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# Geothermal Development in the Comoros

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**ABSTRACT**
The government of the Comoros has embraced sustainable development and seeks to establish the use of geothermal energy in the country. The use of this new form of energy in the country will play an important role in economic development. The Government of the Union of Comoros entered into an agreement with the national company of Kenya, KenGen, to carry out studies to identify the existence of geothermal potential in the country.

The first studies were conducted in April 2008 with the execution of five MT surveys. The results indicate the presence of geothermal potential in the region of Karthala.
To complement these studies and locate drill sites, additional geophysical and geochemical surveys are planned for the year 2012.

The Government has established a research department of geology to promote geothermal development with financial support from the Government of Kuwait. The results of surface exploration will be a basis for siting deep exploration wells. Government is in the process of joining the African Rift Geothermal Development facility (ARGeo). The ARGeo will provide technical support for geothermal exploration and the risk mitigation for drilling exploration wells. It will also promote information exchange and sharing of equipment and expertise.

## 1. INTRODUCTION

The Comoros is currently using fossils fuels, hydro and solar energy as the sources of energy. Hydro and solar are inconsiderable. The fossil fuels are still expensive and a cause of economic problems in the country. To overcome this problem, government is promoting renewable sources of energy including geothermal. Geothermal exists in the region of Karthala and La Grille. Preliminary geophysical and geochemical surveys were carried out in the first half of 2008. Detailed surface investigations are needed to locate drilling sites. The Comorian Government is sourcing for foreign companies, associations and organizations that have experience in the field of geothermal energy to support the exploration program.

This paper presents the current energy situation, the geological setting and geothermal studies done in the archipelago.

## 2. STATUS OF ELECTRICITY PRODUCTION OF MAMWE[1]

### 2.1. Current Total Installed and Effective Capacity

The total installed capacity is 22.6MW of electricity (Mamwé, April 2012). The effective capacity is 13.8 MW. The installed and effective capacities are presented in Table 1.

**Table 1: Installed and Efective Capacity for Electricity Generation**

| Island | Installed capacity (MW) | Available capacity (MW) | Total power available (MW) | Total installed capacity (MW) |
|---|---|---|---|---|
| Ngazidja | 15.6 | 9 | 13.8 | 22.6 |
| Anjouan | 6 | 4 | | |
| Mohéli | 1 | 800 | | |

### 2.2 Cost and Production of Mamwé

To produce electricity, Mamwé needs 65,000 liters per day in all the three islands (Mamwé, April 2012).
Costs and details are shown in Table 2.

**Table 2: Production and Cost**

| Island | Ngazidja | Anjouan | Mohéli | Total |
|---|---|---|---|---|
| Litres/month | 180000 | 60000 | 20000 | 260000 |
| Cost in €/month | 683000 | 228000 | 76000 | 987000 |

### 2.3 Energy Solutions

A sum of €200 million was spent on fossil fuels import in 2011 (Mamwé, April 2012). This shows the magnitude of the energy crisis in the country. There is therefore a need to

[1] National society of production of water and electricity of Comoros

look for solutions to the energy crisis in a short, medium and long-term. The proposed candidates are renewable sources that include solar energy, wind and geothermal.

With favorable geological conditions, the development of geothermal energy is a better option to avert the energy crisis in the Comoros. Geothermal has the following advantages:

- ✓ Meets the demand in a short, medium and long-term.
- ✓ Reduces electricity cost to increase affordability, promote industry, tourism, employment.
- ✓ Environmental benign.
- ✓ Can be developed in small increments of 20 to 30 MW to satisfy increasing demand.

## 3. STATUS OF GEOTHERMAL DEVELOPMENT IN THE COUNTRY

### 3.1 Geological Setting

In the current state of knowledge, the geological setting of the archipelago can be described as follows:

- ✓ The Comoros were built following major volcanic phases separated by periods of rest during which erosion could act. It should be noted that the volcanic activity still persists in the island of Grande Comore.
- ✓ Due to her volcanic setting, the Comoros archipelago has an extremely high geothermal potential.
- ✓ The Comoros were formed from the migration of the lithospheric plate from Somalia over a hot spot relatively stationary and active during the last 10 million years.

The volcanism of the Comoros is probably controlled by a complex of regional constraints related to the movement that separated Madagascar from the African main land (Flower, 1970).

Geological maps of the three islands namely Moheli, Anjouan and Ngazidja have been updated by highlighting the fracture systems (Figure 1, 2 and 3). Studies of the volcano have located the magma chamber and the fluid circulation system in the caldera. The hydrothermal system in the massif is formed by fracture networks associated with the volcano.

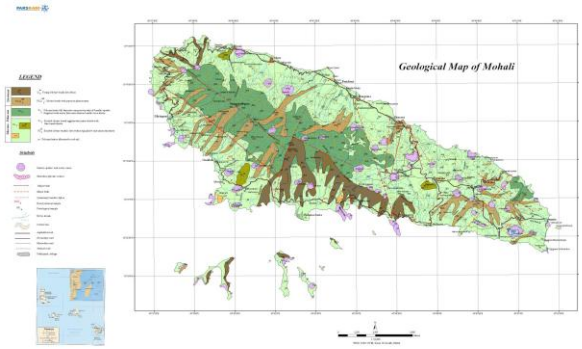


**Figure 24 : Geological map of Mohéli**

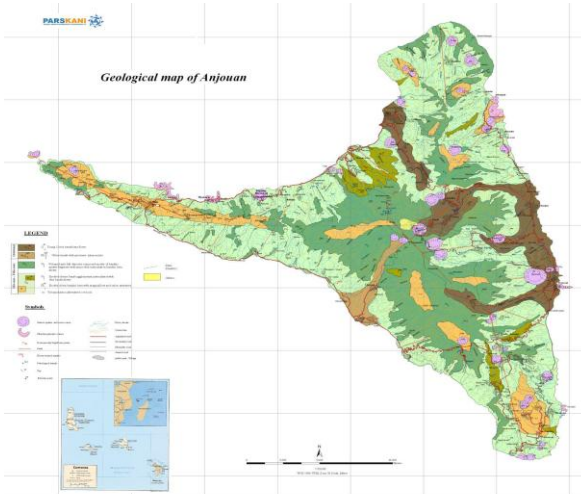


**Figure 25: Geological map of Anjouan**

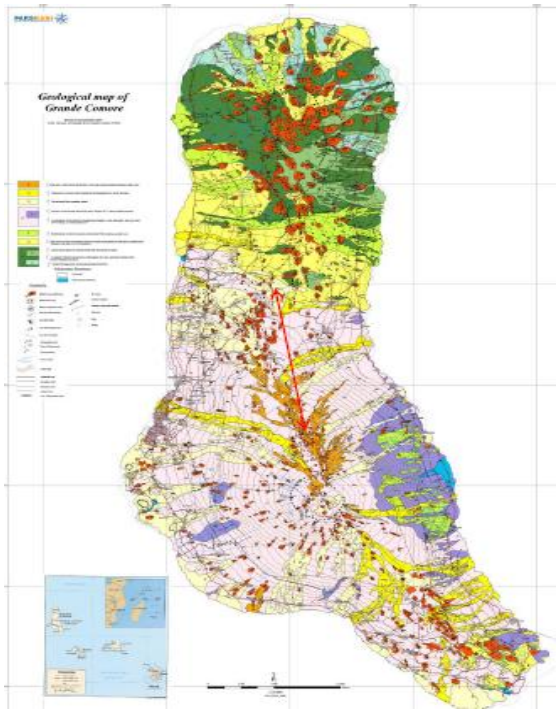

**Figure 26: Geological map of Ngazidja**

### 3.2 Geophysical Studies and Results

Five (5) MT measurements were made with support from the Kenya Electricity Generation Company (KenGen) to predetermine sites to evaluate the resistivity structure and also determine the viability of using such equipment for extensive surface studies. The results would also determine the geothermal reservoir size, depth and the extent of the heat source. The MT surveys were conducted in five locations as presented in Figure 4.

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**Figure 27: Locations of the MT surveys.**

Studies in the zone of Karthala have shown that potential sites for geothermal development are located in the north and outside the crater (Figure 5).

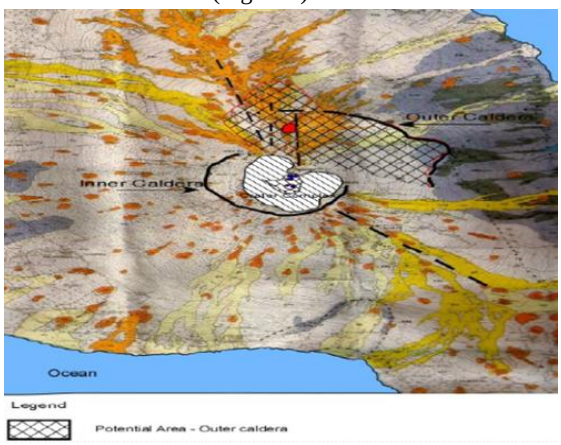


**Figure 28: Karthala geothermal prospect**

The results of the MT surveys in the three areas from the data collected and analyzed by KenGen are presented in Figure 6.

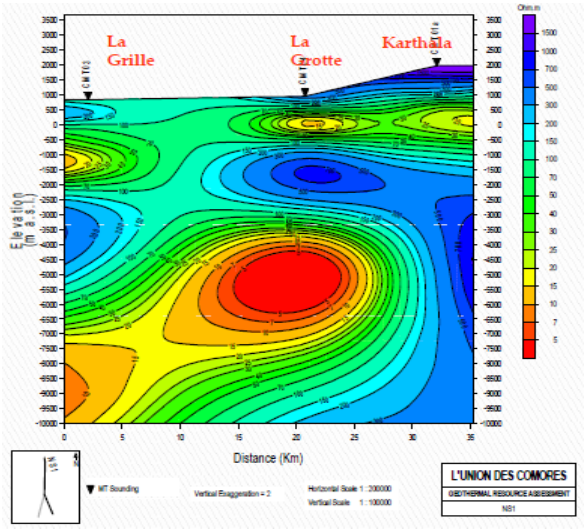


**Figure 6: Surface geophysical model showing the location of Grille, Grotte and Karthala.**

The interpretation of geophysical data shows evidence of a geothermal reservoir at a depth of 1000- 1700m and a heat source for the geothermal system at a depth of more than 5000m. It is important to note that the results are preliminary and more data is required to delineate the dimensions of both the geothermal reservoir and the heat source (Geoffrey, Stephen, James, 2008).

### 3.3 Geochemistry Studies

Parallel geochemical studies were conducted. Geochemistry work involved sampling and mapping of the available water and gas samples across the Grand Comoro Island. Five water samples from boreholes and springs and one gas sample were collected for chemical analysis. The gas sample was collected from a high temperature fumarole at the Peak of Karthala Mountain located slightly to the north of the main summit crater, while water samples were collected mainly from boreholes spread across the island. The Geochemical results are shown in Tables 3, 4 and 5.

**Table 3: Water Chemistry Results**

| Date sampled | Sample ID | pH | Temp (oC) | $CO_2$ | $SiO_2$ | B | Na | K | Ca | Mg | $SO_4$ | Cl | F | TDS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2.4.08 | CS-01 | 8.7 | 21 | 145 | 63 | 0.1 | 53 | 16 | 49 | 8.2 | 11 | 33 | 2.5 | 97 |
| 4.4.08 | CB-01 | 8.3 | 24.6 | 298 | 75 | 0.4 | 226 | 22 | 49 | 47 | 72 | 595 | 1.3 | 853 |
| 4.4.08 | CB-02 | 8.9 | 21 | 326 | 63 | 0.9 | 246 | 14 | 36 | 23 | 66 | 725 | 0.8 | 2183 |
| 5.4.08 | CB-03 | 9.2 | 20.8 | 117 | 67 | 0.2 | 248 | 17 | 34 | 23 | 56 | 794 | 1.3 | 756 |
| 7.4.08 | CB-04 | 8.73 | 20 | 41.1 | 66 | 0.1 | 93 | 22 | 49 | 6.2 | 14.4 | 293 | 0.1 | 305 |

**Table 4: Gas Chemistry Results**

| Date sampled | Sample ID | Temp (oC) | $CO_2$ (ppm) | $H_2S$ |
|---|---|---|---|---|
| 3.4.08 | CF-01 | 96 | 17120.4 | 2.38 |

Table 5: Calculated gas geothermometry temperatures

| Geothermometer | $TCO_2$ | $TH_2S$ |
|---|---|---|
| Estimated Temperature | 302.6 | 249.8 |

The results suggest that the water sampled from selected boreholes do not show a geothermal signature. The gas sampled from fumaroles suggests a geothermal source with predicted subsurface temperatures of 250-300°C. (Geoffrey, Stephen, James, 2008)

### 3.4. Proposed Uses of Geothermal Energy

The preliminary results indicate that there is a potential for geothermal energy. The Government should therefore start planning for further studies that will lead to drilling at selected sites. The Comoros is planning to install a geothermal power plant of 30 MW by 2020. The 30 MW will offset the electricity demand by the population of the archipelago.

This geothermal energy will be used in various sectors including:

- ✓ Households
- ✓ Industries
- ✓ Tourism
- ✓ Public lighting.

## 4. INVESTMENT OPPORTUNITIES

The Government of the Union of the Comoros has created favorable conditions for potential investors, public and private, in development of the geothermal resources. It will continue to support and provide information on key resources through the institution of geological exploration. It will put in place legislation for geothermal development, institutional and regulatory frameworks for development and utilization of the resources.

## 5. OUTLOOK AND CONCLUSIONS

The potential for geothermal development exists around the Karthala volcano extending to La Grotte in the north with predicted subsurface temperatures of 250 – 300°C. The heat source for the geothermal system is located at a depth of more than 5000 m (Geoffrey, Stephen, James, 2008).

There is a need to carry out more studies to delineate the geothermal reservoir and the heat source.

It is therefore recommended that government undertakes the following:

- ✓ Implement other complementary geophysical (60 and 60MVTEM) and geochemical surveys in the zone of Karthala volcano and the Massif. These studies would increase the accuracy in locating drill sites.
- ✓ Conducting geological and hydrological studies that will identify the structures controlling the flow of the geothermal fluids.
- ✓ Train geoscientists in the fields of geophysics, geology, hydrogeology and geochemistry.
- ✓ Prepare a proposal for exploration drilling.
- ✓ Create relationships with companies in the field of geothermal energy.
- ✓ Speed up the process of joining the ARGeo to exchange information with other countries in the region.
- ✓ Sourcing for funds for continuous exploration and development.

## REFERENCES

Geoffrey, G. M., Stephen, A. O. and James W.: Reconnaissance and Inception Report for Geothermal Resources Exploration Program of the Grande Comore, (2008).

Esson, J., Flower, M. F., Strong, D. F., Wadsworth, W. J. and Upton, B. G. J.: Geology of the Comoros archipelago, Western Indian Ocean. Geological Magazine (1970), 6, 549–557.

National society of production of water and electricity (Mamwé), (April 2012). Quarterly accounts of energy.