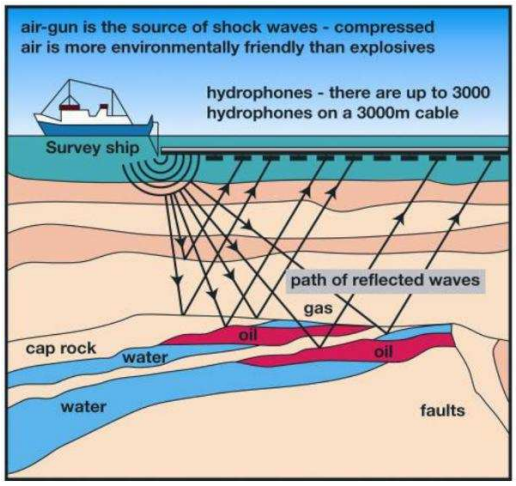
Probing the ground – by physics

Using the remote sensing power of physics, to find what is beneath the ground

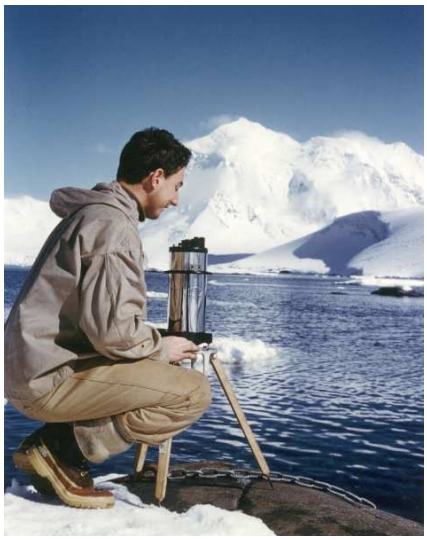
Sometimes, people want to find out what is under the ground without digging up the surface. You might want to probe for buried infrastructure (like cables, water mains or foundations), archaeological remains (e.g. artefacts, bodies or buildings) or natural resources (like metal ores or fossil fuels).

In this activity, students are divided into small groups of two or three, and each group is given a copy of the sheet on page **4.** They are asked to discuss their answers and to fill in the sheet. Which of the methods listed might be used to probe the ground in the right circumstances and which could never be used?
Some answers are given below:

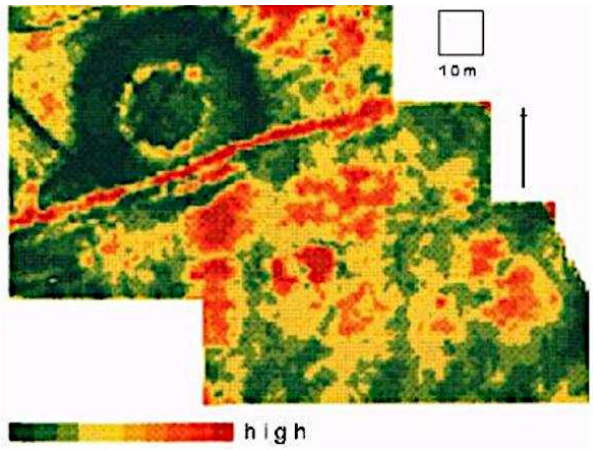
Physical remote sensing method – could this be used to probe the ground	**Could this method be used?**		**Explanation**
Shock wave	Ultrasound	x	Wouldn't penetrate the ground sufficiently.
	Audio sound	x	Detection of reflection devices not sensitive enough.
	Seismic waves (Infrasound)	✓	Used to identify rock boundaries and to map underground geology. Used to detect buried structures which might contain resources like oil/gas and metal ores under land or sea.
Electromagnetic radiation	Radio waves	x	Would penetrate the ground, near surface only. Long wavelengths would diffract around objects therefore little sensitivity.
	Microwaves (radar)	✓	'Ground penetrating radar' - used to detect underground archaeology, near surface penetration.
	Infra-red waves	x	Wouldn't penetrate the ground.
	Visible light	x/✓	Does not penetrate the ground but can be used to detect dry areas (crop marks) and changes in vegetation, which might have been affected by underlying metal ores and associated minerals
	Ultra-violet waves	x	Wouldn't penetrate the ground.
	X-rays	x	Hazardous; would penetrate the ground.
	Gamma radiation	x	Hazardous and most would pass straight through the objects.
Ionising radiation	Alpha radiation	x	Hazardous; wouldn't penetrate the ground.
	Beta radiation	x	Hazardous; wouldn't penetrate the ground.
	Gamma radiation	x	Hazardous; wouldn't penetrate the ground.
Magnetism	Magnetic variation	✓	Used to detect underground archaeology, buried infrastructure and magnetic ores.
	Induced magnetism	✓	Used in metal detectors.
Electricity	Variation in electrical ground currents	x/✓	Variation in natural electrical currents in the ground wouldn't be affected enough by archaeological remains but is used to detect ores.
	Resistivity	✓	Used to detect underground archaeology and ore deposits.
Gravity	Local gravitational variation	✓	Cannot detect small infrastructure or archaeological anomalies but can detect ore bodies and potential oil/gas trap areas.



Using shock waves to find oil and gas
©The Energy Institute, redrawn by ESEU



Peter Kennett (ELI Team) taking a gravity reading at Port Lockroy, Antarctica
© Ken Archibald



Electrical resistance plot shows a round barrow, a prehistoric burial mound
© Alistair J. Marshall, Geophysical Surveys of Bradford



Surveying the landscape with a Bartington gradiometer. The pegs and poles of the survey grid can just be seen
© ESEU

The back up

Title: Probing the ground - by physics

Subtitle: Using the remote sensing power of physics, to find what is beneath the ground

Topic:
An investigation into the physical remote sensing methods that could be used to probe the ground. These methods are used by structural engineers, mining engineers, geologists (geophysicists, geochemists), archaeologists, surveyors, forensic pathologists.

Age range of pupils: 14 plus

Time needed to complete activity: 10 minutes, maybe more depending on the degree of discussion

Pupil learning outcomes: Pupils can
- describe and explain a range of remote sensing methods used to penetrate the ground surface for technological, archaeological or geological purposes;
- explain which areas of physics are not suitable for these purposes.

Context: These remote sensing methods may be discussed in Physics lessons as well as in Geology and in the Environmental Sciences. They are methods used in many disciplines.

Following up the activity:
Students could search the internet for further examples of remote sensing and they could try the following Earthlearningideas:-
Electrical ground probing
https://earthlearningidea.com/PDF/96_Electrical_ground_probing.pdf
Modelling remote sensing geophysics
https://earthlearningidea.com/PDF/270_Remote_sensing.pdf

Underlying principles:
- Various remote sensing methods can be used to probe the ground.
- Seismic shock waves can be used to identify rock boundaries, detect oil/gas traps and structures related to metal ores under land and sea.
- Radar using microwaves can detect near surface underground archaeology.
- Variation in local magnetism may indicate there is something different beneath the ground.
- Metal detectors using magnetism can detect magnetic objects under the ground.
- Electrical resistivity can be used to detect underground archaeology and ore deposits.
- Gravitational variation can detect ore bodies and potential oil/gas trap areas.

Thinking skill development:
Deciding if certain aspects of physics can be used to find out what is under the ground involves construction. Discussion about the answers is metacognition. There is cognitive conflict when some aspects of physics cannot be used to find what is under the ground. Realising that all the methods mentioned are used in a variety of real-life disciplines is bridging.

Resource list:
Copies of the chart on page 4

Useful links:
Remote sensing Journal
https://www.sciencedirect.com/journal/remote-sensing-of-environment
USGS What is remote sensing and what is it used for
https://www.usgs.gov/faqs/what-remote-sensing-and-what-it-used

Source:
Developed by Chris King, for the Earth Science Education Unit Earth Physics Workshops
'Earth Physics: the geophys story'. Adapted for Earthlearningidea by Elizabeth Devon

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Gravity	Local gravitational variation		