Geophysics 424 Mid-term exam
Friday October 15th 2010

Name _____

Student number _____

Time allowed : ***55 minutes****.*

Attempt all ***FIVE*** *questions*

Note the number of points allocated for each part.

Calculators and rulers may be used

Notes and textbooks may not be used during the exam

Explain all working

Please hand in this exam, with your name and student number listed above

Total points for whole exam = 50

Question 1 – Resistivity of rocks (Total = 6 points)

The pore space of a sandstone is saturated with salt water , salinity = 10g per litre
The rock has isolated pores and a porosity of 1%
The pore space is 90% saturated with the saltwater.
The rock grains have a resistivity of 1000 Ωm

(a) Use Archie's Law to calculate the resistivity of the sandstone **(4 points)**

(b) Comment on your answer to (a) **(2 points)**

Question 2 : Maxwell's equations (Total = 12 points)

A **plane** EM wave with frequency, f, is travelling **vertically** downwards in the Earth in the *z*-direction. The conductivity of the Earth is σ

The wave has an angular frequency, ω, and varies with time (t) as $e^{-i\omega t}$

The electric field is **polarized** in the x-direction

It can be shown that Maxwell's equations reduce to a single differential equation for E_x

$$\frac{\partial^2 E_x}{\partial z^2} + i\omega\mu\sigma E_x = 0$$

(a) Find a solution to this equation of the form $E_x = Ae^{kz}$

The EM signal has $E_x = E_o$ at $z = 0$ m

Derive values for A and k. Explain your method clearly.

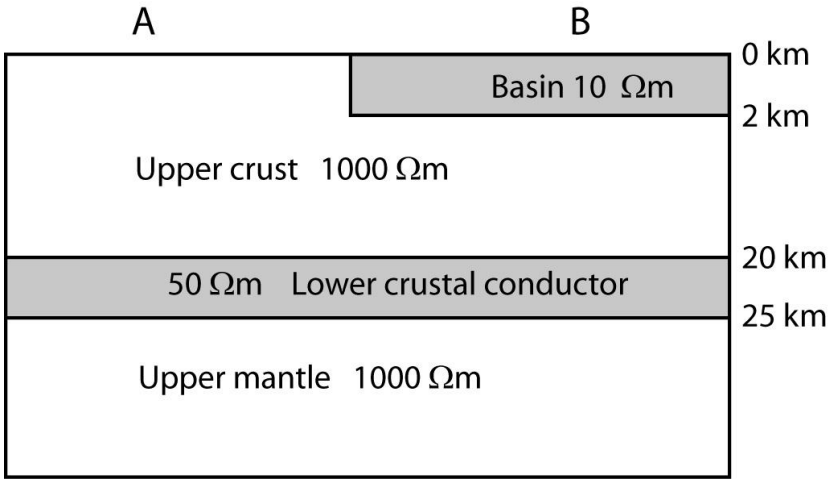
(6 points)

(b) Give a definition of the skin depth (δ) and show that

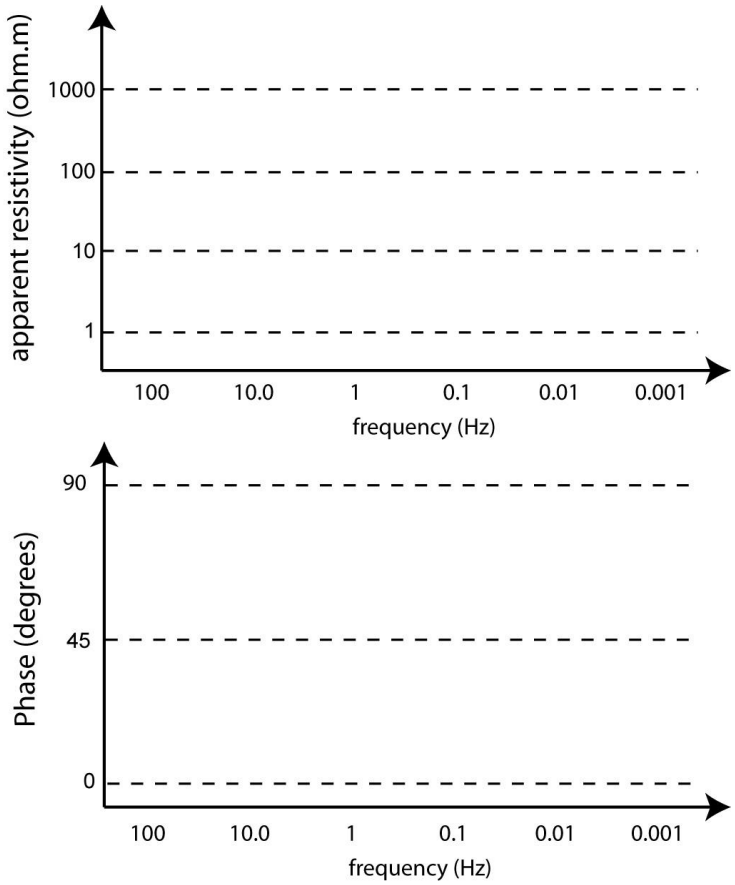
$$\delta \sim \frac{503}{\sqrt{\sigma f}} \text{ (m)}$$ **(6 points)**

Question 3 : Magnetotellurics (Total = 14 points)

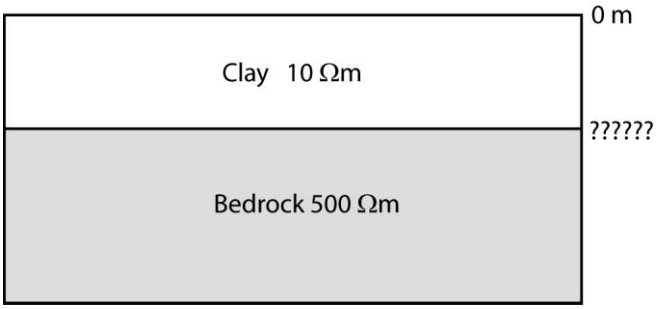
MT data (100-0.0001 Hz) are being used to image a lower crustal conductor. Site A is located on exposed basement rocks, while B is in a sedimentary basin.



- Sketch the MT apparent resistivity and phase data at sites 'A' and 'B'.
- You can assume the structure at each location is 1-D. Be quantitative where possible.
- Would **long period** or **broadband** MT instruments be needed?



Question 4 : EM34 (Total = 10 points)



An EM34 instrument is being used to map the depth of a bedrock layer.

- Frequency = 6400 Hz.
- TX-RX separation = 10 m
- TX and RX dipoles are oriented **vertically**
- TX and RX dipoles are placed on the ground (z = 0 m)

(a) The apparent resistivity is measured at 125 Ωm. What is the depth to the bedrock? **(4 points)**

(b) Describe **two ways** that an EM34 can be used to investigate the **variation of resistivity with depth** **(4 points)**

(c) Why is an **oscillating** primary magnetic field used in this instrument? **(2 points)**

Question 5 : Magnetotellurics (Total = 8 points)

(a) You are collecting MT data at the North Magnetic Pole where the geomagnetic field is **vertical** and has a value of 60,000 nT

A magnetic fluxgate sensor is buried **horizontally** in the ice and oscillates at a frequency of 0.1 Hz, with an amplitude of +/- 1° from the horizontal.

What **magnetic noise level** will result from this motion? **(4 points)**

(b) Name the two sources of MT signals, and approximate frequencies **(4 points)**