The Use of GPR to Identify Historic Burials
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Abstract - There are many reasons why burial sites may require investigation. These may include new developments with the population pressure on urban areas, extensions and remedial work to churches, or academic research. Whatever the reason may be more often than not it is the primary objective of the investigator to inform the client of the location of any burials that may be present, and of the nature of any associated structures.

The detection of burials using geophysical methods has long proved to be problematic and can depend on many variables which are often unknown in advance. This paper will focus on the use of ground probing radar in identifying a series of different types of burial showing examples from surveys undertaken throughout the United Kingdom.

Keywords – ground probing radar, burial, vault, church.

I. INTRODUCTION
The demand for land in the United Kingdom is an ever increasing issue. With the continuing rise in population the spread of urban developments for new housing, public amenities, industry and so on persistently encroaches on more green field sites each year. For some time now a well defined argument has existed for the re-development of disused urban sites. This should take place not only to reduce the virgin land take but also to financially and socially regenerate derelict urban districts. Part of this process often involves the demolition of derelict buildings to create additional space. It can also include construction on sites that have been silently left to nature and the elements for decades, or even a hundred years or more. An example of one such category of sites is cemeteries.

II. THE REQUIREMENT FOR SURVEY
The introduction above states just one example of why a cemetery may require investigation. Examples of additional reasons may include extensions to existing church structures, opening up an old site to new burials, or an academic research project. Prior to any work of this nature taking place it is a prudent step for the investigator to clarify the location of suspected burials and any associated structures. Not only is this intended as a mark of respect towards the remains, but it is also a practical issue as new foundations laid around burial structures may prove to be unstable in the future.

Records cataloguing burials that have taken place in particular locations do exist. However, with the passage of time these records can become lost or destroyed. It is not unusual for burials, and in particular headstone markers and slabs, to be re-located perhaps several times throughout the history of a site. The potential loss of information through these mechanisms leads to inaccurate records and raises the question of how an investigator can locate the existence and position of burials?

III. VARIABLES
The wide variety of site and preservation conditions makes the detection of burials using geophysical methods problematic. Examples of the variables likely to be encountered include

- Burial age/depth/preservation
- Associated structures e.g. slab, vault, shaft burials and coffins
- Density of burials within the area
- Rock/soil types
- Alignment e.g. Christian burials are normally west-east
- Ground use and conditions since burial

Each of these will affect the results and subsequent interpretations of the data. Many of them will be entirely unknown in advance.
The potential success of any technique of geophysical survey will depend on the above variables, but there is also a separate sliding scale of detect-ability that lists any associated structures (Figure 1). This scale ranges at one extreme from a body placed in a simple cut with no coffin, right up to a large walk in vaulted crypt constructed using masonry. Assuming all other variables being equal then the more associated structures that are present the higher likelihood of detection.

Figure 1. Flow diagram showing a simple scale of detect-ability. The more associated structures that are present increases the chances of locating the burial.

This paper will focus on the use of Ground Probing Radar (GPR) to help locate burial features over a number of example sites from across the United Kingdom.

IV. SIMPLE INHUMATIONS
The following data show examples from the lowest section of the detect-ability scale. Theoretically these are the most difficult type of burial to identify.

4.1 Saxon Burial Ground
Figure 2 shows an example radargram gathered on a site that is located in a private garden adjacent to a known Saxon burial ground. The data was collected using a GSSI SIR 2000 system using a 400MHz antenna taking traverses 0.5m apart on a parallel grid. The travel time has been converted to depth using an average value of measured point diffractions. To the right hand side of the radargram a strong discrete response can be seen. This forms part of a contiguous set of anomalies that are observed in four adjacent traverses. The total length of this feature is thus approximately 2m long, 0.75m wide and 0.75m deep. These are the typical dimensions of a grave cut. Several other responses taking this format were also observed in one area of the site, while the rest of the site showed no specific enhancement. This was interpreted as showing the continuation of the burial ground and its ultimate extent.

Figure 2. Shows an example radargram identifying a strong discrete response.

4.2 Post-Medieval Church Yard
A GPR survey was carried out at St Paul’s, Hammersmith in November 2006. The site was located to the exterior of the west end of the church over a drive way and graveled area (Figure 3). The first church on the site was consecrated in 1631 [1] and the graveyard was in use from 1664 until 1854 [2].

Figure 3. Site photograph showing the survey area which is east of the church. The church is on the left behind the blue hoardings.
The survey was carried out using a Multi-Frequency (MF) system manufactured by Ingegneria Dei Sistemi (IDS). The system incorporates both 200Mhz antenna and 600MHz antenna in an array that was used to collect 6 channels of data simultaneously over a 2m wide sweep. This results in traverses with an effective separation of around 0.35m. These were gathered on a north-south aligned grid so that they are perpendicular to any potential burials that may be present.

Figure 4 shows an example radargram identifying two weak discrete responses. These have been interpreted as being caused by grave cuts. In total 40 other contiguous responses are observed on the site, with 8 stronger anomalies (Figure 5). It is likely that these 8 stronger responses are caused by graves that have some associated structure, perhaps a stone slab or high status coffins.

The reflections arising at this site are far weaker than those observed at the Saxon burial ground in section 4.1. Logic dictates that as burials age they will become increasingly more difficult to detect using geophysics as they homogenise with the local soil. A possible explanation for this discrepancy is the local geology. St Paul’s is located on London Clay, compared to the Saxon burial ground that is situated on a chalk bedrock. Clay is a notorious absorber of electromagnetic energy and thus can result in low contrast responses and a reduced penetration depth. Both these phenomenon are observed at the St Paul’s site.

V. VAULTED BURIAL CHAMBERS

5.1 St Nicholas’s Church, Hurst

Two phases of investigations were carried out St Nicholas’s Church, Hurst in late 2001 - early 2002. The east gable of the building had been suffering from structural movement (Figure 6 & Figure 7). The first phase of work was intended to characterise the ground conditions around the eastern end of the church. This consisted of GPR surveys both outside the building and within the North Chapel and Chancel. During the second phase high frequency GPR was carried out over the walls themselves. This paper will focus on phase 1.

Figure 6. The east gable of St Nicholas’s Church which is experiencing structural movement.
Figure 7. The east gable of St Nicholas’s Church after phase one has taken place showing the erected scaffolding for phase 2 on-wall radar and remedial work.

Phase 1 data was gathered using a GSSI SIR 2000 system with a 400Mz antenna. Traverses were taken on a 0.5m orthogonal grid layout.

Church records allowed the locations of several burials within the church yard to be identified. Figure 8 shows an example radargram indicating these positions relative to the data.

Two broad crested responses can be seen, each in the area of multiple known graves. It is likely that these are related to burial chambers with vaulted roofs constructed using masonry. The records did not predict they exist and it is probable that they are family chambers due to the position of the multiple known burials.

Figure 8. Example radargram showing the grave record numbers and locations. Two broad crested anomalies can be seen which are likely to be associated with burial chambers with vaulted roofs.

Similar results are also observed within the North Chapel and Chancel (Figure 9 & Figure 10). These responses appear wider than those observed outside. Considering the position of these beneath the main structure of the church it is likely that they are associated with vaulted crypts and probably form part of the main foundations from the original period of construction. It is also possible to identify discrete anomalies at either side of the broad crested response in the Chancel (Figure 10).

These may be related to columns or walls supporting the vaulted roof above. These do not appear to be present in the North Chapel (Figure 9).
VI. CONCLUSION
The case study sites discussed in this paper demonstrate that it is possible to identify the location of individual burials. Certain conditions will effect the success rate including the burial age, geology and any associated structures. The detect-ability chart shown in Figure 1 seems to hold true that burials with other funerary features can be identified more easily than a simple grave cut. The examples given indicate that burial age is perhaps not as a significant factor as previously thought as the Saxon grave cuts are quite apparent, although this may be down to the more suitable geology rather than age.

There is no single anomaly type that can categorically be identified as a burial. One method that can be used is to look for responses over contiguous close centred traverses spanning around 2m in length and 0.75m wide. This can act as a guide but can not be guaranteed as cemeteries with a long history may contain closely spaced or overlapping burials causing confusion. Ultimately the interpretation will rely on the skill and experience of the operator to identify the potentially significant anomalies.

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REFERENCES