

Wolverhampton Archaeology Group

How to do a Gradiometry Survey

By

M R Holland

2010

Contents	
Introduction	2
Dress	2
Setting up	3
Zero the gradiometer.	3
Set up the Datalogger.	3
Check the Menus.	4
Zero the Memory.	4
Zero the Datalogger.	4
Surveying	4
Laying out Grids	5
Taking readings	5
Logging drift	6
Editing data	6
Downloading data	6

Introduction

The Geoscan Fluxgate Gradiometer measures small changes in the earth's magnetic field. When rocks are laid down, particularly if they have been heated, the atoms and molecules rearrange to lie along the earth's magnetic field. Over a period of time, the magnetic north changes and the rock is no longer aligned with the earth's magnetic field. This results in a small change in the earth's magnetic field. As this occurs at a scale of many square kilometres, it is too large a scale to be detected by normal geophysical surveys, which cover, usually, over tens of square metres. However, there are three instances where gradiometry can be used.

- Man-made structures such as walls. The stones used to build walls are laid randomly so any magnetic alignment in the rock is destroyed. This can result in small deviations in the earth's magnetic field.
- Metal, particularly iron, distorts the earth's magnetic field and this usually gives rise to a large signal.
- When stones are heated, the atoms and molecules have a chance to realign with the earth's magnetic field. Over a period of time, the magnetic changes so the once-heated stones are no longer aligned with the earth's magnetic field giving rise to a magnetic anomaly. Gradiometry is particularly useful for detecting this type of effect, which is found in hearths or kilns

Dress

The gradiometer is designed to detect small changes in the earth's magnetic field and it is **extremely** susceptible to the presence of metallic objects near by. Those who wish to use the gradiometer should consider the following dress code which aims to eliminate metal wherever possible: -

- **Footwear.** Beware of metal eyelets for laces, metal ends to laces and studs. Rubber boots or trainers are suitable alternatives.
- **Lower garments.** Trousers may have metal zips, studs and belt buckles. Even some tracksuits may have zips at the ankles. Remove metallic articles from pockets such as money and keys.

- **Upper garments.** As with trousers, beware of metal zips, fasteners and studs. Remove watches and rings. Glasses are usually far enough away not to interfere.

The Geoscan manual states (in more than one place) that it is not worth doing gradiometry unless the operator has achieved a suitable magnetically free environment. The problem is that movement of the operator relative to the gradiometer can introduce fluctuating signals, which may mask any real changes in the earth's magnetic field.

Setting up

The gradiometer is very sensitive to temperature changes so it is advisable to switch it on for at least thirty minutes before using it so that it can achieve thermal equilibrium with its surroundings. The gradiometer contains two sensors, which detect changes in the magnetic field at right angles to each other. The aim of the setting up procedure is to zero the sensors in the north-south and east-west direction. If this is done properly, the gradiometer reading will not change significantly as it is turned through the compass points so fluctuations in its orientation during operation will not introduce a false signal.

Zero the gradiometer.

- Move to an area which seems (on inspecting the display) to be magnetically quiet. Hammer a tent peg in at this point. This will be your zero reference point. You will be returning to it frequently. Place a compass on the ground close by so you can align the gradiometer.
- First, you need to check the balance. Face North and take the reading. Rotate the gradiometer about its handle so the long end is pointing to the sky, still facing north. Get a helper to take another reading. Adjust the balance screw with the screwdriver provided so the reading moves halfway to the first. Be careful not to push the screwdriver into the small speaker hole or you will damage the speaker.
- Now, holding the main body of the gradiometer to your body, pivot over the peg so you are facing north. Note the reading. Now face south and note the reading. Remove the screw cap cover from the N-S adjuster and turn the knurled knob so the last reading moves halfway to the first. i.e. if the two readings were 180 and 60, the adjustment would be to 120. Check it again until the difference between the two readings is less than 2 nTeslas.
- Now do exactly the same for the E-W adjustment aligning yourself east and west. When this adjustment is satisfactory, recheck the N-S adjustment.
- When completed, place the gradiometer on the tent peg, face north and press the zero button until you hear 4 beeps.

These adjustments may seem long-winded and fiddly at first, but it is vital that they are correctly done or you will not get good results.

Set up the Datalogger.

You are advised to use the button to take readings. Plug the button cable end into the datalogger. There is also a timer, but you will need to walk at a known constant speed in order for the timer to take data points at the correct places on the ground (you often see Time Team doing this, but they have had years of practice or are they just doing it for the cameras?).

Check the Menus.

This is slightly different from the RM15 (resistivity). Each press of the Menu button gives you a different menu item and the left and right arrows choose different values. The choices are listed below, recommended settings are underlined.

- Resolution 0.1 1 10
- Read average off on
- Log 0 drift off on set to “off” if using Geophys
- Log interval 0.25m 0.5m 1m might as well take 0.5m readings
- Grid size 10 20 30 set this to suit your grids
- Average 16 32 64 n/a unless you use read average
- Baud rate 600 1200 2400 set to 1200, same as resistivity
- Ext trigger Encoder Manual manual if you are using button or timer
- Check offset off on

Zero the Memory.

If you are sure you no longer need the data, press "Enable Log" and hold the "Delete" key down for 4 beeps.

Zero the Datalogger.

Go to your zero reference point, face north and press the "Zero" button.

Surveying

Geophysics measurements are done in 10 or 20 metre square grids. Before laying these out on the ground, try to visualise how the grids will relate to each other on the ground and on the computer screen. The grids must be generated the same way, Geophys will draw the traverse line horizontally on the screen. When taking measurements, ideally, start at the top left hand corner of the grid. The first traverse line is then towards the top right hand corner. Note the compass direction of this line and also order in which the grids are generated, this will be the order in which the files are downloaded to Geophys. It does not matter which order this is, so long as you know what it is so you can specify it later when creating the mesh. You will find it useful to arrange the grids so that the next one starts where the previous one finishes where possible. Suggested layouts are



Where → indicates the traverse direction

Grids **must** all be the same size and orientation. Any missing grids can be replaced with a dummy grid later. Make a drawing of how the grids relate to each other, you will need this to put the grids together in a net, for example:

X→ Grid 1	X→ Grid 3	X→ Grid 2
X→ Grid 4	X→ Grid 6	X→ Grid 5

Where X→ marks the start point and traverse direction. The grids were measured in the order Grid1, Grid2, Grid3 etc. Later on, you will find it useful to add to this diagram the site name and mesh name and file it with the site records.

Laying out Grids

Try to align your first grid with a permanent feature such as a building wall or a fence. Having decided where your first grid will go, put a peg in the ground to mark the first corner and run a tape from it at least 20 metres to mark the first side and second corner. Using 2 tapes stationed at each end of the first side, mark up the third corner. One tape is a side (10 or 20 metres), the other is a diagonal (14.14 for a 10 metre square, 28.28 for a 20 metre square) – where they meet is the third corner. Repeat for the fourth corner then recheck the diagonals. They should agree to within 5cm. It is important to get this first square positioned correctly and square or all your subsequent grids will be out. You should also tie it in to known points on the site, either a site grid point or prominent object such as the corner of a building or telegraph post. Make a drawing of this in the site records. You can either:-

- Measure from one grid corner to two points
- Measure from two grid corners to one point.
- Measure from two grid corners to two points (and the distance between them).

The latter is better as it fixes the orientation of the first side.

Now the traverse lines must be laid. These are wires marked at half metre intervals with tape. Lay the first one in the direction of traverse, one metre in from the side. Lay as many others as you can at 2 metre intervals, the last should be 1 metre in from the far side. Peg them down so that they overlap the side tapes and hold them in place.

Taking readings

Having enabled the log move to the first marker on the first traverse line. Hold the gradiometer in front of you with the datalogger pointing either to the left or the right (which way doesn't matter, but you must not change its orientation). You might as well take readings at half metre intervals, note however that the last reading for the line (the 40th) will be on the end measuring tape. When you turn round to come back, your first reading will be also on the tape and the last will be on the last marker (where you are starting from). Walk alongside the traverse line holding the gradiometer loosely so it hangs vertically and straight across in front of you. Press the datalogger button when the gradiometer passes each marker, you will get a beep when the reading is taken. At the end of the line, the datalogger will give a single long beep and you must turn round to come back. Remember, the gradiometer must keep pointing in the same direction so you turn round but the gradiometer doesn't. It takes some getting used to, particularly remembering. It is very easy to inadvertently press the

button when turning round, but you can remove false entries with the delete button. Now come back along the traverse line, but on the other side of it taking readings as you go. Your last reading should be on the last marker. At the end of the first traverse wire and the second line, move to the next traverse wire. When you reach the end of the grid, the datalogger will beep twice.

Logging drift

If you have log zero drift turned on, you will have to go to your zero reference point, face north and take another reading. If you are not using log zero drift, it is highly recommended that you zero the gradiometer after every grid. Go to your reference point, face north and press the zero button. You should do this also when a new operator takes over or after any short break and definitely at the end of each grid.

Editing data

If you take a reading by accident, you can delete it by pressing the DEL key. If you cannot take a reading, for example, there is a hedge in the way or a path crosses press the DUMMY LOG key. If you put dummy readings in at the end of a line, you may have to enter the same number of dummy entries to start the new line. The easy way to do this is to press END LINE and then IMAGE LINE on the datalogger which puts the readings in for you. When you have finished, it is safe to turn the datalogger off, the readings are safe. The datalogger remembers what you have done so you can turn it off over lunch, for example, and continue with new grids in the afternoon.

The gradiometer datalogger can store only 4 grids 20 by 20 metres with sample intervals of 0.5m. Before you do a 5th grid, you must download the data and zero the memory.

Downloading data

We do not have the software (geoplot) which came with the datalogger, so we use the programme geophys instead. This is described in a separate document.