The Renaissance in Forensic Geology

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Abstract:
Since 2002, Forensic Geology has experienced somewhat of a renaissance in the UK and other parts of the world into two broad fields, 'geological (trace) evidence' and 'search'. This involves the collection, analysis and interpretation of soils, sediments, rock fragments, micro-fossils or man-made materials, which may be transferred onto a victim, offender or object during a crime. A subsequent evaluation may help to determine if there is an association between, for example a suspect and a victim. Alternatively, a forensic geologist may assist the police by applying methods, techniques and instruments conventionally used in mineral exploration and geotechnical ground investigations, to help search the ground for buried or concealed graves, weapons, drugs or other items.

The Revival of Forensic Geology

Forensic Geology is the application of geology to criminal investigations (Figure 1). Since 2002 Forensic Geology has experienced somewhat of a revival in the UK and some other parts of the world. However, geologists have been assisting the police in some type of criminal investigations since the middle and latter part if the nineteenth century, so why has there been a 'recent' increase in awareness of Forensic Geology?

Before 2002, there were relatively few forensic geologists working in close association with the Police throughout Britain. There was no formal professional society or organisation specifically aimed at developing and supporting Forensic Geology. However, in 2002 this began to change and in recent years there has been increased awareness of the potential benefits which geologists may bring to some aspects of policing and law enforcement. Since 2002 there have been at least 14 international meetings on or including the different aspects of forensic geology (Figure 2 and Figure 3). In addition there have been several books written, numerous scientific papers, conference proceedings, technical meetings abstracts published, magazine articles and some radio and TV documentaries. Why has this change taken place? The reasons are not entirely clear and it is difficult to attribute one individual event to this, but this renaissance in forensic geology may have benefited from a combination of the following:

Figure 1 Human remains found at a crime scene in woodland, in Europe (after Donnelly 2008, The Geological Society of London, Forensic Geoscience Group)

Figure 2 The first Latin American course on Forensic Geology, held in Bogota, Colombia, from 30 March to 3 April 2009.

Figure 3 Invited speakers for the first Latin American course in Forensic Geology, Bogota, Colombia, from 30 March to 3 April 2009. From left to right: Mr Bill Schneck, Dr Ray Murray, Dr Carlos Martin Molina, Dr Laurance Donnelly and Dr Alastair Ruffell.

1. March 2002, Westminster Palace Presentation

In March 2002, Laurance Donnelly was invited to Westminster Palace, Houses of Parliament, to give a presentation on the work he had been doing in forensic geology since 1994 and in particular for the search of the grave of a person thought to be buried in a remote location in northern Britain (this continues to present day). The event at Westminster Palace was organised by Cally Oldershaw in her role as Administrative Secretary to the All-Party Parliamentary Group for Earth Sciences (Donnelly 2002a). The meeting served to raise the profile of forensic geology and its potential applications including its relevance in police searches (Donnelly 2002b, 2003). At the same time other geologists who had worked with the Police in the UK and internationally began to express a desire to collaborate more closely with other Forensic Geologists and to help promote and develop Forensic Geology.

2. Geology the Science and the Profession (2004-2011)

'Geology' both as a 'science' and 'profession' has taken an active interest in forensic geology and as a result special forensic geology groups have become established to promote and develop the discipline and to support both operational and academia based forensic geologists. In 2004, the Geological Society of London (GSL) held its first 'Forensic Geoscience' conference (Pye & Croft 2004). At the same time the potential for the setting up of a new group began to emerge, and in 2006, the Geological Society of London Forensic Geoscience Group (FGG) became established (Donnelly 2006). This was followed in 2009 by the Working Group on Forensic Geology (WGFG) established by the International Union of Geological Sciences (IUGS), Commission for Geoenvironmental Management (GEM) (Donnelly 2009a). Essentially, both FGG and IUGS-GEM, WGFG were established to promote and develop forensic geology in the UK and world-wide, respectively

3. The Police

Since the millennium, some police and law enforcement officers have worked closely with geologists. This has, without doubt, provided the opportunities for those police officers to become exposed to and made more aware of the application of techniques in geology to some types of criminal investigations. The establishment of the National Policing Improvements Agency (NPIA), Expert Advisors (EA) data base, which now includes forensic geologists has also helped promote the use of geology in policing.

4. Academia

Some British universities have begun to teach forensic geology/geoscience, which forms modules on BSc geology degree courses. Others actively undertake PhD research and work closely with the police in different aspects of forensic geology.

5. The Media

Both 'forensic science' and 'geology' have been popularised in 'recent years' in the media. These have been the focus of Hollywood movies, TV drama and documentaries (see for example CSI Miami, Dante's Peak, Volcano, The Core and Jurassic Park). This type of public exposure has, without doubt, helped raise the profile and increased awareness public perception of 'forensic science' and 'geology'. It is therefore not surprising when these two 'interesting' disciplines are brought together, that 'forensic geology' has captured the imagination and interest of the public and professionals. In reality however, the professional practises of geology and forensic science are often somewhat far removed from that portrayed by the TV and media. Nevertheless, there appears to be an overall perception, that forensic science and geology, and therefore forensic geology is 'interesting' and 'entertaining'. Therefore, if these programmes, documentaries and coverage inspire and motivate the next generation of professional geologists, they arguably have an overall positive influence.

Brief Overview of the Early History of Forensic Geology

Although there has been a 'recent' surge in interests in forensic geology around the world, the recorded origins of forensic geology can be traced back to the middle part of the nineteenth century. Around 1856, Berlin based geologist and zoologist Professor Christian Gottfried Ehrenberg (1795-1896) was asked by Police if he could assist in a substitution case on one of the Prussian railways where silver had been stolen from barrels and the silver had been replaced with sand. Prof Ehrenberg analysed samples of sand with his microscope that had been collected from the different stations the train had passed. An expert on diatoms (micro-fossils), he was able to identify the station from where the sand must have originated. This helped police focus their investigation at that particular station, which subsequently resulted in the arrest of the offender (Anon 1856, quoted in Ruffell and McKinley 2008).

In the late 1800s and early 1900s forensic geology was adopted by Sir Arthur Conan Doyle, in his Sherlock Homes stories. For instance, Sherlock Homes was able to identify the location where Dr Watson had been walking in London due to the colour and consistency of 'mud splashes' on his trousers. In practise, this principal was used in a number of cases. For example in 1891 Hans Gross (1847-1915) used a microscope to analyse soils and other materials recovered from shoes to link a suspect to a crime scene. George Popp (1867-1928) was able to identify the mineral constituents of 'soil' and 'face powder' which showed that a suspected offender must have been present at the scene of a murder. These investigations were based on what is now referred to as the Locard Principal developed in 1929 by Edmund Locard (1877-1966). This suggests that when two different materials come into contact there is always the transfer of material from one object to the other. The transfer may be short lived or beyond detection but, nevertheless, has taken place. This is one of the basic fundamental principles of trace evidence forensic geology, which continues to be valid today. Geological trace evidence analysis was also further pioneered by the 'Berkeley Scientists (1914-1940).

Geological Trace Evidence

Geological trace evidence continued to be used to assist the police throughout the 1900s in determining if an offender or suspect had on his body, clothing or possessions geological materials (minerals, soils, rock fragments or microfossils) or man-made materials (derived from geological raw materials, such as slate, bricks, glass, plaster board, macadam, building materials, etc.) consistent with those occurring at a scene of crime (Figure 4). The United States Drug Enforcement Agency (USDEA) and the Federal Bureau of Investigation (FBI) are reported to have used geological methods from about the middle part of the 1900s onwards to the present day. Further significant advancements in forensic geology occurred in the 1970s (see Murray and Tedrow 1975; reproduced in 1992).

Today there are a variety of analytical methods that can be used to determine if rock fragments, soils, sediments or man-made materials may have been transferred onto a victim's and/or offender's body, item of clothing (or other objects). The analysis of the materials will result in their description and classification to determine for example, if the two samples are 'similar'. The evaluation of the samples will help to establish if there is an association between the

Figure 4 Soil adhered to different objects, typical of those which may be associated with a crime including the soles of boots, a spade, knife and on the tyres and wheel arches of a car (after Donnelly 2010).

samples collected from the crime scene, victim or object and samples collected from the offender/suspect.

For more recent publications on or including geological (trace) evidence see for example; Murray 2004, 2005; Murray & Solebello 2005; Ritz, Dawson & Miller 2009; Ruffell & McKinley 2008; Pye & Croft 2004; Morgan and Bull 2007.

Search

In addition to the provision of physical geological (trace) evidence, forensic geologists may also advise the police on search. Offensive/detective police searches are undertaken to, for example, locate evidence to support a prosecution; gather intelligence; deprive criminals of their opportunities and resources to commit crime and locate missing persons or graves. Defensive/protective searches include for example, the protection of vulnerable targets, be it people or venues.

Police searches may be conducted of a person or people, for a person or people who are missing under suspicious circumstances (e.g. they may have been abducted) or who have voluntarily 'gone missing' (e.g. to commit suicide). These types of searches will differ from a 'Search & Rescue' type search where the person(s) lost is active in their self discovery. Searches may also include vehicles (bikes, cars, vans, trucks), vessels/boats, houses/buildings and other structures, water bodies (streams, rivers, canals, lakes, reservoirs, ponds, the sea) and the ground. Some geologists are particularly experienced to provide the Police with advice on the searches of water bodies and the ground.

Before the mid 1980s police searches seemed to reply on visual line searching and on occasions the use of large numbers of volunteers, observations from the air and the use of specially trained police cadaver dogs. These types of searches were often labour intensive and relied heavily on the 'expertise' and 'judgement' of individual officers who were 'co-ordinating' the search. However, one of the principal drivers for change occurred in 1984, when the Provisional IRA attempted to assassinate the British Cabinet and the then Prime Minster, Margaret Thatcher. A time delayed bomb was placed in the Grand Hotel, in Brighton, and the explosion resulted in several fatalities (Mrs Thatcher survived the blast). The enquiry which followed suggested that the Police should be better trained in 'search'. The British military at this time had experience in searching the ground for explosive devises in parts of the Middle East and Northern Ireland and therefore assisted in training the police in search methods and techniques. This eventually led to the establishment of the National Police Search Centre (PNSC), which currently forms part of the NPIA. These organisations provide training and operational support for the Police in search.

Geologists are trained to investigate the ground. There are a variety of methods and techniques to map, investigate and characterise the ground as part of, for example, mineral exploration or geotechnical site investigations. In 1994, geological techniques started to be applied by the author to search the ground for graves. This has evolved and the three following phases of a geoforensic ground search have become established.

Figure 5 Police officers and a forensic geologist make a reconnaissance visit to a search area to plan for a search for a murder victim's grave in a remote, mountainous part of Eastern Europe. The adverse weather conditions, which require detailed logistical and operational planning (after Donnelly 2008, 2010, The Geological Society of London, Forensic Geoscience Group).

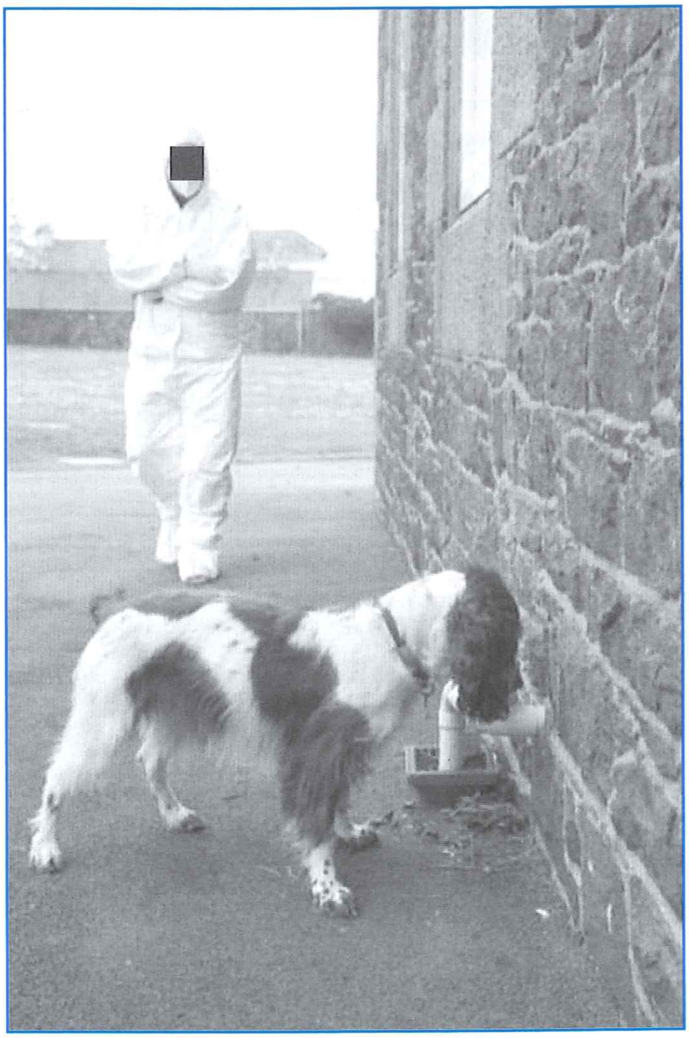

Figure 6 Specially trained detector canines (Victim Recovery Dogs, or VRDs) in an urban environment (after Donnelly & Harrison 2010a).

- **Phase 1:** Pre-search. This phase involves an initial briefing meeting with the Police to discuss the search objectives, location, area, nature of target being search for, case details, intelligence and the results of any behaviour profiles of the offender and/or victim. Geological maps, memoirs and other data may also be collated and analysed at this stage. This may be followed by a reconnaissance visit to the search area to conduct a walk-over survey to allow the inspection the geology and ground conditions, and observations to be made. Any technical or logistical constraints will be considered at this stage. For example, the presence of wire fences or underground utilities and cables may exclude the use of certain types of geophysical instruments. Search area access and egress will be considered along with planning for the management of the press, media, and members of the public and family members who may visit during the search. Diggability surveys may be conducted to assess the soil types and to provide an indication of possible grave/burial locations. Colour coded RAG (**R**ed-**A**mber-**G**reen) maps may be produced to allow the proportionate and prioritisation assignment of search resources. The appropriate choice of search assets will be sourced. Finally, a Standard Operational Procedure (SOP) will be produced, which is a document giving the search strategy, methodology, types of search assets to be used, methods of recovery of items found and their recording, and the mapping of the search (Figure 5) (Donnelly and Harrison 2010b).

- **Phase 2:** Search. The search phase involves the actual deployment of the search. This begins with the establishment of a test-site to make sure that all search equipment is fully operational at the start and end of each search day. This also provides the opportunity to check and calibrate

Figure 7 Police officers and a forensic geologist conduct a search for a murder victim's grave in a remote, mountainous part of Eastern Europe (after Donnelly 2008, The Geological Society of London, Forensic Geoscience Group).

Figure 8 Probing of the soil to locate buried objects in a remote location in Eastern Europe (after Donnelly &Harrison 2010a).

the instruments should there be any technical problems with or too many 'false-positives'. The types of search instruments and techniques used will be pre-determined by the nature of the target being sought and the geology and could consist of the following:

a) Specially trained detector canines (police dogs) (Figure 6);

b) Visual observations;

c) Intrusive methods (probing and trenching) (Figure 7 and Figure 8);

d) Airborne methods and satellite imagery ;

e) Geophysics including for example; ground penetrating radar, magnetic, electromagnetic, conventional metal detectors or microgravity (Figure 9 and Figure 10).

f) Geochemical surveys may involve the groundwater and soils being sampled and analysed to detect the presence of any gases or leachate associated with human decomposition or isotopes (Figure 11).

g) Other specialists may also form part of the search team and could include clinical psychologists, environmental profilers, botanists, mycologists, military personnel, archaeologists and anthropologists.

Figure 9 Non-invasive geophysical surveys used as part of the search strategy to help locate a burial (after Donnelly & Harrison 2010a).

Figure 10 Forensic Geologist, Dr Laurance Donnelly, conducting a geophysical survey (electromagnetic) to search and locate a murder victim's grave in Europe (after Donnelly 2010)

Figure 11 Geochemical surveys used as part of the search strategy to help locate a burial in Northern Europe.

Figure 12 The confirmation of positive indication (ie. dog 'hits' or 'geophysical anomalies') in Europe (afetr Donnelly & Harrison 2010a).

Figure 13 Police officers recover small metallic objects indentified by a geologist buried in the ground in Europe

Figure 14 Geological mapping and surveying of the search area and the GPS recording of any finds in Eastern Europe

- **Phase 3:** Post-search. If the geologist and search team has located the burial, recovery would normally take place by an appropriately qualified specialist under the control of a Crime Scene Manager (CSM). This may involve a forensic archaeologist, forensic anthropologist and/or Exhibits Officer. All finds will be accurately described, photographed and recorded (Figure 12 and Figure 13). The search area will also be mapped, photographed and recorded using, where appropriate, Global Positioning System coordinates, conventional or ground based surveying (Figure 14). The search will usually be concluded by a formal de-brief.

For more recent publications on, or including geoforensic search see; Donnelly 2002b, 2003, 2008, 2009b, 2009c; Donnelly & Harrison 2010a, 2010b; Harrison 2008; Harrison & Donnelly 2008, 2009; Ruffell 2005; Anon 2006.

FGG & IUGS-GEM, Geoforensic International Network (GIN)

In 2006, the Geological Society of London, Forensic Geoscience Group (FGG) became established (Donnelly

Figure 15 Dr Ray Murray (left) and Dr Laurance Donnelly (right) on route to Police headquarters in Bogota, Colombia.

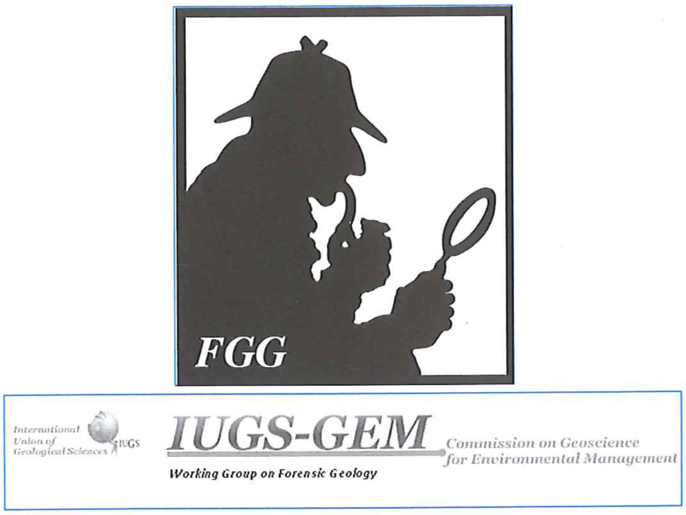

Figure 16 The Geological Society of London, Forensic Geoscience Group (FGG) and the International Union of Geological Sciences (IUGS), Commission on Geoscience for Environmental Management (GEM), Working Group on Forensic Geology; are both actively promoting and developing forensic geology and promoting best practice in the UK and world-wide.

2006). Its aim is to develop and promote the study and understanding of forensic geoscience (geoforensics), by creating a network for geoscientists and related specialists to; share knowledge, review and disseminate information, facilitate multi-disciplinary collaboration, promote best practice, discuss case -histories, share geoforensic experiences, develop contacts, stimulate discussions and debates.

In 2009, the International Union of Geological Sciences (IUGS), Geosciences for Environmental Management (GEM) committee approved the formation of the special interest Working Group on Forensic Geology (WGFG) (Donnelly 2009). The Geoforensic International Network (GIN) became established as part of this working group. The aim of this working group and GIN is to develop forensic geology internationally and promote its applications. IUGS-GEM, GIN has a growing network of contacts and brings together forensic geoscientists and related experts from; academia, industry, consultancy, government, police, law enforcement and the military, from around the world.

FGG and IUGS-GEM continue to actively advance and developing forensic geology and promoting its use in policing and law enforcement. This is achieve by; the circulation of emails, organisation of meetings, conferences, seminars, workshops and field visits, collaboration with related forensic and other specialist groups, promoting research, training and teaching in the field of forensic geology (Figures 15 and 16).

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