Lab 2: Magnetics Part I

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DUE:

Overview

Magnetic surveys are useful when trying to identify a target which has a significant contrast in magnetic susceptibility with the background material. Some examples include unexploded ordinance (UXO) detection, locating steel infrastructure, and mineral exploration. In this lab you will have the chance to go down to the beach and collect magnetic data in order locate and characterize the anomalies due to a number of different steel objects. Fundamentals developed to understand these simple anomalies form a basis for interpreting magnetic data in more complex environments.

Instructions

- For this lab we will be walking down to Wreck Beach to collect magnetic data.
- Bring suitable shoes and be prepared for the weather (ie. water bottle, rain gear: umbrella, poncho)
- Form groups of 4 to work with for this lab (Note: Labs are still turned in individually.)
- There will be four separate stations on the beach. Station 1 is field data acquisition. Station 2 is magnetization of metallic objects. Station 3 is sand drawing. Station 4 is shovel search. Every group needs to finish tasks at all stations, but you can choose the order.
- You do not need to prepare the log book for data recording/plotting, but you should bring printouts of this worksheet and a notebook or clipboard for writing the assignments.
- Please arrive at the Wreck Beach before the lab starts (3pm on Monday, 1pm on Tuesday, 3pm on Wednesday). The lab stations are about 100 m to the left (south) of the bottom of the stairs at the end of Trail 6 (access from NW Marine Drive).

Resources

- GPG: Magnetics

1 Station 1: Collecting Data with the Magnetometer

At this station, you will be using the proton precession magnetometer to collect a profile of data along a line which passes over a buried re-bar. It is your job to identify the horizontal (along line) location of the re-bar, and later estimate its depth of burial.

There will be four jobs for every data point taken, 1 person will hold the magnetometer (the pole on which the sensor is mounted needs to be held steady and vertical, your data quality will be poor otherwise), 1 person will hold the receiver box and read the numbers, 1 person will record the measurements on a log book, and 1 person will make a plot of the data in real-time. Be sure to remove all magnetic objects (belts, keys, cell phone and other electronics) from your person before data collection to minimize sources of noise.

To make data collection feasible within a short time span, and also to provide everyone with an opportunity to become familiar with the data acquisition process we will proceed as follows.

(a) Re-bar has been buried in the survey area and a measuring tape has been provided so that the locations at which data have been collected are known. The experiment has been designed so that the survey line is perpendicular to the orientation of the rebar.

(b) The class will be divided into groups of four. Each group can decide who will do which job. Each group has a number.

(c) Three groups will be present at Station 1 at any time: (a) at bat (actively collecting data) (b) on-deck (watching the data collectors) (c) in-the-hole (getting organized)

(d) Group (a) will collect 1 data point at the base station, 5 data points along the line, and then tie back in with the base station.

(e) Data at each location are recorded 3-5 times to ensure repeatability.

(f) The data location and data values are read out and written down in a log book (provided). Newly measured data points are also plotted and viewed in real time.

(g) While group (a) is collecting data groups (b) and (c) are observing to learn proper survey procedures and analyzing the scatter plot of data acquired thus far to determine which 5 additional data points they will collect. Note: you can choose to repeat

measurements at locations that have been surveyed previously if you think the data quality needs improvement.

(h) Data collection stops once all groups have cycled through.

(i) Remark: The data collection book also serves a log book on which to write relevant notes.

Q1. Explain how your group selected the positions of the 5 data points you collected.

Q2. Name 2 potential sources of noise.

Q3. Sketch the magnetic field data (curve) along the profile you have obtained so far. How did your data help locate the re-bar?

2 Station 2: Evaluating the potential for using magnetic surveys to find metallic objects

Q4. You are given a suite of objects. Suppose each of these was buried in the sand. In fact, you will have to opportunity to do that.

a. Using Table 1 indicate whether each of the samples below would or would not be detectable when buried under 1cm of sand based on their susceptibility contrast with that of sand and their size.

b. What other physical properties of the metal targets would you expect to differ from that of the surrounding material and what type of geophysical survey would you use to detect this physical property contrast?

Q5. Now you are going to use a magnetometer app to characterize the magnetic response of different objects.

Sample	Detectable	Not Detectable
A (Steel Pipe)		
B (Steel Rod)		
C (Copper Pipe)		
D (4cm Steel Bar)		
E (Angle Iron)		
F (Steel Block)		
G (Steel Cylinder)		
H (Aluminium Block)		
I (Stainless Steel Sheet)		
J (Zinc Sheet)		
K (Copper Sheet)		
L (Steel Re-bar)		

Table 1: Detectability Estimates

a. Before we can characterize the magnetic response of other objects we first need to measure the background field so that we have a baseline for comparison. Remove metallic objects and other electronics from your person, orient yourself so that you are facing north and record your measurement of the Earth's inducing field.

Total Field	
B_x	
B_y	
B_z	

Table 2: Background Field Measurements

b. Now characterize the magnetic field of the bar magnet. Provide a labeled sketch showing the orientation of the magnetic field lines. Be sure to keep the magnetometer oriented in the same manner as it was for your measurement of the Earth's inducing field so that all measurements can be compared.

Pole	Total Field	B_x	B_y	B_z

Table 3: Magnetic Field measurements from the bar magnet

c. Using the magnetic field measurements from the bar magnet determine whether the observed field is primary due to induced magnetization or remanent magnetization? Be sure to use the the recorded measurements as evidence to support your assertion.

d. You will now characterize each of the samples provided in the same manner that you characterized the magnetic field of the bar magnet. Fill in Table 4 to indicate the following:

- Is the material susceptible enough to produce a measurable anomalous field?
- Is the sample remanently magnetized?
- If the sample is remanently magnetized describe the general orientation of the remanent magnetiztion using the object labels (top, bottom, sides 1, 2, 3, 4).

Sample	Susceptible	Remanently Magnetized	Remanence Orientation
A (Steel Pipe)			
B (Steel Rod)			
C (Copper Pipe)			
D (4cm Steel Bar)			
E (Angle Iron)			
F (Steel Block)			
G (Steel Cylinder)			
H (Aluminium Block)			
I (Stainless Steel Sheet)			
J (Zinc Sheet)			
K (Copper Sheet)			
L (Steel Re-bar)			

Table 4: Characterizing the anomalous magnetic field of metallic samples

3 Station 3: Sketching the anomalous field

The following exercise will help you interpret and understand your recorded data. In your team, sketch out the secondary response and plot the total magnetic field in the sand for a variety of different inducing field orientations specified by the TA's. Be sure to talk through these examples. Everyone needs to understand these sketches and be comfortable making them since they can provide a great deal of incite into the magnetic response of more complex targets. Space is provided below if you would like to make any notes.

4 Station 4: Shovel Searches

A section of the beach has been marked off containing a buried piece of re-bar which is within the top metre of sand. Each group will be given a shovel and 5 min. A prize will be given to the group which is able to recover the re-bar in the shortest amount of time without the use of any instrumentation. Good luck!