# The International Union of Geological Sciences, Initiative on Forensic Geology


**Dr Laurance Donnelly** BSc (Hons), PhD, CGeol, CSci, EurGeol, FGS, FGSA, MIMMM

Founder and Chair, International Union of Geological Sciences (IUGS), Initiative on Forensic Geology (IFG)

Founder and First Chair, Geological Society of London (GSL), Forensic Geoscience Group (FGG)

Listed as an Expert Adviser (Forensic Geologist) with the UK National Crime Agency (NCA) | laurance.donnelly@akgroup.com| geologist@hotmail.co.uk | forensicgeologist@hotmail.com


## IUGS Initiative on Forensic Geology

Forensic geology, also known as 'forensic geoscience' or 'geoforensics' is; *'the application of geology to policing and law enforcement, which may potentially be applicable to a court of law.'* In 2006, Dr Laurance Donnelly established the Geological Society of London, Forensic Geoscience Group and became its first chair. In 2009, he then established the IUGS Working Group on Forensic Geology. In 2011, this working group evolved into the IUGS Initiative on Forensic Geology (IFG). The principal aim of IUGS-IFG is to develop forensic geology internationally and promote its applications.





Examples of IUGS-IFG and Geological Society of London publications (Source: GSL and IUGS).

## Mining, Minerals and Metals Crimes

Civilisation has always relied on geological materials, and it would not exist as we know it without the use of minerals. For the foreseeable future minerals will remain fundamentally important commodities. Criminal activity in the mining, minerals and metals industries includes; illegal mining and smuggling, theft, adulteration substitution, conflict minerals, fakes, fraud and associated environmental crimes.

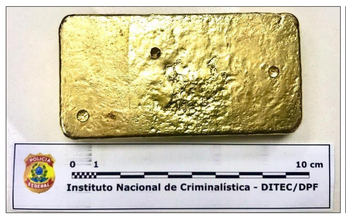
Illegal small-scale mining in Pakistan (left) and Colombia (right) (Photos: Dr Laurance Donnelly).

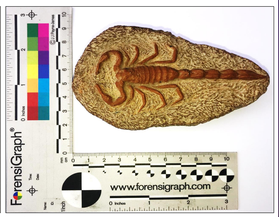
Illegal mining, and the trading of illicit minerals and metals has increased significantly in recent years. Driven in part by the high metals price and a change in Modus Operandi as some cartels and terrorist organisation use established trade routes for minerals instead of, or in addition to drug trafficking. The beneficiaries are cartels, criminal gangs, trans-national organised crime groups or terrorists that are well-organised and well-resourced. The substantial profits are subsequently legitimised via complex international money laundering schemes. Criminal and illegal mining takes place by illegal armed groups, outside national laws and regulations and without the appropriate state permissions and licenses to explore and operate. The scale can vary from small to huge complex mining and mineral processing operations. Gold and other precious minerals are particularly susceptible to illegal mining, but also coal and industrial minerals. Interestingly, the illegal extraction of sand exceeds in value illegal metalliferous minerals.

There are an estimated 13 million people involved in artisanal and small-scale mining (ASM), although not all ASM is illegal. ASM is characterised by no or poor geological control, basic exploration, low mechanisation, labour intensive, no regulations and polices, poor health & safety, poor capital investment, low salaries and intermittent mining controlled by the metal's price, weather conditions and other cultural, economic, and social factors.

Conflict minerals are tin, tungsten, tantalum and some types of gold, referred to as 3TG. Cobalt is not formally a conflict mineral, but is under scrutiny. These are mined by armed gangs, augmented by corrupt officials, and the proceeds fund wars and conflicts and human rights abuses against local people.

Geologists have been working in collaboration with police and law enforcement agencies to detect, deter and disrupt these practices. Techniques including elemental, mineralogical and isotope profiling that can assist with determining the provenance of minerals and metals, and their traceability.




Illegal gold leaf plated onto copper (left) and a fake fossil (right)(Photos: Dr Laurance Donnelly).

## The Scene

A forensic geologists may be required to assist the law enforcement investigator, crime scene manager or forensic scientists to examine a crime scene; to collect geological samples and provide interpretations of the soil, sediment, rocks, and man-made materials.

This may include a variety of exhibits that have been seized by law enforcement as part of an investigation to provide evidence. IUGS-IFG has developed methodologies for the recovery of geological samples from crime scenes and exhibits. Guidance has also bee provided by IUGS-IFG on exhibits handling, the recovery of geological evidence from clothing, footwear, motor vehicles and human remains. All of these have the potential to support or comprise a case if not properly undertaken in a forensic capacity. The samples collected must be unbiased and representative of the original mass..

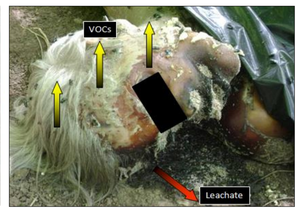

Forensic geology training (Photos Dr Laurance Donnelly and Dr Alastair Ruffell).

The sampling strategy depends on the offence committed, the crime scene conditions, and the questions being asked. For instance, a random sampling approach can provide bulk samples and facilitate geostatistical analysis to demonstrate geological variability.

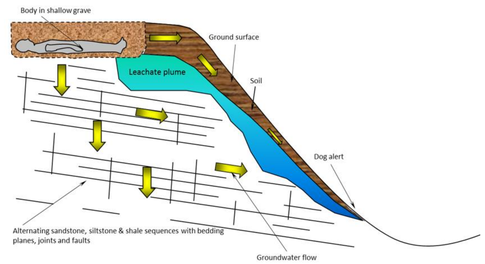
Targeted sampling takes place where offenders and/or victims have potentially contacted the ground, for example by leaving footmarks where he/she stood, lay or knelt. The surrounding area should also be sampled, such as tracks and points of access and egress.

If the ground is homogenous, such as an area of hardstanding concrete, macadam, open woodland or grassland, then a systematic grid sampling strategy may be needed.


Recovery of geological evidence (Photos: Dr Laurance Donnelly).


The generation of of leachate during human decomposition (Dr Laurance Donnelly, in Donnelly et al., 2021. A Guide to Forensic Geology).




Conceptual Hydrogeological Model (CHM) for a shallow, unmarked, homicide grave (Source: Dr Laurance Donnelly, Donnelly 1994, Donnelly & Harrison 2010, 2021).

A conceptual hydrogeological model (CHM) for a shallow, unmarked, homicide grave, can be used to develop a leachate and volatile organic compounds (VOC) sampling strategy, to help explain false-positive detector dog indications, and to locate the buried target based on an understanding of surface water and groundwater flows.

## The Sample

Geological trace evidence involves the collection, analysis, interpretation, presentation and explanation of geological evidence. Trace evidence may be transferred onto the body, person or the clothing of a victim or offender or onto vehicles or other objects from and to a crime scene. This, when interpreted by an experienced forensic geologist can help with crime reconstruction and may be admissible as evidence in a court to support a prosecution or defence.

The recovery of geological trace evidence from a boot, beneath finger nails and a spade (Photos: Dr Laurance Donnelly).

Geological trace evidence on a knife, exterior of a car and a homicide victim found in a sallow, unmarked grave (Photos: Dr Laurance Donnelly and Prof Robert Fitzpatrick).

Geological trace evidence includes; minerals, rocks, soils and sediments (superficial deposits), minerineralised rock, ore and mineral concentrate, refinery and smelter products (e.g. blister, anode, cathode, dore, matte, sweeps and bullion), anthropogenic (artificial) deposits (e.g. made ground, filled ground and disturbed ground), man-made materials derived from geological raw materials (such as bricks, concrete, glass or plaster board), micro-fossils, groundwater, leachate or surface water, gases and volatile organic compounds.






The recovery of geological trace evidence (Photos: Dr Laurance Donnelly).

Geological trace evidence may be required to determine if there may be a comparison between two or more samples to determine if they originated from the same source or not.

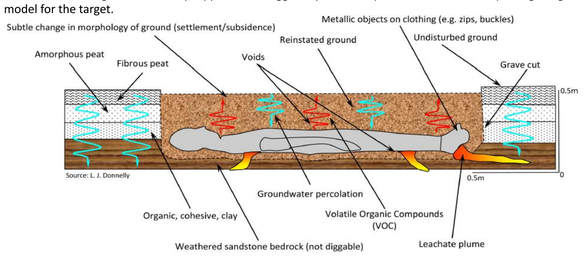
Geological trace evidence may be transferred onto the body, person or the clothing of a victim or offender or an associated item/object. This is based on the principle devised by Dr Edmond Locard (1877-1966) on the premise that when two items or objects meet, every contact leaves and trace; this may be beyond detection or short lived, but nevertheless that transfer has taken place.

When geological trace evidence is interpreted by an experienced forensic geologist this can help with crime reconstruction and may be admissible in a court as evidence to assist a prosecution or defence case. The aim may be to help determine if there could be an association between the samples collected. The range of fundamental and sophisticated laboratory techniques commonly used by a forensic geologist have been outlined by IUGS-IFG.


Geological investigations at crime scenes (Photos: Dr Laurance Donnelly).

## The Search

The need to conduct complex, open area searches for burials brought together the very different yet complimentary experiences of a geologist and a law enforcement officer; both interested in 'the ground', but from differing perspectives. A new and innovative search strategy developed, referred to as the, 'Geoforensic Search Strategy (GSS)'. A law enforcement perspective provides; an evaluation the offenders motive and resources, behavioral profiling, victimology assessments, management of search assets, logistical and tactical planning, acquisition of aerial imagery, classification of search types, press and media management, family liaison, crime scene management, forensic recovery and recording, briefings and de-briefing. A geological perspective provides; reconnaissance (walk-over) survey, collation and assessment of geological data and information as part of a desk study, geological evaluation of intelligence and aerial imagery, evaluation of geomorphology and hydrogeology, determination of geophysical, geotechnical and geochemical properties, assessment of target detectability, appraisal of diggability and the production of a conceptual geological model for the target.




Conceptual Geological Model (CGM) for a shallow, unmarked, homicide grave (Source: Dr Laurance Donnelly, Donnelly 1994, Donnelly & Harrison 2010, 2021).

This blended approach enabled an appropriate selection of search assets to be identified. A pragmatic, proportionate and cost-effective methodology was then devised to provide the highest level of assurance for the presence or absence of the target suspected by the law enforcement officer or police officer to have been buried as part of a criminal act. GSS developed over 25 years and this new strategy for open area ground searches, has since been adopted for ground searches in the UK and internationally.


Search for a homicide grave using a helicopter to detect geomorphological ground disturbances indications and soil probes (Photos: Dr Laurance Donnelly).

The Conceptual Geological Model (CGM) enabled to most suitable suite of geophysical methods and associated search assets to be chosen, which were appropriate for the prevailing geological conditions and grave being sought. There are three phases of the Geoforensic Search Strategy (GSS):

- Phase 1: Pre Search: This largely involves defining the search type, area, identification of the search assets and their method of deployment, planning and logistics. Ground search should extend from the macro to the micro scale and from the non invasive to the invasive to preserve forensic evidence where possible.
- Phase 2: Search: The implementation of the search should follow and agreed Standard Operational Procedure (SOP). This should also be dynamic and flexible to be modified based on materially relevant field observations at the time the search is conducted.
- Phase 3: Post Search: Once a positive observational, geophysical, geochemical or VDD anomaly (also known as a 'hit' or 'indication') has been identified and verified, the recovery and recording stage of the search should take place. This may require additional support from, for example, a Crime Scene Manager (CSM), forensic scientist or forensic archaeologist with appropriate qualifications and experiences.

Ground searches for burials using electromagnetic and magnetic geophysics (left) and ground penetrating radar (Photos: Dr Laurance Donnelly).

A combined geological and law enforcement (police) approach may provide the greatest levels of assurance to help detect a target that has been buried associated with a criminal act, terrorism or organised crime. Or negate its presence so far as possible within the limits of the resources available. The GSS enables the searcher to develop a methodology that best suits the prevailing geology and in context with the nature of the targets being sought. This method offers a high assurance, cost-effective, proportionate and pragmatic search to be deployed to negate or locate the presence of suspected target buried at a shallow depth in the ground. This strategy is now increasingly being used in the UK and internationally for open area searches for burials. The recovery and recording of any 'finds' should be in a manner consistent with the requirements for the item(s) to be exhibited and admissible in a court of law