainable exploitation of the resources. This is what brought the French Government to create the CIFRE PhD scholarships program, which allows PhD students to have part time schedule in a private company, and part time as an academic researcher, in order to maximize the chance of knowledge transfer (Plantec et al, 2023). A modern example in France is the research conducted for the exploitation of co-products of geothermal resources such as lithium, hydrogen and helium, or anthropological research concerning the appropriation of the geothermal resource by concerned indigenous people (cf. PhD at EHESS of Susan Onyango, from Kenya, supported by CIFRE

and Géo2D, Onyango & Varet, 2014, 2016, 2018). Together with specific EU opportunities, this is also an interesting way to finance the research handled in Euro-African partnership.

On the other hand, in geothermal, appropriate research is a relatively low-cost but efficient way to derisk the projects at prospection and feasibility levels, before engaging costly exploration wells, by producing valuable information on the characteristics of the reservoir and the resource. This is particularly true in green fields such as in Ethiopia, where several projects suffered from the lack of appropriate research and field and laboratory studies.

Geothermal resources are a multi-thematic field of research. Therefore, each researcher is specialized in a particular aspect of the geothermal environment. To fully understand it, besides trans-disciplinary approach of the research itself (Varet, 1975), collaboration between researchers and experts is mandatory. More, collaboration with local scientists and experts is also compulsory as they have a long-run access to data and observations, and usually already contribute with their own interpretation.

From a training point of view, international projects are the occasion for the researchers to develop some expertise and experiences that they can later share with their students, increasing the quality of their teaching. This also provides good opportunities for students to have access to data and material produced in different contexts, and to have access to laboratories in the frame of internships. It can also bring students in a given country to collaborate with foreign students and hence contribute to develop an international network. For example, students in a given country can collect data in the field which will be modeled by other students in another country in the frame of collaborative work. Students from both countries will then interact for the interpretation, discussion and conclusion of the common work. On a very pragmatical point of view, the fact that local students conduct research in partnership with international universities gives the opportunity to the latter to have access to field data that they would never be able to obtain otherwise.

Partnerships between universities in academic research are usually fertile as cultural differences induce various way to treat the same questions, and in a front of a given phenomenon, the questions raised might not even be the same, resulting in different approaches and results. For example, geothermal in hot countries can be thought in terms of cooling while in colder countries it is rather used for heating, but the approach of these questions could benefit from each other situation and experience. At places, local development should be favored in the absence of grid, whereas large size plants should be considered to feed the grid, and projects may be considered in view of covering successive steps from locally handled off-grid to further deepening and enlargements, as underlined in the UN report on Direct uses Developments (Varet, 2022). This brings students and their teachers to exchange ideas with other countries' conditions and experiences and get more knowledge about geothermal and the uses it allows.

Utilization of geothermal resources is in constant progress worldwide. Each country developed particular skills due to their local context and requirements. For instance, France developed many skills in the direct use and in district heating (Varet, 1982; AFPG, 2023): expertise in doublets engineering, reservoir management and surface engineering, wells maintenance, corrosion and scaling mitigation, regulatory framework to facilitate the development of deep geothermal installations in urban context, etc. Joint academic research allows knowledge transfer and transposition of technical solutions to other countries.

3. ETHIO – FRENCH PARTNERSHIPS FOR TRAININGS IN GEOTHERMAL

French universities have multiple collaborations with their Ethiopian counterparts, but collaborations related to geothermal resources are rare.
France has a long history of collaboration with Addis Abeba University in the field of geosciences, starting in 1970 with the CNRS (France) and CNR (Italy) program of exploration of Afar (see f.i. Barberi & Varet, 1970; Barberi et al. 1972), and reconducted in 2024 with a masters-agreement between the university and the French embassy in Ethiopia.

CY Cergy-Paris Université together with two consultants (WGS and Geo2d) and another academic partner (ECAM-EPMI) was supported by the French Ministry for Foreign Affairs (ADESFA program) and the French Embassy in Ethiopia to launch in 2023 a training program called Ethiopia France Training in Geothermal (EFFEG) aiming at (1) identifying the needs in geothermal trainings for Ethiopian students (2) running a first batch of trainings for Addis Abeba and Arba Minch universities students, and (3) welcoming in Cergy two delegates from both universities for a 2-week training program in June 2024. An additional FSPI program financed by the Embassy of France in Ethiopia allowed to invite 2 delegates from Jijiga, Dire Dawa and Samara universities to join those from Arba Minch and Addis Ababa for a 2-day workshop at the Alliance Française in Addis Ababa in October 2023. This workshop conducted by the French geothermal expert (WGS represented by Timothée Dupaigne assisted by Cergy-Paris University concluded on the highest interest of five Ethiopian universities (Addis Abeba, Arba Minch, Semera, Djidjiga and Dire Dawa) for a collective approach on geothermal trainings for post-graduate students. A roadmap was defined and an action plan was decided for short, middle and long terms. Creating standardized Masters degree in geothermal resources appeared to be the most relevant action, to be implemented in the shortest possible time.

In June 2024, five teachers of Cergy and two external experts in geothermal provided three days of training in each Arba Minch and Addis Abeba universities, gathering not less than 60 students and young staff.
The program was designed to be adapted to the background of the students, and to identify the thematic needs. The program included (in the form of an initiation) :

- Volcanism
- Fractures and fluid circulation
- Geothermal play-types
- Geochemistry
- Hydrogeology
- Clays and secondary mineralization
- Case studies
- Thermodynamics
- Geophysics

The June sessions were followed by a training of trainers during which two teachers from Addis Abeba, and two teachers from Arba Minch university, were invited for a two-weeks visit in France and welcomed by CY Cergy Paris University.
The program was tailored to provide an overview of the geothermal research and industry in France.
Several site visits were programmed, and notably: (1) the industrial site of Rittershoffen (heat delivered to a starch production industry, and geothermal lithium extraction pilot in the frame of European-funded research programs) in the Upper Rhine Graben, (2) shallow geothermal installations (Figure 1), (3) deep geothermal district heating plant in Paris district. The laboratories of Cergy and Nancy universities were visited and fundamental and applied courses on hydrogeology, geophysics, geochemistry and field-measurements were delivered. The reasons for the failure of a deep geothermal project that began in the early 1980s in Cergy were also studied to point out the important parameters to be taken into consideration when launching a new project (Figure 2).

Figure 1- Visit of a shallow geothermal surface installation. “Eau de forage”: water from well, “eau froide primaire”: primary cold water, “aller”: forward, “retour”: return.

Figure 2 – Site of a failed deep geothermal project in Cergy (France). “…D’UNE NAPPE D’EAU CHAUDE SOUS L’AXE MAJEUR A 1500 METRES DE… » : … OF A HOT UNDERGROUND WATER TABLE UNDER “THE MAJOR AXIS” AT A DEPTH OF 1500 M ….

These two years, the EFFEG program generated many opportunities for discussions and networking at academic, institutional, political, and industrial level. To summarize those discussions, the following key points can be highlighted:

- At academic level, the needs are: (1) to favor joint research with international researchers and provide access to masters and PhD grants for Ethiopian students; (2) to develop full, standardized curricula including undergraduate and post-graduate programs; (3) to support skill developments of teachers through training of trainers.
- At institutional level, there is a request for consolidation of the geothermal branch by creating bounds between actors from all segments, and by creating awareness among institutions.
- At private sector level, many constraints are identified as most of the sites under investigations were green fields until recently, and because this requires a mentality change at every level. However, let us recall that research is an excellent way to create good technical conditions for project development, by providing access to fundamental knowledge and, doing so, by derisking projects. For example, an improved knowledge about structural geology and hydrogeology of a given area will lower the risk of dry wells.
- At political level, there is clear interest for collaboration between France and Ethiopia, which was illustrated by cross visits at French Embassy in Ethiopia and Ethiopian Embassy in France, where both sides encouraged the stakeholders to continue the efforts.

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4. PERSPECTIVES

Two top priority actions are identified and will focus the attention of the stakeholders.

The first one is the development of the post-graduate offer in geothermal for Addis Abeba and Arba Minch universities. Once this step succeeds and proves its relevancy, similar action will be undertaken with Semera, Dire Dawa and Djidjiga universities, and/or other universities to scale up the process.

The second one is the intensification of joint research aimed at geothermal resource exploration and geothermal exploitation. The possible topics are multiple and depend on the sites, and fields of research of the respective researchers. This action should go together with the multiplication of grants for PhD students involved in geothermal research. It should also be conducted in collaboration with Ethiopian institutions involved in geothermal (Ethiopian Electric Power and Ethiopian Geological Institute for instance).

Other perspectives include the replication of these initiatives at rift level, in other countries. This could happen through an Africa-Europe partnership, as several other initiatives have certainly been commenced by other academic actors.

Field observation being fundamental for a solid comprehension of geothermal resources, it has been mentioned that a "geothermal reference camp for students in geothermal" could be set in Afar region, benefiting from extremely favorable geothermal conditions and numerous study sites.

Finally, developing a partnership between Ethiopian and French universities and extending it to other African and European universities, and also to geothermal industrial actors, will favor the better knowledge of geothermal resources in the East African Rift and the use that can be done of them. This will also need the identification of (1) end users and (2) the needs for industrial or domestic uses of the produced energy.

CONCLUSION

At present, due to its large geothermal resources still essentially untapped, Ethiopia should open the way for important development of various kinds, from diversified Direct Uses to Electricity production, and from local, small-size projects to large-size power plants. This should imply numerous job opportunities, with well trained staff in the large variety of fields of expertise involved. The implementation of ad-hoc training programs at Universities level is therefore a must in order to succeed in this challenge.

Geothermal resources are highly diversified in Ethiopia, and still relatively ill-known, despite favorable geological conditions. But the experience is still limited and unexpected difficulties have been encountered on a few development projects. As a consequence, the risk exists that - due to the lack of proper knowledge and expertise - this may discourage investors and even public policies. The responsibility of universities is therefore high in creating and organizing high level research and teaching programs in order to best support the future developments to be considered in the country, which is among the world's best gifted in geothermal resources and development perspective.

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