

Geophysics 424 Mid-term exam
Friday March 1st 2013

Name _____

Student number _____

Time allowed : 55 minutes.

*Attempt all **FOUR** 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 = 41

Question 1 – Resistivity of rocks (Total = 10 points)

A sandstone reservoir has a uniform porosity of 10%

Both salt water and oil are present in the pore space

Well logging measures the bulk resistivity values shown below.

The pore space is poorly connected

$\rho = 400 \Omega \text{ m}$	Well	Oil + water
$\rho = 80 \Omega \text{ m}$		Water

- (1a) What value of m should be used in Archie's Law? **(1 point)**
- (1b) The pore space in the lower layer is completely saturated with salt water.
Calculate the resistivity of the salt water. **(2 points)**
- (1c) In the upper layer, the pore space contains a mixture of oil and salt water.
Estimate the fraction of the rock that is occupied by oil. **(5 points)**
- (1d) State **two** major assumptions made in your answer to (1b) and (1c) **(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

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

(2a) Find a solution to this equation of the form $E_x = Ae^{kz}$

The EM signal has amplitude $E_x = E_0$ at $z = 0$ m

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

(6 points)

(2b) Give a definition of the skin depth (δ) and show that

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

(6 points)

Question 3 : Controlled source electromagnetics (Total = 7 points)

A survey is measuring the near surface resistivity structure of the Earth from the surface to a depth of 10 m depth. The average resistivity of the ground is 500 Ωm .

The EM instrument has TX-RX distance of 8 m and a frequency of 5000 Hz.

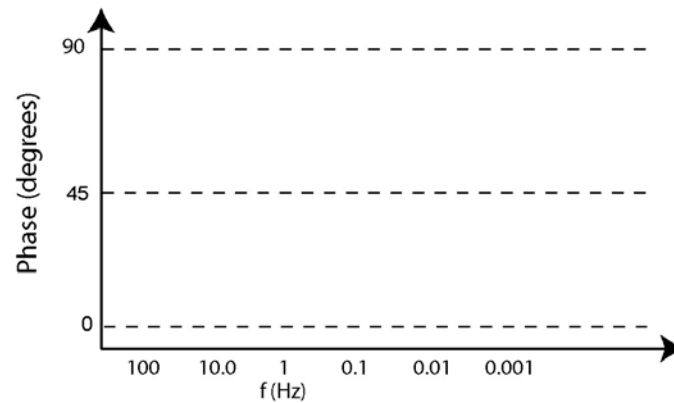
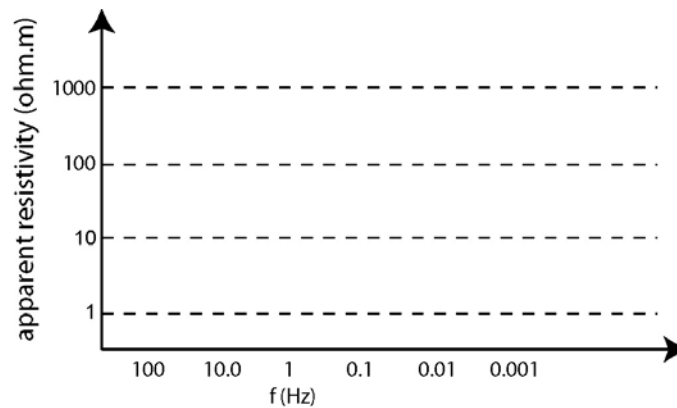
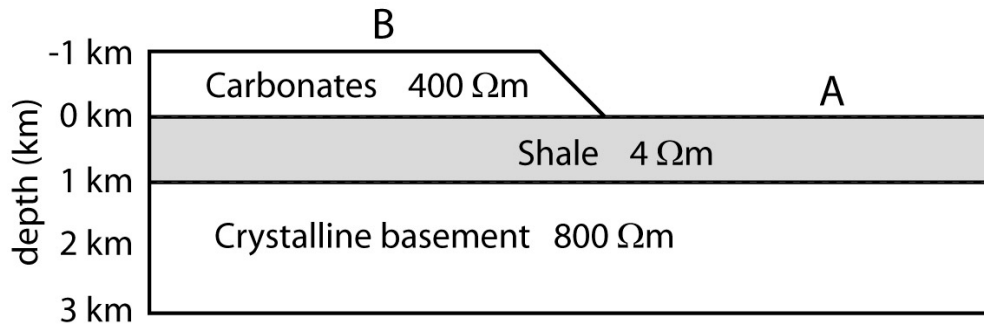
(3a) Describe two factors that make an EM survey more effective than an MT survey in this case. **(4 points)**

(3b) Will the EM survey be near field or far field? Explain how you obtained the answer. **(3 points)**

Question 4 : Magnetotellurics (Total = 12 points)

Broadband MT data are being used in hydrocarbon exploration in a mountainous area to determine the depth of a layer of potential reservoir rocks (shown in grey).

Station 'A' is at sea level, while 'B' is 1 km above sea level.



(4a) Sketch the MT apparent resistivity and phase data at sites 'A' and 'B' on the graph above. The resistivity structure at each location can be considered 1-D.

Be quantitative where possible.

(12 points)