MAGNETOMETER CONE (MagCone)



Introduction

A magnetometer is a scientific instrument used to measure the strength and/or direction of the magnetic field. The Earth's magnetic field (the so magnetosphere) varies from place to place, for various reasons such as inhomogeneity of rocks and the interaction between charged particles from the Sun and the magnetosphere. A mass of ferromagnetic material creates though a detectable disturbance in this magnetic field. This magnetic anomaly produces a weak alternating magnetic field that is picked up by the magnetometer, amplified electronically, and fed to the << GeoLogger >> and subsequently recorded on a computer.

Magnetometers are typically used in ground-based electromagnetic geophysical surveys (such as magnetotellurics and magnetic surveys) to assist with detecting mineralization and corresponding geological structures and the detection of buried or submerged objects.

MagCone

The magnetometer can either be equipped with a dummy tip or mounted on top of an electric S15CFI(P) (piezo-)cone made of a high-grade non-magnetic steel. Due its high strength and small diameter (44 mm) the MagCone is capable of penetrating soils up to greater depths with relative ease.

The MagCone can, in the configuration with a (piezo-)cone, also collect CPT(U) data, such as cone tip resistance (qc), lateral sleeve friction (fs) and in-situ pore pressure (p) needed to produce soil profiles and pile designs simultaneously in one operation. This saves the cost of running two operations.

The MagCone and (piezo-)cone share the same << CPT sounding cable >> for data transmission to the surface and fit directly on the << GeoLogger >> data acquisition unit. The << GeoExplorer >> data acquisition software fully supports the magnetometer and produces magnetometer test results graphed against depth in an Excel-format for further processing.

The MagCone allows for tri-axial magnetometer testing for magnetic anomaly modelling. The magnetic field is measured in three orthogonal directions and a resultant is calculated as well. Furthermore, the gradient of the resultant will be calculated, which gives a much better indication of changes in the magnetic field.

As the magnetometer survey begins, the module containing the tri-axial magnetometer and, if mounted, the CPT(U) electric (piezo-)cone is pushed into the ground by means of a CPT penetrometer rig. The MagCone can detect magnetic anomalies up to 2m away laterally so that each probe position clears a vertical cylinder of land up to 4m diameter.

Gouda Geo-Equipment B.V.
Veerpolder 5-D • 2361 KX Warmond • The Netherlands
Tel.: + 31 (0)715.318.475 • Fax: + 31 (0)715.311.694
URL: www.gouda-geo.com • E-mail: info@gouda-geo.com

The MagCone generates data from all three directions and transmits these signals separately to surface so that the anomalies can be fully modelled using geophysical software helping to define the source and character of any anomaly.

Possibilities and Advantages

The MagCone has two major advantages over other systems for magnetic anomaly modelling, i.e.:
- In situ tests are done without pre-drilling or any other preparation
- It obtains both geotechnical and magnetic field data simultaneously in one single push

Since the magnetometer senses variations in the subsurface magnetic field materials and relays these variations to a geophysicist in real time, it is an excellent tool to identify metal targets to depths exceeding 20 m in soft sediments. This high-resolution method has proved to be very suitable for:

- Unexploded bomb/ordnance surveys (UXB/UXO)
- Determination of the driving depth of foundation piles
- Determination of the length of sheet piles
- Determination of the position of retaining or tieback anchors
- Determination of the position of power cables

Advanced processing provides the option of producing a detailed 3D model of site hazards.

UXB/UXO Unexploded Bomb Detection

Since the MagCone is that suitable magnetic anomaly modelling, it has proved to be highly effective tool for the detection of ferrous UXB/UXO. Since the MagCone is used primarily for this purpose, we wish to elucidate its capabilities.

Unexploded ordnance surveys are important to reduce and manage the underground risks faced by construction contractors on many bombed sites in areas underlain by relatively soft soil. The typical depth of investigation for an unexploded bomb survey is 6 – 15 meter.

The MagCone rapidly maps in-ground structures with a high-resolution and enables to detect and locate ferrous unexploded ordnance. The fact that the magCone can be pushed into the ground using the effective direct-push CPT technology allows for exceptional productivity and associated cost savings, ensuring you to deliver projects on time and on budget.

The MagCone clears the way for piling, excavation and tunnelling by confirming a site is safe from unexploded ordnance. Obstacles can be avoided by using the information to modify pile location plans or to conduct a bomb clearance programme if necessary. It is vital for the redevelopment of locations where ordnance or buried obstructions may pose a special risk - such as sites that were subjected to wartime bombing, and former military ranges.

Technical Specifications

- Fluxgate sensor in XYZ direction enables to determine the position en orientation of an object
- Measuring range 100,000 nT or 250,000 nT
- Sensitivity 1nT
- Accuracy better as 0,5% of the full scale (FS)
- Resolution better as 5nT (10nT for the 250,000 nT version)
- Noise level less than 20 pT
- Built-in bidirectional inclinometer in line with the XY sensors with a measuring range of +/- 25° (accuracy better as 0.1°) for determination of the orientation of the magnetic field

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- Length of the magnetometer module 350mm (excl. cone or dummy tip)
- Length in combination with a dummy tip 500 mm
- Length in combination with a non-magnetic S15 type (piezo-)cone 750 mm
- Diameter 44mm
- Non-magnetic housing
- "*North*" Marking on the exterior of the housing (Y-axis)
- Standard tapered thread on top for connection to the string of CPT sounding tubes
- Resolution in Z-axis direction 10 mm

<< GeoExplorer >> data acquisition software allows the operator to enlarge/decrease the scale during testing such for optimum presentation of the graph.

Supervision

When a magnetometer is deployed for unexploded ordnance surveys it is strongly recommended or even compulsory by law to have the UXO/UXB surveys supervised by degree-qualified geoscientist / geophysicist with appropriate experience to ensure that the surveys are conducted within the limitations of the equipment. This person ought to have authority to stop the probing if a UXB is detected or suspected.

The geophysicist should monitor the magnetometer tests; he can view all data sets and soil profile being plotted in real-time on the computer screen whilst the MagCone is being pushed. If a suspicious magnetic anomaly comes into view then the test may be stopped and the anomaly is to be identified by excavation if necessary.

Interpretation

It is extremely important to be well aware that the interpretation of magnetometer data is a specialist job and not to be judged lightly.