# THE PRELIMINARY RESULTS OF THE GEOPHYSICAL INVESTIGATION ON THE GHOUBBET PROSPECT.

**Hassan Mohamed, Nasroudin Ahmed**
*Centre d'Etudes et de Recherches de Djibouti (CERD)*

## ABSTRACT

A combined Magneto telluric (MT) and Time Domain Electromagnetic (TDEM) investigations have been carried out in the Ghoubbet prospect in the north of the republic of Djibouti to determine the distribution of the electrical resistivity of the subsurface. The objective of this geophysical study was to delineate the boundaries of the geothermal reservoir. On this site, we carried out 21 MT soundings and 26 TDEM soundings around a horst delimited by normal faults where the principal thermal manifestations are localised. The data from these soundings are interpreted with a one-dimensional (1D) approach to determine the conceptual model of the geothermal system.

**Keyword:** Magneto telluric, Time Domain Electromagnetic, electrical resistivity, geothermal reservoir

## INTRODUCTION

There exist several techniques for measuring the resistivity of subsurface rocks. They can be divided into galvanic or direct-current (DC) methods and electromagnetic (EM) methods. Some decades ago, the DC methods (mainly Shlumberger soundings) were widely used. Nowadays, the electromagnetic methods are largely used, mainly the Time Domain Electromagnetic method and the Magnetotelluric method.

The MT method is based on measuring currents induced in the ground by time variations in the Earths magnetic field. The fundamental theory was first developed by Cagniard (1953) and Tikhonov (1986).The time varying magnetic field and the electric field generated in the surface are measured simultaneously. The electric field is measured in two perpendicular horizontal directions and the magnetic field in the same horizontal and the vertical direction. The measured time series are Fourier transformed into harmonic components with different periods. The harmonic components of the electric field are related to the magnetic field by the so-called impedance tensor, which depends on the subsurface resistivity. For short periods the tensor is mainly dependent on shallow resistivity structure, but for long periods it is mainly dependent on deep resistivity structure. The MT method has the greatest depth of exploration of the available EM methods (some tens or hundreds of kilometres) and is practically the only method for studying deep resistivity structures particularly in volcanic medium.

TDEM Method as for it admits a depth of investigation from 200 to 300 m according to the size of the transmitting loop and provides a geoelectrical model with a good resolution. The fundamental principles of the Time domain electromagnetic method were developed by Kaufman (1983) and Decloîtres (1998). This technique also makes it possible to correct the static shift which affects the apparent resistivity of the MT method in the near surface. The principle of this method consists to injecting an electric current in the ground by a loop of wire (transmitting loop). This electric current will induce a magnetic field in the ground. Then, this current is abruptly off and there is creation an electromotive force (f.e.m) which will generate electric currents called eddy currents in the ground. These currents induce in the ground a second magnetic field which will be to measure by a one second loop wire (receiver loop) posed on the ground.

## GEOLOGICAL SETTING

The republic of Djibouti is located in the Horn of Africa where three major extensional structures, the Gulf of Aden, the East African Rift and the Red Sea, meet and form the Afar Depression. Most of Djibouti is covered by volcanic rocks, mainly basaltic. There exist most geothermal sites in Republic of Djibouti as shown in the figure 1. The Ghoubbet prospect was selected for its proximity with the Asal prospect where a geothermal reservoir was identified and existence a possible recharge of the system by the high plateaus located in north contrary with Asal. The Ghoubbet prospect is located in the nord-east of the north-westward extension of the Gulf of Aden-Tadjura, from the Gulf of Ghoubbet in the sud-east and to Lake Asal in the nord-west which is 155 m below sea level. This area is presently the most active part of the Afar Depression. The Ghoubbet field is approximately 4-5 kilometers broad and the most currently active part is contitued by a horst bounded by the impressive normal faults. The thermal manifestations are widespread which form a NE and SW tendency. These thermal manifestations are primarily fumeroles with a hot spring.

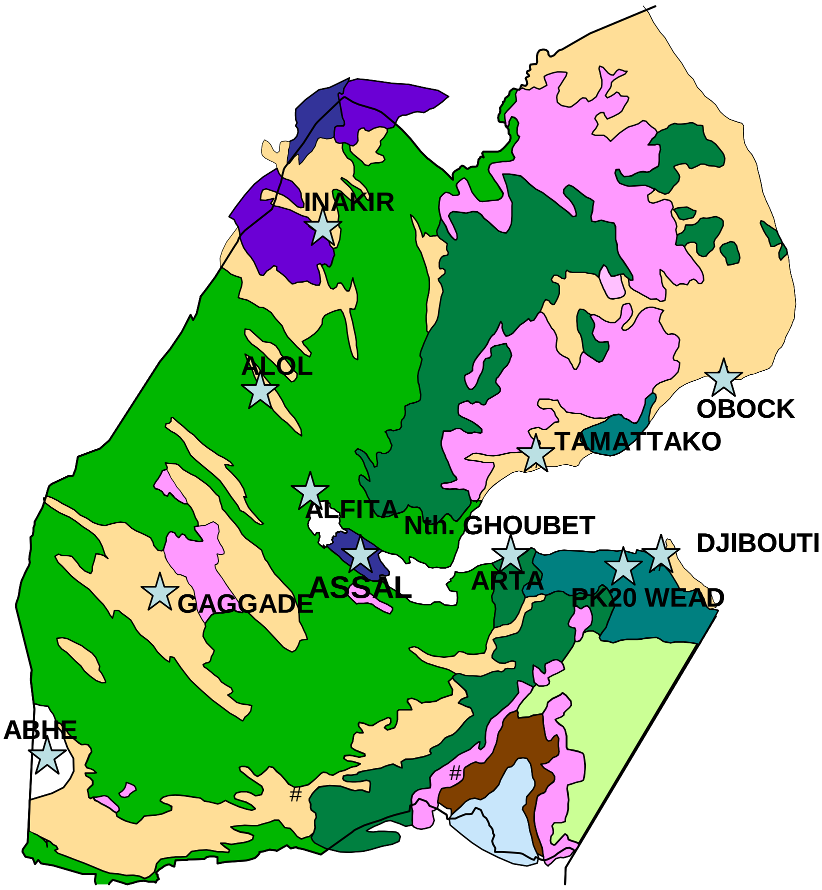


**Figure 1**: Geothermal sites in Republic of Djibouti.

## FIELD WORK

During this geophysical survey on the Ghoubbet prospect, 21 MT soundings and 26 TDEM soundings have been carried out as shown in the figure 2.In this field work, the system used to record the MT data was Metronix, MT system, with ADU-06 data logger, MFS-07e induction coil magnetometer and EFP-06 electrodes. In order to record the desired frequency range, the time series at each sounding was recorded in three different bands representing different frequency intervals. These three different bands are described in the table 1. For the Sampling frequency 128 Hz, we have applied a digital filter to obtain the sampling frequency 32 Hz.

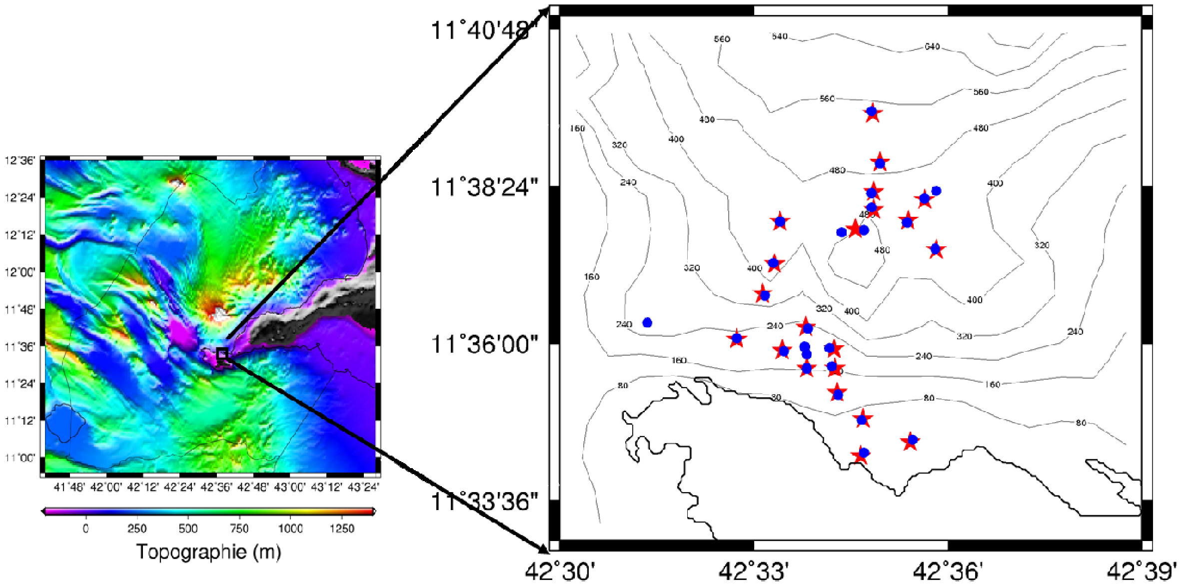


**Figure 2**: Location map of the study area (topography map). Stars: MT soundings. Cercles: TDEM soundings.

| Band name | Sampling frequency | frequency | Recorded length |
|---|---|---|---|
| HF | 2048 Hz | 200000-500 Hz | 2 m |
| LF1 | 256 Hz | 1000-10 Hz | 40 m |
| LF1 | 128 Hz | 1000-10 Hz | 20 h |

On the field, the data measured were the time data. Then, these time series were transformed to the frequency domain impedance tensor using magneto telluric programme MAPROS (Friedrich 2007). The figure 3 shows an example of the transfert function for a MT sounding realised on the Ghoubbet prospect. On this figure are represented the apparent resistivities (in top) and the phase (in bottom) in directions XY and YX.

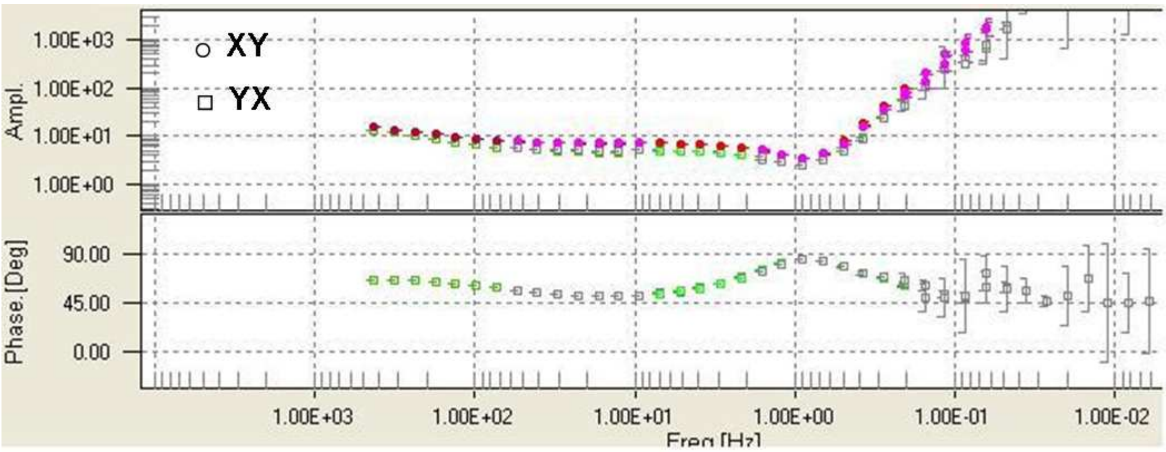


**Figure 3**: Apparent resistivity and phase responses for a MT sounding carried out on the Ghoubbet prospect.

For TDEM method, the system used during this study was terraTEM system. This instrument is a new transient electromagnetic survey system constructed by Australian firm. With this equipment, there exist a several configurations to measure the distribution of the electrical resistivity of the subsurface. In our case, we have used a coincident loop configuration with a size loop 100 x 100 meters.

## CONCLUSION

The geothermal reservoir on the Ghoubbet prospect has been studied on the basis of the electromagnetic data (MT and TDEM). These data are in the course of treatment in order to determine a conceptual model of deep structure.

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