

Development of Geoforensic Strategy & Methodology to Search the Ground for an Unmarked Burial or Concealed Objects

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Geologists' conventionally use a variety of techniques to map and investigate the Earth's surface (the ground). Some of these methods can provide a valuable contribution to the police during a ground search to help locate objects, which may be buried in or concealed on the ground, which include for example; an unmarked murder victim's grave, firearms, explosive devices, money, coinage, jewellery and other valuable items or drugs (known as the 'target').



Geological mapping and geomorphological observations may identify ground disturbances such as this depression on the ground and distinct change in the colour of the soil. This depression possibly may have been caused by the settlement of the reinstated soil above a burial and the deposition of soil dug from deeper levels and placed on the surface of the excavation.

To ensure a search can be undertaken to a high-level of assurance this must be carefully managed and co-ordinated between the forensic geologist and the Senior Investigating Officer (SIO), Police Search Advisor (PoISA) and/or Crime Scene Manager (CSM).

Searches may be conveniently sub-divided into three distinct phases, as follows:

1. **The pre-search phase** involves determining why, when, where and how a search should be conducted, the geology and topography, search instruments and techniques (known as 'assets'), methodology, logistics, resources required and the identification of the search objectives, type and area.



Establishment of the 'search area'
defined by high visibility string marking
the individual search lanes.

2. **The search phase** is the actual deployment and recording of the search.
3. **The post search phase** is the de-briefing and documentation of the search.

Pre-search

A geologist's involvement in police searches may often begin by an approach from the SIO or PoLSA. Usually, the geologist would be registered with the National Policing Improvement Agency (NPIA) as an Expert Advisor (EA) on the NPIA database. He/she would be expected to have past experiences in searching the ground with the police and an understanding of police protocols. The SIO will initially provide information giving some of the relevant details of the case. This will vary from case to case but may include for example; the nature/type of the object or body desirable to be found, the circumstances surrounding its disappearance or abduction and the possible search area or areas where the burial or concealment may have taken place. The geologist's involvement in a search is often variable and case specific. It may be limited to the provision of advice over the telephone to the design and deployment of a full scale search.

If, following the initial briefing, it was considered that the geologist may contribute to the search, then Terms of Reference (TOR) would become established. The TOR would define the financial arrangements, including costs, expenses, disbursements, time frames, contract and reporting structure (if required) ahead of deployment.

Police searches may involve the search of or for people, vehicles, vessels, houses, buildings, civil-engineering infrastructure (such as roads, motorways, bridges, dams, tunnels) and the ground. Ground searches may include for example; gardens, beaches, woodland, inner city urban areas, areas of public open space (e.g. parks), rural locations, moorlands, mountains, quarries, landfill sites, caves and shallow abandoned mine workings.

Searches also may take place on or in water bodies such as canals, streams, rivers, ponds, reservoirs, estuaries or the sea. This paper refers only to searches involving objects or items that have been buried or concealed at a shallow depth in the ground (i.e. on land).

Ground searches commonly are conducted to locate murder victim's burials. They may however also be commissioned to search, for example, protected targets, locate vulnerable or missing persons, deprive criminals of their resources and opportunities to commit crime, to collate intelligence or to gain intelligence for a prosecution.

Often the investigative police officers or PoLSA will have limited knowledge in geology. Similarly, the geologist may have little or no experience in policing. Therefore, effective communications (both spoken and written) between the SIO, PoLSA and geologist is vital to ensure the successful deployment of a high-assurance search. Effective communication is also important between other specialists that may be involved with the search, particularly when multi-disciplinary experts are involved. This may include behavioural and geographical profilers, clinical psychologists, dog handlers, botanists, crime scene managers and so on. Such specialists may all play an important role in identifying the location of possible crime scenes or search areas.

The PoLSA and/or SIO will often make the final decision on the management, implementation and recording of the search including why the search is being undertaken, how and when the search will be deployed, what is being sought and under what lawful authority. They also will be responsible for determining whether to include in the search a forensic geologist (geological search consultant).

The ground can be highly variable (reflecting its complex geological evolution) in all dimensions and it may vary over time since the burial took place. No two crime scenes or search areas are likely to have identical geology. The types, thickness, physical and chemical properties and characteristics of the soils, rocks, ground-water and any artificial ground (for example, concrete hard-standing, macadam, tipped materials and landfill) must be assessed as part of the conceptual geological model, with particular emphasis on the generation and migration of any leachate plumes or gases (odours) as these may enable the target search area to be increased. The conceptual geological model will provide an estimate of the grave or burial conditions. This is important to help determine the most suitable search assets required (see Emergency Global, January 2010,19-22).

Data and information relevant to the crime scene or search area will then be obtained, collated and analysed. This data may be variable but in general should include at least the relevant scale topographical maps published by the Ordnance Survey, the British Geological Survey's published geological maps, (available at both 1:50,000 and 1:10,000 scale or greater), memoirs and technical reports and high resolution air photographs. Additional information which also may be obtained could include for instance unpublished geological data and information, an Envirocheck (Landmark) Report, a Coal Authority's Mining Report (if appropriate) and Forestry Commission maps. These may provide information on the geology, ground conditions, past and recent land use history and developments.

The above data would require analysis and interpretation so that the geology and ground conditions can be identified. This would result in the production of a conceptual geological model (see above) of the suspected burial site and the search area. It will provide information on the soil types, areas of past tipping, digging or excavations (for example associated with engineering or agriculture), superficial deposits (soil types), principal lithologies (rock types) and their layering or sequencing (stratigraphy), groundwater conditions (hydrogeology), geological structure, mineralisation, land use changes and geomorphological processes active at, during and the time elapsed, since the suspected burial took place. Local history societies, museums and amateur scientific groups also may provide valuable information regarding a possible search site, but this may be time consuming.

A reconnaissance site visit should take place at the search area. Ideally this initial inspection will include all necessary officers, the geologist and other experts who may be involved in the search or the investigation. The pre-search visit will allow the search area to be accurately defined.

This may vary considerably from the confines of a small garden behind a house to an entire mountain, area of moorland or large tracts of the coastline. A pre-search reconnaissance visit also will enable the testing and verification of the conceptual geological model. This allows for the model to be modified based on the field observations and the development of a more detailed preliminary geological model of the search area.

Reconnaissance site visits of this type also allow the opportunity for any technical, logistical, operational and health and safety matters to be identified and discussed, which may influence the search. For example, the presence of overhead or underground cables, power lines, utilities, metal fences, tipped or disturbed ground may exclude the deployment of certain geophysical techniques and limit excavations. Alternatively, in urban inner city areas the search area may need to be cordoned and the public and media may need to be effectively managed to enable the search to efficiently take place.



Managing the press and media may create logistical and operational difficulties during high profile searches and this requires careful management (after Donnelly, The Geological Society of London, 2008).

Poor weather conditions such as snow, fog and prolonged rainfall can also influence the search strategy.



Police officers and a geologist search for buried objects in adverse weather conditions which require detailed logistical and operational planning.

During the site reconnaissance visit to the crime scene/ search area, the determination of the search area diggability will allow the production of diggability maps and RAG (Red-Amber-Green) colour coded maps. These will identify high, medium and low priority search areas. It should be noted that **RED** conventionally indicates the search area of highest priority in a police or military search. However, this may differ significantly from some maps produced by a geologist where **GREEN** may delineate the priority search area. Field trials using soil augers will provide information on the depth to bedrock interface, the ease by which excavations or burials may be dug, diggability restrictions (for example, the presence of shallow bedrock or boulders in the soil profile or tree roots in areas of woodland) the most likely sites that may potentially conceal the target and the resources required for invasive works (such as, spades, picks, mattocks or mechanical excavators).

An estimation of the physical and chemical properties of the target and the surrounding geology and ground-water will help to determine the detectables (for instance, what is actually there to be found on, or in association with the target). Understanding the properties and likely condition of the target will also pre-determine the most suitable choice of search assets that are likely to be successful in locating it. The choice of search assets should not be based on equipment and resource already easily available or on the basis of the success of a particular asset at other crime scenes in the past. This is because the success of a search asset at one particular location cannot automatically guarantee that it is suitable at another location, where the geology may be different, even within distances of just a few metres and the items sought are of differing materials.

The most common types of assets used to search the ground may include a combination of the following:

- **Visual geological observations** by an appropriately qualified, trained and competent geologist and PoISA may provide one of the most cost-effective methods to determine whether an area of ground has been subjected to digging for the burial of the target. This is effective provided there is a visible “scarring” of the land or subtle ground disturbances associated with digging and soil reinstatement.



The positive identification of objects buried in the ground noted by high visibility markers

- **Specially trained detector canines** for human remains, drugs or explosives, (known also as Victim Recovery Dogs, or VRDs).



Specially trained detector canines (Victim Recovery Dogs, or VRDs) in an urban and rural environment.

- **Geophysical surveys** include for example; ground penetrating radar (GPR), electrical resistivity, conductivity, magnetics, conventional metal detectors and microgravity (if looking for voids) and seismic (not likely but possible in some circumstances).



Non-invasive geophysical surveys used as part of the search strategy to help locate a burial.

- **Intrusive methods** include the use of soil augers/probes and the digging of controlled trial pit excavations and trenches.



- **Geochemical surveys** are still somewhat experimental but in certain circumstances these may include for example; the analysis of groundwater or soil to help detect leachate plumes, specific isotopes or volatile organic compounds (VOCs) associated with decomposing human remains in an unmarked burial.



Probing of the soil to locate buried objects in a remote location in Eastern Europe (top) and in woodland (lower left) and the garden of a house (lower right).



Geochemical surveys used as part of the search strategy to help locate a burial.

- **Air-borne methods** may be useful if large tracts of land are to be searched or the search area is remote and difficult to access by traditional ground based search methods (for example; coast lines, beaches, estuaries, moorlands and mountains). A range of instruments, traditionally used in mineral exploration or some types of geotechnical ground investigations, are available that can be mounted onto a fixed-wing aircraft or helicopter to help image and map the ground surface. These however, may be expensive and time consuming and possibly only financially justifiable in high-profile or critical case searches.
- **Satellite imagery** may have applications in some high-profile and critical case searches. As with airborne techniques these may be expensive, time consuming and could involve specialist military resources for the acquisition, analysis and interpretation of the data.
- **An environmental profiler** such as a botanist who may through expert observation identify anomalous growth patterns or vegetation forms that may be associated with concealed human remains, drugs or explosives.
- **A clinical psychologist** may help with the identification of general search areas based on his/her assessment of the offender and the victim.

It can be seen from the previous section that the 'pre-search' phase is perhaps the most challenging, time consuming, resource intense and difficult aspect of any search. The deliverable of the pre-search should be a written search strategy detailing the Standard Operational Procedure (SOP to be deployed). This will identify, amongst other information, the search strategy, instruments and equipment to be deployed (search assets), operational methodology, search personnel and specialists required, instructions on the recording and reporting of any finds, associated logistics and the search exit strategy. This written search strategy should also link in with any written forensic strategy to ensure the consequential actions of search activity do not negatively impact on any forensic recovery, particularly in relation to the intrusiveness or destructive nature of the search and any cross contamination issues that the searches may cause coming into contact with any finds.

The Search

The search will begin with a briefing so that personnel become familiarised with the search objectives, type, area, equipment and instruments, management of the media and the public, and the target object(s) desirable to be found.

All searches must be intelligence led. The aim of the search will be to apply and manage the Systematic Operating Procedure (SOP) which was developed in the pre-search phase, with the most cost-effective suite of search assets. The search must be measurable and proportionate to the item being sought. The search should be designed and managed to give a high-level of assurance to prove the presence or absence of the target. The searchers must also be appropriately qualified,

trained and experienced and skilled in the techniques and equipment they are using.

As the search develops, the conceptual or preliminary geological model, devised in the pre-search phase, must be updated as more information on the ground conditions at the crime scene/search area are obtained. This, if necessary, will allow the refinement of the search methodology within the scope of the SOP.

At the crime scene or search area, if geophysical surveys are to be conducted as part of the search, these must be tested or 'ground-truthed' to check that they are operational and suitable to locate the desired target in the particular geological environment where they will be deployed. A test site should be established, not within the search area but in a location where the geological conditions are similar to the search area. This should involve the burial of an object similar to the target item, or at least made from materials of the same type, dimensions and condition (for example, clothing may be buried if a murder victim's burial is being searched for, similar to what the victim is reported to have been wearing). The burial and imaging of these objects at variable depths will enable the detectable limits to be determined and instrument calibrations to be made if required. This also will provide the opportunity for search team members to become familiarised with the operational aspects of the instruments and to practise its deployment ahead of the main search. The test site should be protected and may be used if for example there is suspected instrument failure, there are too many false positives, which require subsequent instrument calibration and to ensure that the instruments are still operational at the end of each search day (or phase). If there has been no positive geophysical anomalies detected the instruments must also be tested on the controls. Usually at least two differing geophysical methods will be deployed consecutively during a search in a systematic manner to provide a higher level of assurance.

The search strategy and the methodology will follow the pre-determined sequence as set out in the SOP. Ideally this should move proportionally from the macro to the micro scale, from reconnaissance to detailed search and from the non-invasive to the invasive. For example, during the search for an unmarked burial this may include

- **Phase 1:** Secure the search area, marking of the search lanes, photograph/video recording, mapping and taking of GPS co-ordinates prior to any search activity.



GPS surveying to record a search

- **Phase 2:** Visual line searching; the forensic geologist may be able to identify subtle ground disturbances and possibly determine if these may be associated with digging and burial, or natural geological processes. Here, critical separation of search personnel will be determined by the target size sought and the terrain.
- **Phase 3:** Reconnaissance VRD search depending on what is being sought (for example, firearms, drugs, blood, human remains).
- **Phase 4:** Deployment of first geophysical search instrument and the marking of any positive indications. Here, the aim is to survey the whole search area marking any anomalies using colour coded non metallic plastic or wood markers or paint. In this phase there is no invasive exploration of any positive anomalies.
- **Phase 5:** Deployment of second geophysical search instrument and the marking of any positive indications. A different colour marker will be required so that each positive anomaly can be associated with a specific instrument.
- **Phase 6:** Probing of the search area (or search lane) using soil augers (there are a variety of different types of augers to suit different ground conditions).
- **Phase 7:** Second deployment of VRD to detect any gases (scent/odour/vapour) released during the auguring.
- **Phase 8:** All indications, whether these are positive dog 'hits' or 'geophysical anomalies' should be repeatable. The subsequent invasive investigation of any VRD or positive geophysical indications (by probing and then selective digging of the ground and if required the cutting of an exploratory trenches and inspection pits).



The investigation of positive indication (i.e. dog 'hits' or 'geophysical anomalies').

- **Phase 9:** Forensic strategy enacted for the recovery, recording and identification of any finds. Soil collection may be required for further geological analysis.
- **Phase 10:** Mapping and recording of the areas searched and post search report completed.

Any positive finds will usually require the expertise of a forensic anthropologist, archaeologist, Exhibits Officer (EO) or Crime Scene Investigator (CSI). Such forensic examinations often may rest beyond the conventional training and experiences offered by the geologist. Any such invasive ground recovery investigations must be conducted in the least intrusive manner to prevent the loss of forensic evidential material. There should be a pragmatic balance between search costs and resourcing for conducting high-level assurance searches, which will not negatively impinge on any forensic investigations, cross-contamination or evidential finds.

Post Search

At completion of the search a de-briefing should take place. This will provide the opportunity for the SIO, PoISA, forensic geologist, each searcher, team member and investigators to discuss whether the search objectives have been suitably met and a record of any lessons learned.

A comprehensive documentation report and evidential briefing pack will then be written and submitted to the police investigators. This will include maps to show the search areas, details of the search assets used, time frames involved, names of the searchers, location of any positive anomalies/indications and a photographic and descriptive account of the search and any finds that have been recovered; including information on their depth of recovery, dimensions, conditions and a description of the geology (ground conditions at and in the vicinity of the burial).

It must be remembered that all search assets, strategies and methods have limitations. The best service the forensic geologist can offer a police investigator or PoISA is the development of a conceptual model for the search area, determination of diggability, choice of search assets and contributions to the design of a cost-effective, high assurance search. Furthermore, the objective of a search is not necessarily to locate missing or buried items but sometimes to prove its previous presence or absence, based on intelligence. Therefore, searches that do not locate any objects can be regarded as having been successful and contribute to the overall police investigative process.

* Images credited to Doctor Laurance Donnelly and Prof Mark Harrison

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