Resistivity Module Unit 3: “Geophysical Mapping”

Student exercise

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# 3.1 Introduction

This unit is designed to introduce you to the basics of geophysical data acquisition using two techniques that both record variations in the electrical conductivity of the Earth [1] electrical resistivity imaging (EI), and [2] electromagnetic (EM) conductivity mapping. The advantages and disadvantages of using galvanic (EI) and non-contact (EM) techniques for measuring electrical conductivity are described. You will use Ohm's Law to investigate how measurements of the electrical resistance are related to the electrical conductivity of soils. The field implementation of both EI and EM techniques will be demonstrated using the surveys performed in Harrier Meadow as an example. You will investigate how variations in survey configuration parameters (e.g. electrode configuration and electrode spacing in EI, frequency and coil spacing in EM) control depth of investigation and spatial resolution. The concept of pre-modeling a geophysical survey to evaluate the likely investigation depth and sensitivity of the measurements to the subsurface resistivity distribution is introduced.

The Excel-based Scenario Evaluator for Electrical Resistivity (SEER) tool (Terry *et al.*, 2017) is used to demonstrate some key concepts.

# 3.2 Tasks

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| Tasks 3.2.1 and 3.2.2 Comprehending electrical resistivity and EM conductivity mapping measurements1. Watch the narrated ‘*Short Tutorial on Geophysical Mapping*’ slideshow that summarizes the basics of applying the electrical imaging and EM conductivity mapping geophysical techniques in the field.
2. Also watch the 9 minute ‘*Setting up an Electrical Imaging Survey*’ video where two students from the University of South Florida introduce you to an electrical imaging system. As you watch this video be ready to take some notes on [1] how to correctly handle resistivity cables, [2] checking contact resistances to make sure that the all the electrodes are electrically connected to the ground and [3] key definitions of the main parts of a resistivity imaging system
3. Answer the questions in Task 3.2.1 and Task 3.2.2 of the student worksheet.
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| Task 3.2.3 Basic calculations: resistivity and EMThe Excel spreadsheet Unit 3.xls contains three tasks (Tasks 3.2.3D-3.2.3F) that should be completed in this part of the student exercise. The equations needed to perform the calculation are all included in the tutorial for this unit. After completing the calculations, answer the questions listed under Task 3.2.3 of the student worksheet. 1. In Task 3.2.3D complete the calculations of the geometric factor (K) and the resistivity (r) of the soil column given the data shown. Record your answers in the spreadsheet.
2. In Task 3.2.3E complete the calculations of the geometric factor (K), voltage (DV) recorded and the signal to noise ratio (SNR) for the *Wenner* and *dipole-dipole* arrays. Follow the instructions provided in the spreadsheet. Record your answers in the spreadsheet.
3. In Task 3.2.3F, follow the instructions on the spreadsheet to calculate the skin depth (d) and induction number (NB) as a function of apparent soil conductivity (ssoil(a)) and coil separation (r).
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| Task 3.2.4 Exploring measurement sensitivity with SEERThis task uses the Excel-based Scenario Evaluator for Electrical Resistivity (SEER) to complete some exploration of resistivity measurement sensitivity described in the document ‘*SEER handout*’. 1. First, watch the accompanying [SEER video](https://www.youtube.com/watch?v=3WK1YJotbfw) that describes the SEER spreadsheet and also gives some useful general information about the limitations of geophysical imaging and the need for pre-modeling exercises.
2. Complete the activities described in the SEER handout, which ends with a table that must be included to analyze the differences in sensitivity between the Wenner and dipole-dipole arrays.
3. Answer the questions in Task 3.2.4 of the student worksheet.
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# 3.3 Assessment

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| Complete the student assessment worksheet provided with this module. The grading rubric below will be used to grade the module.  |

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| **Component** | **Exemplary** | **Basic** | **Nonperformance** |
| Sections 3.2.1-3.2.2 | 4 points:Eight to nine questions correctly answered showing full comprehension of tutorial and video | 2–3 points:Five to seven questions correctly answered showing some comprehension of tutorial and video | 0–1 point:Four or less questions correctly answered showing significant gaps in understanding of the tutorial and video |
| Section 3.2.3 | 5-6 points:Excel spreadsheet fully completed with correct solutions. Thoughtful and correct answers to questions in student assignment | 3-4 points:Excel spreadsheet mostly completed with correct solutions and some solid comprehension of significance of results reflected in answers to questions in student assignment | 1-2 points:Incomplete Excel spreadsheet and/or incorrect answers; weak attempt at the questions in the student assignment with demonstrated lack of comprehension |
| Section 3.2.4 | 5-6 points:Assignment in SEER handout completed and table entries on sensitivity correct. Thoughtful and correct answers to questions in student assignment  | 3-4 points:Assignment in SEER handout mostly completed with a good effort at thoughtful answers to questions in student assignment.  | 1-2 points:Incomplete effort at the assignment in SEER handout ; weak attempt at questions in the student assignment with demonstrated lack of comprehension |

**3.4 References**

Terry, N., Day-Lewis, F. D., Robinson, J. L., Slater, L. D., Halford, K., Binley, A., Lane, J. W. and Werkema, D. (2017) ‘Scenario Evaluator for Electrical Resistivity Survey Pre-modeling Tool’, *Groundwater*, 55(6), pp. 885–890. doi: 10.1111/gwat.12522.