GEOL 384.3 and GEOL 334.3

Lab #7: Three-component magnetic profile over a dipole

In this lab, you will acquire and analyse three short magnetic profiles over a dipole magnetic source using a three-component magnetometer placed on the modeling table in Room 265 Geology.

To measure each component of the magnetic field, the fluxgate magnetometer (Figure 1) uses a pair of Tx-Rx coils similar to those you will study in induction lab #8. These coils are coupled through a magnetically susceptible core, with current high enough to make the response of the Rx core nonlinear. Because of this nonlinearity, the magnetic response of the core varies with the changing ambient field of the Earth, which causes variations in the output of the receiver coil measured by the voltmeter (Figure 1). Thus, similar to the Lacoste gravimeter (labs 1 and 2), the fluxgate magnetometer is a relative instrument sensitive to the variations of the magnetic field.

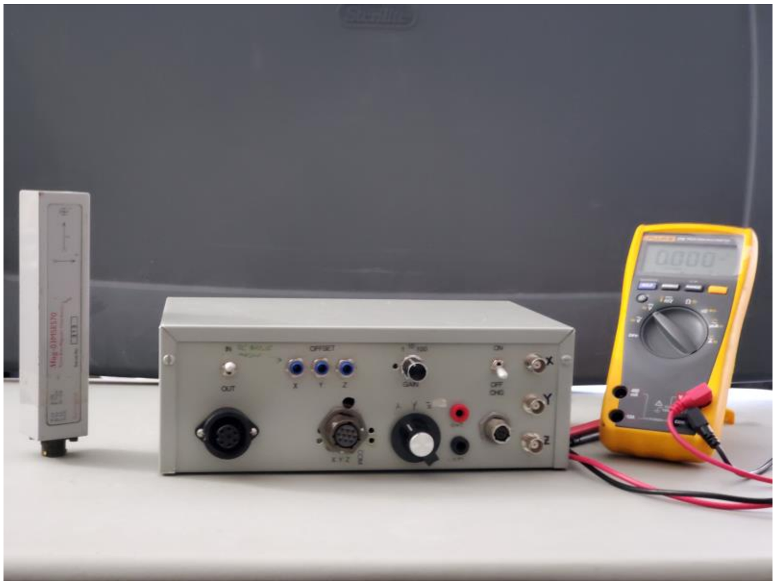

Figure 1. Fluxgate magnetometer (left), its receiver (middle) and millivoltmeter for data recording.

In this lab, instead of moving the receiver over a fixed target underground, we will fix the magnetometer on top of the modeling table and a moving a target underneath. As the target, we will use a coil tilted with DC current placed on rails under the lab table (Fig. 2). Instead of moving the magnetometer over the source, as in a field situation, we will move the source under the magnetometer. Make sure you know where the magnetometer is in these coordinates. In the resulting plots, you will need to present the source is as fixed underground and the receiver moving along the surface.

Figure 2. Dipole magnetic source (coil of copper wire) in tilted at 30° position and sliding along rails on the floor.

Assignments

1) Set up the source and the three-component fluxgate magnetometer on the modeling table. Set up the source so that it is located at position 1 m in the profile. **Measure the height of the magnetometer above the source.** You will be estimating the height from your data.

The first step in planning a mag survey is to decide on the station spacing. If the station spacing is too large, your data may be of no use in answering important questions about the source. If the station spacing is too small, you will do more work than you need to. The spacing should be dense over the target but maybe wider at a distance from it. In the first <u>Profile 1</u>, let us start by examining this spacing.

2) With the source coil oriented vertically, **record the three components of the field in a single profile along the center of the table**. Record the <u>three-component</u> results in <u>Profile 1</u> table in the spreadsheet.

The magnetometer is read with a voltmeter, and the readings in mV must be converted to nT (nanoTesla).

The calibration factor is 0.143 mV/nT, or 6.99 nT/mV on the '1' gain setting in the magnetometer. This value is marked on the sensor.

You can remove a constant field from the results by adjusting the small screws on the sensor power supply. It is a good idea to do this, so all your numbers will be a manageable size.

3) In the attached data spreadsheet (worksheet file), note that the suggested station spacing is wide (~20 cm) at both ends and only 5 cm in the middle. **Explain why did I pick these station spacings**? **Does it appear sufficient?**

4) In the data spreadsheet, **fill the table of magnetic field strengths in nT** on the right. Use the calibration factor specified above. Also **evaluate the column of the Total field.**

The total field is the magnitude of the three-component vector: $T = \sqrt{X^2 + Y^2 + Z^2}$, where Z denotes the vertical component, X is measured along the table, and Y is across the table.

The next several questions relate to the analysis of these data for the vertically-oriented source. They can be answered later, and in the lab, you will likely continue with data acquisition in question 10.

5) **Plot each of the three components *X, Y, Z,* and the total field *T*** for Profile 1.

Because we are in a building, the magnetic field in the room may be variable in time. This is really a drift (time variation) of the field or an instrument drift, but it will look like a regional field. This regional filed will probably be small and we can safely neglect it. If the regional field is large, (and in a field work, it would probably be large), you would need to subtract the regional before doing the depth estimates.

6) **Subtract the regional level of each of the components *X, Y, Z,* and *T***. The regional levels can be estimated as the mean of the values at the leftmost and rightmost positions on the profile. **Plot each of the components again.**

The observed mean levels of X, Y, Z, and T may be the regional fields as well due to magnetic structures in the room. If the profiles have a regional of more than ten nT, you will need to remove it before you can do depth estimates, etc. After regional removal, the apparent zero of the anomaly should be at zero level in all graphs.

Note the shape of the curves, particularly as to how they relate to the known position of the source (at x = 1 m). Note especially how the in-line horizontal components (X and Y) differ from the vertical component (Z).

7) **Try to reconcile what these curves look like with what you would expect from a vertical magnetic dipole**.

8) **Was the station spacing near the target too large, too small, or just about right**?

9) **Using the calculated total field *T*, estimate the depth to source using the Linear-Slope Distance (LSD) and Peters' slope methods**. How well does this agree with the known depth?

10) Next, to **collect data <u>Profile 2</u>**, tilt the source 30° in the profile direction and perform a similar data acquisition. This case illustrates magnetization common at our latitudes. You may record only the Z-component data in Profile 2 columns in the worksheet (but if you record all three, it should not hurt).

11) **Collect another <u>Profile 3</u>**, with vertical source and the source line offset by 30 cm to the side of the line. This profile will simulate a situation in which you are walking not exactly over the top of the target. Also record only the Z component in Profile 3 column.

12) For Profiles 2 and 3, **perform calibration calculations**, **plot the data**, and **estimate the depth to the source again**. Explain the differences between all three profiles. In particular, **for Profile 3, is the apparent depth of the source deeper as expected** from shifting the source by 30-cm sideways?

13) For Profiles 2 and 3, **use the E-line method and Werner's method** to estimate the position of the source. How well do they agree with the known position?

Hand in:

Brief answers to the questions highlighted in **bold** above with figures embedded in a Word or PowerPoint document by email.