Forensic Geology and CSI

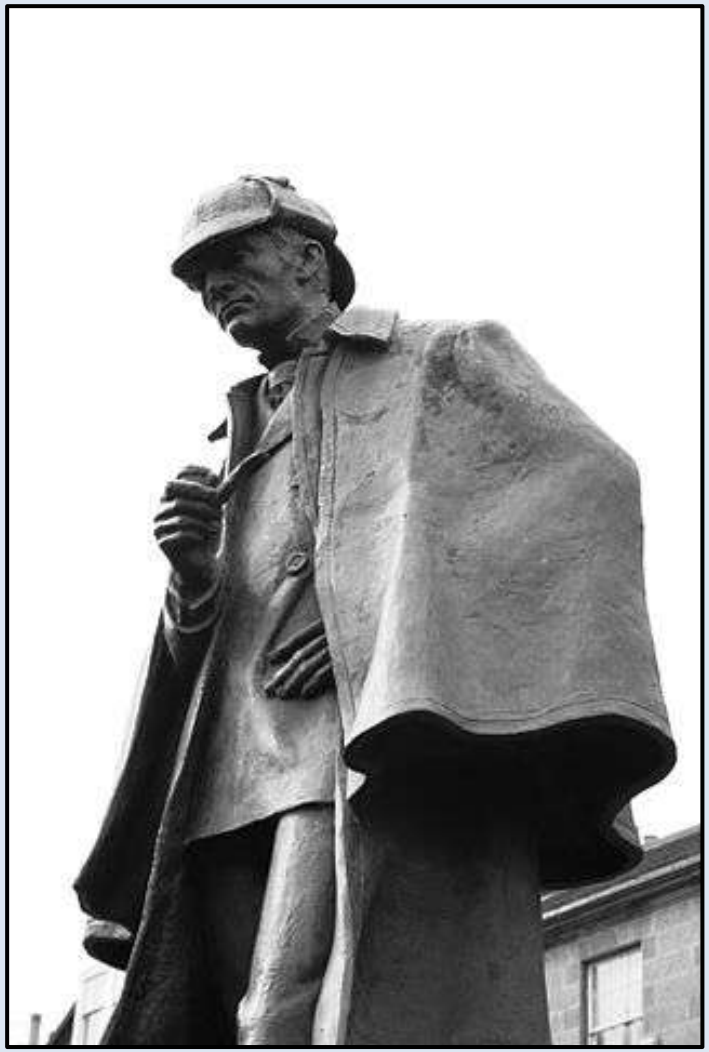
Dr Maggie Williams

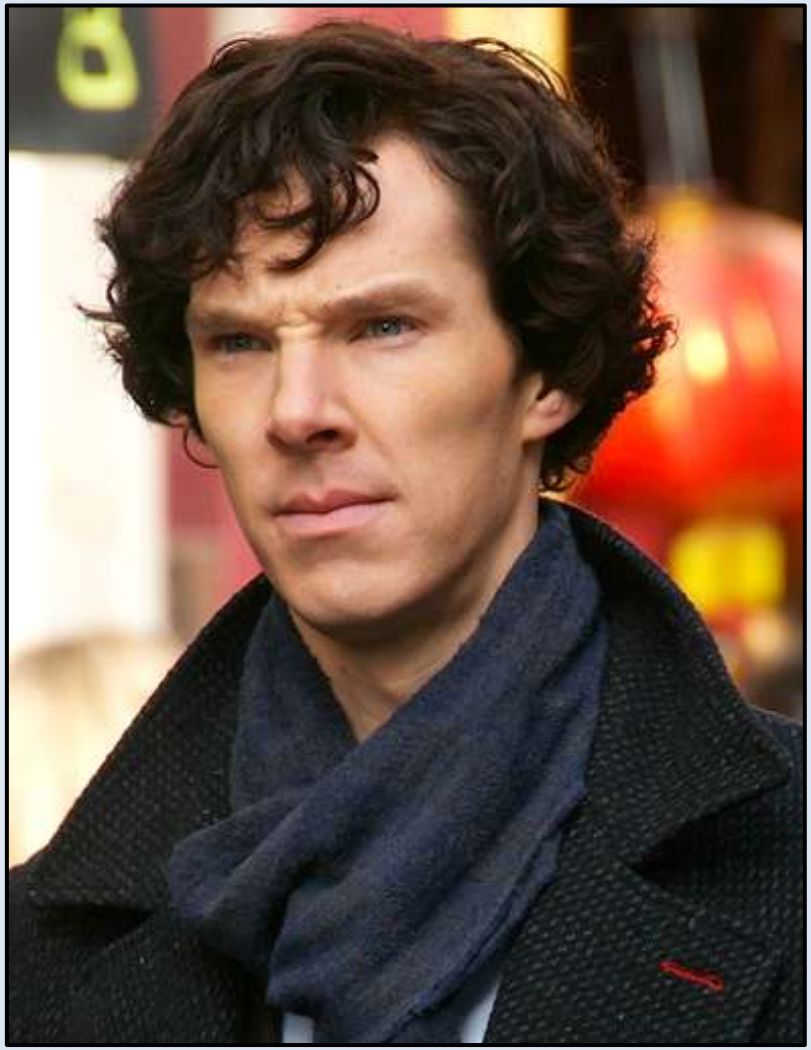
Introduction

Aims

- To outline the development of forensic geology
- To look at the materials used by forensic geoscientists
- To consider geological methods & skills used by crime scene investigators
- To look at some criminal cases solved using forensic geology
- *To set some problems for you to solve?*

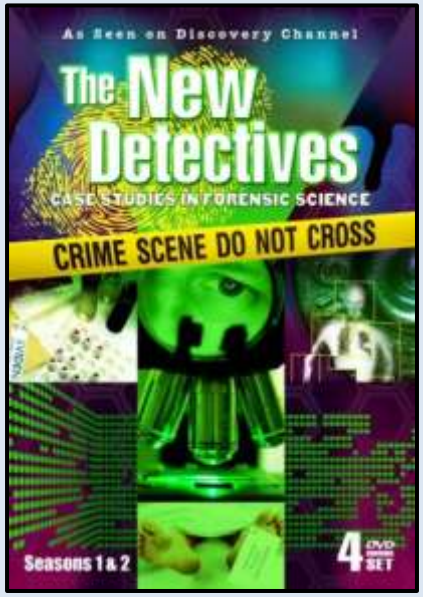
Fiction from Sherlock Holmes …





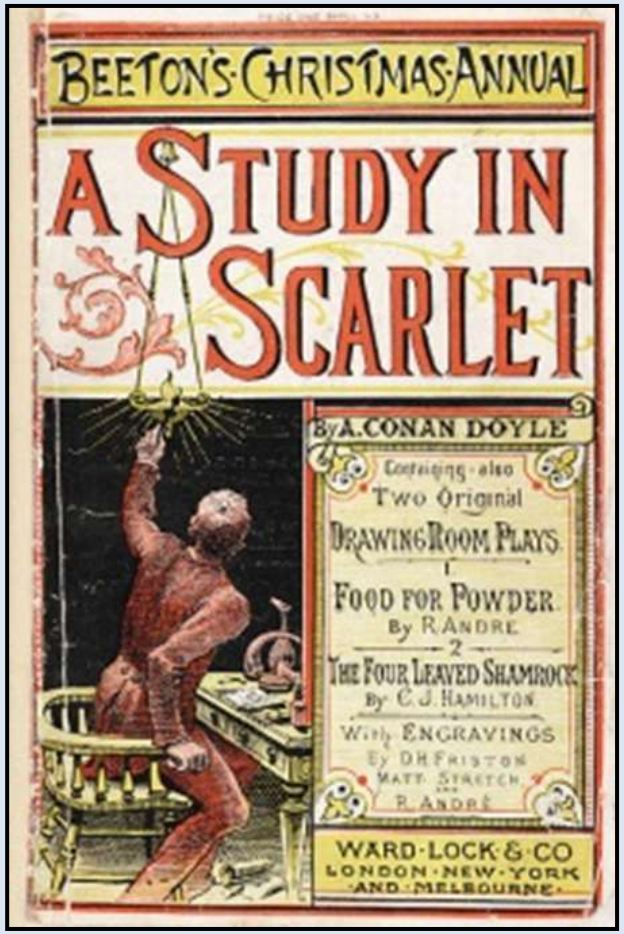
Credit: http://en.wikipedia.org/wiki/Sherlock_Holmes#Forensic_science

… to the present



Sir Arthur Conan Doyle

Publication of the Sherlock Holmes series 1887 – 1893



Credit: http://en.wikipedia.org/wiki/Sherlock_Holmes#Forensic_science

In *A Study in Scarlet*:

Dr. Watson assesses Holmes's abilities thus:

- Knowledge of Literature — nil.
- Knowledge of Astronomy — nil.
- Knowledge of Politics — feeble.
- Knowledge of Botany — variable. Well up in belladona, opium and poisons generally. Knows nothing of practical gardening.

- Knowledge of Geology — practical, but limited. Tells at a glance different soils from each other. After walks, has shown me splashes upon his trousers, and told me by their colour and consistence in what part of London he had received them.

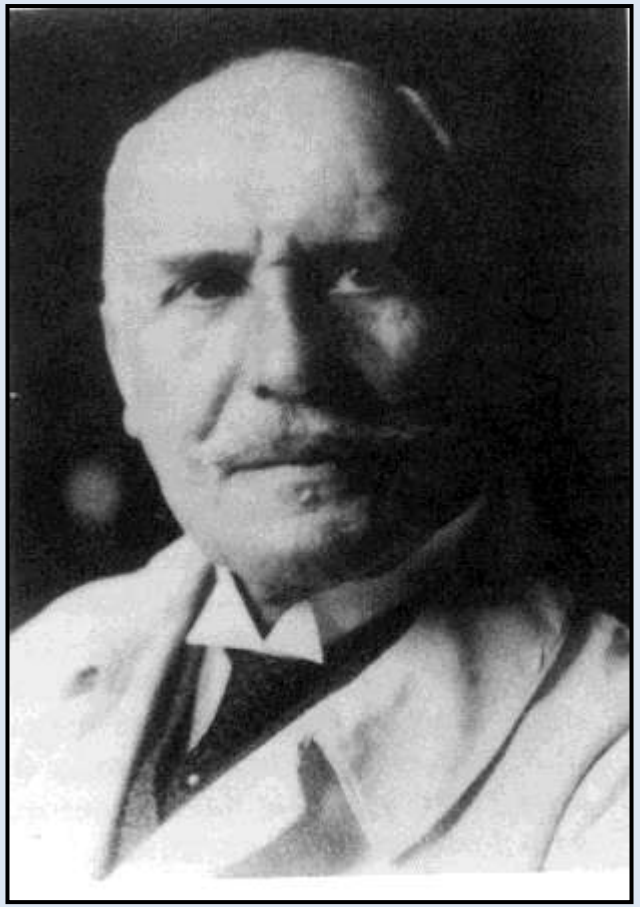
- Knowledge of Chemistry — profound.
- Knowledge of Anatomy — accurate, but unsystematic.
- Knowledge of Sensational Literature — immense. He appears to know every detail of every horror perpetrated in the century.

- Plays the violin well.
- Is an expert singlestick player, boxer and swordsman.

Ideas published in fiction first applied

Hans Gross, 1893

Handbook for Examining Magistrates



Georg Popp, 1904

First example of Earth materials used as evidence in a criminal case

Locard's Material Exchange Principle (1929)

http://science.howstuffworks.com/locards-exchange-principle1.htm

"Whenever two objects come into contact, there is always a transfer of material."

The state of the ‘art’ today






Credit: http://www.forensic-science-society.org.uk/home

CSI: Types of physical evidence

- Blood, semen, saliva
- Documents
- Drugs
- Explosives
- Fibres
- Fingerprints
- Firearms & ammunition
- Glass
- Hair
- Impressions
- Organs & physiological fluids
- Paint
- Plastic bags
- Plastic, rubber & other polymers
- Powder residues
- Rock fragments
- Serial numbers
- Sediment, soil & minerals
- Tool marks
- Vehicle lights
- Wood & other vegetative matter

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Links to forensic geoscience

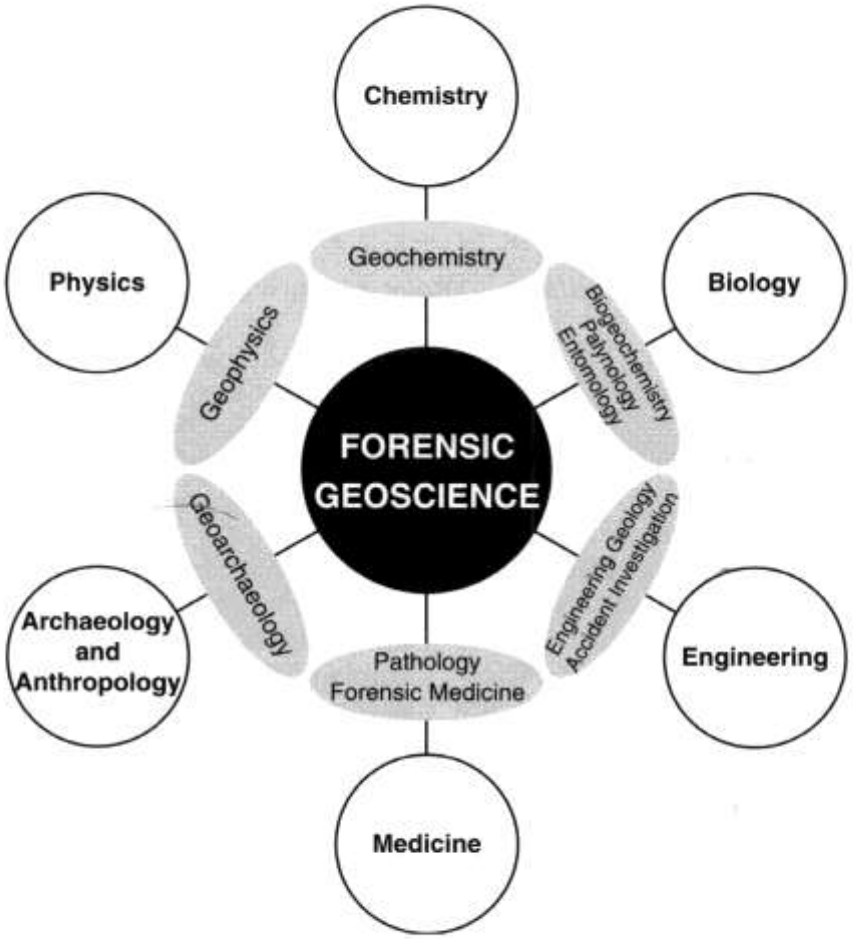


Fig. 1. The relationship of forensic geoscience to some other disciplines and subdisciplines.

From: Pye and Croft, 2004

Geological materials used as evidence in criminal investigations

- Rocks
- Mineral grains
- Sediments (sands or gravels)
- Roofing slates & flags
- Soil
- Fossils and microfossils

What is forensic geology?

The scientific application of Earth sciences to legal matters.

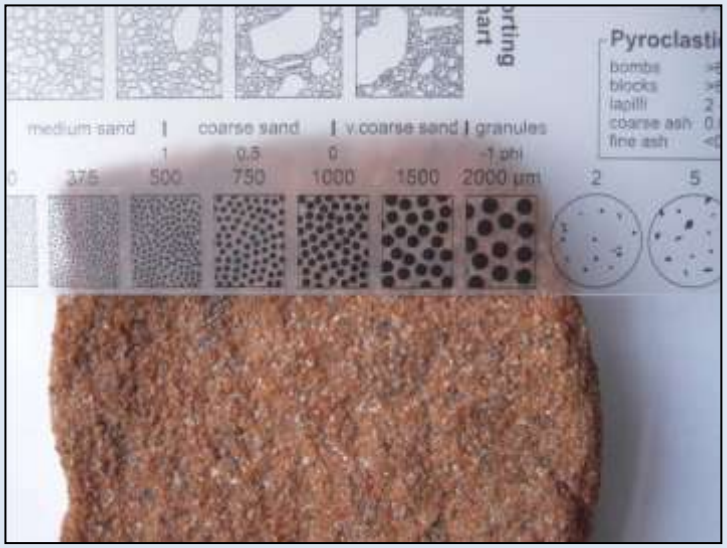
Forensic geologists identify, analyse, and compare Earth materials found on a suspect, object or a vehicle to possible source areas.

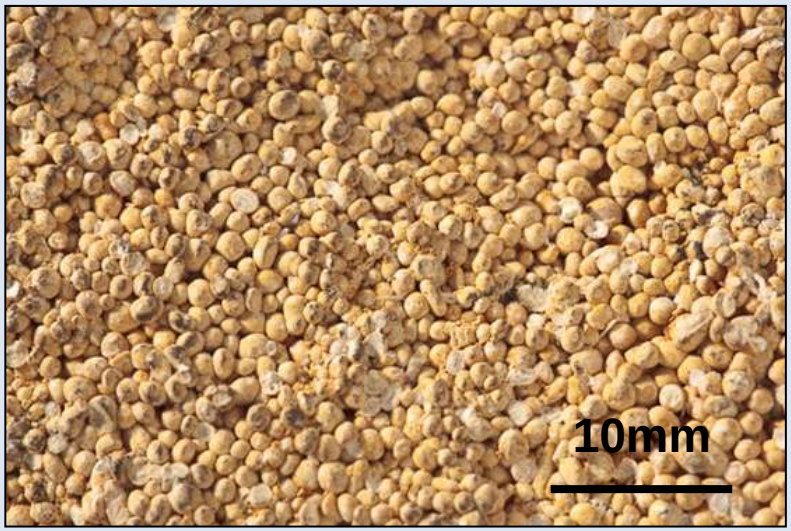
Comparisons:

- establish the degree of probability that the material was or was not derived from a particular location
- associate or dissociate a person or object with a particular location.

Methods of investigation

1. Hand specimen identification





Methods of investigation

1. Hand specimen identification

Tracing Bin Laden:

Limestone behind Bin Laden shown in this 2001 photograph identified a particular location
(after Al-Jazeera News)

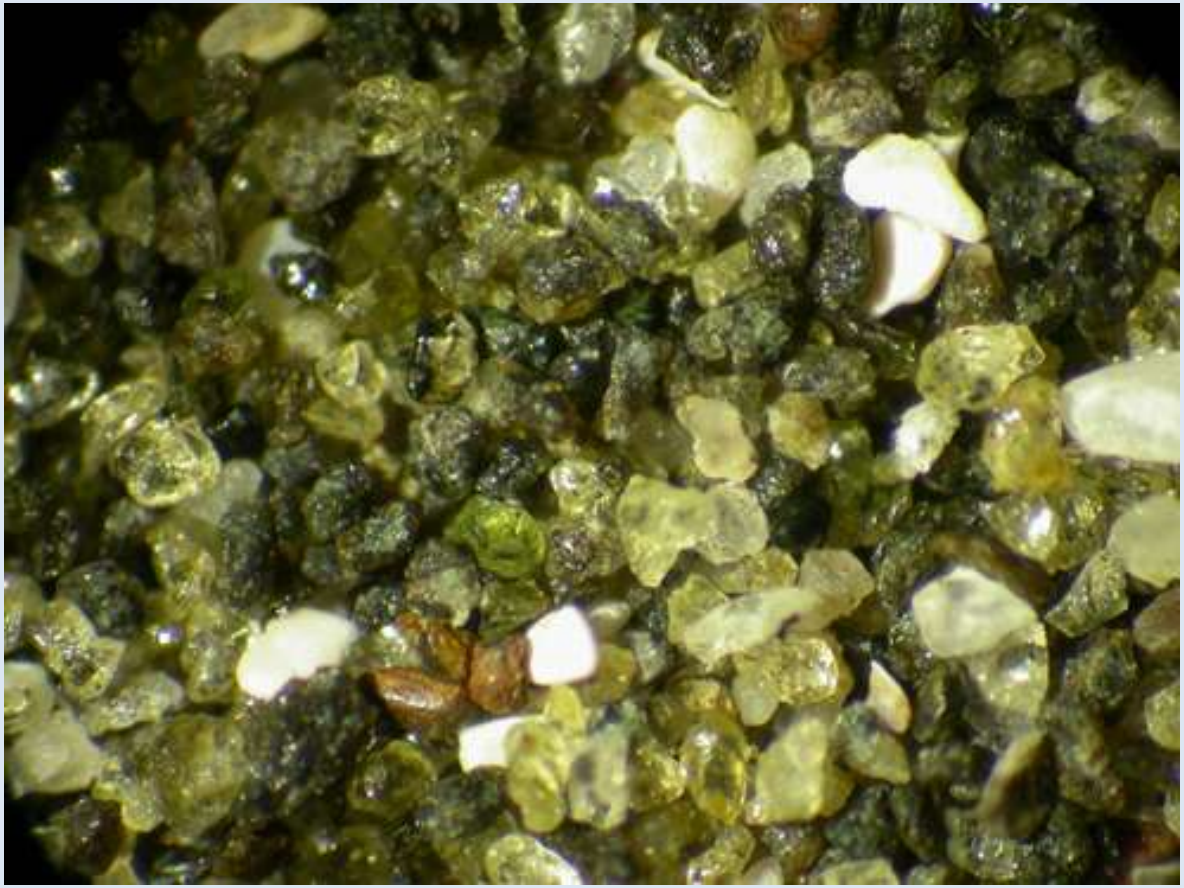
Amanda Knox case:

Shocking truth about evidence <u>not</u> collected by forensic police

Meredith Kercher crime scene – Police waited six weeks to collect as evidence the rock used to break into the cottage

Methods of investigation

2. Sieved soil/sand particles – identification of constituent minerals



2mm

Sample: Glenbrittle, Skye

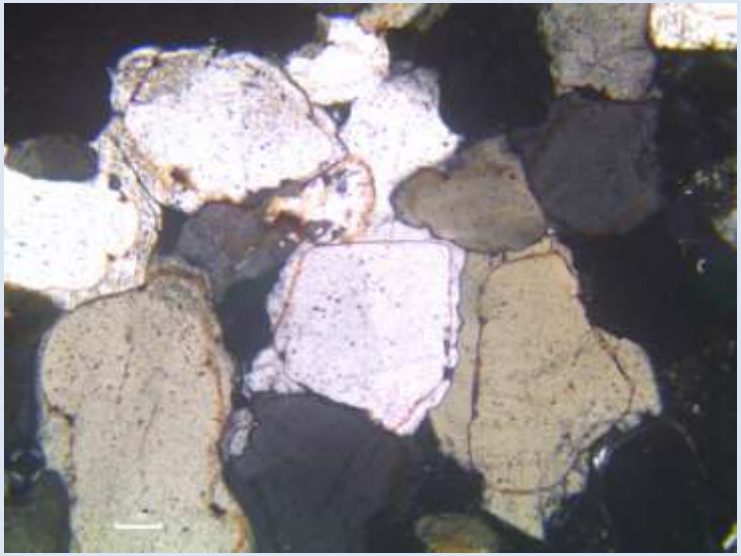

2 mm
Sample 12, Myrdalssanour

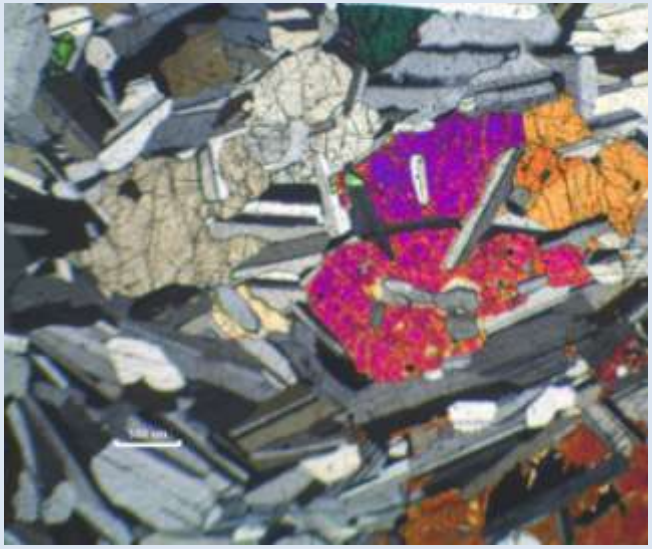

2 mm
Sample 86, Libya

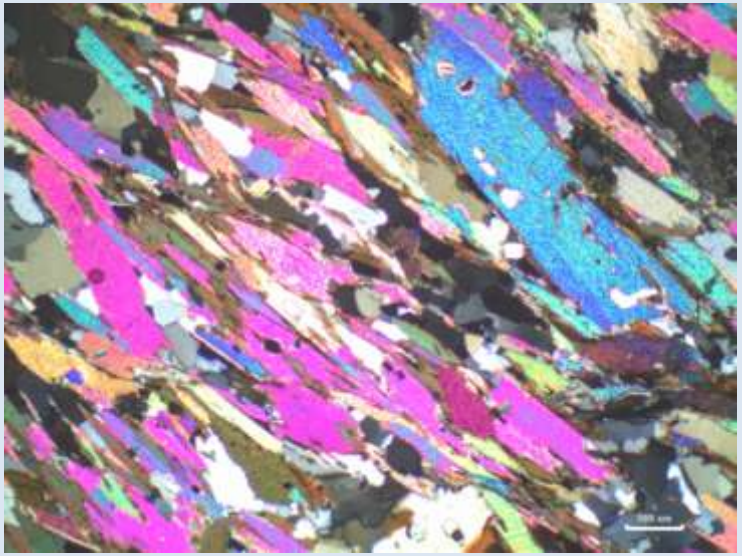
Objects with soil which typically may be associated with a crime (after Donnelly/Emergency Global 2010)

Methods of investigation

3. Optical microscopy

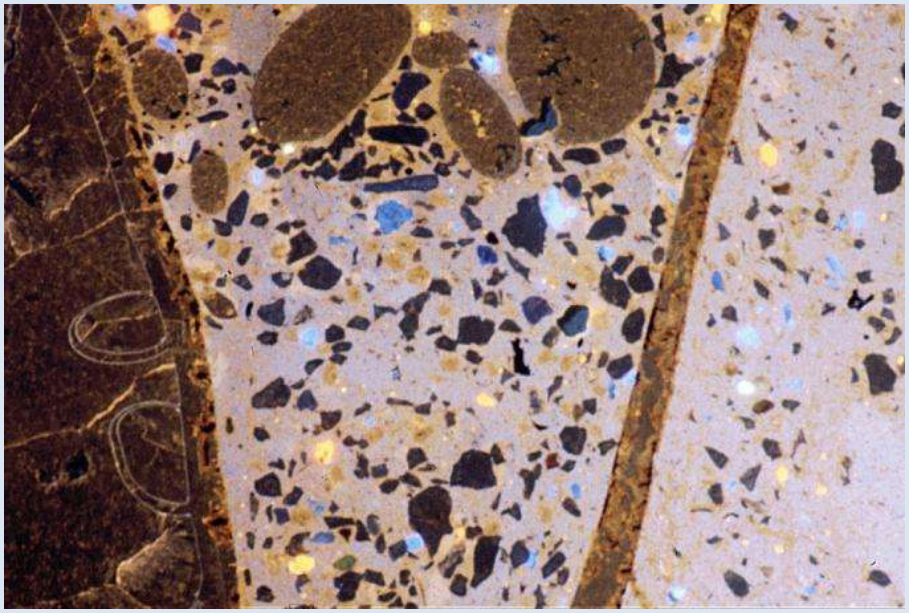


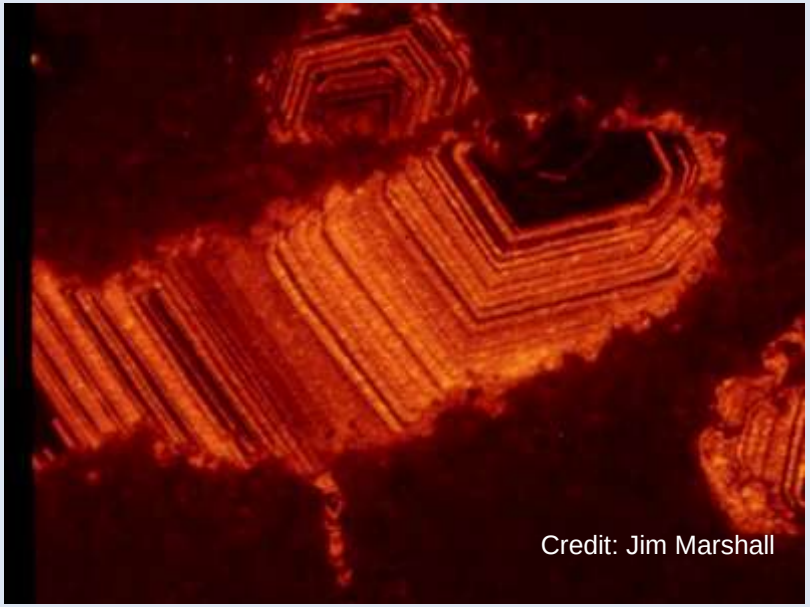




Methods of investigation

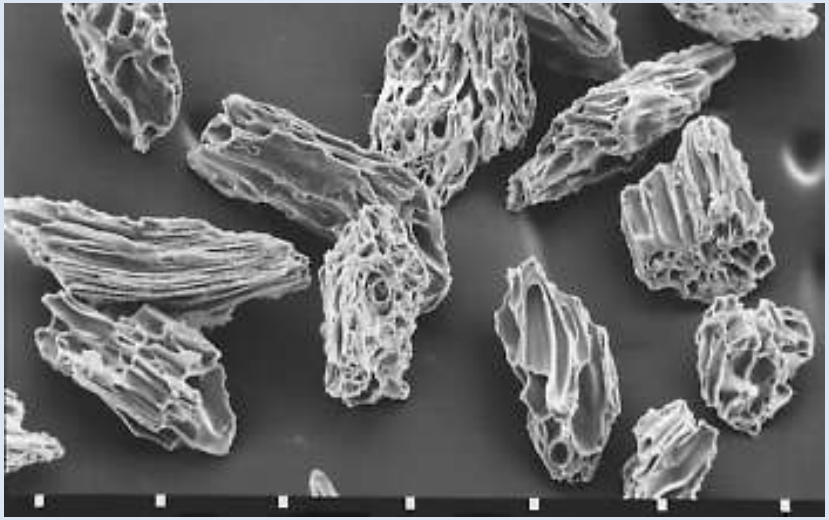
4. Cathodoluminescence microscopy



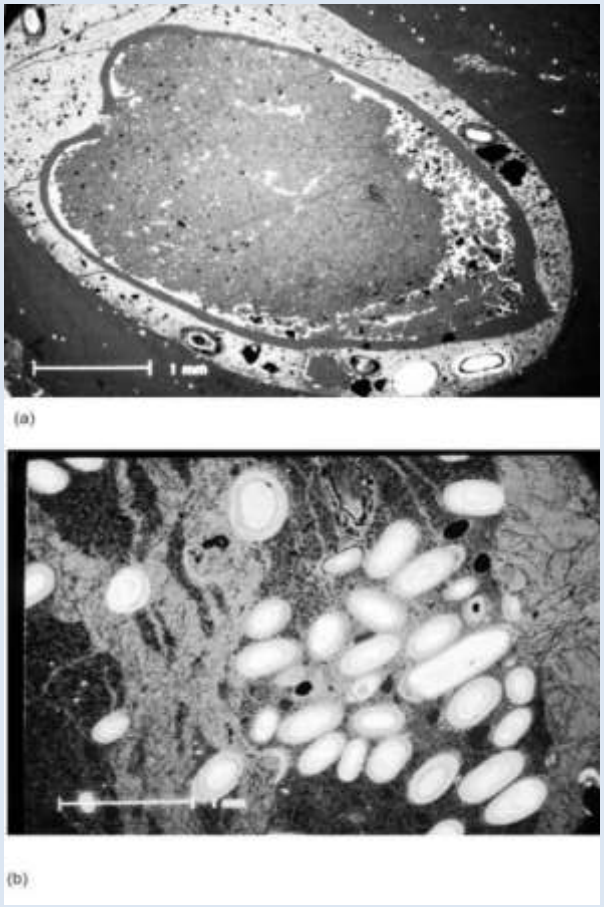


Methods of investigation

5. Scanning electron microscopy
   - SEM images
   - BSEM images



Credit: USGS



Methods of investigation

- QemSCAN

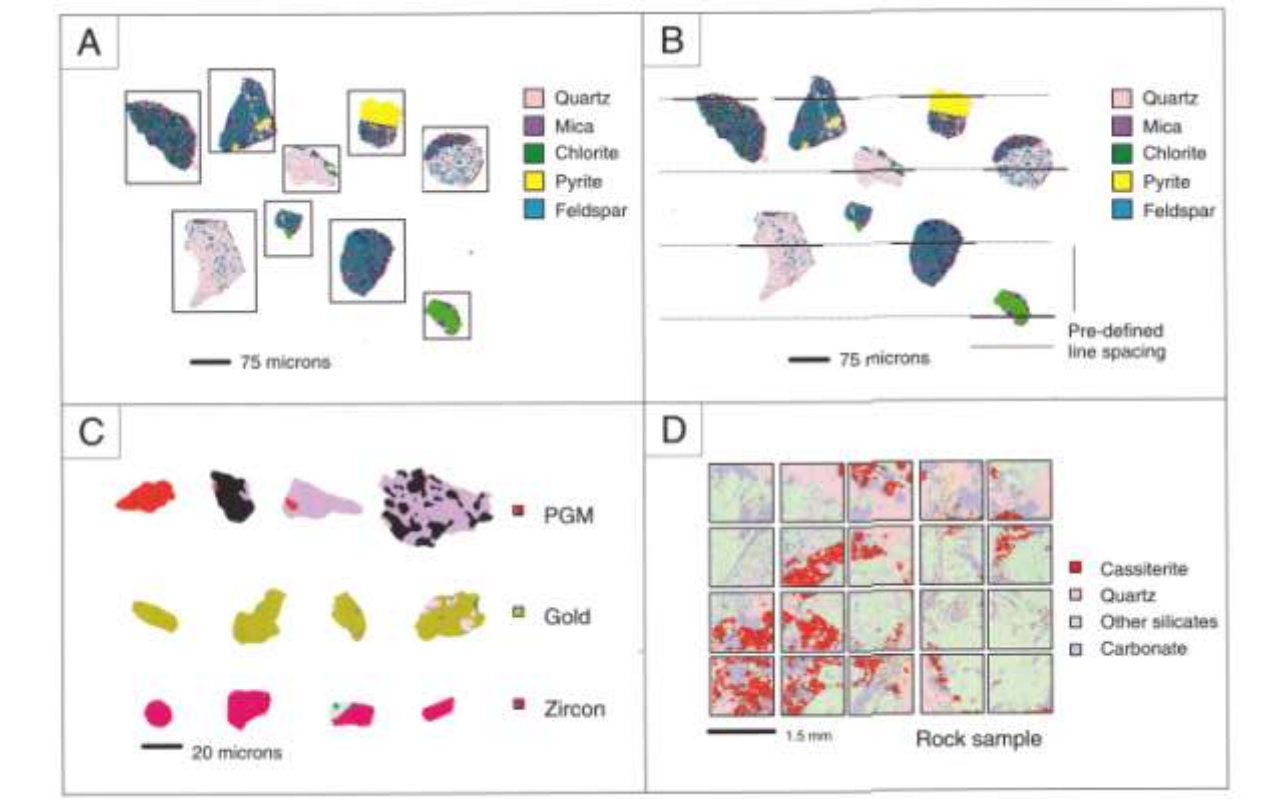


Fig. 2. Automated mineral analysis can be carried out using QemSCAN in four different operational modes: (a) particle mineral analysis; (b) bulk mineral analysis; (c) trace mineral analysis; and (d) field area analysis.

From: Pye and Croft, 2004

Methods of investigation

6. XRD & IR identification of minerals
7. Stable & radio-isotope geochemistry
8. Trace element geochemistry
9. X-ray fluorescence & infrared spectrometry
10. Electrical Resistivity Tomography (ERT)
11. Geochemical tracers (n.b particularly good for identifying post-mortem movement of bone remains)

… the list goes on & on!

Key geological principles used

1. The law of original horizontality

Key geological principles used

2. The law of superposition

A crime scene investigation?

Key geological principles used

3a. Cross-cutting features

Key geological principles used

3b. Cross-cutting features in tracks and trails

Credit: Moussa Direct Ltd

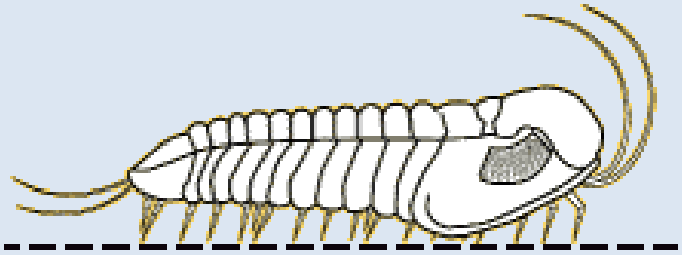
Credit: "Cruziana2“ Licensed under CC BY-SA 2.1 es via Wikimedia Commons

Credit: www.lightproductionsvideo.com/Cambrian-Animals.html

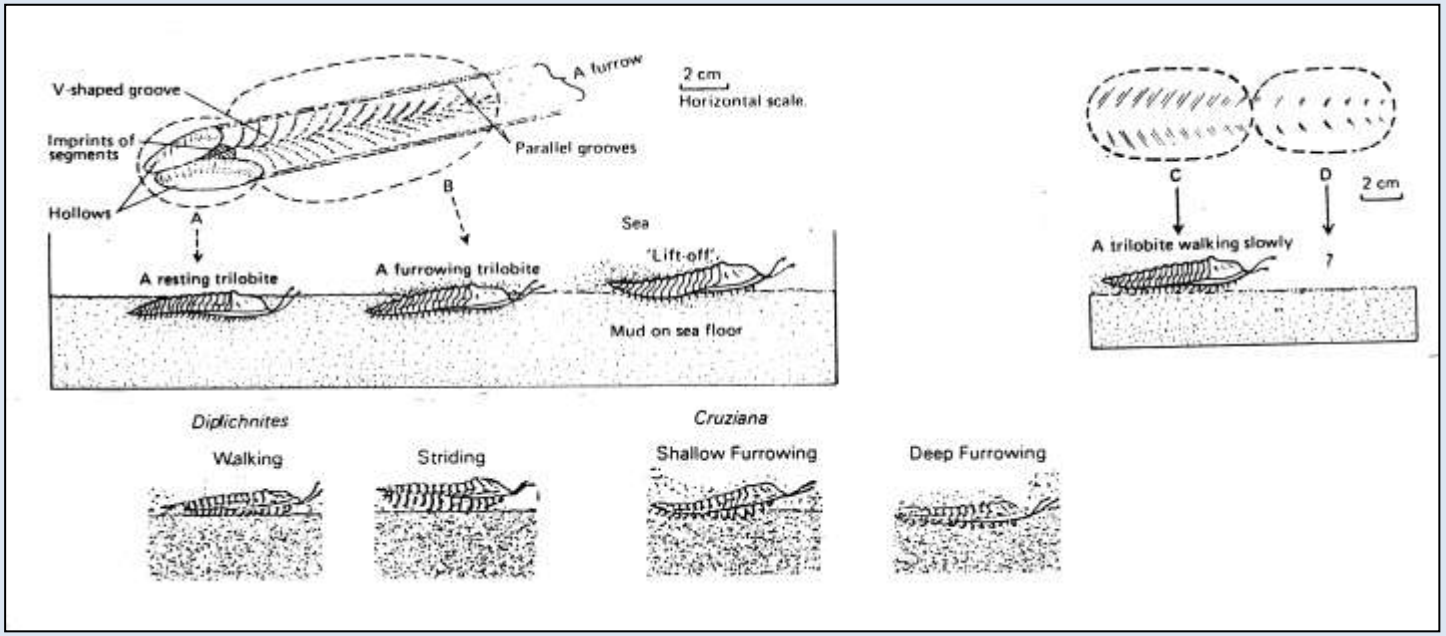
Key geological principles used

3b. Cross-cutting features in tracks and trails

Cause …

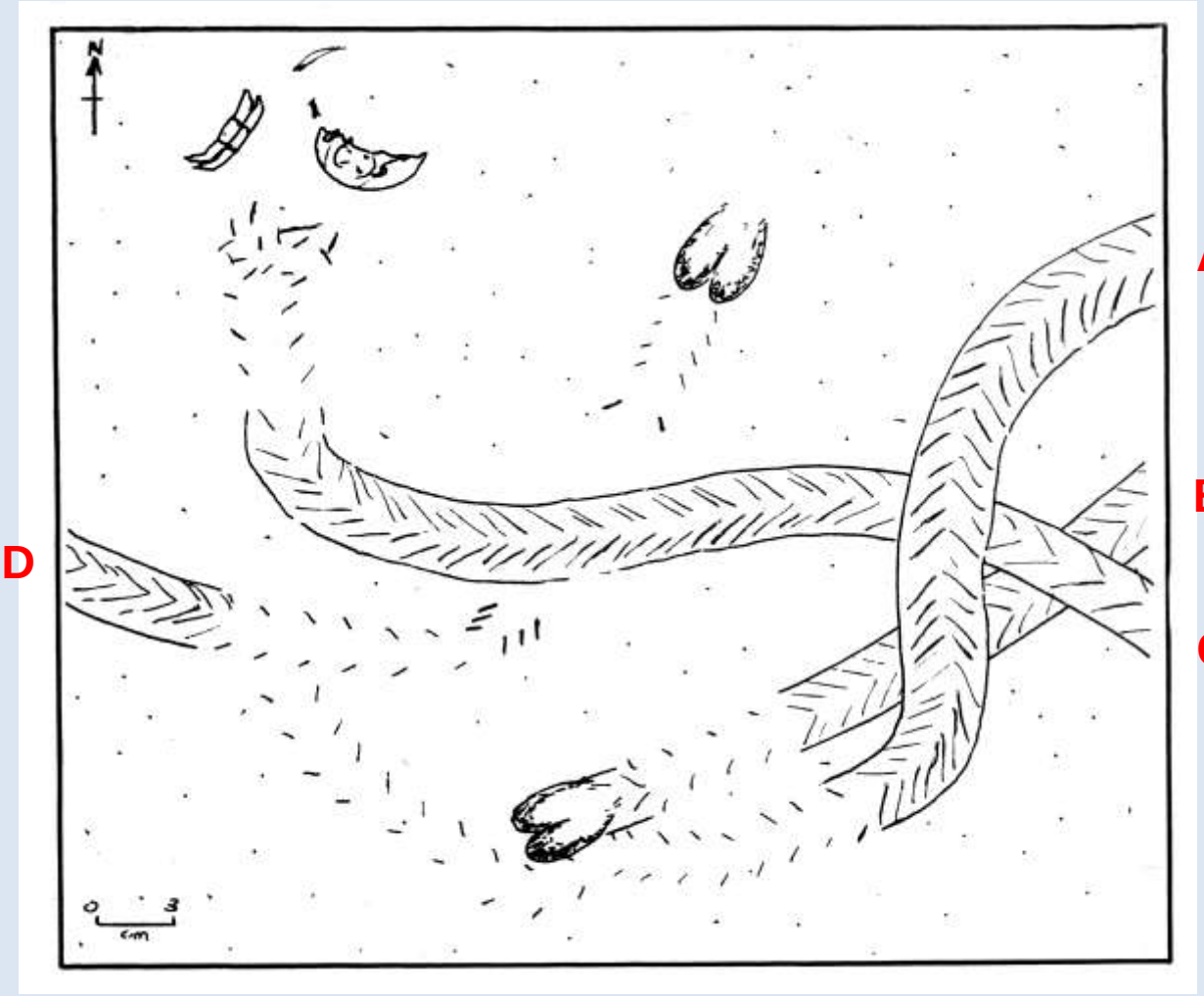


Effects …

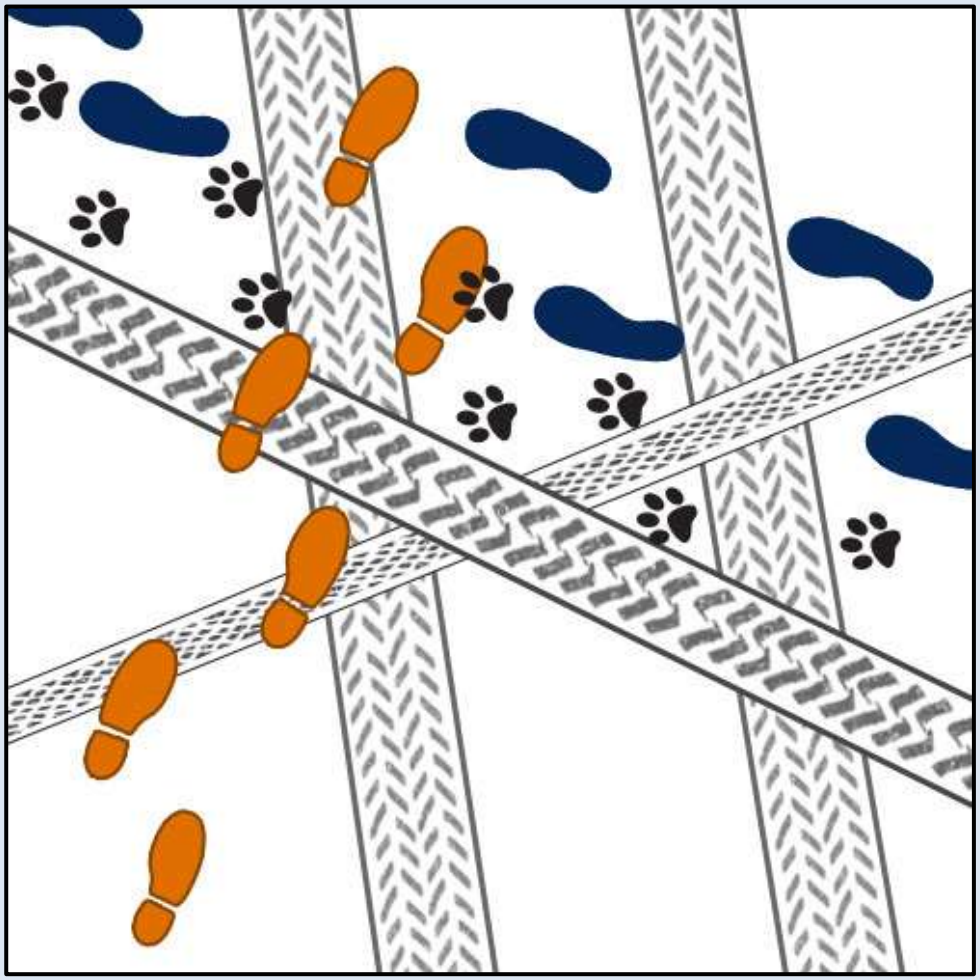


- and a few problems to solve …

A Cambrian Detective Story by Agnatha Cruziana



Who dunnit?



At the scene of crime, where the wife of the owner of the house was murdered, it had rained during the night, so the ground was full of footprints and tyre tracks.

The diagram shows the prints on the ground. By observing these, and by taking into account the information gleaned from interrogating the house tenants, you should be
able to identify the culprit.

1) The house owner drives a car.
2) The maid rides a bicycle to work.
3) The cook rides a motorcycle.
4) The butler walks to work.
5) The neighbour has a dog, and visits often.

Key geological principles used

4. Included fragments

Xenolith **A** is older than igneous rock **B.**

Another puzzle? What about fragment **C**?

Collecting the Evidence

Credit: http://www.forensic-pathways.com/products-and-services/forensic-pathways-product/evidence-collection

Collecting the evidence

Well preserved, uncontaminated evidence is vital to uphold the law's requirement for 'proof beyond all reasonable doubt'.

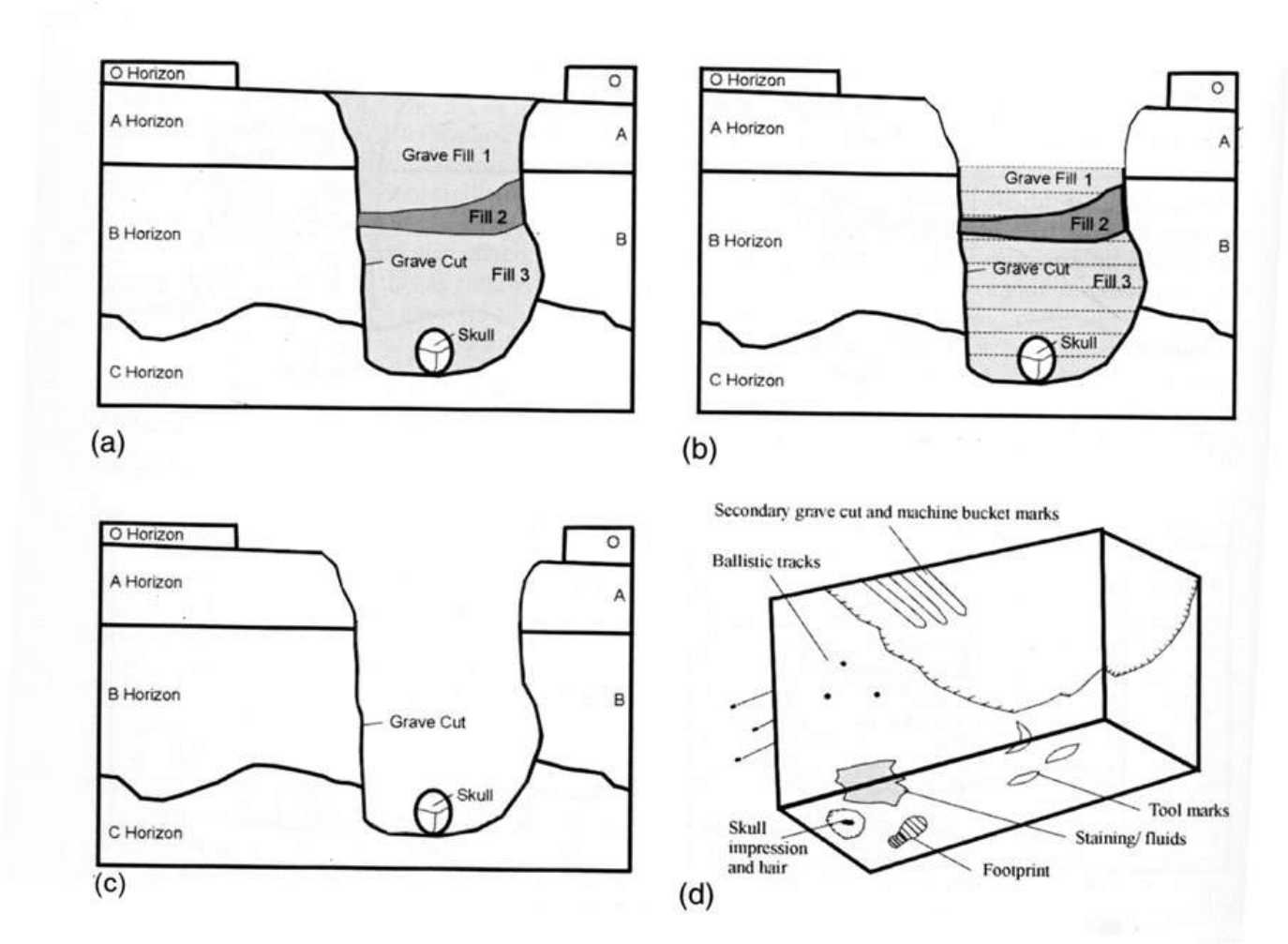
Recording the evidence

All finds must be accurately described, photographed and recorded.

The search area must be mapped, photographed and recorded using, where appropriate, GPS coordinates, conventional or ground based surveying.

Collecting the Evidence

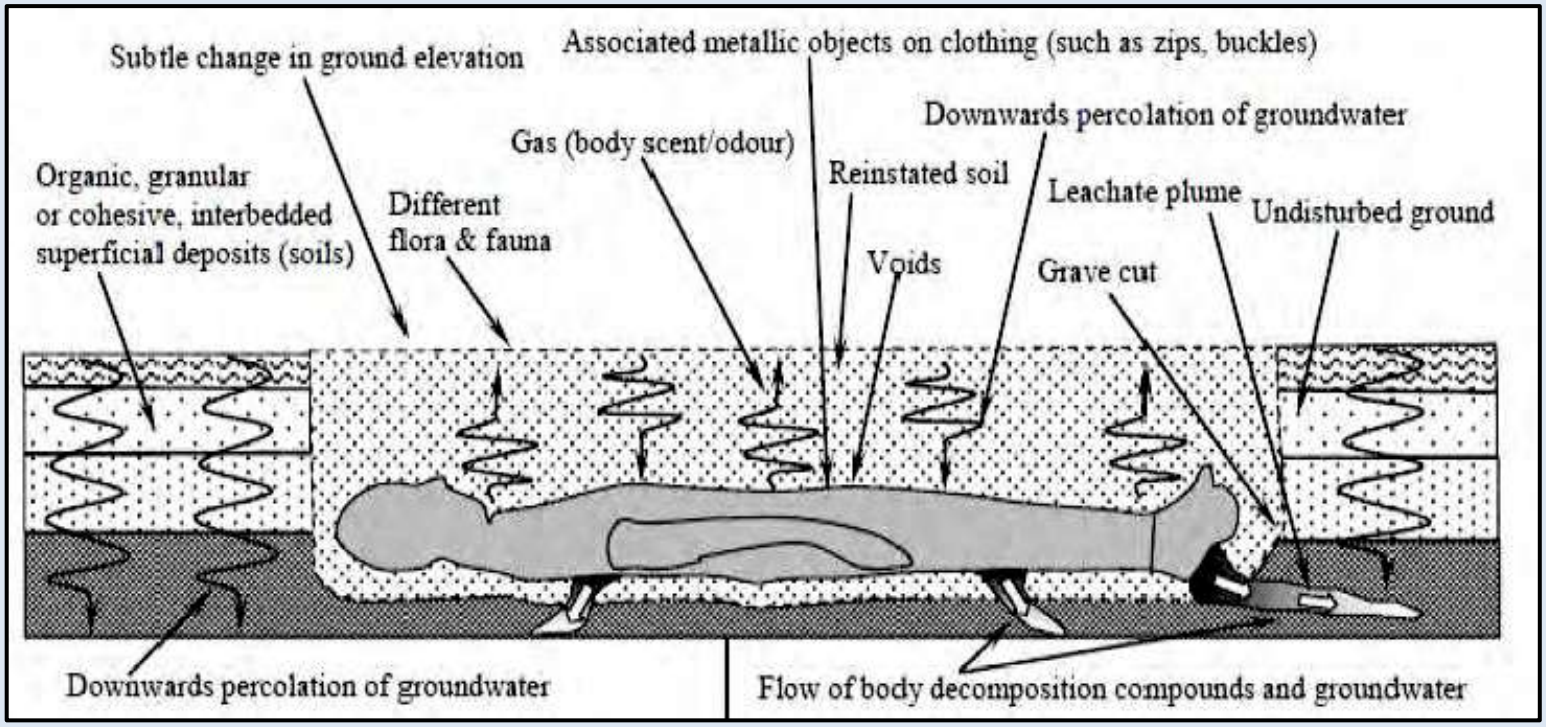
Avoid loss of evidence – undertake stratigraphic excavations



From: Pye and Croft, 2004

Collecting the Evidence

Remember to take into account all geological evidence



Geological model for a body in a grave (after Donnelly/FGG 2008)

Criminal cases solved using geological materials

Case 1: Finding the Soham murderer

Fingered by grains of quartz

THE world's first database of quartz grains from soil will soon be available to help police in England solve difficult crimes.

Peter Bull and Ruth Morgan at the University of Oxford examined more than 40,000 quartz grains from 1000 locations in England under an electron microscope and found about 40 types of grain. If the same combination of types is found in two samples, it's very likely that they come from the same place, they reasoned.

Bull used the database to help police investigate the deaths of two schoolgirls, Holly Wells and Jessica Chapman, in Soham, Cambridgeshire, in 2002. The vacuum cleaner used to clean a car belonging to the man later convicted of the girls' murder contained the same combination of quartz grains as was found where the girls' bodies were discovered. Mud under the car also had a matching combination. "It might only be a few grains of quartz, but it's another line of evidence," says Bull.

The database will be published in the journal *Science and Justice* later this year. Bull eventually plans to expand it to include samples from all over the world.

New Scientist 10/9/05

The geological key to solving this crime:

The vacuum cleaner used to clean a car belonging to the man later convicted of the girls' murder contained the same combination of quartz grains as was found where the girls' bodies were discovered. Mud under the car also had a matching combination. "It might only be a few grains of quartz, but it's another line of evidence," says Bull.

Case 2: Stolen diamonds

A consignment of diamonds despatched to Japan and stolen.

The geological key to solving this crime:

Thames valley gravels were used to replace the diamonds.

Case 3: The safe breakers

A safe broken into in Maryland, USA.
Two suspects were picked up, but only one admitted to the crime.

The geological key to solving this crime:

Particles of vermiculate mica safe insulation were found in both suspects' trouser cuffs and in their cars.

Case 4: The “Lady in the Lake”

A body found in Coniston Water, Lake District 30 years after the woman had “disappeared”.

The geological key to solving this crime:

Slabs of local rock used to weigh down body matched samples in the garden wall of the house built by the murderer (her husband).

Case 5: Gold 'fingerprints'

Stolen gold was smuggled out of the country & re-imported with a claim it was mined in another country.

The geological key to solving this crime:

Relative amounts of 30 impurities including platinum, palladium, lead, thallium & bismuth provide a ‘fingerprint’.

The suspected illegal gold – compared with samples from a database to prove its origin.

Case 6: Stolen Scotch

A person working for a Scotch distributor was suspected of stealing bottles of Scotch after cases of Scotch opened in a shop in Canada were found to contain blocks of limestone and not bottles of whiskey.

The geological evidence to solving this crime:

The limestone in the cases was from a particular quarry in central England. The suspect had access to the quarry and had often been seen taking home quarry samples.

Case 7: Badger baiting

Spades & boots (with abundant soil adhering) were seized from suspects & their vehicles following reports of digging at badger setts.

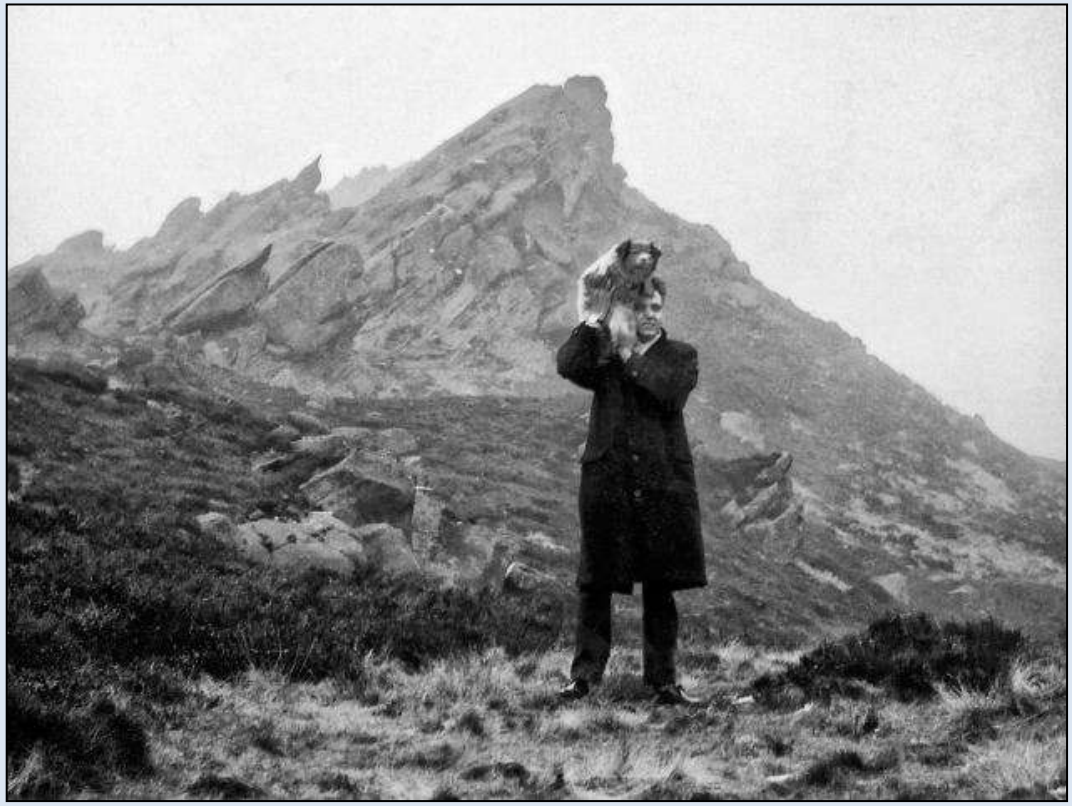
The geological evidence to solving this crime:
Particle size distribution and composition of mineral grains in the soil on the spades & boots matched those in the soil at the site of the badger setts.

Other general uses for forensic geology examinations

- Tracking pathways taken to & from crime scenes
- Placing suspects at arson scenes
- Mine site disaster investigations
- Determining time of death in grave sites by soil alteration
- Locating grave locations
- Working out sources of drug shipments

Criminal cases to be solved using geological materials?

Trophy pictures taken by ‘Moors Murderers’ Myra Hindley and Ian Brady near the graves of their victims.



Photograph showing Ian Brady holding a dog above his head at Ramshaw Rocks in Staffordshire.

Is this photograph of landscape features a potential clue/grave marker for the place where Keith Bennett’s body was buried?

Conclusions

- Forensic geology is only ~100 years old.
- The science is multidisciplinary - & is still evolving.
- Geological methods, techniques and skills are used by crime scene investigators.
- Forensic geology provides crucial evidence in CSI.

References

Evidence from the Earth: Forensic Geology & Criminal Investigation,
Raymond C Murray, Mountain Press Publishing Co., 2004

Forensic Geoscience: Principles, Techniques &Applications,
Pye K & Croft DJ, Geol. Soc., London, Special Publication 232, 2004

Geoforensics
Alistair Ruffell & Jennifer McKinley,John Wiley & Sons, 2008

Geological and Soil Evidence: Forensic Applications,
Kenneth Pye, CRC Press, 2007

And finally …

Here is a crime you can try and solve yourselves:

http://pcwww.liv.ac.uk/geo-oer/forensic%20geoscience.htm

THE DAILY CHRONIC

BODY FOUND IN WEST MIDLANDS

People smuggling four arrested

White van found abandoned near Worthing.

pcwww.liv.ac.uk/geo-oer/

Contact:

hiatus@liv.ac.uk


1


Royston
"I don't need to check anything with 'the boys in forensics', I know it was you."