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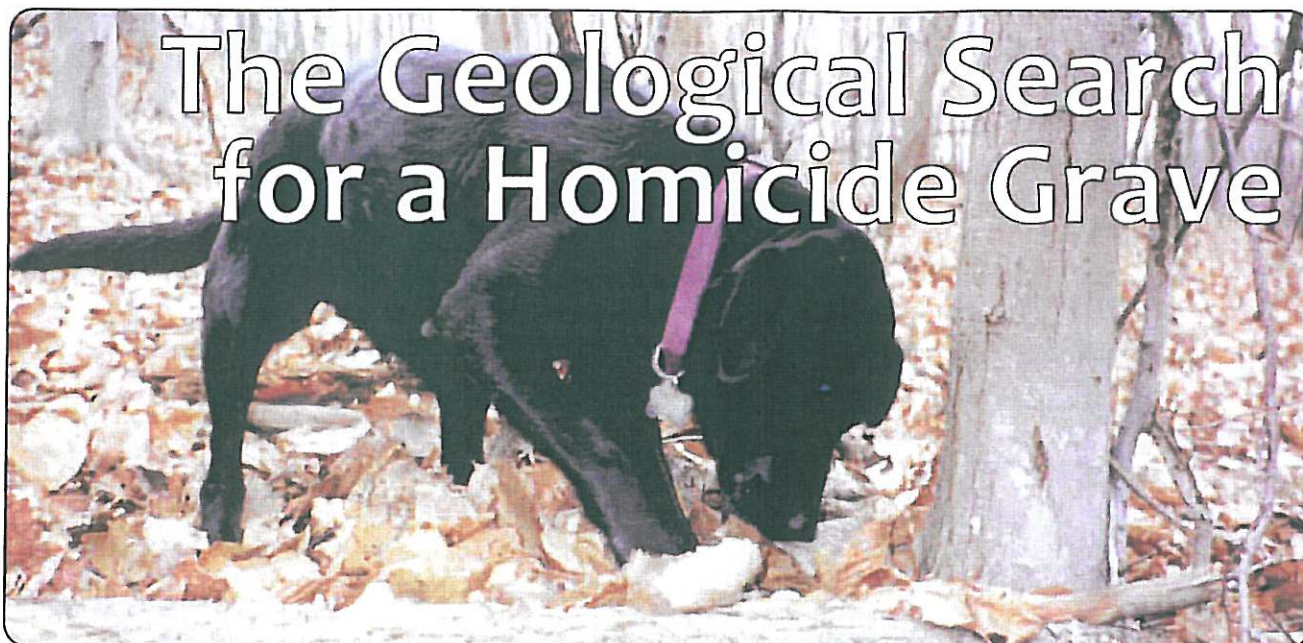
ESSENTIAL READING FOR TODAY'S INVESTIGATORS



Lights!
Camera!
Action!

'CSI effect' could
harm investigations
Conference special report





The Geological Search for a Homicide Grave

Geoforensics expert Dr Laurance J Donnelly explains the valuable role the science can play in homicide investigations.

What is Geoforensics?

Geoforensics (known also as Forensic Geology or Forensic Geoscience) is the application of geology to criminal investigations. These may include for example; domestic incidents, international terrorism, humanitarian, environmental, geohazards, mining, geotechnical, civil engineering, materials engineering and fraudulent investigations. Geoforensic specialists may support law enforcement investigations to help determine what happened, where and when it occurred, how and why it took place. In a law enforcement context geoforensic specialist may support the police in two broad fields of geoforensics:

Trace evidence

This involves the collection, analysis, interpretation, presentation and explanation of physical (trace, or micro-scale) evidence, which can be soils, rocks, micro-fossils or man-made materials (such as concrete or bricks). Using evidence sampled from a crime scene, human remains (such as skin and finger nail scrapings), vehicles, clothing or other object, a forensic geoscientist may be able to assist the police in determining the possible location where a crime took place, linkage of the offender or evidence to a crime scene, linkage of the offender

to the victim, assess the possible movement of human remains, or eliminate potential suspects or offenders. Although these types of geological samples are analysed in a laboratory it is important they are properly collected by the geoscientist, from the crime scene, object, or body.

Search

The mapping and exploration of the Earth's (ground) surface and ground investigative techniques are used to help the police search for locating (and sometimes the recovery of) buried or concealed organic remains (such as a murder victim's graves, mass graves and human remains) or non-organic objects (such as clothing, weapons, firearms, improvised devices, explosives, drugs, stolen items, money, jewellery and antiques).

These searches may take place in urban, rural and remote locations, in both the terrestrial (land) and marine (including also underwater such as canals, rivers, streams, seas, lagoons, estuaries, reservoirs, lakes and ponds) environments.

What is a search?

A search is the application and management of systematic procedures, combined with appropriate detection equipment to locate specified targets (or object). It is the skill of looking for a specific object and the art of finding it.

What is the aim of a search?

A search may be conducted to; obtain evidence for prosecution, gain intelligence, deprive criminals of their resources and opportunities, locate vulnerable persons, protect potential targets, search for homicide graves and associated buried items or objects.

History and development of search

Traditional police methods of finding graves often involves large-scale gridded areas with personnel 'finger-tip/line searches' and 'trial-and-error' excavations. These may be inefficient, labour intensive, may destroy evidence and ignore subtle ground disturbances possibly related to a burial. They may be supported by non-specialists, such as public volunteers and local interest groups. However, the effectiveness of large numbers of public volunteers, or military infantry forming large lines and walking through large gridded areas of open land or woodland, must be considered with respect to whether such groups will successfully locate a highly concealed sub-surface burial.

What are the types of search?

An offensive search is used to locate a specific item sought obtain evidence or to restrict an individual's room to manoeuvre and their operation. A defensive search is used to maintain freedom of action and movement for the public.

What are the types of search?

These include; person search, missing person search, building searches, vehicle searches, motorway and road searches, mass fatality searches, search 'for' and 'of' crime scene searches (water and land based). Geologists mainly will be involved with the latter.

Search philosophy

In order to find a grave we must first understand what we are looking for? The search for a grave is a pragmatic balance between a minimum acceptable standard and minimal expenditure. It is the search for rather than of a crime scene.

Search considerations

What are the choices of search assets, what is the equipment availability and limiting factors, what are the financial, logistical and technical constraints, is the search measurable, cost-effective and proportionate, can the search achieve a minimum standard resolution for a high probability of success, what is the exit strategy?

What are the external factors that may influence a search?

Weather conditions, type of terrain, press & media, psychics, the public and communities, victims family members and friends, time frames involved search area.



Forensic geologist conduct a search for a murder victim's grave in a remote, mountainous part of Eastern Europe.

What are the different search categories?**Search and rescue**

The person is lost and active in their self discovery. This is based on 'area searching' and an the assumption that a person, or persons, will travel a maximum given

distance within a set time, if mobile. These searches may cover geographically large areas. The search is subjective and based on assumed actions of missing or lost persons.

Scenario based

This uses behavioural profiling of the offender(s), geographical profiling and victimology assessment so the victim. It requires the investigator to generate a hypothesis. There is no correlation of distance with time. The search is objective and is based on known facts and the victim's last movements.

Feature based

Based on the identification of primary, secondary and tertiary physical (geological) markers which may have been consciously or sub-consciously used by the offender to locate the grave site. In other

words this involved decoding the offender's modus operandi?

Intelligence led

All law enforcement searches should be intelligence led based on facts and intelligence that enables a hypothesis to be generated.

Systematic Operational Procedure

A SOP should be applied to all searches. This provides an assurance of search consistency and enables peer and independent reviews. This should be in written format and forms part of the search documentation.

Predictive models

Databases and 'models' may facilitate a search and include for example; offender profiling or geographic profiling, missing person, suicide, weapon, drug concealment and body deposition models.

Offender behavioural characteristics

Offenders who dispose of victims may consider:

The principal of least effort

That is, choose the easiest option to dig a grave.

'We go where we know'

Choose a location he/she is familiar with, previously visited by the offender so he/she can; have an explanation for his/her presence if disturbed or arrested, facilitate ease of access and egress, can find his/her way in darkness, contains familiar landmark features.

Concealment

Low witness potential, act of concealment/burial is under cover.

The Conceptual Geological Model for a Grave

As a completely concealed burial takes place in the ground a reconnaissance visit to the crime scene/search area must be conducted, by the forensic geologist and law enforcement officer, so a conceptual geological model may be developed. This will enable an estimation of the graves conditions and this in turn will pre-determine the

most likely choice of search assets to locate the grave. A conceptual model of a potential burial site gives an estimate of what is likely to be found and the condition of the target. Conceptual geological models are developed at the beginning of a search. It is a model to be tested, revised and tested again until it can be verified (at discovery) or proven

otherwise and therefore abandoned.

A conceptual model is often based on the individual geologist's experience from conducting geological investigations in comparable geological settings.



Human remains found at a crime scene, in Europe.

High quality geological information (such as published geological maps, memoirs, papers and technical reports) will support a search effort with a high level of assurance, but a weak geological model for the grave site will introduce uncertainty into the search, now matter how precise and accurate the subsequent exploration (search) techniques.

The development of a geological model for a victim of homicide, or a grave, requires a specific understanding of the natural (geological) ground conditions and how these have been influenced by the activities of the offender (eg digging, and subsequent reinstatement of the disturbed ground).

At any one location there are likely to be a number of interactive, dynamic, active surface geological processes, which have affected the rocks, soil, groundwater and topography. These processes were active long before burial took place and are likely to have continued in the time which has passed since. No single geological model suits all types of search areas and there is no single approach to producing a geological model, as each homicide case and search area will have unique characteristics.

This is one of the primary roles for the geoscientist, which will vary from case to case. The most valuable contribution a geologist can give a law enforcement (police) officer (or search strategist), is to 'get the geology right'!

Geological factors

The development of a conceptual geological model must consider; the geological setting, hydrology and hydrogeology (groundwater), principal soil types and superficial deposits, nature of the bedrock interface, principal lithologies, engineering and physical properties of the underlying strata (rocks), mineralogy, geological structure, ancient & active geomorphological processes which may have changed the grave since it was originally dug, past and current land use, geological hazards, weathering and erosion, preservations and decomposition of human remains, weather and local climate.



Searching for a grave

Anthropogenic (man's) influences

Man's activities may also influence the search for a grave as these can change the ground conditions and include for example; mining, construction, building works, waste disposal or farming.

Digability and excavatability surveys

Body disposal mainly takes place in soil, superficial deposits, or softer rocks (such as some shales and mud rocks). The ease of which the soil can be dug (ie. its digability) and placed back into grave (or reinstated) is of critical importance.

The offender is likely to choose a site where the soil is sufficiently thick, and can be quickly dug then reinstated, preferably with no or little surface indication that digging has taken. The digability of soil depends on its geological properties such as; intact strength, bulk density, groundwater regime, depth, weathering, proximity of the underlying bedrock interface, slope angle, vegetation cover, stability of the walls upon excavation, bulking and swelling of the soil and the method of digging and

choice of digging implements.

There is no generally accepted quantitative measure of digability. This can only be determined by in situ 'trial and error' testing. In situ digability tests may be easily performed, before the main phase of the detailed survey (usually at the reconnaissance stage), involving either probing or digging using tools similar to those to which the offender is believed to have had access. This also provides the opportunity to inspect the soil

structure and/or weathered bedrock and associated superficial deposits to determine whether it is granular (sand rich), cohesive (clay rich) or organic (peat).

These observations are important as they have critical implications on the efficiency of burial and the preservation or decomposition of human

remains depending on the time elapsed since burial. A digability survey will; provide geological information on the soil processes, groundwater and rock types, demonstrate the level of difficulty or ease, and time required, for a shallow grave to be dug, and the effective depth which can be achieved, demonstrate how effectively the soil can be reinstated and what visible topographical features may exist, to indicate the possible presence of the grave and provide a prediction of the length of time it would take an offender to dispose of the body.

What is being searched for?

Objects or items associated with the victim's body should be considered as these may increase the probabilities of locating the grave.

These may include for example; weapons like firearms or a knife possibly used during the murder, clothing containing ferrous or non-ferrous metal components such as zips, studs and buckles, drugs, money and coinage, leachate plumes associated with decomposition and skeletonisation of human remains, gas/odours/scent being emitted from decomposition of human remains and is there a grave cut (ie. the boundary or contact between disturbed and insitu geology)?

Geological search assets, methods and techniques

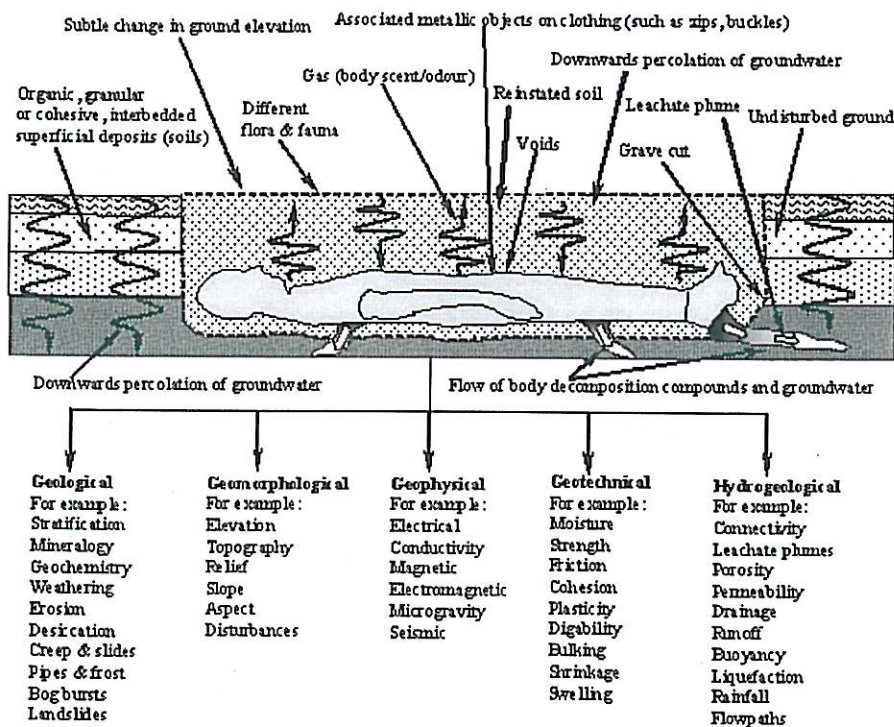
Geological exploration and prospecting methods conventionally used to explore the ground in mineral exploration and geotechnical site investigations are adaptable and applicable to searches for homicide graves.

The type of survey, methodology and interpretation of data acquired depends upon several complex factors including; types of target buried (such as

for a grave may include for example:

Remote sensing

There is now available a variety of remote sensing techniques that may facilitate with the search for a grave. Where large complex data sets are obtained they may be managed and analysed using spatial location and geographic information systems (GIS) and geostatistics.



An idealised conceptual geological model for a shallow homicide grave. The geological, geomorphological, geophysical, geotechnical and hydrogeology properties of the body, reinstated ground and undisturbed ground may change after burial. This type of model may assist in determining the most suitable suite of assets for conducting a search. This may include for example the deployment of geophysical surveys and specially trained cadaver dogs.

human remains, money, explosives, weapons); geological conditions, anticipated depth of burial, age of burial and experience and skill of the individual geoscientist(s).

Geological surveys can be carried out by one person, or a team, they may be non-invasive or invasive. They are usually conducted from the macro-scale (cover many tens of square metres) to the micro-scale (covering just a few square metres of ground) and may take hours to weeks (sometimes years) to complete. Typical geological assets and methods which may be used to search

Typical and remote sensing methods include for example; infrared photography, elevation modelling, satellite modelling, hyperspectral and multispectral imaging, laser scanning, long distance LiDAR, Synthetic Aperture Radar (SAR) and interferometry, X-ray imagery and tomography, neutron activation, field portable x-ray fluorescence and thermal imagery.

Analysis of high resolution air photographs

Conventional aerial photography (vertical and oblique) may often be used in association with geological mapping. This may be particularly useful if the photographs are taken as stereo pairs to exaggerate any ground disturbances.

Ground based geological and geomorphological mapping

This may enable ground disturbances to be identified, analysed and interpreted as being associated with natural geological processes, the activities of man (such as mining and construction) or digging.

Geophysics

Geophysical investigations rarely require any contact with the ground surface (i.e. they are non-invasive) for their operation and therefore adhere

to the law enforcement preference of moving proportionately from the non-invasive to the invasive in forensic searches, thus minimising evidential contamination and damage to crime scenes.

The data obtained provides measures of the vertical and lateral variation of the physical properties of the ground. These data can only be interpreted in the light of knowledge of the likely ground conditions, from the conceptual geological model.

Typical geophysical techniques that may be suitable to search for graves may include; magnetic, resistivity, induced polarisation, self potential, electromagnetic (conductivity), ground penetrating radar (GPR), metal detectors, seismic, microgravity, air borne geophysical surveys, geophysical exploration platforms (multiple geophysical sensors which may be simultaneous deployed to provide a faster and more effective way to survey large areas of land, usually towed behind a 4x4 vehicle or tractor).

Hydrochemistry and geochemistry

An understanding of the hydrogeology in the vicinity of a grave site is necessary as it influences; surface flow paths and run-off groundwater flows, decomposition or preservation of human remains generation of leachate plumes from decomposing human remains, migration of body scent (gas/vapour) and the deployment of the most suitable non-invasive geophysical and geochemical techniques. Leachate plumes may also increase the aerial footprint of geochemical and geophysical signatures and therefore enhance the possibility for detection.

The direction and distance of the plume will depend on several factors such as ground permeability,



The introduction of a geologist to an already established police search team must be carefully co-ordinated and properly managed. The geologist must be able to effectively communicate with the other subject matter experts, be aware of his/her limitations and understand the role and capabilities of other experts (modified after Donnelly 2002, based on an idea from B. Simpson, published in; Donnelly 2008, Harrison & Donnelly 2008).

geological structures, lithology, rainfall and time elapsed since burial.

By comparison with exploration geophysical methods, hydrochemical and geochemical search techniques are less well developed. Carbon-13 and strontium-87 isotope analysis of bone or teeth respectively may also be used to identify the geographic provenance of human remains.

Geological analysis of police intelligence

Written statements, crime scene photographs and body disposal plans, when analysed from a geological perspective may provide information to assist with a search.

Probing

Soil probes when used during a 'line search' at close spacing are an effective means to search for a grave.

Trenching

Hand held digging implements (such as spades, picks and mattocks) may be used to dig exploratory 'trial pits' or 'inspection pits', often to verify a

geophysical anomaly or positive dog indication.

Police dogs

Often known as 'cadaver dogs', 'victim recovery dogs (VRD)', or 'human remains dogs (HRD)' are an essential assets for any search and are reliable in most, but not all, geological conditions.

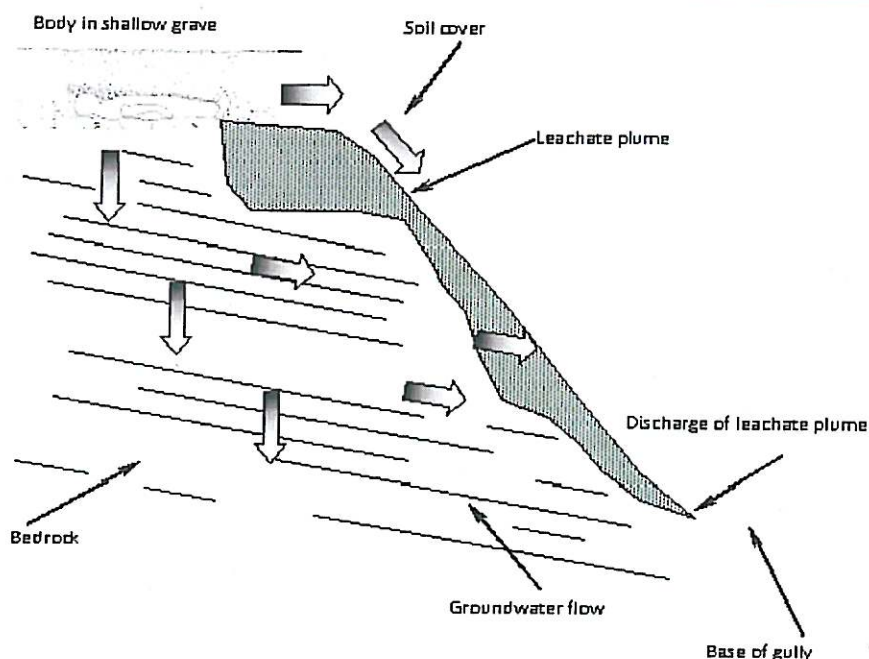
The science which underpins the deployment of police dogs is not yet fully understood or explainable.

Communication between forensic geologists' and the Police

Searches for graves may involve teams of multi-disciplinary experts such as; geologists, anthropologists, botanists, victim recovery dog handlers, remote sensing aerial assets, behavioural profilers, clinical psychologists and the military personnel. These searches are usually co-ordinated and managed by a senior investigating officer (SIO), Police Search Adviser (POLSA) or search strategist.

To successfully carry out the above search, the main challenges are not technical but communication. The forensic geologist conveys all of the above technical information to the SIO and other experts. The police officer may have already a team of multi-disciplinary technical, subject matter specialists. How does the geologist fit into this system?

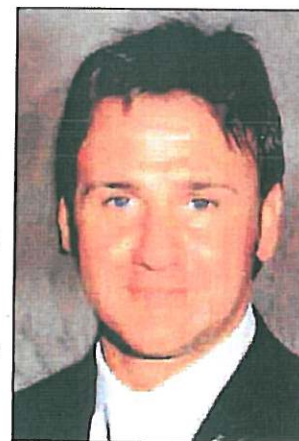
At what stage does the geologist approach the crime scene to reduce the risks of any cross contamination? How can the geologist begin to understand crime scene management and crime scene investigation and what are the strict police protocols involved? The SIO, already possibly overloaded with a range of specialists, now finds that he/she has to deal with yet another specialist, the geologist. This may potentially be problematic if the process is not carefully planned and communicated.



Schematic model to illustrate leachate plumes generated from decomposing human remains. The presence of a leachate plume may increase the target area

About the author

Dr Laurance Donnelly has been applying his knowledge and training in applied geology to criminal investigations for the past 14 years, and has conducted numerous searches and advised the police on searches throughout the UK, USA, Australia and Europe.



He began this work in 1994. 'At this time', he explains, 'geologists rarely formally supported police investigations, apart from a few occasional instances where soil, rock or manmade materials on clothing were analysed'.

There were no formal courses or research which specifically focused on Geoforensics.