Rock, Stock and Barrel:
Rocks and Minerals (and Remains of Living Things)
Nab the Criminal

Safe Cracking

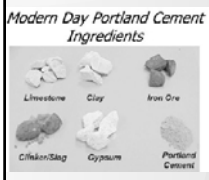
Heat-resistant safes are commonly used for the storage of valuables and important documents

To prevent heat damage of the contents in the safe, manufacturers have used a variety of different materials

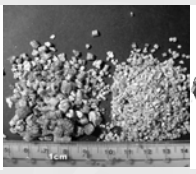
In the past, these materials have included wood chips, cork, cement, asbestos, gypsum, calcite, and diatomaceous earth.

Safes can be determined to be older than 60 years if they contain natural cement (cement produced by crude baking of clay-rich limestone).

Today, the most commonly used insulation materials are Portland cement, vermiculite, and diatomaceous earth.



Portland cement (limestone, clay, iron ore, slag and gypsum mixed together and baked)



Vermiculite (naturally occurring, but produced commercially by heating mica)

Diatomaceous earth (deposit of silica-shelled diatoms)

If these substances are found together, forensic scientists can safely assume that the material is safe insulation (few other products contain this combination of substances).

Diatomaceous earth, a sediment composed of microscopic silica shells of diatoms (aquatic algae) was used in safe insulation up to 1980 (its use since discontinued).

Natural outcrop of diatomaceous earth in Nevada (lake deposit about 10 m.y. old)

SEM image of diatomaceous earth (magnification: approx. 2000x)

Diatoms are used in a manner similar to that used by a paleontologist.

There are over 100,000 species of freshwater and marine diatoms known (fossil and modern).

A diatom deposit that is diagnostic of a particular environment and age serves as a geological fingerprint, due to the presence of characteristic species and the diversity of forms in the deposit.

If a safe is forcibly opened and the insulation layer is damaged, the dislodged material will be transferred to the safe cracker.

If diatomaceous earth is found on the suspect, it provides unambiguous evidence that the suspect was at the scene of the crime

A police officer who was questioning a man suspected of robbery noted white flecks of material on the man's shoulders and head an commented "that's the worst case of dandruff I have ever seen."

Microscopic examination of the "dandruff" revealed 13 different species of diatoms.

Samples of insulation taken from a recently cracked safe (robbed the previous day) revealed that it contained diatomaceous earth and contained the very same 13 species of diatoms found on the suspect.

This evidence led to the suspect's arrest and subsequent conviction.

Note: species identification of plant pollen on transferred soil has been used in a similar way as diatoms.

Southern Maryland

In a similar case in southern Maryland, two safes were broken into (one in a restaurant, and the other in a movie theatre).

Two suspects were apprehended after the incidents took place

One suspect admitted to the crimes and claimed that the other suspect to was innocent.

Examination of the pant cuffs of the supposedly innocent suspect was later found to retain cement particles that matched the cement-type insulation of the restaurant safe.

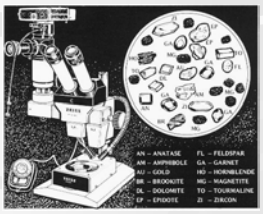
Vermiculite mica was found in the car of the “innocent” suspect. This was the same type of material used as insulation in the movie theatre safe.

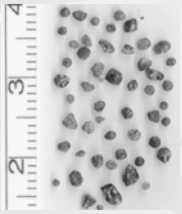
Were it not for mineral evidence, it is likely that the second suspect would have “walked”.

Cement particles in pant cuffs

Vermiculite particles in car

Heavy minerals





Every sand deposit has small amounts heavy minerals (minerals that are more than 2.8 times as heavy as an equal volume of water). Many heavy minerals are resistant to physical weathering and erosion, can therefore withstand sediment reworking.

Some heavy minerals also have variable properties that can accurately indicate their ultimate source.

In the lab, heavy minerals are separated from light minerals in heavy liquids and mounted on glass slides for examination.

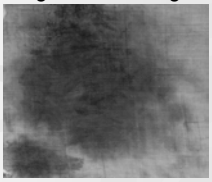
Koklas Case

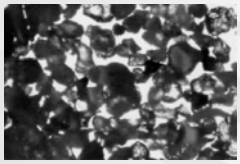
In January, 1968, the body of a man named Andreas Koklas was discovered along a roadside in Australia, apparently a victim of murder

The prime suspect was a man named Da Costa who had travelled with the victim from Melbourne to Mount Isa.

Da Costa claimed that they had an argument, that he left Koklas at Mt. Isa, and took some of his possessions

The possessions included a pair of bloodstained shorts with sand grains adhering to the blood residue.



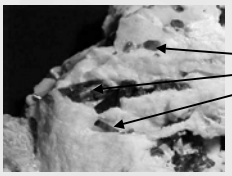


Mount Isa was about 500 km east of where the body was discovered but it was suspected that the shorts had been removed from the body where the body had been found.

Investigators examined heavy minerals in sand samples from the shorts and the crime scene.

The types of heavy mineral grains derived from the shorts (particularly grains of tourmaline with a distinctive chemical composition) matched more closely to the sand at the location where the body was found than at Mt. Isa.

After the first court hearing, the suspect admitted to have murdered the victim at the location where the body was found.

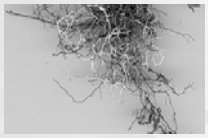


Theft

In April, 1997, the San Diego County, District Attorney asked geoscientists Brad Less, Tanja Williamson and Robert Graham to study material associated with the theft of $40,000 work of stolen palm trees

The owner raised the exotic trees from seed using a unique potting soil he purchased in bulk

Investigators collected ten samples of the potting soil from tree roots left in the victim's yard.



From the yard of the suspect's home, they collected soil samples from root balls of 33 palm trees as well as three samples of native soil from the yard.

The suspect had 7 species of palm trees in his yard.

The victim had raised all but one of these species *Phoenix roebelenii* (so those trees of this species could not have been stolen from him).

Samples from the 7th species (*Phoenix roebelenii)* served as controls in the study.

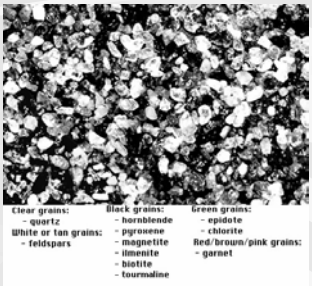
Examiners used several methods in their study, including carbonate determination, colour and particle-size analyses, and mineralogical identification.

Phoenix roebelenii

The ratio of light to heavy minerals was determined and the heavy ones examined more closely.

300 heavy mineral grains were counted.

Heavy minerals included hornblende, biotite, zircon, epidote and opaque minerals such as one would expect in potting soil from weathered granite.



Example of diversity of heavy mineral grains in sand

Hornblende, the most common heavy mineral provided the most useful information.

The examiners concluded that 25 of the suspect's 33 palm trees had been planted in potting soil that compared with that used by the victim.

Analyses accurately discriminated the 6 palm tree species that investigators knew had not been stolen from the victim.

There was no evidence to show that the remaining species had come from the victim's yard.

In a pretial hearing at which prosecutors presented the soil evidence, the suspect changed his plea from innocent to guilty.

Substitution Cases

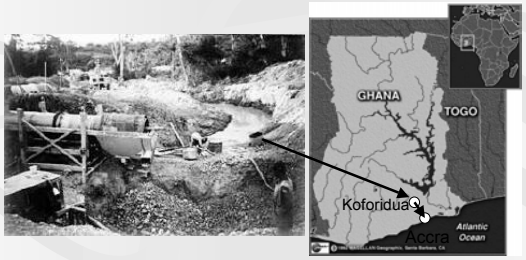
Criminals frequently substitute goods in shipment with other materials to mimic the weight of the goods.

In most cases, the timing and location of substitution is left unresolved.

However, the use of rocks as substitution "ballast" can provide investigators with valuable information on such practises.

The Ghana gold case

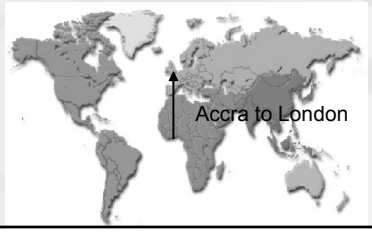
In 1997, a gold shipment worth 3 million dollars was trucked from placer gold mine of Koforidua, Ghana to the coastal city of Accra, Ghana.



The shipment consisted of several crates of placer gold in canvas bags.

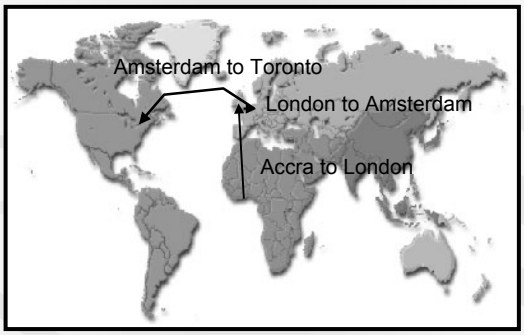
The crates were flown to London for processing, where they sat in storage for several days without customs inspection.

A conflict arose over processing costs in England, and it was decided to do the work in Canada.



The crates were then moved to Amsterdam and stored (again without customs inspection)…

…then flown to Toronto, Canada



Once in Toronto, Canadian customs tagged the crates and gave them additional seals, but failed to inspect them.

Finally, a Brinks security vehicle took them to a secure storage facility and later to the processing company.

When the crates were opened, it was discovered that the gold had been replaced by sand and ingots of pig-iron (iron taken directly from a blast furnace).

So where did the switch take place ?

Investigators suspected that Canadians might have been involved in the substitution.

It was clear, however, that the only secure handling took place on arrival in Canada (the Canadian seals were still intact when the crated were opened).

Original crates were reportedly secured with padlocks (but padlocks had apparently been removed when it arrived in London, and plastic wrapping was applied).

In addition to the crime, there was the question of liability.

Three different airlines had been used as well as multiple land carriers and storage facilities.

Who was to pay for the lost gold ?

Richard Munroe, a forensic geologist and police constable studied the "ballast sand" using optical and scanning electron microscopy.

If the sand was from Canada (or Europe), it would have shown signs of glacial action. Munroe determined that the sand was not of glacial origin (it lacked freshly ground minerals and it had undergone extreme chemical weathering in a tropical climate).

This ruled out Great Britain and the Netherlands and focused the investigation on the port where the gold was shipped from Ghana.

In the sand were fragments of slightly metamorphosed volcanic and sedimentary rocks. These fragments were consistent with Ghana's geology.

Excuses, excuses…

Ghanian police and government officials were contacted about obtaining reference samples for comparison. According to the Ghanians, a follow-up study was apparently impossible. The following reasons were given:

1. Due to rebel activity, accessing the mining district would require an armed expedition.
2. The road system was poor, and much of the journey would have to be on foot.
3. Qualified persons would have to be hired to collect the samples (which would take time)

In addition, investigators could not contact the gold-producing company for comparison samples since it might have been be involved in the crime.

In the end, specific studies to discover the actual transfer site were impossible.

However, the mining company withdrew the insurance claim.

This removed any suspicion from Canada and ended the Canadian interest in the case.

Monroe's study served the government and the people of Canada very well even though what actually happened in Ghana remains a mystery.

Vandalism

The Servizio Polizixa Scientifica, the laboratory of the Italian police in Rome has been instrumental in promoting the use of geological materials in crime solving.

Their competence was put to the text in a case that began in July, 2002.

July 17, 2002 - Rome- Forty graves were desecrated in the Jewish section of the historic Verano cemetery in a nightime attack prior to a traditional Jewish day of mourning (marking) the anniversary of the destruction of the Jewish Temple in Jerusalem in 586 BC.

The perpetrators partially opened one coffin, smashed headstones, and ripped off parts of gravestones with Hebrew writing and Star of David decorations. In all, over 50 tombs were desecrated.

The media reported the event, the first anti-Semitic act to take place in the Verano monumental cemetery in Rome.

In addition to the disturbing nature of the case, officials were concerned about possible links with neo-Nazi groups in Rome or Islamic militants.

After some investigation, police began to suspect a group of unofficial gardeners who spent time beautifying the cemetery.

During a site survey to collect evidence, site surveyors seized the gardeners' equipment, including three picks and two iron bars from a box inside the cemetary.

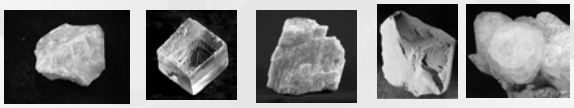
The picks and prybars had white marks and traces of soil on them.

The gardeners claimed they had used the picks to restore some partition walls in the graveyard using cement.

Investigators collected samples of soils inside and outside the Jewish area, as well as pieces of damaged headstones and cement from the partition walls for comparison with the materials found on the tools.

Through detailed microscopic and X-ray diffraction analysis of the materials, a full correspondence was made between the soil sample collected in the cemetery and the materials found on the tools.

The soils contained quartz, calcite, plagioclase feldspar, kaolinite (a clay mineral), and analcime.

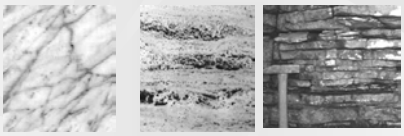


Since the picks and the bars were found inside the cemetery, the presence of graveyard soil on the tools was unremarkable and provided no new evidence.

However, the white marks on the tools proved very interesting.

Had they been caused by impact with headstones, not cement as the gardeners claimed ?

The headstones were made of marble, travertine and clay-rich limestone.



The headstones were found to contain the same materials as the marks on the tools, in the same percentages.

The cement had a different composition, containing calcite, portlandite (a calcium hydroxide found in contact metamorphosed limestones) and larnite (a calcium silicate found in contact metamorphosed limestones).

calcite portlandite larnite

The material evidence provided by mineral analysis revealed that the suspects had lied.

The tools had indeed been in contact with the headstones and they had done the damage.

It later emerged that cemetery gardeners were responsible for the desecration and had picked the Jewish section in order to gain the most publicity.

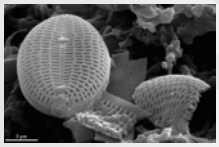
The gardeners had wanted to discredit the new management of the graveyard, who had put a co-operative of ex-prison inmates in charge of attending to the cemetery's monuments and lawns.

Deducing an Event That Preceded a Murder

The burned body of murder victim who had been shot in the head was found dumped on a farm road outside Edinburgh, Scotland.

Particles flushed From the trachea and bronchi of the victim included rounded gravel clasts and fresh water diatoms.

gravel

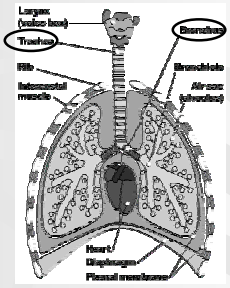


Diatoms

Cause of Death

The large size of the clasts and their considerable depth of penetration into the airways indicated that the clasts must have been brought into the body when the victim was alive.

For this to have occurred, the victim must have sucked in the particles with great force (possibly held face down in a river) prior to being shot.



END OF LECTURE