Collaborative geophysical monitoring of simulated forensic 'crime scenes' in the U.K.

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Summary

This paper provides an overview of current collaborative academic forensic geophysics research on various U.K. test sites to detail the importance of forensic simulated burial sites for forensic search investigators. Academic forensic test sites contain a variety of buried material objects that have been buried for various periods. The team also have access to historical burial grounds for data collection if required. Research is gaining an understanding of optimal search technique(s) for different buried targets, optimum methodologies and sequential search workflows. From this research, additionally a detailed understanding of the local depositional environment(s), particularly soil type(s), age/style of burial and local climate datasets are critical to have a successful detection. Ongoing long-term monitoring efforts are detailing optimal time windows for searches and techniques.

Main Objectives

1. Describe current forensic search best practice

2. Detail collaborative UK academic network

3. Describe forensic geophysics knowledge

4. Detail major forensic geophysics UK sites

5. Describe research findings

New Aspects Covered

Details UK academic forensic test sites and long-term studies to characterise detection technique(s), equipment configuration(s), data spacings/datasets to assist forensic search teams.

Topics

8. Near surface geophysics for forensic applications

2. Archeo-geophysics

Introduction

The successful detection of a clandestine grave of a homicide victim brings closure to family members and gives the public confidence in criminal justice following a trial [1,2]. Accurate determination of the time since burial is also critical for forensic investigators to link suspects to or eliminating them from a crime [3]. Geoscientific methods are being increasingly utilised by forensic search teams for the detection and location of clandestinely buried material [4-5]. In the search for clandestine graves of murder victims, burials are usually shallow (less than 3 m and typically 0.5 m below ground level or bgl [6]), but current detection rates are low and, without locating the victim's body, obtaining a successful conviction can be very difficult [1,2]. Search investigators will use a variety of proved methods, which include scenario-based, feature focused, intelligence-led and systematic Standard Operating Procedures [1,2]. SOPs normally work through sequential workflows, from reviewing case information, sourcing background information and remote data analysis, before deciding upon search strategies, undergoing site reconnaissance and phased site investigations, and lastly intrusively investigating anomalous areas to give a success/failure exit strategy (see Fig. 1 and [1,3]).

Forensic site investigation methods vary depending upon the specific case, search site and numerous other factors that are reviewed elsewhere [4], but include, if appropriate, scent-trained cadaver dogs [7], forensic geomorphology [8], forensic botany [9] and entomology [10], near-surface geophysics [11-13], intrusive probing [14] and soil analysis [15-18] – see Table 1. Research using simulated clandestine grave burials provide critical information on optimal detection method(s), equipment configuration(s), sample point spacings, etc., especially if long-term monitoring are undertaken [6].
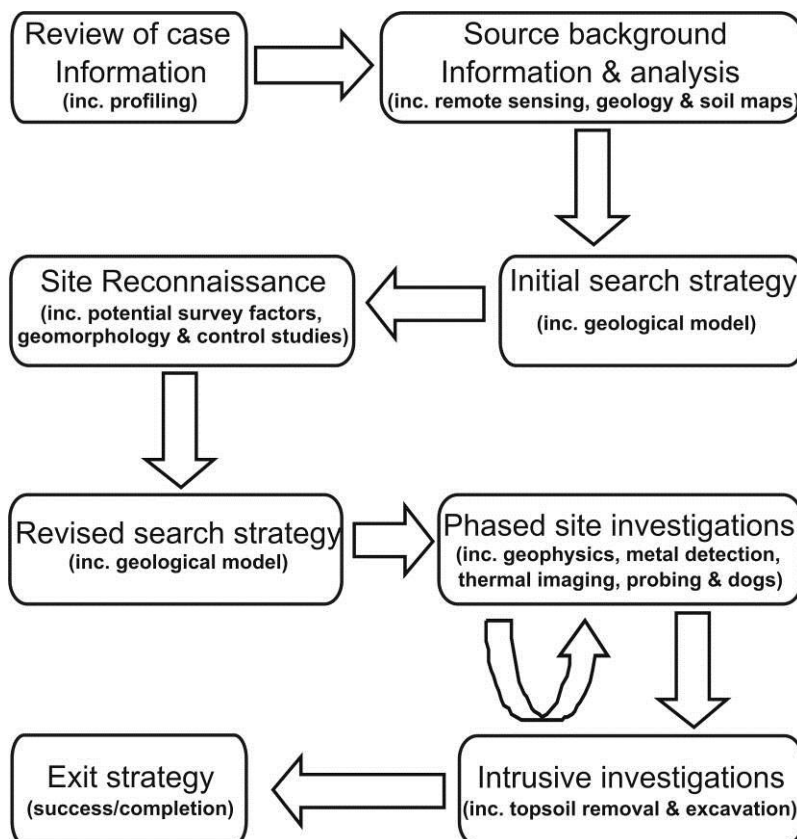

Fig. 1. Current optimised forensic search workflow. Adapted from [4].

## U.K. Academic Forensic Test sites

Keele University has long-established forensic test sites in semi-urban/rural environments. The oldest burials (Dec. 2007) are simulated clandestine burials of murder victims, using three domestic pig carcasses as human analogues. One is wrapped and the other naked to provide the two typical burial scenarios. These have been repeatedly geophysically surveyed by fixed-offset electrical and Electrical Resistivity Imaging (ERI) surveys as well as multi-frequency (110-900 MHz) GPR datasets at least quarterly, and every month in the first three years post-burial. Studies have been published on determining what causes relative resistivity anomalies [19], magnetic surveys [20], measurements of decompositional fluid conductivities over time [3] as well as the 0-3 years post-burial datasets [6]. Repeat surveys suggest winter surveys are optimal and resistivity surveys should be undertaken six months to two years post-burial for optimal success. Conductivity of decompositional fluids could be potential grave location indicators and even date post-burial intervals. Both GPR and resistivity surveys should be undertaken if burial style is unknown. Keele also has access to local graveyard and cemetery sites and a Medieval monastery graveyard for research studies. A domestic patio scenario has also been created (Sept. 2010) with another pig carcass and a variety of buried munitions. Keele also has its own weather station linked into the U.K.'s Meteorological Office so corrections can be made for local temperature/rainfall variations.

Staffordshire University has forensic test sites in urban garden environments. Here studies have been undertaken for initial decompositional fluid research, magnetic survey trials [20] and optimal geophysical surveys for detecting clandestine burials [21], resistivity and GPR deemed optimal. Staffordshire are also leading inorganic chemical analysis of decompositional fluid collected by the research team, Na/K major indicators and cadaverine/putrescene showing grave detection promise.

The *University of Central Lancashire (UCLAN)* have a forensic test site in an upland moorland environment, with the capability of handling large experiments that have been well published (e.g. [22]). They are also replicating the conductivity of decompositional fluid experiment [3].

Cranfield University has a forensic test site in a rural chalky environment. Their test site has been the subject of various decomposition studies and they are replicating the conductivity of decompositional fluid experiment [3]. They also have access to a woodland environment at Lincoln University that has been used for resistivity and magnetic survey studies [20], resistivity anomalies present even when surface remains are not obvious, thought to be decompositional fluids being retained in the local soil.

Queens University Belfast (QUB) have been leading the field in Water-Penetrating Radar (WPR) studies to detect submerged objects, with reviews [23] and research as well as best practice of search using geoscience methods [5] and historical cemetery research [24]. They are also very experienced in environmental forensic research.
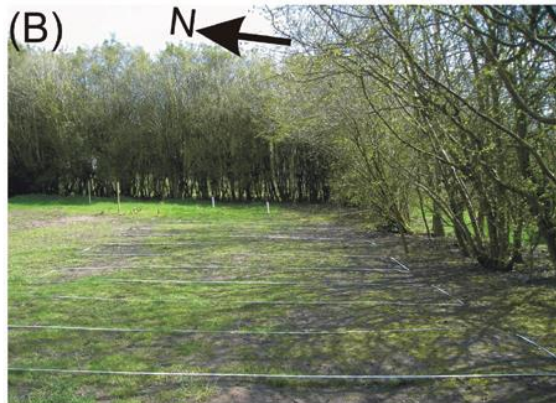
Keele University semi-rural test site

Staffordshire University urban test site
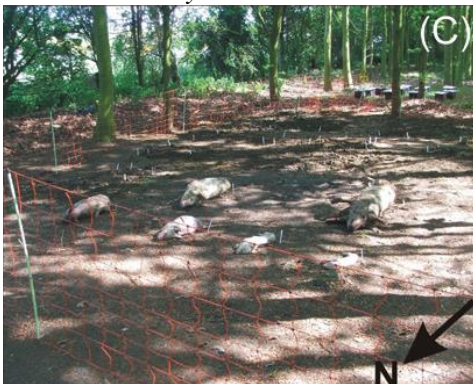
Cranfield's Lincoln woodland test site

UCLAN peat moorland test site

Fig. 2. Photographs of some of the available forensic test sites.

Target(s)	Remote sensing		Site work									
			Geomorph-ology / probing	Thermal imaging[1]	Special-ist search dogs	Near-Surface Geophysics						
Soil type: sand ◐ clay	Photo-graphs	Infra-Red				Seis-mology / Side-scan sonar	Cond-uctivity	Resist-ivity	GPR	Mag-netics	Metal detector	Element analysis
Unmarked grave(s)	●	◐	●	◑	◐	◑	◐	●	●	◐	◑	◐
Clandestine grave(s)	●	●	●	◐	●	◑	◐	●	◐	●	◐	●
UXOs/ IEDs	◑	●	◐	◑	◑	◐	◐	◐	●	●	●	◑
Weapons	◑	●	◐	◐	◐	◐	◐	◐	●	●	●	◑
Drug / cash dumps	◑	◐	◐	◑	◐	◑	◐	◐	◐	◐	◐	◑
Illegal waste	●	◐	◐	◑	◐	●	●	●	◐	●	●	●
Influence of search environment on chosen method(s) (above) effectiveness												
Woods	○	●	○	●	●	○	◐	○	○	●	●	◐
Rural	●	●	●	●	●	●	●	●	●	●	●	●
Urban	◐	○	○	◐	◐	○	◐	○	○	○	○	◐
Coastal	◐	●	●	●	●	●	○	◐	○	●	●	◐
Underwater	◐	○	○	◐	◐	●	○	○	●[2]	●	●	○

Table 1. Generalised search technique(s) for buried target(s) from good (black) to poor (white). Two end-member soil types shown. [1]Time dependent. [2]Water Penetrating Radar (WPR). Adapted from [4].

Conclusions

Clearly collaborative forensic geophysics is rapidly increasing to gain understanding of optimal search protocols and optimum detection types, but more research needs to be undertaken on varied objects in different environments and depositional settings to further increase forensic success rates.

Acknowledgements

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