



Field manual for the operation of the magnetic susceptibility tool.

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Abstract

Instructions are given for operating the Geoinstruments magnetic susceptibility borehole-logging tool in conjunction with the SIE logging equipment.

INTRODUCTION

This manual has been produced to assist in the correct and safe use of the magnetic susceptibility borehole-logging instrument. It is a supplement to the "Field logging handbook for the SIE logger" (Hudspeth, 1985) and should be read in conjunction with that handbook.

The TH-3c borehole-logging equipment is designed to record magnetic susceptibility and inductive resistivity in boreholes. Magnetic susceptibility describes the magnetising ability of a substance. The TH-3 is designed to measure the susceptibility directly in boreholes drilled in rock. A weak source field, which does not saturate the rock, is used for the measurement. The function of the TH-3 is based on electromagnetic induction. The rock around the detector coil produces a change in the inductance of the coil that is relative to the susceptibility. The susceptibility can be calculated from the change in the inductance of the coil in air and in the borehole.

The electric conductivity of the rock influences the susceptibility measurements in two ways.

- (a) it causes losses in the detector coil.
- (b) eddy currents induced in the rock are strong enough to induce an opposing current in the detector coil.

The conductivity channel of the TH-3c can be used as a warning signal to show if any corrections should be made to the results from the susceptibility probe due to conductivity (conductivity measured as inductive resistivity).

DESCRIPTION OF THE INSTRUMENT

Probe

The Borehole Susceptibility Meter model TH-3c is designed to be used with single conductor logging cable. The TH-3c probe consists of an electronic section which contains the measuring electronics, internal Ni-Cd batteries for power, and a detachable coil section.

Resistivity information is also available. Resistivity is measured inductively at a frequency of 1.4 kHz, which limits the usable measuring range to good conductors.

The susceptibility, resistivity and bridge unbalance warning signal are sent to the surface via a single

conductor cable. As the cable carries no current, the loop resistance may be high.

Surface Module

The TH-3c Surface Module is also powered by internal Ni-Cd batteries, which makes it very easy to interface to any recording system. The TH-3c Surface Module contains a frequency to voltage converter, to convert the frequency modulated susceptibility information to an analog voltage, and an amplifier for the resistivity signal. These outputs are monitored by a digital panel meter which can be switched to show either susceptibility or resistivity. Warning indicators for bridge unbalance and too low a supply voltage show on the LCD panel meter.

FIELD OPERATION

Set up the equipment in the logging position at the hole as described in the main manual (Hudspeth, 1985), including connection of the Sonic module in the slot next to the T3 module, which occupies the far left slot. Connection of the cables is as follows.

Cables

- Use the 6 pin to 6 pin lead with flying BNC connector instead of the standard cable (this cable has blue flagging tape attached to it).
- Connect the 6 pin lead (non flagging tape end) to the tape unit signal connector.
- Connect the 6 pin (flagging tape end) to the chart recorder unit signal connector.
- Connect the 4 pin (green military type) connector to the TH-3c surface module probe input connector.
- Join the two BNC plugs (one on the signal cable and one on the probe input cable) together using the barrel connector.
- Connect the susceptibility output on the surface module to the Delta Time input on the sonic module using the BNC to BNC (co-axial) cable.
- For resistivity measurement connect the resistivity output on the surface module to the Sonic input on the sonic module with the BNC to BNC (co-axial) cable. Both resistivity and susceptibility can be measured at the same time on the chart recorder but cannot be displayed on the surface module LCD display at the same time.
- All other connections as per main manual.

Operation

- Set the winch Nuclear/Electric switch to Nuclear
- Turn the T210 recorder power to on. The LED should illuminate giving indication of adequate battery power (this power supply is not used for the susceptibility tool or the surface module; see section on battery charging for the susceptibility meter).

Warning: The battery charger should not be used whilst logging, as this will cause irreparable damage to the probe electronics.

- Switch the power to the Surface Module and then switch the Probe on by momentarily pressing the 'PROBE' switch to the 'ON' position. The mark 'M' appears to the lower right corner of the LCD display to indicate the presence of the susceptibility signal.
- Set the susceptibility and resistivity outputs to zero using the front panel controls. If the susceptibility zero is out of the range of the front panel control, adjust the trimmer labelled 'SUSC.ZERO' on the pc-board of the Surface Module (only to be done by technician).

Important: The susceptibility tool should be located as far away from any magnetic or conductive interference. This may even require the tool to be suspended in mid air for best results (i.e. up a tree).

- Repeat the zeroing after a few minutes warm-up time. If a high accuracy is needed, or the temperature difference between the probe and the borehole is big, the probe should be lowered into the hole below the water table for 15–20 minutes before final zeroing to minimise the temperature drift.

Note: To minimise the drift, the temperature of the Surface Module should be kept as constant as possible during the measurement. The Surface Module reacts to temperature changes relatively quickly.

- Prepare the chosen pen (red pen when CH mode in reverse for susceptibility and blue for resistivity) so that ink flows smoothly onto the chart paper as the chart paper is advanced.
- Calibration of the probe and chart are carried out in the following steps.

Susceptibility

- (1) After some minutes warm-up time, place the probe at least one coil length away from metal objects and set the reading to zero (on the surface module and chart recorder). Run the chart recorder paper for about 20 mm to obtain a zero marking.
- (2) Press the calibration sample (supplied in carrying case) against the surface of the coil and seek the maximum meter deflection. This should be near to equal to the reading marked on the calibration sample (1800×10^{-5} SD). Run the chart recorder for about 20 mm and record on the chart paper the reading of the digital readout of the surface module.

Resistivity

The calibration depends on the same factors as above. The calibration of the resistivity channel can be checked in a similar way by pushing the coil through the calibration sample made of aluminium tube (reading should be about

640). Recordings of the zero and maximum deviations should be recorded on the chart paper as per the susceptibility calibrations.

- Switch the 'chart direction' switch to reverse and turn the 'chart speed' knob to the desired scale. Locate the susceptibility tool in the hole at zero depth and set the depth counter to zero.
- Lower the tool down the hole to the required depth. If required adjust the range switch on the surface module to achieve acceptable on-scale readings and signal-to-noise ratios.
- Switch the 'chart direction' switch to normal and turn the 'chart speed' knob to the desired scale. Mark the depth measurement, identifying information and scales on the chart. Commence logging by bringing the tool up the hole. For best results, the cable speed should not exceed six metres per minute.
- When the tool reaches the top mark, zero depth on the chart, together with identifying information and scale.
- When the logging is completed, switch the power off for the probe, and then switch the susceptibility Surface Module off. The probe 'ON-OFF' switch will not operate unless the Surface Module is powered. Removing of the cable connections will not switch off the probe (see section on warning indicators).
- Turn T201 recorder power off. Remove the susceptibility probe from the cablehead. Wipe the threads and 'O' rings to remove any dirt and water. Replace protective caps.

WARNING INDICATORS

'M' in the lower right corner of the display means that the probe is powered and the susceptibility signal is present at the Surface Module.

'~' in the lower left corner of the display means that the measuring bridge of the probe is not in balance. This may be caused by excessive conductive material around the coil (~ will be shown when the coil is in the casing tube) or by a fault in the coil or probe electronics. The measured values will be incorrect when '~' is lit.

'LOW BAT' in the upper left corner of the display indicates that the battery voltage in the Surface Module is too low. There is no warning indicator for the battery voltage of the probe, except that the power is automatically switched off when the battery voltage falls below 3.7 volts. The probe stays otherwise operative to this limit, but the noise level tends to increase when the supply voltage falls below 4.5 volts.

CHARGING OF THE BATTERIES

Four 4 Ah Ni-Cd cells are used to power both the Surface Module and the probe. Both sets can be charged simultaneously by the battery charger. The charger should be connected to the 'Ext. supply' connector in the rear panel of the Surface Module and the probe joined to the Module via the 'test and charging cable' or logging cable. The charger provides constant current with 6–12 V adjustable voltage limit. If a logging cable is used to charge the batteries of the probe, the charging voltage may require readjustment to overcome the voltage loss in the cable.

If either the probe power supply or the Surface Module power supply is completely flat, a period of about 15 hours of charging is required to give a complete 10 hours of logging. The charging of the batteries should be carried out just before going into the field to use the susceptibility meter. Even if the batteries are showing a charge they should be charged for at least 15 hours before logging. This is to ensure that a reliable record can be obtained without the fear of probe battery failure (as there is no way to test the batteries for amount of charge present).

Both battery sets are loaded by approximately 200 mA under operation, which gives about twenty operation

hours by fully charged batteries (i.e. about 24 to 30 hours charging).

Warning: The battery charger should not be used whilst logging, as this will cause irreparable damage to the probe electronics.

REFERENCE

HUDSPETH, J. W. 1985. Field logging handbook for the SIE logger. *Unpubl. Rep. Dep. Mines Tasm.* 1985/07.

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