

Electrical ground probing

Measuring the electrical resistance of the ground to find buried objects

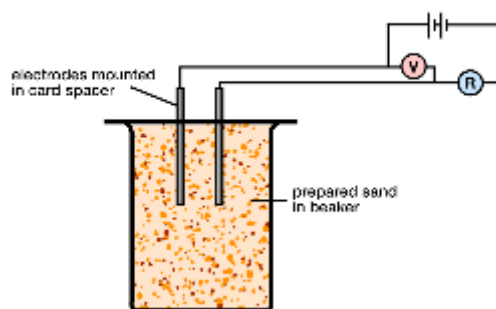
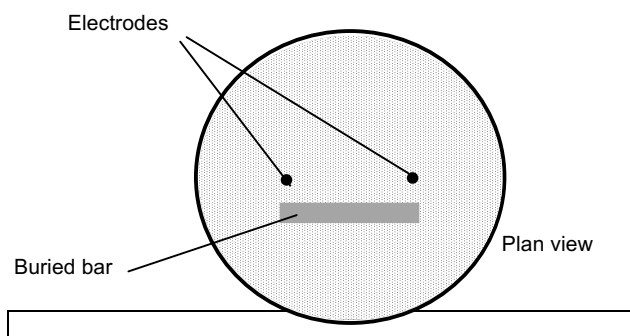
Pupils may be familiar with the principle of using geophysical methods to locate objects and structures buried below ground. Some TV archaeology programmes refer to this as “Geophys”. The electrical resistance of the ground is one property which can be used in this way.

Set up the apparatus as shown in the diagram and photograph. A current is passed from a voltage generator into a beaker of sand, through two electrodes (steel pins), mounted in a piece of card, (so that they are held about 3cm apart). Measure the voltage and current across the electrodes. For the first run, use sand that has been soaked in saturated brine. Adjust the voltage generator so that a voltage of between 2 and 4 volts, and a current of about 100 mA are shown between the electrodes. Record the two values. Then change the beaker for one which contains sand that has been soaked in deionised water, and without changing the setting on the generator, measure the voltage and current between the electrodes and record the values. Finally, change the beaker for one containing dry sand and repeat the measurements. Ask the pupils to calculate the resistance of the contents of each beaker, using Ohm’s Law ($V = IR$, so $R = V/I$).

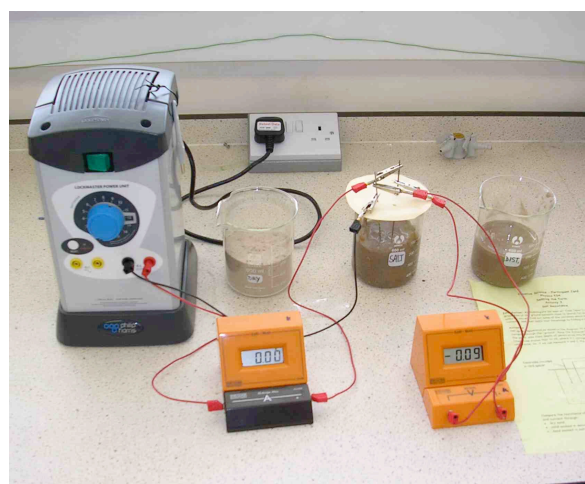
The table below shows figures obtained during a pilot run.

Sample	Voltage (V volts)	Current (I amps)	Resistance (R ohms)
Dry sand	4.76	0	Infinity
Sand soaked in deionised water	3.16	0.01	316
Sand soaked in salt water	2.86	0.45	6.3

Ask students to predict what would happen to the resistance if an iron bar were to be buried horizontally in the sand, parallel and close to the bases of the electrodes (as shown below). Set up such a model, using the brine-saturated sand and repeat the activity. (Caution – do not let this run for too long, since chlorine is eventually produced at one of the electrodes).



Circuit diagram of the apparatus



The apparatus set up to measure the resistance of the sand



The way electrical methods are used in the field – in this case, to locate a buried steel drum
(Photographs by Peter Kennett)

The back up

Title: Electrical ground probing

Subtitle: Measuring the electrical resistance of the ground to find buried objects

Topic: A laboratory demonstration of the principle of 'remote sensing', using the electrical properties of Earth materials.

Age range of pupils: 14 – 18 years

Time needed to complete activity: 20 minutes plus setting up time

Pupil learning outcomes: Pupils can:

- measure a voltage and a current passing through a substance;
- calculate the resistance using Ohm's Law;
- explain why the resistance is less for sand saturated in brine than for sand saturated in distilled water or dry sand;
- predict the change in resistance when an iron object is buried within the sand;
- discuss how such methods could be used to locate buried objects, such as a mineral vein or a hidden cache of illegal weapons.

Context: The activity models the principles involved in surveying by electrical methods. Such techniques are frequently used in mineral exploration or in archaeological surveying. Forensic scientists also use the method to investigate disturbed ground in the search for objects buried by criminals.

In the final set up, the buried iron bar significantly reduces the resistance because it provides a low resistance path in parallel to the direct path between the electrodes.

Following up the activity:

Pupils could be invited to watch TV! Several archaeology series (in U.K.) demonstrate the use of geophysical methods in locating buried objects.

Underlying principles:

- In order to conduct electricity, free electrons or ions must be present to carry the current.
- The dry sand has the highest resistance because such ions are not present.

- The brine-soaked sand has the lowest resistance because the water is rich in ions from the sodium chloride.
- An iron bar has the least resistance of any of the materials used in the activity.
- In the field, mineral veins are usually of low resistance, not so much because of the metal ores present, but from the ion-rich water trapped between the particles of the weathered material above the vein.
- Buried steel objects, such as weapons, can be expected to reduce the resistance of the soil above them.
- For simplicity and in order to use familiar concepts, this activity measures the resistance of the materials and keeps the same spacing and depth for the electrodes. In the field, the spacing of the electrodes is deliberately varied to obtain more information. In this case, it is the resistivity of the medium which is calculated (in ohm metres). Resistivity may be regarded as the opposite of conductivity.

Thinking skill development:

Pupils establish a pattern from the successive measurements. These do not always work out as expected, involving cognitive conflict. Applying the model to the real world of remote sensing is a bridging skill.

Resource list:

- 3 sand samples (400 cm³ dry) in three 500 ml beakers
- 150ml deionised water
- 150ml saturated brine (salt water)
- power pack
- ammeter
- 2 steel electrodes (mounted 3cm apart)
- volt and amp meters
- 5 connecting leads and crocodile clips
- iron bar about 2.5cm long

Source: Based on an activity developed for the workshop "Sensing the Earth: teaching KS4 Physics", Earth Science Education Unit, <http://www.earthscienceeducation.com>

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