

The use of Bartington Instruments Fluxgate Magnetometers in MT (Magnetotellurics)

Instrumentation

- Mag-03MSESL or Mag-03MSS three-axis magnetic field sensor
- Mag639 three-axis wide bandwidth sensor
- Data logger

Applications

Applications include mineral prospecting, hydrogeology, geothermal and oil exploration, astrophysics, and earthquake studies.

Introduction

MT, or Magnetotellurics, is a geophysical method that aims at measuring the resistivity of the Earth's interior using the natural telluric currents that affect our planets. The currents are of two natures, electric and magnetic, and are measured in orthogonal directions at the surface. These two fields allow for the calculation of the impedance tensor, from which resistivity can be obtained. The depth of prospecting will be dependent on the duration of the acquisition period.

This method is of great interest to research, for its potential to prospect at great depths (several hundreds of km), and to applied geophysics, for its potential to create a vertical resistivity log. The set-up involves batteries, magnetometers, electric field sensors, a data logger and cables.

Ideally, two types of magnetometers are used:

- three induction coils for high frequency variations in the magnetic field.
- three-axis fluxgates for measurement of lower frequencies.

Equipment set-up

Magnetometer and electrodes must be installed precisely. The magnetometer must be positioned perfectly horizontal and aligned with the magnetic poles. Similarly, the electrodes must be separated from one another and placed north, south east and west. All instruments are then plugged into the data logger which powers them.

The choice of magnetometer relies on the depth of interest. High frequency fields only penetrate the upper part of the crust and allow low-depth prospecting. Low frequency fields penetrate to much greater depth. Induction coils are used for extremely shallow prospecting, but for other applications, fluxgate magnetometers are the right choice of sensor.

Choice of fluxgate

The nature of magnetotellurics requires that the Mag-03 is environmentally sealed. For increased ease of setup, a square version (Mag-03MSESL) is recommended. A water tight version of the Mag-03 (Mag-03MSS) is available for submarine applications.



Depending on the properties of the A/D converter in the logger, standard or low noise versions are available.

The Mag639 is an evolution of the Mag-03, and presents several advantages in MT applications. The increased bandwidth, up to 12kHz, provides an increased measuring capacity allowing the use of the same sensor for DC to high frequency measurements. This avoids the need for two types of sensors. In particular, this sensor would be suitable for deep to shallow soundings: an earlier limit of the fluxgate technology was the narrow bandwidth limiting to only deep sounding.

Applications of MT

- **Mineral exploration:** the MT method can be used for the detection of ore bodies that are less resistive than the surrounding rocks. The ore body will create a strong contrast that can be easily observed (e.g. sulphides deposits).
- **Hydrogeology:** the presence of water in an underground environment will change the resistivity of rocks, meaning groundwater reservoirs can be mapped. In the coastal environment, salted and unsalted water can be distinguished by the difference in conductivity. It is also possible to monitor pollutants in groundwater.
- **Oil exploration:** whilst not being able to detect oil or gas itself, this method allows an efficient and cheap way to map the substratum and detect hydrocarbon

traps. This method is ideal for mapping in environments unsuitable to seismic methods (e.g. volcanic rocks, salt dome or karsts).

- **Geothermal exploration:** whilst not being able to resolve small individual fluid channels at depth, this method allows the mapping of the general extension of a hydrothermally active area. The circulation of heated and ion-enriched water will modify the structure and resistivity of rocks.
- In relation to magnetic storm detection and protection, MT can be used to determine the required protection for pipes and cables that might be affected.
- The MT method can be used to map faults, providing important information in the forecast and protection against earthquakes.

APPLICATION NOTE



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