

# Step by Step Guide to Conducting a Geophysical Magnetometry Survey

Before you start: ensure you have charged the FM256 fully. Please note that the magnetometer is a delicate precision instrument and must be treated very carefully. Do not drop it or allow it to fall over.

# Equipment

- Black Magnetometer flight case
- Trimmer tool
- Compass
- Washing line tapes
- Plastic grid pegs for marking out the grid
- 1 x 50m tapes
- 2 x 30m tapes
- hand-held metal-detector
- non-metallic clothing and shoes

# Initial set-up of the magnetometer

Empty all your pockets of metal objects and place them in a box away from the equipment (see section on 'Clothing' on p.3). Remove the instrument from the case and switch on the FM256 Fluxgate Gradiometer as soon as you arrive in the field (see picture, right). This is important to allow time for the electronics to adjust and for the alignment of the fluxgate sensors to achieve temperature equilibrium with the environment. A time of between 15 to 30 minutes must be allowed before balancing the instrument and before any detailed survey takes place. This will allow the magnetometer to settle down. During this time, you can set out a grid:



# Setting up the grid

Before starting your survey, you need to set up a grid of  $20m^2$  squares, marked by grid pegs Ensure you use plastic grid pegs rather than metal ones, which will interfere with the equipment. If you are surveying an area smaller than  $20m^2$ , set out a  $20m^2$  grid as best you can, and dummy log in the results for the areas you cannot survey. Alternatively you could set out a  $10m^2$  grid (hypotenuse 14.14m), although you need to remember to program the magnetometer accordingly.

- Set out your initial baseline. Unlike for resistivity, you <u>must</u> set up your grid by the points of the compass, and have your baseline running W-E, so that for your first traverse you will walk North. Run a 50m / 100m tape allong your baseline.
- 2) To create your first grid square, take a 30m tape and lay it at right angles to the baseline at



Om on the 50m tape, unravelling it to 20m on the tape. To find a perfect right angle, take a third tape to measure the hypotenuse (diagonal side of a right-angled triangle). Using Pythagoras' theorem ( $a^2 + b^2 = c^2$ ), we know that the hypotenuse of a 20m<sup>2</sup> grid is 28.28m. Keeping your baseline fixed, use the hypotenuse to create an exact rightangled triangle with both sides of 20m<sup>2</sup>. Mark your three points using grid pegs.

- 3) Do the reverse to find the fourth point of your first grid square, and mark it with a grid peg. Now you have one square, continue in this vein until you have set out all the grid squares using a combination of Pythagoras, optical squares and sighting points. It is a good idea to lay out a few grid squares before starting your survey, since the survey moves quite fast once it has started.
- 4) Draw a plan of the location of your grid squares within the field system and give each square a number according to the order in which you are going to survey them. Use a compass to add a north arrow to your plan, and if you have a GPS, key in your points.







5) Take one of the yellow 'washing line' tapes, and lay it out as the bottom West - East x axis of your first grid square. Lay another yellow tape parallel to it along the top x axis of the square. You will notice that the yellow washing lines have blue tape markers to mark every 2m, starting at 1m from each end. These blue markers mark where the North-South y axis white 'washing line' tapes should lie. So, taking a white tape, lay it between the yellow tapes at 1m in from the left end.



6) You will notice that the **white** 'washing line' has blue marks along it at 1m intervals, starting at 0m, 1m, 2m etc. The blue marks on the white line act as an alignment guide. When you start the survey you will stand just behind the yellow line to start (not 0.5m in, as with resistivity).

# Setting up the Magnetometer

**IMPORTANT!** You must wear non-magnetic clothing and footwear otherwise the sensors and balance will not align and you will get poor results.

#### Clothing

<u>Check and check again</u> before proceeding that you have no magnetic items in, or on your clothing (i.e. money, keys, watch, zips, studs in trousers, eyelets, lacetips, steel toe-caps or midsoles on shoes/boots etc, underwired bras (ladies)). This applies to every person involved with the survey, including those moving the ropes. The FM256 is a very sensitive instrument and any these items left on your person will affect the magnetometer and the data you record. It is not advisable to use the magnetometer as a metal-detector to scan people for metal items, since the instrument may not always detect subtle



metal items especially mid-soles on your person until you start walking with the instrument to conduct a survey. Use the Jigsaw hand-held metal-detector for this.

#### Locating a Zero Reference Point

- 1) It is necessary to set up a zero reference point so that all grids of data match up with one another. A point is chosen outside the area of survey (if possible) and in a region where there are no localised changes observable (e.g. pipes, archaeological features, stray metal objects and areas of modern disturbance). Any variations must be within a range of -2/+2nT e.g +26 to +30nT. This is achieved by scanning the area prior to locating a suitable point. Whilst scanning, keep the machine oriented in the same direction, as the readings will change if you rotate it.
- 2) Once you think you have found a suitable location, scan a 2-3m radius to make sure it is 'quiet'. At the centre of the area lower the gradiometer nearer to the ground; the reading should change only by 2-3 nT. If the changes are much greater, then it is likely that there is a magnetic object buried nearby: you will need to try another location. However, some soils e.g. ironstone have a high magnetic susceptibility and therefore allowances should be made in these cases
- 3) Once you have found a suitable zero reference point, place a marker on the ground to indicate the compass points, North, South, East and West as well as the direction in which the grid is going to be surveyed by using a compass (see picture). Use non-magnetic canes or sticks for this and ensure no-one moves them. This is your measurement constant for the site and it must stay as it was when you started using it.

You may find it useful to put a long plastic grid peg in the centre of the cross.



#### **Clearing the Memory and Removing Previous Zeroing**

4) Check that the memory is cleared/empty. To do this you need to press to check the memory. If memory contains data (e.g. in the example below the magnetometer thinks you are about to start your third grid)





you should then proceed to **clear the memory** by pressing and holding for 4 beeps.



Warning: do not clear the memory each time you go back to check sensor alignment and re-zero the instrument during the course of the day, otherwise you will lose all your data.

The following message appears:



If memory is successful, you should see the following on the display:



Now press

Enable Log to return to the previous screen as illustrated here:



5) Ensure the machine's **previous zeroing** has been reset. Press '**Menu**'. The following screen appears:



#### Sensor Alignment and Balance Proceedure

6) The next step is to adjust the balance control and the fluxgate sensor alignments. Remove the sensor caps labelled **'N-S'**, and **'E-W'**.







7) To adjust the fluxgate sensor alignments, firstly face North to note the reading and its polarity (-/+). Then rotate 180° to point South and note the reading (see picture, right). Return to face North and adjust the sensor by turning the dial until the readings are the same in both directions.

**IMPORTANT!** You <u>must</u> point the instrument in the correct magnetic directions – NORTH, SOUTH, EAST, WEST when aligning the instrument.

If you have placed a long plastic grid peg in the centre of the cross, you can rest the magnetometer on it when taking measurements. The instrument will rest on the peg for all but the inverted test. This makes sure the instrument is always over the same point and at the same height above the ground.

Once you have balanced the machine North-South, the target reading for East-West is going to be the same. Repeat the same procedure for the **East** - **West** alignment.

When all the readings are the same in every direction (N-S-E-W), return to face North.

8) Now check that the background magnetic field is the same when the magnetometer is pointed upward as it is pointing downward. Switch on the hold function by pressing 'Menu' on the keypad. The following menu appears:

Select option 3 by pressing



Switch the hold function to ON by pressing

Delete Line



twice to return to original screen.

An 'H' for 'hold' should now appear in the top left corner of the screen:



9) Turn the gradiometer upside down so that the keypad and screen are facing the ground (pictured right). Press the black 'Start - Stop' button to hold the reading so that when you return it to its normal position the display will look like this:



Now you can check the reading to see if it reads the same as that facing North. Make a note of the reading and then press the 'Start-Stop' button to release the hold and work out the difference between the inverted and normal reading.

10) Orient the instrument to the north and insert the orange/red trimmer tool into the side of the instrument (see picture) and turn the trimmer either clockwise or anticlockwise so that the normal reading and the inverted reading is the same. This will require several iterations of the previous

stage. The trimmer will slightly affect the readings, so make sure you hold it at least 1.5m away when comparing the readings.

11) Once all the readings are the same, face the direction in which the grids are going to be

walked from, stay absolutely still and press and hold the until it has zeroed.

12) Replace the 'N-S', 'E-W' sensor caps. You are now ready to start surveying your first grid.





key for 4 beeps

# Conducting your Geophysical Survey

**Note:** the methodology for conducting a magnetometry survey is slightly different to that for resistivity so do read this section carefully.

# Starting a Grid

Choose one person to walk one whole grid. Because everyone's magnetic field is different, you cannot swop operators mid-grid. It is possible for you to change operators after each grid has been surveyed. Do not put the magnetometer down between lines or let it fall over; if you do, you will need to delete the grid's data and restart surveying the grid. If you have several willing helpers to move your grid lines for you, there should be no need to put the instrument down.



 Stand on the yellow line at the beginning of the grid about 0.5m to the right of the white tape. The meter should read:



meaning you are about to start **G**rid 1, **L**ine 1, **P**oint 1. If it tells you anything else it means you have data logged on the machine from a previous survey. Do not clear this data from the memory unless it has already been downloaded and saved on the computer.

When you are ready to start, press



- 2) To start recording, press the **Start/Stop** button and start walking along the line. The magnetometer will beep at each 1m blue marker until you reach the end of the line when a long beep will sound and the instrument will stop recording.
- 3) At the end of the line turn round and face back you have come from, but move to the other side of the white tape and stand on the yellow line. Turn the instrument round to ensure it is facing the same direction as you walked the first line, as pictured below.



Line 1, Point 1 - start



Line 2, Point 1 – return

- 4) Press the **Start/Stop** button to start the line and walk along it until to reach the other yellow line. This method is called a 'zig-zag' traverse.
- 5) Now you have to move the white line to the next blue marker along the yellow line. With this in place, you can continue your survey along the third and fourth traverses. Continue this procedure until you have finished your grid square.

Enable

Log

6) At the end of the grid press

to return to the previous screen.

7) Repeat the steps in **'Sensor Alignment and Balance Procedure**' (p. 5-6) after each completed grid until you have completed all of the grids. If the same operator is conducting the whole survey, you only need to do this every two grids.

# Troubleshooting

#### **Mistakes**

The **Start/Stop** button allows you stop at any time if you are unsure about anything, especially if you have made a mistake part way along the line you are surveying.

If you log a point wrong, press '**Delete**' on the magnetometer. N.B. readings are recorded every 0.25m so there will be 4 readings per meter.

If you get a whole line wrong, press and hold down on and the memory won't clear).



for 4 beeps (any less

# Dummy logging

At some point during your survey you are likely to encounter a situation where you can't log a point because there is a physical obstruction in the way, such as a tree or concrete surface. Instead of skipping out this point, press 'Dummy Log' on the magnetometer so it recognises a missed reading, and it should give a warble sound in confirmation. Do this as many times as you have points you need to dummy log. **Readings are recorded every 0.25m so there will be 4 readings per meter.** It is best to dummy log 1m's worth at a time. For example if the first 1m is not surveyable, dummy log the first 4 readings. Your first point should then read '5', for 2m it will be '9' and so on. Try to avoid doing 0.5 metre points.

#### **Regular Incomplete grid squares**

You will encounter a problem when you come across grid squares that are smaller than 20m<sup>2</sup>. For example, if your field has dimensions of 28m x 60m, the first three 20m<sup>2</sup> squares are easy to do, but you will encounter a problem with each 8m x 20m grid squares. Following the dummy logging procedure, you could '**Dummy Log**' each of the blank points, but this would be repetitive and time-consuming. Instead when you reach the point where you can't take any more readings press the **Start/Stop** black button. Then press '**Finish Line**', which dummy logs all the remaining points in for you. Then press '**Image Line**'. The number of points you have just dummy logged in will be mirrored at the start of the next line, leaving you to finish the second line's survey as per normal. NB: this will only work in squares with regular dimensions.

#### **Default Set-up Parameters**

If the survey parameters have been adjusted, you can change them back to the default settings by pressing the Menu key, selecting '1 Map-m' and changing the following parameters to these settings:

Grid length = 20m Sample Interval = 0.25m Grid width = 20m Traverse Interval = 1m Traverse Mode = zig-zag

Exit '1 Map-m' to go back to the main menu and then select '2 Range' and change the following parameter to this setting:

Resolution 0.1nT

Exit '2 Range' to go back to the main menu and then select '3 Setup' and change the following parameter to this setting (if using Snuffler to process the data):

Data Format Fast ASC

For more information about the Menu key settings see section 4-4 of the Fluxgate Radiometer instruction manual (version 1.6, 2004).