Geophysics and forensics:
use of technology to locate burial sites and other subsurface anomalies

In geophysics, non-invasive technology is used to observe characteristics of the earth's subsurface.

In most cases, characteristics of buried materials can be recognized based on the behaviour of vibrations (e.g. radio waves, seismic waves, or light waves), as they interact with the material in question.

Magnetometers

Magnetometers measure minor differences in the strength of the Earth's magnetic field.

Most sedimentary rocks are nearly non-magnetic (although some sedimentary rocks such as sandstones can have local concentrations of magnetic minerals such as magnetite).

Igneous rocks generally have a stronger magnetic effect.

Because of these different effects on the magnetic field, measurements can be made to work out the vertical thicknesses and lateral distribution of rock units.

In general, rocks containing magnetic minerals such as magnetite have greater magnetic susceptibility and therefore produce more intense magnetic readings.

Major ore deposits (especially iron-bearing units) have been discovered with magnetometers.

A mass of iron locally intensifies the earth's natural magnetic field. Magnetometers, installed in airplanes and boats, are routinely used in geophysical surveys.

The location of large iron-rich objects, such as sunken ships, can be accomplished using magnetometers.

Magnetometers: Forensic Applications

In a recent case,a well-known citizen of a midwestern U.S. town disappeared in his new Cadillac.

A few months later, a person remembered seeing the vehicle near an active open-pit coal mine.

There was reason to suspect the missing man had been murdered.

In an open-pit mine, large volumes of earth are removed from the surface, exposing the coal tens of metres below the surface.

Overlying earth is carried away on giant conveyor belts and dropped in large piles away from the area to be mined

Investigators suspected that the vehicle (possibly containing the victim) had been driven under the unattended end of the conveyor belt and buried.

Company records indicated the general area of dumping during the time of the disappearance. But by then, the area was covered by several hectares of waste material many metres thick.

A magnetometer survey was planned.

Prior to the survey, a car of similar make was place in the mine near the edge and measurements were made on the surface above the vehicle.

It was determined that the instrument could detect the car even buried up to 70 feet.

The test survey produced several areas of high magnetic intensity.

While no anomalies seemed to high enough to indicate a mass of iron as large as a car, areas of minor increases in magnetic susceptibility were drilled..

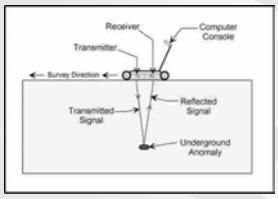
In this case, the lead proved false.

The magnetometer uncovered iron wire only.

Neither the Cadillac, nor the victim, was not found.

Ground Penetrating Radar

Ground penetrating radar (GPR) is another common geophysical technique.



The system includes a radio transmitter and receiver.

The transmitted radio signal penetrates a short distance into the ground, and is reflected back up to the receiver.

Some of the signal reflects off any object with different electrical properties than the host material.

Pilot studies have been conducted on the feasibility of using GPR in forensic work.

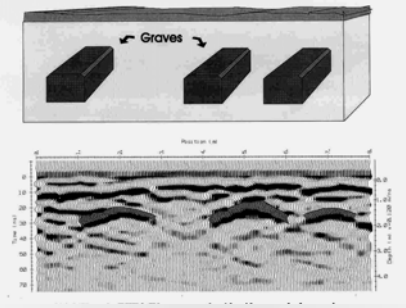
Studies have included projects in which pig carcasses were buried.

Investigators followed up from time to time with an instrumental search to see what pattern could be detected as the bodies decomposed.

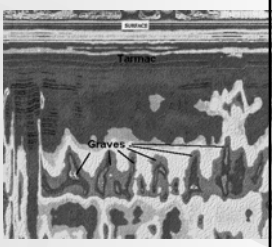
In British Columbia, a study led by Mark Skinner of Simon Fraser University, proved very successful.

Two goats and a bear were buried in a certain area for give years. Study participants first reduced the size of the search area by looking for disturbance and young vegetation. At that point, GPR easily located the three burial sites.

The promising possibilities of using GPR forensic work are well illustrated by GPR studies at the University of Calgary, where students have been successful in locating unmarked gravesites.



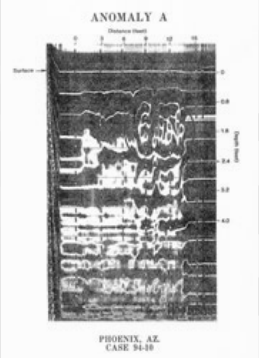
Another example of grave location (in UK) using GPR



Physical remains of murder victim were suspected to have been buried under a concrete pool deck.

Location of remains was pinpointed using GPR (note chaotic signature of circled area, indicating disturbance of the soil layers).

Prosecution resulted in First Degree murder conviction.



Geiger Counters

Many minerals are naturally radioactive. Among these are uranium and thorium, and many geologists are employed to explore for ores of these metals.

Fortunately, two common instruments, the Geiger counter and the scintillation counter detect radioactivity directly.

In forensic work, radioactivity comes into plat in several wasy. Smetimes investigators must detect radioactive minerals. In addition, it is possible to use radioactive powders and pastes, detectable later with a counter, to show that a person or object was in contact with the substance at some point

In one case in the late 1930s, lead bars were stolen from the Palmer Physical Laboratory in Princeton, New Jersey.

These bars were not ordinary lead bars, but contained radioactive cobalt !

Assuming that the thief disposed of the lead by selling it to a junkyard, investigators searched all such places in the area with a Geiger counter and recovered the lead.

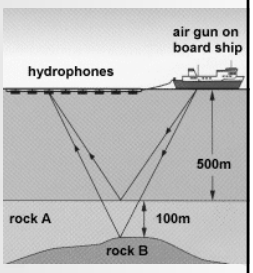
Seismic Surveys
(As Used in Exploring For Oil Under the Sea)

Shock waves are used to help give a picture of deep rock structures.

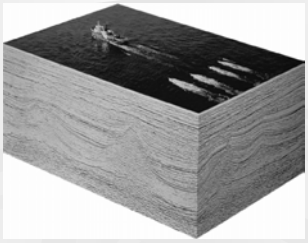
The shock wave travels through the water and strikes the seafloor. Some of the energy of the wave is reflected back to the hydrophones.

The rest of the wave carries on until it reaches another rock layer. The time taken for the waves to travel from the source to the hydrophones is used to calculate the distance travelled - hence the thickness of the rock layers.

The strength of the reflected wave gives information about the density of the reflecting rock.



Seismic Surveys



After seismic signals are collected and processed by computers, they form the basis of seismic cross-sections of strata.

These “seismic images” show buried structures such as faults, folds, and unconformities that can provide clues for the location of petroleum traps.

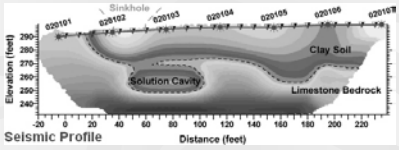
A similar approach is taken for land-based studies.

For *small-scale*, land-based surveys, a shock wave is generated by a large hammer struck on a metal plate.

The vibrations thus generated, travel through the ground.

At a certain distance from the hammer, the energy arriving at the geophones will have been refracted along any boundary between substances of different seismic velocities.

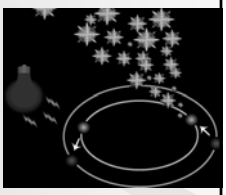
The time at which the energy arrives at the geophone will give information on the speed of sound in that medium (which is indicative of the types of substance eg soils have slow seismic velocities in comparison to rock) and the depth to that boundary.



Seismic surveys can be useful for locating large features such as tombs but are somewhat limited for locating small features. Nevertheless, seismic surveys are essential for providing information on the depth of the soil profile, and the location of unusual subsurface features that may be significant to forensic investigations.

Fluorescence

In ultraviolet light, some minerals (and certain forms of organic matter) glow with a colour different from their colour in white light.

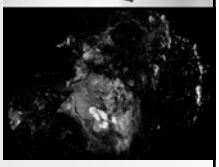


When a fluorescent mineral is exposed to UV light, the atoms in the crystal lattice become excited and electrons jump to a more distant shell around the atomic nucleus. When the electrons fall back to their original shell, energy is released as light.

UV light has long been used to identify minerals that fluoresce.

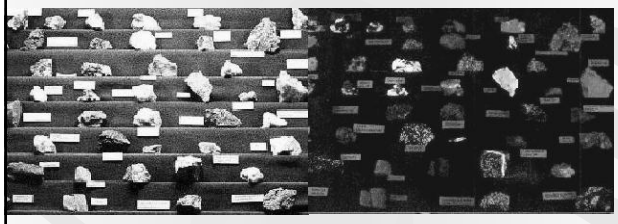
The fluorescence may appear as shades of blue, brown, green, orange, yellow or red (the colour depending on the material).

This is a rock sample from the Franklin Mine (New Jersey)



Roeblingite glows bright red.
The orange is Clinohedrite
the purple is Xonotlite
and the green is Willemite

Comparison of minerals in visible vs. ultraviolet light



Visible light

Ultraviolet light

Fluorescent paste is commonly placed on tripping levers of alarm boxes to identify people who set off false alarms

But you have to be careful with this stuff ! (fluorescent materials are not as rare as one might think).

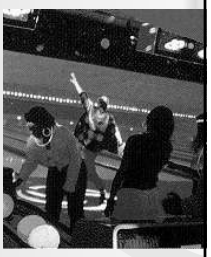
In one case, an individual was apprehended while apparently running away from the scene of a false fire alarm.

His fingers were examined under UV light and the skin showed a strong fluorescence (this was stated at his first trial).

However, a second examination two days after the suspect's apprehension revealed that he wore a jacket made of synthetic fibres with fluorescent dye.

Microscopic examination indicated that the loose fibres from the coat stuck to his hands by sweat were what fluoresced.

The first identification was shown to be in error and the suspect's innocence was established.

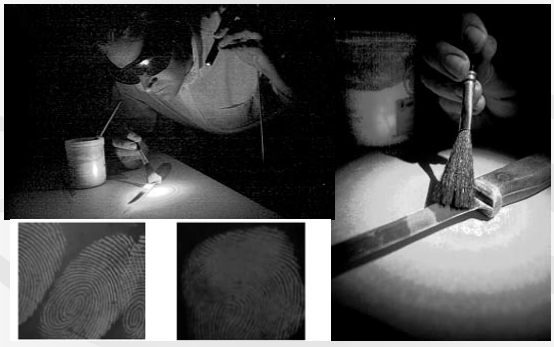


To be certain the suspect had not had paste on his hands and deliberately removed it in the time between examinations, a sample of the paste was tested.

The "control" material was still fluorescent and identifiable on the skin after several days.

To prevent such cases of mistaken identity, finely ground, distinctive minerals are commonly mixed with a fluorescent paste or powder for use at a single location, providing an unambiguous identification.

Fluorescent powders can also be used to enhance the visibility of fingerprints for purposes of identification



Other geophysical tools

Metal detectors: can be used to detect buried metal objects (basically detecting changes in an electrical current run through a coil the detector is passed over a metallic object)

Methane sniffers: instruments that can detect small amounts of methane that might be expected to be released from a decomposing corpse

Thermal Imagery: infrared (heat) radiation may be released from a decomposing corpse (pilots studies have been conducted on animal corpses buried under controlled conditions).


END OF LECTURE