Questions: DC Resistivity and Induced Polarization

1. What physical property are we most interested in measuring when we perform an IP survey, and what are the typical units we use?
   a. Resistivity in Ohm\*m
   b. Conductivity in Siemens/m
   c. Chargeability in Volts
   d. Chargeability in mVolts/Volts

2. What method could be used to compute chargeability?
   a. Knowing the voltage measured just before and just after the current is turned off
   b. Knowing the area under the decaying curve and voltage just before the current is turned off
   c. Knowing the rate of voltage decay and the voltage just before the current is turned off
   d. Both a) and b) are correct

3. Which are the following statements is incorrect when considering induced polarization?
   a. IP response can be identified through the phenomenon that the voltage continues to increase in time as constant injected current into the ground.
   b. IP effect is also known as the over-voltage effect
   c. Chargeability is closely related to IP
   d. The value for the intrinsic chargeability (\(\eta\)) is usually \(\eta > 1\)

4. Choose the incorrect unit of IP response
   a. Msec
   b. mV/V
   c. S/m
   d. Mrad

5. Which of the following statements about pseudo-sections is NOT accurate?
   a. Pseudo-sections are typically used for plotting 2D DC and IP data.
   b. Pseudo-sections can be easily interpreted to identify the location of anomalous bodies.
   c. The vertical axis on a pseudo-section relates to separation of the current and potential electrodes, and therefore does not provide a true depth.
   d. Pseudo-sections are often useful for reconnaissance purposes since they can help you pick out the rough along line location of anomalous targets.
6. Which of the following factors will not influence your ability to resolve a conductive target using a DC resistivity survey?
   a. The conductivity of the overburden.
   b. The depth of the conductor.
   c. The abundance of free charges within pore fluids
   d. The geometry of your electrodes.

7. When considering both DC resistivity and IP surveys, which of the following statements is NOT true?
   a. DC resistivity data is measured only during the on-time for current.
   b. DC resistivity data allows us to measure chargeability.
   c. IP data depends on measurements made during the current off-time.
   d. Both DC resistivity and IP data are dependent on the conductivity of the subsurface.

8. What applications would be better suited to a DC resistivity survey than an IP survey?
   a. Searching for voids in a karst region.
   b. Looking for mineral deposits within a region of extensive geothermal alteration.
   c. Locating a buried metallic object.
   d. Both a) and c)

9. Which of the following DC resistivity survey arrays tends to illuminate more of the ground (to greater depths) but it has the lowest spatial resolution?
   a. Dipole-Dipole
   b. Pole-Dipole
   c. Schlumberger
   d. Pole-Pole

10. Which factor least affects the depth of investigation of a DC resistivity survey?
    a. Current electrode separation
    b. Conductivity of the overburden
    c. Separation between the potential electrodes
    d. Distance between current and potential electrodes.

11. Of the factors listed below, which does not contribute to the electrical conductivity?
    a. Density
    b. Porosity
c. Salinity of fluids
d. Hydraulic permeability

12. Conductivities of earth materials are often expressed in mS/m. A value of 100 mS/m corresponds to what resistivity.
   a. 100 ohm-m
   b. 1 ohm-m
   c. 10 ohm-m
   d. 0.01 ohm-m

13. Which of the following statements is NOT true for a DC resistivity survey
   a. The DC resistivity datum is the voltage difference at the surface of the earth measured between two electrodes.
   b. The current flow in the earth is distorted because of the variation of electrical conductivity in the earth.
   c. The strength of the measured voltage difference is related to subsurface charges through Coloumb’s Law.
   d. A generator connected to a single probe inputs current into the ground.

14. An IP datum has units of
   a. mV/V
   b. msec
   c. mrad
   d. All of the above

15. Of the following options, which is the best definition of “apparent resistivity”
   a. Measured voltage divided by the known current.
   b. The resistivity of the ground between the current and voltage electrodes.
   c. The resistivity of a uniform earth which reproduces the observed voltage.
   d. The same as the “true” resistivity.

16. Consider the following statements concerning pseudo-sections. Which is most correct?
   a. The image can often be interpreted directly in terms of geologic structure.
   b. The horizontal axis is true distance in the spatial domain and the vertical axis is true depth.
   c. The numbers plotted reflect the true resistivity of the earth at the plotted location.
   d. Each datum plotted in a pseudo-section is the result of charges distributed throughout the entire volume of the earth.

17. The depth to which a DC resistivity survey can “see” depends upon:
   a. The value of the measured voltage.
   b. The largest distance between electrodes.
   c. The amplitude of the current divided by the measured potential.
   d. All of the above
18. Induced polarization refers to
   a. The polarization of the electric field in the earth that has been induced by the transmitter current.
   b. The development of dipoles of electric charge that occur when an electric field is applied.
   c. The magnetization set up inside the earth when a current is applied.
   d. The polarization that arises from the time varying current from the direct current generator.

19. DC resistivity surveys might be useful in which of the following situations
   a. Finding sand and gravel deposits in a peat bog.
   b. Determining the depth to bedrock
   c. Finding a buried tunnel
   d. All of the above

20. Which of the statements below is true for time domain IP surveys?
   a. IP data are collected with DC resistivity but require altered locations for the potential electrodes so the data are sensitive to the chargeability.
   b. IP data are collected simultaneously with the DC resistivity data but require that the current in the generator be switched off.
   c. IP data are collected simultaneously with the DC resistivity data while the current is on.
   d. IP data can be collected simultaneously with DC resistivity data but require a larger input current in the transmitter.

21. In a “sounding” mode the DC array
   a. Keeps the same geometry but is translated laterally along the surface.
   b. Employs a combination of (a) and (c).
   c. Keeps the same geometry but is symmetrically expanded about a fixed point.
   d. Requires a buried current electrode.

22. Which suites of earth materials will display the highest chargeabilities?
   a. Gravels, and sulfides
   b. Clays, graphite and pyrite.
   c. Alluvium, clays, limestone
   d. Pyrite, limestone and clays

23. The chargeability of earth materials is dependent upon
   a. The pore structure of the material
   b. The surface to volume ratio of the grains that make up the soils or rocks.
   c. The electrical conductivity of the fluids in the pores.
   d. All of the above.
24. Which of the following statements is correct
   a. The DC resistivity data are first inverted to produce an electrical conductivity model which is then used when inverting the IP data.
   b. The IP data are first used to generate a pseudo-section which is then directly inverted to yield chargeability. The process is identical to inverting DC resistivity data.
   c. The IP data are plotted as pseudo-sections and then directly interpreted in terms of geology.
   d. The IP data are converted to voltages and then inverted as DC resistivity data.

25. A volume of earth material is subjected to an electric field after the generator in a DC resistivity survey is turned on. Which of the following statements is true?
   a. The charges associated with the IP effect are built up instantaneously and they are the same for all rocks.
   b. The charges take time to build up and the time for build-up is the same for all rocks.
   c. The charges take time to build up and the time for build-up can vary between rock-types.
   d. The charges are built up instantaneously but their magnitude differs because of rock-type.

26. Which of the following statements are true regarding the differences between a pseudo-section and an inverse model?
   a. Pseudo-sections can be used to display apparent conductivity values, while inverse models will show conductivity.
   b. Both can be used to determine the depth of a conductive anomaly.
   c. Both can be used to make interpretations about anomalous structures.
   d. All of the above.

27. Which of the following scenarios can present difficulties for a DC resistivity experiment?
   a. Locating a resistive target beneath a thick conductive overburden.
   b. Locating a conductive target beneath a thick conductive overburden.
   c. Locating a shallow, air filled tunnel in a moderately conductive background.
   d. Both a) and b)
   e. a), b) and c)

28. Which of the following statements is false?
   a. A conductivity model is required to invert for chargeability.
   b. Chargeability and conductivity are positively correlated.
c. In a time domain system DC potentials are measured during the on time, while IP data are measured during the off time.
d. Both DC and IP data are sensitive to the buildup of charges.

**Short Answer Questions**

Consider the current electrode geometry outlined below.

![Diagram of electrode geometry](image)

a) Sketch the electric potential along a line that extends from (-10, 50) m. As indicated, A is the positive current electrode and B is the negative current electrode.

b) Indicate on your sketch what the voltage (potential difference) would be if the voltmeter is attached to the locations M and N. For the voltage measurement, M is connected to the positive end of the voltmeter and N is connected to the negative terminal.

c) Suppose that the input current was 5 Amperes. The current waveform and the measured voltages are shown below.
• (4pts) What is the apparent resistivity of the earth that gives rise to the measured potential?

• (2 pts) What is the value of the IP datum at time $t^*$?

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1. Use the figures below to sketch out the current density distribution which control the potential differences you would measure at the surface in a DC resistivity survey.

   a. First provide a sketch, using arrows, which shows the direction of current flow within a uniform half-space due to the dipole transmitter.
b. Show the current distribution when a small body ($\sigma_2 < \sigma_1$) is included?

c. Show the current distribution when a small body ($\sigma_2 > \sigma_1$) is included?
The below resistivity (left) and chargeability (right) models shown below were recovered by inverting DC and IP data collected over a waste deposit in South Africa. Note that on the left plot, red is more resistive, and on the plot on the right, red indicates a more chargeable material. There are several geologic units to consider:

- gravels
- sediments
- granitic basement
- organic waste
- leachate with a high ion concentration

Fill in the table indicating the expected range (high – H / medium - M / low – L) of the following physical properties:

<table>
<thead>
<tr>
<th>Material</th>
<th>Resistivity</th>
<th>Chargeability</th>
</tr>
</thead>
<tbody>
<tr>
<td>gravels</td>
<td></td>
<td></td>
</tr>
<tr>
<td>sediments</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Granitic basement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organic waste</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leachate</td>
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</tbody>
</table>

The granitic basement is overlain by sediments and cut by a fault. The surface layer is composed of gravels. Use the physical properties, and the geophysical results below to draw an interpreted geologic cross section (including all of the materials discussed above).