Lab 9: Electromagnetics Part II - Expo Site

Name:____________________ ID:________________________

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Due: Before next Monday, Tuesday or Wednesday (depending on your designated lab session)

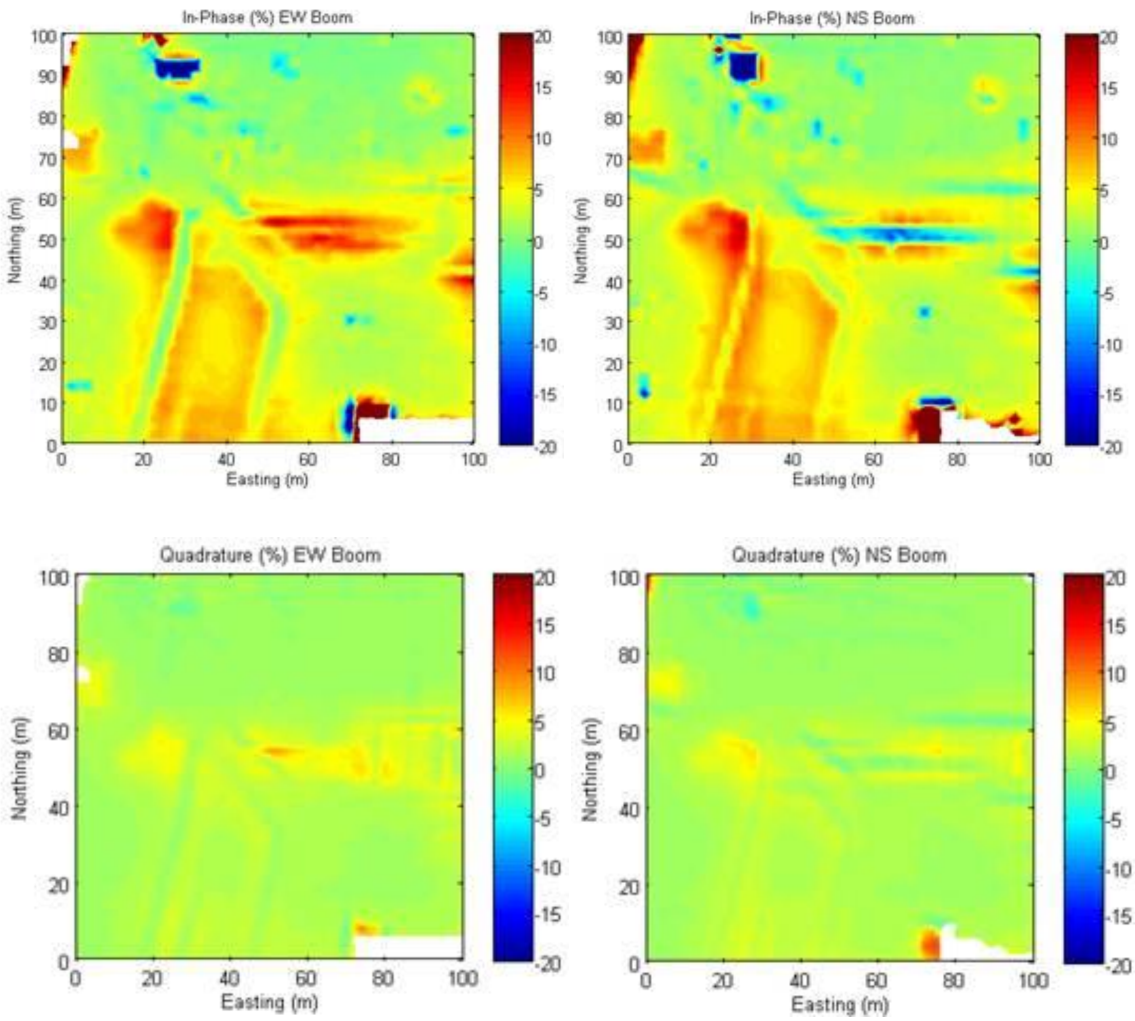
Overview

In this lab, we examine data sets obtained at the old expo site in the false creek area of Vancouver. The site has a fairly complex industrial history, and was set to be remediated and turned into a public space. Before any remediation could take place, the site needed to be characterized. You will be examining geophysical data collected over this site. To detect anomalous conductive or resistive targets, we first treat frequency domain EM data collected with the EM-31 instrument. We will interpret the measured EM data sets and characterize the subsurface of the site. To increase reliability we also study gradient magnetics data to obtain information about the magnetic susceptibility subsurface. By integrating these two geophysical data sets we better characterize isolated targets embedded in this region.

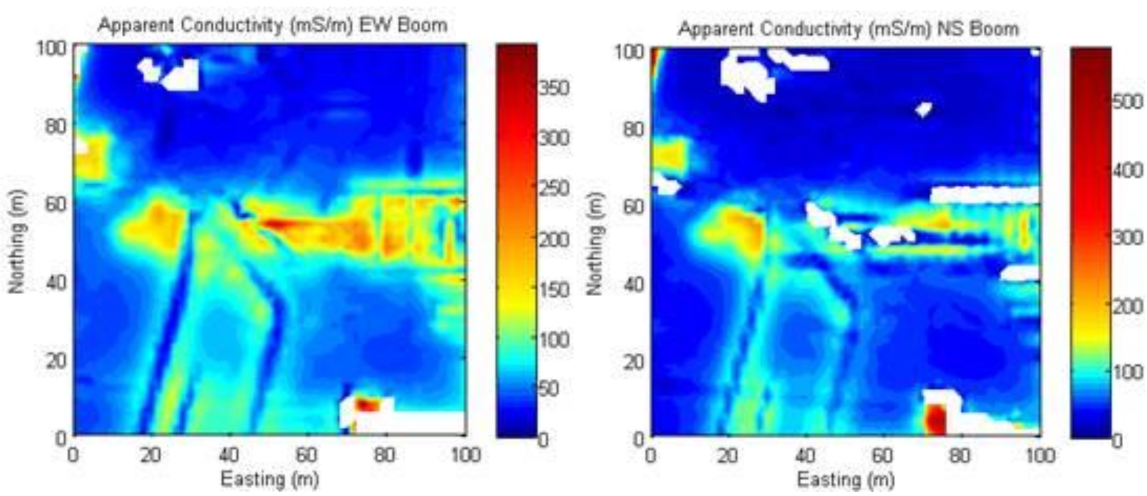
Read the background information from the Expo site characterization report (https://gpg.geosci.xyz/content/electromagnetics/electromagnetic_interpretation.html) and use it to answer questions regarding the EM-31 and magnetic gradient surveys.

Expo Site EM-31 data maps

EM-31 data are measured on a 2m-spacing grid with the boom about 1 m above the surface. At each station, in-phase and quadrature components of Hs/Hp (%) are recorded for EW and NS boom orientations, resulting in four maps as shown below.



The quadrature data are then converted to apparent conductivity maps. Apparent conductivity can be a good representation of the ground conductivity if the earth is uniform and the Tx-Rx separation is much less than the skin depth.



Q1. The EM-31 is often used to measure the Earth's conductivity. Look at the apparent conductivity maps using both EW and NS boom orientations (error readings and negative readings are plotted as white) and answer the following questions.

a. What are the maximum and background conductivities for each map? Calculate the skin depths for the maximum and background conductivities for each map.

b. Based upon this criterion, do you think the inferred ground conductivity at the location with maximum apparent conductivity is reliable? Why or why not?

c. The apparent conductivity values computed using the EM-31 data are based on the assumption that the earth is a uniform half-space. Based on the apparent conductivity maps, where are the regions that might satisfy this assumption?

d. There are some areas with negative apparent conductivities, which are not realistic. Why could this happen? Hint: think about how an apparent conductivity is calculated and the sign convention of EM-31 data; recall the 3-loop model diagram.

Q2. Oil/hydrocarbon-bearing strata are usually more electrically resistive than their hosts. Oil was found to have contaminated the water table in the North-West section of the map at (20E, 80N). Knowing that oil is present in the region near (20E, 80N), draw a contour line on the apparent conductivity map (either EW or NS boom) that might indicate an approximate extent of the hydrocarbon contamination.

Q3. Note that there is considerable linear structure in the maps. Now let's examine the E-W trending feature at Northing = 50m.

a. From the data spreadsheet (download "em-31.xls" from the course website), extract the in-phase and quadrature data along a N-S profile recorded at Easting = 70 for both of the boom orientations. For the NS boom orientation data, make a line plot of the data for the in-phase and quadrature. Then perform the same exercise for the EW boom orientation. Use different colors and line styles to distinguish the four plots. Adjust the scale and range of the x-axis and y-axis so we focus on the anomaly near Northing = 50 m. Attach your plots below.

b. Compare the amplitudes of in-phase and quadrature data at each location. What information about the conductivity of the target near Northing = 50 can be inferred?

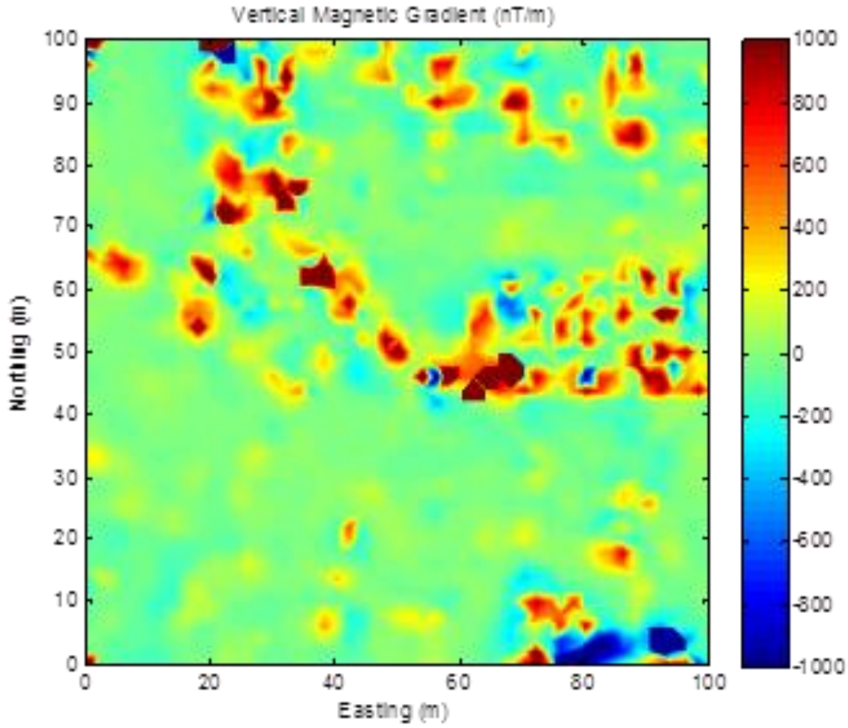
c. What is the major difference between the anomalies observed with EW and NS boom orientations near Northing = 50? Why does the orientation of the boom make such a large difference?

d. By looking at the in-phase maps, what type of object do you think could explain the observed data? Support your answer with evidence based on conductivity and shape of the anomaly.

e. Look at the linear features striking NNE in the bottom left hand portion of the in-phase maps. Describe the difference of these anomalies in the EW boom map and in the NS boom maps and provide an explanation.

f. On the in-phase data map, circle those places (at least four) that you suspect could have buried metal conductors. Annotate with your interpretation of what they could be based on the available a prior information.

High magnetic gradients will be observed when there are magnetic objects close to the surface. From your background reading about the site, there could be many of these. Iron, rebar, pipes, drums and buried locomotives are conductive and magnetically permeable. Thus, the EM-31 and the magnetic gradient results can provide complementary information. Use the vertical magnetic gradient map below to answer the following questions.



Q4. Briefly describe what the vertical magnetic gradient is. How is it acquired? What is it sensitive to and why? And what benefits does it provide over total field data?

Q5. How does the use of both magnetic gradient and EM-31 data help in the identification of iron targets? How would the two responses from an iron target differ from that produced by a copper target?

Q6. What inferences could you make about the NNE linear features (in the south-west quadrant of the plots) when you compare the EM and the magnetic plots?