Forensic Geology and CSI

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Introduction

...we now turn to an expert on this subject, who doesn't actually know any more than we do. But he looks sincere, sounds convincing and has 'Dr.' in front of his name.
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)

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

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

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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 not 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

Sample: Glenbrittle, Skye
Objects with soil which typically may be associated with a crime (after Donnelly/Emergency Global Global 2010)
Methods of investigation
3. Optical microscopy

![Optical microscopy images]

*Images show various microstructures under optical microscopy.*
Methods of investigation

4. Cathodoluminescence microscopy

Credit: Jim Marshall
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
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

Collecting the evidence

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

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).
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.
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?
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


*Geoforensics*

And finally …

Here is a crime you can try and solve yourselves:

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

Contact:
hiatus@liv.ac.uk
"I don't need to check anything with 'the boys in forensics', I know it was you."