Ethiopian Geothermal Resources and Their Characteristics

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ABSTRACT

Ethiopia is considered to be one of the favored countries with respect to high geothermal energy potential. If there is the possibility of exploiting the geothermal resource for direct use and electric energy generation, it can play an important role for the development of the country.

Geothermal exploration in Ethiopia dates back to 1969. The country is currently using hydro and thermal plants as electric energy source. The proven geothermal fields, Langano and Tendaho may provide access for the utilization of the geothermal energy for electricity generation in the future. A geothermal power plant with a capacity of about 7 Mwe is expected to be in operation at Aluto Langano in the year 1998.

In this paper the geothermal resources and the development problems in Ethiopia are discussed briefly.

Introduction

The country’s high enthalpy geothermal energy is mainly concentrated in the Main Ethiopian Rift and in the Afar Rift (Fig 1), which is the Tertiary-Quaternary tectonic system of the great East African Rift. Ethiopia is considered to be one of the favored countries with respect to high geothermal energy potential. Even though the country is fully aware of having high potential geothermal resources (which can be used especially for electric generation) the attempt made to start the exploitation of the proven fields is yet in its infancy. Except for some areas used for resort and therapeutic purposes, most geothermal areas are not yet exploited.

The attraction for resort and belief in curative properties, attributed by the local people causedermal manifestations to be used for balneological purposes and gained religious significance in Ethiopia. Geothermal exploration activities for electric power development on a regional scale were begun by the Ethiopian-United Nations Development Program in 1969-1970 (UN 1973). This activity included studies of the geology, geochemistry and hydrology of the hot springs throughout the East African Rift System within Ethiopia, and encompassed over 500 hydrothermal features. Further geological and volcanological studies have been carried out over the last two decades by the Ethiopian Institute of Geological Surveys (EIGS) in many selected prospect areas. In most of the prospects, the heat sources, possible reservoirs and reservoir depth, controlling structures, temperatures and other important characteristics have been described in the studies. These studies may form the basis for further prefeasibility and feasibility studies.

Resources

Aluto Langano Geothermal Field

The Aluto Langano geothermal field is located on the floor of the Main Ethiopian Rift valley, in the Northern part of the lake Langano (fig.1). Previous studies indicate the existence of heat source associated with a shallow magma chamber beneath Aluto volcanic center. This possibility combined with easy accessibility and proximity to the existing high voltage national electric grid, resulted in the drilling eight exploratory wells in the field from 1981 to 1985.

The first two deep wells, LA-1 and LA-2 were drilled on the southern and western flanks of Aluto volcano to a depth of 1217m and 1600 m respectively, and both wells encountered low thermal gradients. These discouraging results led to the drilling of shallow temperature-gradient wells on the Aluto complex. Interpretation of these shallow temperature-gradient wells resulted in the drilling of six additional deep exploratory wells (maximum depth at LA8, 2500m) on top of the volcano. All were found to be productive (greater than 7 Mwe) except the well LA-3. The temperature recorded in Aluto wells ranges from 180°C-335°C and is associated with moderate permeability.

Aluto Langano geothermal field is related to a hydrothermal system controlled by a recent fault (Wond) fault belt that acts as an up flow channel for hot geothermal fluids (ELC 1985-1986).
Lateral flow occurs through the Bofa basalts and crystalline ignimbrite, which acts as a geothermal reservoir of the field.

Simulation of field performance indicated that the fluid be sufficient to feed 30 Mwe unit for 30 years (Abubakr 1987). Another development option is to use the hot fluid directly for drying the Soda ash extracted from Lakes Abyasa and Shalla.

The Ethiopian Electric Light and Power Authority (EELPA) is preparing to install 7 Mwe pilot plant in the Auto Langano geothermal field in 1998. This is expected to be the first geothermal power plant in the country.

**Tendaho Geothermal Area**

Exploration of the geothermal resource in Tendaho region focuses mainly on the Dubti plantation area. The Dubti geothermal field is located in the North Afar Tendaho Rift which is part of the Afar depression and part of an active NW-SE trending basin filled with lacustrine deposits and post stratoid basal flows.

After a long integrated exploration program in the area funded with the financial assistance of the Ethiopian and Italian governments, four deep exploratory wells were completed in 1995. Three deep wells (about 2000m each) and one shallow well (460 m) proved the existence of a shallow reservoir characteristic by a proven well productivity of about 5 Mwe (Aquater 1996). The limits of the shallow reservoir and its maximum total potential have not yet been defined. Moreover, the productivity of TD2 (15 kg/s, total depth 1811 m) from deep permeable zones, isolated from shallow reservoir is an indication for the existence of deep reservoir (Aquater 1996). Two more shallow wells are planned to be drilled at the end of 1997 to obtain further information on this shallow reservoir for the exploitation and development of the field.

**Main Ethiopian Rift Geothermal Areas**

Following the reconnaissance survey of 1969-1973 conducted by the UNDP and Ethiopian government, further detailed geological, geochemical and geophysical surveys were carried out by EIKS in the Abaya, Corbetti and Shalla areas (Figure 1). These studies indicate the existence of heat sources associated with a shallow magma chamber beneath the Abaya and Corbetti fields. Based on the available data the area of the Lakes district Rift was given priority for further exploration activities.

In 1980, the technical review committee (with the participation of United Nations experts) selected the highest priority areas next to the Auto Langano geothermal field. The Corbeti and Lake Abyasa geothermal areas were recommended as the second and third priorities, respectively.

As mentioned in the above, the Auto Langano geothermal field is in a feasibility study stage, while the Corbeti area which is located on the rift floor 250km south of Addis Ababa between Lake Shalla (to the north) and Lake Awas (to the south) has not yet experienced deep drilling. Corbeti caldera is a promising geothermal prospect area where six temperature gradient wells were drilled to depths of 91-178m within the caldera, and some of the wells (TG1, TG4 and TG7) show good temperature gradients (Solomon 1988).

**Northern Main Ethiopian Rift and Afar Region Geothermal Prospect**

During the 1985-1987 a geothermal reconnaissance study was carried out on ten selected areas. The ten prospects are Tullu-Move, Gedemsa, Bossetti, Kone, Fantale, Dofan, Meteka, Teo, Lake Abe and Danab. Out of these prospects, four of them (Gedemsa, Tullu-Move, Dofan and Fantale) were selected as high priority for further detailed studies based on geological and volcanological characters and socio-economic consideration. These studies include soil geochemical, geoelectrical, gravity and even drilling of shallow temperature gradient wells. Geological and geothermal considerations led to the hypothesis of the existence, in most prospects, of two distinct and well separated geothermal reservoirs, located at a depth of 300-2000 and 300-500 m, respectively (ELC 1987). Based on the result of a reconnaissance study, for Gedemsa and Dofan areas, drilling of 4 to 6 multipurpose holes to a depth of about 300 m was recommended, in order to bring the two prospects to a prefeasibility level. For the remaining prospects, integrated geosciences were proposed for siting shallow wells.

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**Figure 1**: Geothermal features and proposed areas in the Ethiopian Rift Valley (Modified from UNDP 1973).
Afrera and Dallol are other geothermal prospect areas which are located in Northern Afar (Danakil Depression). These areas were surveyed during the reconnaissance survey of the Ethiopian Rift Valley (1970-1973) and are considered as the most significant targets for further exploration activities.

Development Problems

* Lack of Awareness: In the vicinity of some of the geothermal prospect areas, there are state-owned agricultural farms (such as horticulture and tobacco) and factories (pulp factory and sugar plant). Therefore there is a possibility of using direct geothermal energy. However, despite this possibility, these potential users and other nearby organizations are not aware of the geothermal potential. And even if there is awareness of the use, the initial cost for installation is too high and traditional methods are preferred.

* Time Required for Exploration and Exploitation: Geothermal energy projects are divided into pre-investment projects (reconnaissance and feasibility level studies) and capital investment projects (feasibility level studies and field development (construction of power plants) (Caldron 1995). These stages of development of geothermal energy would take several years under normal conditions without obstacles. This time span may itself contribute to expenses and not show desirable results for the government in a short period, thus adding to the negative impact.

Discontinuity in our geothermal projects, that is starting with good potential up to the feasibility level, but without construction of a power plant has occurred in the projects. The Asoto Langano Geothermal Project is a good example. The feasibility study was completed in 1986, but the project was stopped due to financial constraints. It would have been the first geothermal power plant to be used in the country.

* Exploitation Problems: Sealing and brine disposal present additional problems. The possibility of sealing in productive wells is already evident in Langano wells. Disposal of residual geothermal brine must be planned carefully to allow for environmentally acceptable operations.

* Skilled Man Power: The EIGS has the capacity of conducting geothermal exploration activities up to the feasibility level with limited participation of foreign experts, but in the exploitation stages additional skills are needed. Ethiopia needs international co-operation and foreign assistance to train and upgrade their professionals' knowledge.

Conclusion

For solving energy problems, geothermal energy played and is also expected to play an important role in the world. This is because it is indigenous, controllable and predictable environmental effects. So Ethiopia should try to get benefit out of this renewable energy which is very useful for the country's development.

Ethiopia has a geothermal prospect areas which can be used for direct and electrical energy due to its volcanic environment. The EIGS has to work hard on geothermal projects to increase the number of feasible geothermal prospect areas for exploitation, so as to minimize the initial risk to attract external donors as well as to influence the government. Planning is needed for proper linkage at appropriate levels between exploration and development for eventual utilization.

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References


Ethiopian Institute of Geological Surveys, Geothermal Exploration project.


