National Exams December 2018

18-Geol-A7, Applied Geophysics

3 hours duration

NOTES:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.

2. This is a CLOSED BOOK EXAM.
   Approved Casio or Sharp calculator is permitted.

3. Six (6) questions constitute a complete exam paper.
   The first six questions as they appear in the answer book will be marked. If you decide you do not want an answer marked, put a single diagonal line through your answer

4. Each question is of equal value.

5. Each question should take about half an hour.

5. All questions require an answer in essay format. Clarity and organization of the answer are important. Please write legibly, as we can only grade what we can understand. Drawing and labelling diagrams is strongly encouraged, as long as the diagram is explained.

Choose six (6) of the following ten (10) questions:

1. Electrical conductivity is an important physical property in geophysics. Define this quantity and give some typical values for rocks, minerals or materials of interest to geotechnical/engineering studies. Explain how conductivity differs from the resistivity and the conductance and why all these quantities are important in geophysics?
2. Draw a diagram showing the location of the source and sensors for a *refraction* seismic survey when there is a low-velocity layer over a higher-velocity half space (basement). Trace and label all the ray paths for important arrivals. Give the equation for Snell's law and explain how Snell's law can be used to determine the angle for critically refracted rays. For the same model sketch the arrival-time curves for a profile and describe how you might estimate the velocity of the two layers and the thickness of the top layer. In what circumstances and for what purposes might a refraction seismic survey be used?
3. Describe three types of ionizing radiation and discuss which is the most important for the gamma-ray spectrometry method. Describe what happens when uranium-238 undergoes radioactive decay. Explain why gamma rays associated with bismuth-214 are important in the gamma-ray spectrometry method. In an exploration project, the gamma-ray reading on fresh outcrop indicated a reading of 500 ppm equivalent uranium. However, geochemical analysis of a sample from the same outcrop showed 15 ppm uranium. How could this situation be explained?
4. Draw a diagram showing the geometric configuration of a resistivity array and describe how the electrodes are moved in the process of undertaking a sounding **and** a profiling survey. What is the formula for the apparent resistivity for this configuration? Explain the difference between the resistivity of a rock and the apparent resistivity as determined from an electrical survey. If you have just acquired a resistivity profile, describe how you would go about processing and interpreting the data.
5. Explain the differences between ferromagnetism, anti-ferromagnetism and ferrimagnetism, giving geological or geotechnical examples where appropriate. What is the difference between induced and remanent magnetism? How do geophysicists quantify the relative sized of the remanent and induced magnetization? Discuss the ways that remanent magnetization can be dealt with in magnetic interpretation and modelling. Give an example where remanent magnetization could be evident in an applied geophysics survey.
6. What are the laws of physics that are important in the electromagnetic method? Describe in words how a transmitter can excite the earth and how this excitation results in a receiver measuring a response. Describe a case history when electromagnetic methods have or could be used for exploring for minerals or hydrocarbons, or for solving a geotechnical problem.
7. Describe an instrument that could be used for measuring the gravitational acceleration in an applied geophysics project. What are the data reduction and processing steps that would have to be applied to these data prior to interpreting the data? Describe a case history where gravity methods could be used for exploring for minerals or hydrocarbons, or for solving geotechnical problems.
8. Select three tools or methods used for geophysical well-logging surveys and describe what they measure, how they measure it, and how each tool may, or may not, be sensitive to a

physical property of the surrounding rock. Give an example of a situation where each tool would be applied to solve an applied geophysics problem.

9. Describe the procedure for collecting magnetotelluric data. Draw a graph showing an example of the data that might be collected at one station and discuss how this (and possibly other) data might be processed or interpreted, giving as much details as possible. Describe a case history where the magnetotelluric method has been used for mineral or hydrocarbon exploration, or in solving a geotechnical problem.
10. Draw a diagram showing the location of the source and sensors for a *reflection* seismic survey. Trace all the ray paths for each sensor. For the case of three horizontal layers draw the reflected arrivals as a function of the two-way travel time when there is a single source and sensors on either side of the source (source gather). Using a separate diagram draw some examples of multiples and then discuss how these can be suppressed as part of the seismic processing sequence. In what circumstances might a reflection survey be used?