Locating the Missing: A critical examination of the taphonomic alterations and the archaeological and forensics techniques that can be used to identify them during the search for mass graves.

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In December 2022

I certify that all material in this thesis which is not my own work has been identified and that any material that has previously been submitted and approved for the award of a degree by this or any other University has been acknowledged.

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Abstract

Mass grave investigations are complex due to the size of the grave, the number of victims, the nature in which they were created, and their often remote or inaccessible locations. Most mass graves are the result of conflict and/or human rights atrocities, despite the implementation of international laws, conflict and the creation of mass graves are still recurrent issues today. In most cases, investigations take place many years after the grave was first created, often, witness statements are the only information available to investigators to suggest the presence of an undiscovered mass grave. However, the passage of time causes the landscape to recover and change reducing the accuracy of witness information. Current methods that are effectively applied to locate single graves are also not necessarily designed to handle large-scale operations; wasting time, resources, and risking potential damage to evidence. This can have major implications for a forensic case, especially if it is to be presented in court. There is a need to find cheaper, more effective and less time-consuming methods that are specifically designed to locate large-scale gravesites, as there are still many mass graves which need to be found.

This research project aimed to determine if the taphonomic signatures commonly found at burial sites have a big enough impact on the subsoil and surrounding landscape to be used as a method of locating archaeological and forensic mass graves. Examining archaeological mass graves alongside their forensic counterparts provided empirical knowledge on how the soil and landscape change over time, to determine which signatures offer the best chances of successfully identifying mass grave locations. Firstly, this project examined victim recovery rates from six countries, the results showed that recovery rates in Iraq are 2%, 3% in Argentina, 8% in Spain, 12% in Colombia, 59% in Cyprus, and 70% in the former Yugoslavia. This low rate of recovery suggests current location and recovery protocols are ineffective. Secondly, legislation, standards and guidance, and policies used to ensure that any gathered evidence is admissible in a court of law were reviewed. However, regulations are complex and vary depending on whether the casework is domestic (carried out in the UK) or international (carried out under the international criminal court), therefore the suitability and admissibility, of the recommended approaches will vary on a jurisdictional basis. Finally, this

research critically assessed the physical, stratigraphical and chemical alterations caused by the creation of a mass grave, the subsequent decomposition of the bodies interred within, and the techniques which can detect these changes. It showed that the changes a mass grave causes in the vegetation, stratigraphy, soil phosphorus and pH levels potentially have a long-term impact on both the subsoil and surrounding landscape. Highlighting, they could be used as alternative ways to locate both archaeological and forensic mass graves quicker, faster and cheaper than existing approaches.

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Acknowledgements

I would like to thank the following individuals from the Department of Archaeology at the University of Exeter: My supervisors Dr Laura Evis and Professor Linda Hurcombe for their patience, guidance, feedback and support. The archaeology technicians for lending me the geophysical equipment and Jack Cranfield for teaching me how to use it in the field. I would also like to thank Charlie Farmer for being my go-to when I needed someone to read over my work, to check that it made sense. Finally, I would like to thank my friends and family for tolerating my constant talk of mass graves, and everyone else who has supported me throughout this process.

Chapter One: Introduction

Mass grave investigations are complex processes, given both the scale of the grave and the nature in which it was created (Cox et al., 2008). Between 1945 and 2008, approximately 313 armed conflicts occurred worldwide, whilst accurate statistics presenting the true extent of missing persons are limited, these conflicts have resulted in millions of missing and/or unidentified people (Bassiouni, 2010; Hanson, 2016). Despite the implementation of international declarations (e.g. the Geneva Conventions), conflict and the creation of mass graves still happen today. Although mass graves are largely associated with modern-day war, many archaeological mass graves exist. A boundary separates a mass grave from being classed as archaeological or forensic; within the United Kingdom (UK) the boundary is approximately 100 years, whereas, internationally the limit can be as low as 50 years or less (Corrieri and Márquez-Grant, 2015: 394; BABAO, 2019:16).

Archaeology is the study of human history and prehistory, investigations are conducted to obtain new knowledge, revise theories, and interpret existing artefacts and physical remains to provide insight into the past (Collins Gem, 1989; Department of the Environment, 1990; Bahn, 2012; Wilkinson, 2020). Whilst the term forensics refers to that which can be used in or is connected to a court of law (Collins Gem, 1989). Forensic Archaeology, therefore, applies archaeological field techniques, methods and theories to investigations carried out in a forensic or humanitarian context (Connor and Scott, 2001; Blau, 2004; Dilley, 2005, Powers and Sibun, 2013; Blau and Ubelaker, 2016). Their unique skill set means police and/or international organisations call upon them to assist with locating, recovering and identifying human remains, to help provide survivors and families of the missing with answers (Snow et al., 1984).

Whilst in the UK forensic archaeologists play greater roles in search and recovery teams than forensic anthropologists, on the international stage the work of anthropologists is equally relied on and applied to homicides, human rights violations and war crimes (Boddington et al., 1987; Cox, 2001; Hanson, 2004; Cox et al., 2008). Forensic anthropology, a subdiscipline of physical anthropology, applies osteological methods to medico-legal contexts (Stewart, 1979; Reichs, 1998; Ubelaker, 2006; Christensen et al., 2014). Osteology is the study of bones, anthropologists build a biological profile of skeletal remains suspected or known to be human, this profile contains the estimated age at death, sex, physical characteristics and skeletal trauma. The final report is then presented to forensic pathologists who use it to support their findings in determining the transpired events at or around the time of death and narrow down the potential identity of the individual. In recent years, archaeologists and anthropologists have been pushed to the forefront of an increasing number of international scientific investigations because they are extensively trained to recognise gravesites, exhume remains and support the process of human identification (Steadman and Haglund, 2005).

The process of digging and backfilling a grave, and the subsequent decomposition of the human body results in the alteration of surrounding plants, soil and environment; the documentation of which is crucial for understanding what happened (Dirkmaat and Cabo, 2015). Studying the subsoil and land surrounding a mass grave falls under the remit of taphonomy. Taphonomy was first developed by Ivan Antonovich Efremov, a Russian palaeontologist in 1935. The word itself originated from the Greek words, *taphos* (burial) and *nomos* (law), and described the transition organisms undergo when they pass from the biosphere into the lithosphere or geological record (Efremov, 1940; Lyman, 1994; Blau, 2014; Schotsmans et al., 2017; Behrensmeyer et al., 2018). The term was first used to interpret and understand the processes soft-bodied fossils go through as they decay. However, this initial definition is widely considered to be limited, as it only explored the removal of data, it does not examine how taphonomic data can be added to a site or area of interest (Lawrence, 1968; Lawrence, 1971; Lyman, 2010; Briggs and McMahon, 2016).

The definition of taphonomy varies slightly across every discipline (Schotsmans et al., 2017). In archaeology, taphonomy is described as the assessment of what happens to any archaeological object or organism between the time of deposition and its recovery (Renfrew and Bahn, 1991). It was first applied to archaeology in the 1970s as a way of explaining how and why skeletal elements and/or assemblages ended up in the context they were found to interpret how human behaviour changes over time (Whitlam, 1982; Behrensmeyer and Kidwell, 1985; Bahn, 1992; Beary and Lyman, 2012; Christensen et al., 2014). Applying taphonomy to an archaeological context is considered a routine process, when interpreting burial sites and human remains it provides archaeologists with a means of reconstructing the events associated with the deposition, dispersal and modification of human remains (Christensen et al., 2014; Baker et al., 2017).

Forensic taphonomy, however, places greater emphasis on studying the remains within the context of their discovery by investigating the biological, physical, chemical and stratigraphic alterations to determine how and to what extent the remains have altered them (Haglund and Sorg, 1997; Dirkmaat and Cabo, 2015; Sorg et al., 2015). The analysis of these processes can help to determine the antemortem period (at the time of death), the perimortem period (around the time of death and deposition) and the postmortem period (from deposition to recovery), to reconstruct the circumstances surrounding their death (Haglund and Sorg, 1997: 13; Haglund and Sorg, 2002: 7). In short, forensic taphonomy is the study of what happens to the human body after death through the application of interdisciplinary methods and theories to establish the time of death, deposition and recovery (Haglund and Sorg, 2002; Blau, 2014; Christensen et al., 2014; Sorg et al., 2015; Schotsmans et al., 2017; Stodder, 2019; Martin et al., 2020). Since its development, forensic taphonomy has become central to the research and analysis carried out by forensic anthropologists and other related disciples (such as entomology and botany) working on cases involving human rights investigations, mass disaster fatalities, mass graves and other large forensic recoveries (Sorg et al., 2015). As it can be used to identify patterns of dispersal, the removal of remains and/or evidence to help establish how the scene has been altered (Dirkmaat and Cabo, 2015).

Like most disciplines in archaeology and forensics, forensic taphonomy is split into two subfields; *Biotaphonomy* and *Geotaphonomy*. Biotaphonomy examines the modifications that occur to the remains themselves, as a way of understanding, interpreting and reconstructing the things responsible for the destruction and decomposition of soft and hard tissue (Nawrocki, 2016). Divided into three categories biotaphonomy explores the environmental, individual and cultural factors which may impact the preservation of remains and the ease with which they can be found and recovered. Geotaphonomy however focuses on the effect the remains have on the local environment, to understand, interpret and reconstruct the impact a grave has on the surrounding geology and vegetation (Hochrein, 1997; Hochrein, 2002a). Divided into seven areas, geotaphonomy explores stratification, tool marks, bioturbation, sedimentation, compression/depressions, internal compaction and pH alterations (Evis pers comm, 2020). These factors leave behind clear indicators on the surface and within the subsoil, which could present a useful way of aiding with the search for mass graves.

Therefore, the focus of this research project is to critically examine the effects mass graves have on the subsoil and surrounding landscape, to determine if it is possible to use these geotaphonomic modifications as alternative methods to locate both archaeological and forensic mass graves. This need for finding more effective detection methods is essential, as there are still so many undiscovered mass graves. The use of ineffective methods can also waste vital time and resources, cause loss of evidence and have major implications on a case should it ever be taken to court.

1.1 Research Question

Do taphonomic signatures have a big enough impact on the surrounding landscape and subsoil to be used as a method for locating mass graves?

1.2 Research Aim

This research aims to determine which, if any, of the taphonomic signatures commonly found at burial sites can be used as a method for locating both archaeological and forensic mass gravesites.

1.3 Research Objectives

To achieve the research question and aim the objectives of this research project are:

To critically review published academic literature to identify possible taphonomic signatures of a mass grave.

To use published academic literature to determine the effects taphonomic signatures might have on the subsoil and surrounding landscape.

To ascertain if the taphonomic effects of an archaeological mass grave are different from that of a forensic mass grave.

To identify the techniques used/could be used to locate archaeological and forensic mass graves.

To determine which techniques could successfully detect the taphonomic signatures created by a mass grave.

1.4 Research Structure

The structure of this project follows the processes used during forensic procedures. Forensic investigations begin with desk-based analysis, designed to identify and gather background information on a specific area under investigation. Once the site has been identified archaeologists and anthropologists visit the scene to carry out a non-invasive search, designed to minimise the disturbance or damage of any evidence. An invasive search is then carried out to confirm the presence of a grave and to gain a greater understanding of the subsoil before a full-scale excavation is conducted.

Chapter 2: Mass Graves, looks at what a mass grave is, the types of burials associated with mass graves, examples of known archaeological and forensic mass graves, and recovery rates of mass grave victims.

Chapter 3: Regulations, explores the regulations that underpin every investigation. Archaeologists are expected to follow the correct laws, legislation, standards, guidance and policies to ensure the protection and preservation of archaeological evidence. Forensically, upholding the required regulations helps to ensure the integrity of the investigation, so evidence can be used in a court of law if needed. For those who do not study regulations they can be complicated and confusing, this chapter provides background on domestic and international legal systems and the regulations that affect archaeologists and forensic personnel within the UK.

Chapter 4: Desk-based assessments, discusses the planning of an investigation, and the gathering of information through witness-led approaches, remote sensing, historical records and cartographic analysis.

Chapter 5: Physical alterations, considers how mass graves physically alter the surrounding landscape, the use of visual foot searches and the application of remote sensing to detect these alterations.

Chapter 6: Stratigraphic alterations, examines geological vs archaeological stratigraphy and stratification, geophysical prospection, and the invasive approaches that can be used to confirm the presence of a mass grave and detect geotaphonomic phenomena.

Chapter 7: Chemical alterations, analyses decomposition and the causes of chemical alterations, as well as the use of cadaver detection dogs, thermal imaging and soil analysis techniques to detect these changes.

Chapter 8: Key findings, presents the key taphonomic alterations and techniques for identifying these taphonomic signatures in the form of tables.

Chapter 9: Discussion, draws together everything from each of the previous chapters to summarise the applicability of every taphonomic signature and detection method in line with each of the research objectives.

Chapter 10: Conclusion, answers the overall research question and aim by stating which taphonomic signatures could be used to detect mass graves.

Chapter Two: Mass Graves

The characterisation of a mass grave is highly disputed. Although, the term is regularly discussed in conjunction with the number of individuals it contains (Haglund et al., 2001; Schmitt, 2002; Wright et al., 2005; Wright, 2010; Tyner, 2014; Blau et al., 2018). This debate is evident when comparing the work of Mant (1987), Skinner (1987), Schmitt (2002), Robertson (2007), Jæger (2012) and Guyomarc'h and Congram (2017). Whilst there are overlaps, they all present different interpretations of the subject.

Mant (1987) and Schmitt (2002) argue a minimum of two individuals should be present to classify a mass grave, whereas (Skinner (1987) suggests at least six individuals. In contrast, Jæger (2012) and Guyomarc'h and Congram (2017) imply a minimum of three, to distinguish it from a double or joint grave. Regardless, defining a mass grave solely on the number of people interred within presents inconsistencies and potentially causes smaller mass graves to be misinterpreted or overlooked (Jessee and Skinner, 2005). As such, each researcher does collectively agree that the remains within the mass grave should be indiscriminately placed, tightly packed and often commingled (Mant, 1987; Skinner, 1987; Schmitt, 2002; Robertson, 2007; Jæger, 2012; Guyomarc'h and Congram, 2017). More recently, Klinker and Smith (2020: 4) in the Bournemouth Protocol on Mass Grave Protection and Investigation defined the term mass grave, which is undefined in international law, as a site or defined area containing a multitude (more than one) of buried, submerged or surface scattered human remains, where the circumstances surrounding the death and/or the body-disposal method warrant an investigation as to their unlawfulness.

Having taken into consideration the different definitions of mass graves recorded above, throughout this project, a forensic mass grave will be classified as any burial site containing the bodies of victims who have died as a result of war and/or human rights atrocities, and then placed indiscriminately, disrespectfully and/or deliberately into a grave.

To effectively examine the taphonomic impact of a mass grave, it is first necessary to analyse the following:

- What types of burials are associated with mass graves?

- Examples of mass graves in archaeological and forensic practice.
- What are the recovery rates of mass grave victims?
- What are the reasons for the current recovery rate figures?

The discussion of these points provides background and insight into why more effective ways of locating mass graves are needed.

2.1 Categorising Burials

Whether single or mass, a grave is categorised as either a primary, secondary or sometimes tertiary deposit, internment or burial site (Garland and Janaway, 1987; Haglund and Sorg, 1997; Killam, 2004; Cox et al., 2008; Dupras et al., 2012).

2.1.1 Primary Burials

A primary burial refers to the original internment site, in most mass grave cases, it is the execution site or where the victims are transported soon after death (Garland and Janaway, 1987; Haglund and Sorg, 1997; Roksandic, 2002; Sprague, 2005; Hester et al., 2008; Dupras et al., 2012). The remains will appear jumbled and/or disorganised with evidence of the execution method and smaller bones visible (Mant, 1987; Skinner, 1987; Schmitt, 2002; Jessee and Skinner, 2005). Despite naturally occurring decomposition movement, they will appear articulated and in the correct anatomical position, indicating that since the start of advanced decomposition, they have not been moved (Hester et al., 1975; Roksandic, 2002; Dupras et al., 2012). These key features imply the grave remained undisturbed before the archaeologist’s excavation.

2.1.2 Secondary Burials

A secondary burial is created when decomposing remains are removed from their original resting place and deposited in another location (Ubelaker, 1974; Duday, 1985; Sprague, 2005; Hester et al., 2008; Smits and van der Plicht, 2009). Forensically they are designed to conceal crimes and prevent police/international organisations from finding the remains (Jessee and Skinner, 2005; Jugo and Wastell, 2015). Whilst secondary mass graves are associated with forensic casework, burial pits excavated in Ypenburg (Netherlands) revealed they are also present in archaeological casework (Killam, 2004; Smits and van der Plicht, 2009).

The remains are severely disarticulated and commingled unless deliberately placed anatomically into the new grave, as they are usually transported by heavy machinery (Roksandic, 2002; Jessee and Skinner, 2005). This causes the bones to become fragmented, often only the skull, long bones, and flat bones are present in the new grave because the smaller bones get missed and left behind (Duday, 1978; Killam, 2004; Dupras et al., 2012).

2.1.3 Comparing Primary and Secondary Burial Features

Primary and secondary mass graves have many distinguishable features (Table 1) used to define the type of grave being excavated. Remains in a primary mass grave are likely to be deposited in a disorderly fashion, but will still show articulation, soft tissue and soil staining from decomposition fluids. In secondary mass graves, however, remains will be severely commingled, disarticulated and fragmented, with most of the soft tissue and smaller bones missing. Whilst there are many key differences, they also present similar features, making distinguishing between the two challenging. Due to the large-scale nature of a mass grave, bodies may have been interred at the same time or added into the grave over a specific period before it was backfilled. This, and the victims' position within the body mass, there is likely to be significant variations in the physical, chemical and biological alteration, depending on where the body is positioned within the grave structure.

Table 1: A comparison of the main differences and shared features associated with primary and secondary mass graves.

Primary Features	Secondary Features	Shared Features
Remains are deposited in a disorderly fashion.	Remains are often severely commingled.	Bodies are buried at once or added over a specific period.
The remains are relatively articulated.	Remains are often disarticulated.	Variation in physical changes depends on body position.
Remains are in or near anatomical position.	The remains are unlikely to be in anatomical position.	Variation in chemical changes depends on body position.
Soft tissue may be present.	Bones may be fragmented.	Variation in biological changes depends on body position.
Faster rates of decomposition around the edges of the body mass.	Partial skeletal remains present.	
Slower rates of decomposition in the centre of the body mass.	Soft tissue is likely to be missing.	
Evidence of execution method in or close to the remains.	Disarticulated elements such as smaller bones missing.	
No noticeable disruption to the decomposition of the remains.	The soil and artefacts from the primary site will be mixed with secondary site evidence.	
Soil staining from decomposition fluid.		

Regardless, primary mass graves should not be discerned merely because the remains are in the correct anatomical position. The victims may have been transported during the early stages of decomposition or wrapped in cloth/tarpaulin, preventing the remains from becoming disarticulated during transit (Roksandic, 2002). Therefore, archaeologists also look for putrefaction anomalies within the body mass, as a primary site will show no evidence of disturbed decomposition (Jessee and Skinner, 2005). Meaning both bodies and skeletal remains will be present, whereas a secondary or disturbed burial site will have no clear decomposition pattern.

Categorising the type of burial site is particularly important in forensic casework. It helps archaeologists understand the events that took place, find key evidence and locate further victims buried in other locations. For example, many of the former Yugoslavia mass graves contained deliberately removed remains that were commingled and/or dismembered (Skinner et al., 2003). These are characteristic features of secondary burials, meaning archaeologists needed to work with extreme caution to ensure key evidence does not get missed. Secondary mass graves also contain traces of soil and artefacts from the original gravesite, the analysis of which can lead archaeologists to the original sites and/or link the remains to other previously undiscovered mass graves (Roksandic, 2002; Jessee and Skinner, 2005; Vaduveskovic et al., 2020).

2.2 Examples of Archaeological and Forensic Mass Graves

This section contains a range of archaeological and forensic mass grave examples. Whilst there are many more which could have been researched and written about, the majority of these case studies are referred to in later chapters.

2.2.1 Archaeological Mass Graves

Mass graves are commonly considered a post-World War Two phenomenon, implying they are solely associated with forensic casework (Steele, 2008). Whilst archaeological mass graves are harder to locate and in many cases stumbled upon by accident, there is documented and excavated evidence of them occurring throughout history and prehistory.

Case Study A1 – Neolithic Death Pit: Talheim, Germany

One of the earliest known mass graves was located in Germany during the early 1980s. Known as the Talheim Death pit, the remains have been radiocarbon dated to the Neolithic period (Wahl and König, 1987; Meyer et al., 2015). Although commingled, the skeletons within the 2m deep pit showed signs of being articulated and well-preserved (Meyer et al., 2014; Wahl and Trautmann, 2012). Osteological evidence suggested at least 34 individuals were originally interred within the pit, with all showing evidence of having been killed either from blunt force trauma or arrow wounds, before they were thrown into the grave (Meyers et al., 2014; Meyers et al., 2015).

Case Study A2 – Towton Hall Mass Grave: North Yorkshire, United Kingdom

In July 1996, a mass grave linked to the Medieval Battle of Towton was found by construction workers carrying out ground penetration work at Towton Hall (Fiorato, 2007; Curry and Foard, 2016). The Battle of Towton was fought on March 29th, 1461 by the houses of York and Lancaster, it was considered to be the bloodiest War of the Roses battle, with chronicles reporting 28,000 fatalities (English Heritage, 1995; Sutherland and Schmidt, 2003; Fiorato, 2007; Banton, 2014; Curry and Foard, 2016). Upon discovery, work at the site was stopped and the authorities were altered, once it was determined the remains were not recent nor a threat to public health an application for an exhumation licence was filed with the Home Office under the Burial Act 1857 (Fiorato, 2007: 2). The unexpected discovery of the grave meant the archaeologist's primary aim was to recover the remains as quickly as possible, although they also tried to identify the nature of the grave and its associated features (Burgess, 2007). A 5m x 3m area was excavated, and the remains were located c.45m below the modern deposit (Burgess, 1997; 2007). In total 37 skeletons were recovered, which equates to less than 1% of the reported battle fatalities. However, people who died in battle were often initially buried on the battlefield and later moved to consecrated grounds (Curry and Foard, 2016). Suggesting this particular site could be a primary burial that was missed or a secondary site the remains were later placed in.

Case Study A3 – Thornton Abbey Black Death Plague Pit: North Lincolnshire, United Kingdom (Willmott et al., 2020; 179-196).

More recently, a mass grave related to the Black Death was found at Thornton Abbey by a team of archaeologists from the University of Sheffield, who were conducting geophysical and topographical surveys, and targeted excavations of the Abbey. Results from a resistivity survey revealed a high-resistance feature, which was initially believed to be the site of a subsidiary post-medieval structure. Upon opening a trench, it was found to be a grave containing human remains. Whilst a cut feature, such as a grave, would normally create a low-resistance anomaly, the combination of sandy soil, the density of bodies and the ease with which water could drain through caused the high-resistance reading. The sandy soil also made the grave cut initially difficult to make out and caused poor bone preservation. In total 48 individuals were excavated from the site, whilst they were buried in a single layer, the eight rows overlapped and became more compact together towards the western section of the grave.

2.2.2 Forensic Mass Graves

Case Study F1 – San Vincente Cemetery Mass Grave: Córdoba, Argentina (Olmo et al., 2016: 321-331)

The existence of San Vincente came to light in 1984, when a letter was sent to Comisión Nacional Sobre la Desaparición de Personas (CONADEP). Under the orders of the Federal Judiciary, cemetery personnel excavated the suspected section with bulldozers, disregarding the correct way to recover and handle remains/evidence. A mass grave containing an undetermined number of skeletons was destroyed and the recovered bones were cremated. The disappointing outcome, the Judiciary's lack of interest, and the laws which limited the capacity to prosecute the perpetrators meant the case was subsequently shelved. In the early 2000s, Congress prevented the implementation of laws that would grant immunity to lose accused of crimes against humanity. At the same time, the Judiciary accepted the lawsuits filed by relatives of the missing, allowing the Córdoba's Federal Court to reopen the case.

Conformation of the mass grave's existence was approved by the Argentine Forensic Anthropology Team (EAAF). Through the use of witness testimonies, which confirmed the 1984 excavation, work began in Sector C to locate the grave. Aerial photographs were also used to confirm no burials had been carried out in the area before 1974. After the initial 11 trenches yielded no remains, the excavation was moved east of trench 11. This area was named 'North Front', the first layer of the grave contained the remains of 19 individuals (estimated burial: July 1976), and 30cm below this layer were a further 72 skeletons (estimated burial: April 1976).

Case Study F2 – Guadalajara, Castilla La Mancha Mass Grave (Owens, 2021:100156)

In 2017, 24 victims were recovered from 'Collective Grave 1' in a walled-off area in the southwestern corner of Guadalajara Municipal Cemetery. The grave was approximately 3m deep and orientated southwest to northeast. All remains showed good osteological preservation, were fully skeletonised and laid in an extended position. Each skeleton was superimposed, either through direct contact or separated by a thin layer of soil, there was no indication of the victims having been tied up or blindfolded and very few personal possessions. Two sets of remains had legs in disarray, and six has sprawled arms, indicating the bodies were dropped/thrown into the grave rather than carefully placed.

Currently, in Spain, there is no access to government funding, nor support for the excavation and identification of victims, due to the lack of acknowledgement of the civil war. Although the Law of Historical Memory was enacted in 2007, removing all public symbols and monuments associated with Francoism from public spaces, very little has been done to recover the victims. In 2000, the Asociacion para la Recuperacion de Memoria Historica (ARMH) was founded. Funded by international and private bodies, around 153 excavations and 1,330 remains were recovered between 2000 and 2012, which is a fraction of those suspected to be missing.

Case Study F3 – Tomašica Mass Grave: Prijedor, North of Bosnia (Salihbegović et al., 2018: 234-235; Fournet and Groningen, 2020: 23-31).

The Tomašica mass grave is considered the largest European mass grave since the Second World War, stretching over 5,000m^2 and 10m deep. The site was investigated three times between 2000 and 2006, with little found. A final excavation took place in September-November 2013, uncovering the full extent of the area. Conducted by the Bosnian Institute of Missing Persons with the assistance of the International Commission on Missing Persons (ICMP), the exhumation and subsequent post-mortems were authorised by the Prosecutor's Office of Bosnia and Herzegovina, to establish the cause of death and obtain evidence of a potential war crime. Upon discovery of the grave, the Prosecution under Rules 73, 85 and 89 of the Tribunal's Rules of Procedure and Evidence requested the case against Radovan Karadžić be reopened so any new evidence could be introduced.

Four hundred sets of remains were recovered 10m below the surface in clay and iron-rich soil. Of the remains, 275 were complete and 125 were partial. The true number of victims originally interred in the grave was complex, as it was excavated (robbed) in 1993 when a large number of remains were removed and placed in secondary mass graves. This conclusion was drawn as the grave showed signs of machine tool marks, consistent with heavy machinery, it was estimated that 30-40% was disturbed before the investigation. Investigators were also later able to link the Tomašica mass grave with a secondary site in Jakarina Kosa. The remains were well preserved, whilst many were completely or largely skeletonised, a substantial amount still had skin, soft tissue and internal organs. The majority also showed evidence of gunshot injuries either to the head, chest or both.

2.2.3 World War One and World War Two Mass Graves

At the start of this project, the boundary between archaeological and forensics was established as 100 years. Following that timeframe means mass graves associated with World War One (WW1) would be classed as archaeological, whilst World War Two (WW2) mass graves are still within the forensic boundary. From a legal perspective, in some countries, WW1 and WW2 casualties fall under the remit of the archaeological framework, whilst in others, a forensic legal framework is referred to (Márquez-Grant et al., 2021). Given this grey area and the complexity of defining it as archaeological or forensics, within this research, they have been categorised separately.

Case Study WW1 – Battle of Fromelles, 1916 Pheasant Wood Mass Grave (Loe et al., 2014: 1-87)

A joint operation between the Australian Imperial Force and the British Army, the Battle of Fromelles took place on the 19th/20th of July 1916 and resulted in 5500 Australian and 1500 British casualties, of which 2000 Australians and 500 British died. Eight mass graves were dug by the Germans near Pheasant Wood, Fromelles, Northern France. Although the battlefields were searched and the recovered bodies buried in Commonwealth War Graves Commission (CWGC) cemeteries after Armistice in 1918, those buried in Pheasant Wood went undiscovered.

In May 2009, Oxford Archaeology carried out the excavation and analysis of 250 soldiers buried in unmarked graves at Pheasant Wood. Undertaken on behalf of the CWGC acting for the Australian Department of Defence and the UK Ministry of Defence, the project team was comprised of 30 specialists and consultants, many of which had mass graves excavation experience. Throughout the excavation, a forensic chain of custody approach was maintained. All remains and artefacts had to be signed for whenever they were moved. Only authorised personnel could enter the graves, all of which were covered by tents. The compound itself was handed to security every night and was inspected every morning for signs of grave disturbance. Site evidence logs and strict protocols were followed, and all evidence was also signed over to the mortuary manager at the end of each day and kept under lock and key.

Aerial photograph's taken after the battle revealed evidence of eight negative features dug in two parallel lines at the edge of Pheasant Wood. Photos taken before the 19th of July 1916 showed no sign of these features, whilst photos taken after the 23rd of July 1916 did. References to the mass graves were also recorded in a letter written at the time and in a soldier's memoirs. The 21st Bavarian Reserve's war diary, held in a Munich Archive, also contained detailed instructions for burying the 'English' dead in mass graves south of Pheasant Wood. At the site, topography, geophysics, ground penetrating radar (GPR), and metal-detecting surveys confirmed the existence of the eight features. Test excavations were then conducted to confirm the presence of the graves and that the remains interred within were Australian and British soldiers.

In total, eight graves were excavated over four months, these graves were approximately 10m by 2m, and between 1.57m and 0.98m deep. Five of the graves contained 44-52 individuals buried in two layers, two graves contained no individuals, and one grave contained just three individuals lying one on top of the other. Once the graves were pedestalled, all bodies and artefacts were removed stratigraphically and following the sequence of procedures recommended by Cheetham et al., (2008). Per French law, the first exposed bodies were witnessed and signed off by the local gendarmes (police). Along with the remains and artefacts, lumps of chalk and lime, groundsheets and cables were also discovered within the graves. The presence of fly pupae indicated the bodies were either buried or the graves were backfilled 5-10 days after the battle took place.

At the time of publication, 144 Australian soldiers have been identified. Of the remaining 106, 75 are considered to have served in the Australian Army, two in the British Army, and 29 are unknown.

2.3 Recovery Rates of Mass Grave Victims

Across archaeological and forensic casework the existence of accurate records depicting the number of missing people is limited (Tabeau and Bijak, 2005). Archaeologically, records are likely to have been lost, not recorded or exaggerated. Medieval battles provide key examples of this, the chronicles recording the battles predominantly exaggerated the number of dead, particularly on the losing side; this was done to claim the winning side has a bigger, more impressive victory (Sutherland, 2009). Forensically, the most recorded number of missing people is the result of armed conflict and/or human rights atrocities, which have been investigated through tribunals and prosecutors. However, data verification is not always possible, which often results in the records being incorrect (Leitenberg, 2006; Hanson, 2016). The figures relating to the number of missing people are rarely collected by a neutral party, there is often an underlying agenda causing statistics to be too high or too low (Leitenberg, 2006; IOM, 2014). Data compiled by Human Rights groups are often higher than official figures, to have a bigger impact on their target audience. They also have different criteria when recording missing people, some figures only include combatants, whilst others also include civilians, altering the data. Authorities are also more reluctant to acknowledge/conceal information regarding civilian deaths/missing to avoid prosecution (ICRC, 2006).

2.3.1 Archaeological Recovery Rates

Due to the reasons stated above, archaeological recovery rates cannot be calculated. Whilst in the case of many medieval battles the chronicles recording it exists, there is no way of knowing if the figures are correct or exaggerated by the winning side. The comparison between three archaeological mass graves and three forensic mass graves (Figure 1) suggests they contain significantly fewer victims that their forensic counterparts.

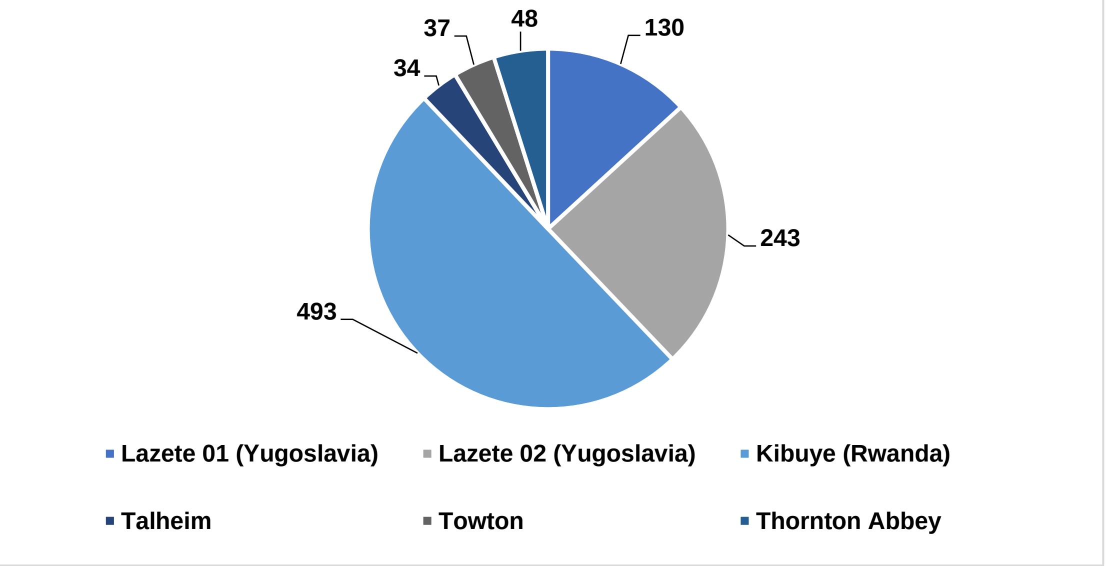


Figure 1: Comparison of the number of remains recovered from three archaeological mass graves

and three forensic mass graves (Data collated from Haglund et al., 2001: 62; Meyers et al., 2014: 313; Jugo and Wastell, 2015: 157; Willmott et al., 2020: 183).

2.3.2 Forensic Recovery Rates

The scale and nature of forensic mass graves mean victims can be buried for a matter of months, years, or decades; as most investigations take place many years later and/or last for many years (Hanson, 2016). Initially, victim recovery rates are often high and subsequently drop with each passing year. This is evident in Figure 2, although the recovery rate in Cyprus follows a natural rise and fall trend, the number of victims found each year has significantly dropped particularly since 2015. This decrease in recovery rates could be due to several reasons, such as the reduction in the number of witnesses and their fading memories of the event, environmental changes, and the building of infrastructure on potential gravesites (Abate et al., 2019).

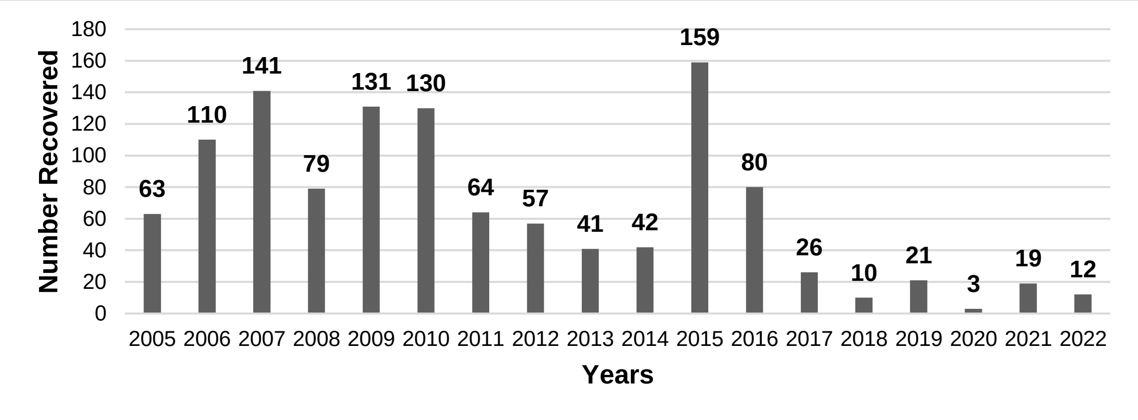


Figure 2: The mass grave victims recovered by the Committee on Missing Persons in Cyprus (CMP) between 2005 and 2022 (Data collated from CMP, 2022).

Although determining the exact number of people originally buried within a mass grave is difficult, recovery rates can be calculated using the overall number of missing people and the number of remains already recovered. Figure 3 presents the number of missing for six different countries, Argentina (20,000), Colombia (45,154), Cyprus (2,002), Iraq (300,000), Spain (114, 226), and the former Yugoslavia (40,000) (Hernandez, 2013; Soendergaard, 2013; Sarkin et al., 2014; UN Human Rights Council, 2014; Hanson, 2015; CMP, 2022). These figures are relatively broad due to the size of the country and the length of time the conflict lasted, the total number of missing in Iraq is also likely to be higher than what is recorded here, as the data was collected in 2015.

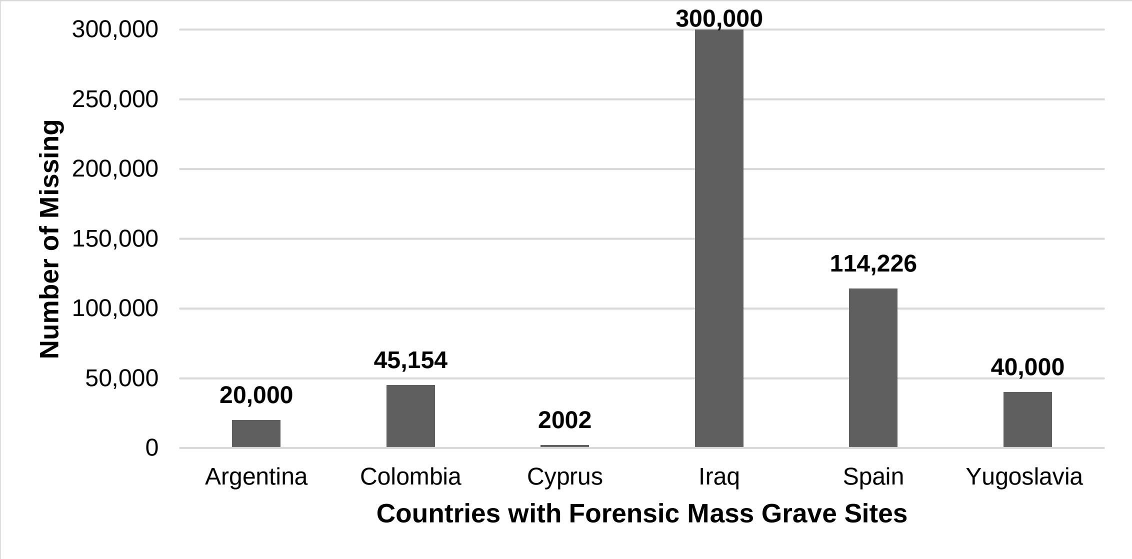


Figure 3: People missing as a result of conflict and/or human rights atrocities in Argentina, Colombia, Cyprus, Iraq, Spain, and the former Yugoslavia (Data collated from Hernandez, 2013; Soendergaard, 2013; Sarkin et al., 2014; UN Human Rights Council, 2014; Hanson, 2015; CMP, 2022).

Despite mass grave investigations lasting for many years, forensic teams are often only able to recover a small percentage of those reported missing (Hanson, 2016). The data presented in Figure 4 highlights the number of victims recovered from Argentina (as of 2013), Colombia (as of 2013), Cyprus (as of 2022), Iraq (as of 2015), Spain (as of 2020), and the former Yugoslavia (as of 2014).

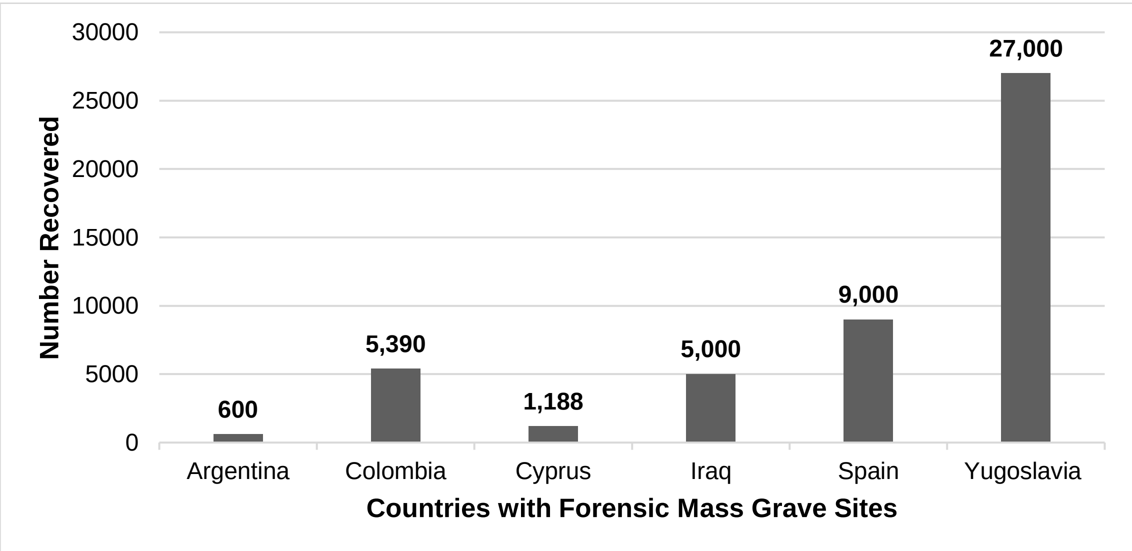


Figure 4: Victims recovered from mass graves in Argentina, Colombia, Cyprus, Iraq, Spain and the former Yugoslavia (Data collated from Hernandez, 2013; Soendergaard, 2013; Sarkin et al., 2014; Hanson, 2015; Medina, 2020; CMP, 2022).

Whilst the majority of the data above is not up-to-date, Figure 5 clearly shows that the recovery rate of mass grave victims is incredibly low. Particularly when looking at the recovered percentages for Argentina (3%), Colombia (12%), Iraq (2%), and Spain (8%). Although the rates of recovery are significantly higher in Cyprus (59%) and the former Yugoslavia (70%) there is still a long way to go before all the victims are recovered.

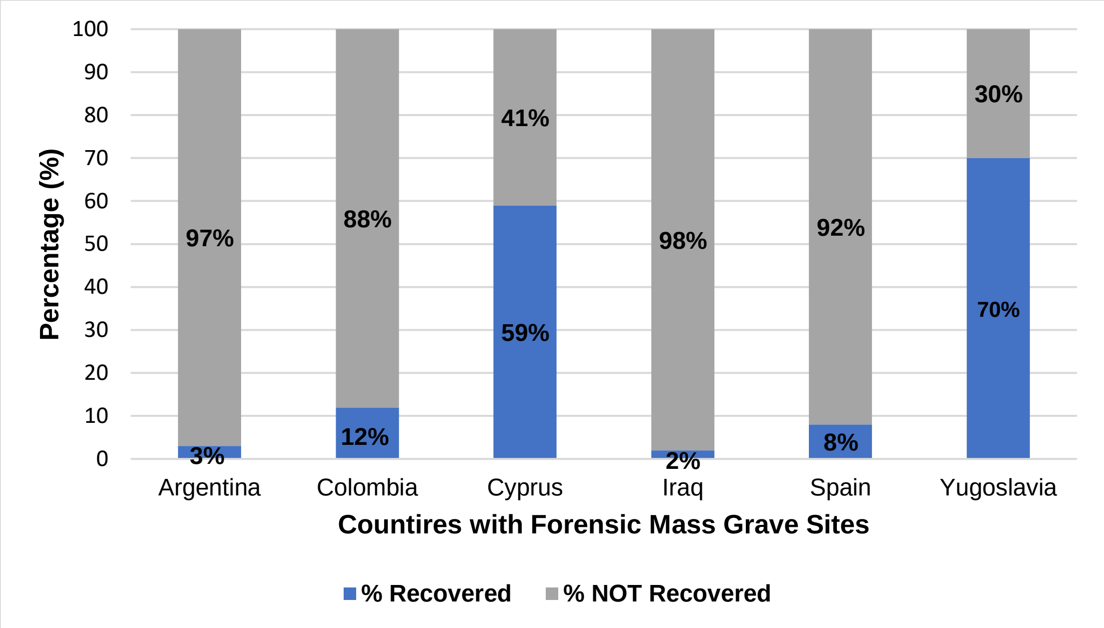


Figure 5: Percentage of victims recovered compared to the percentage not yet recovered (Percentages calculated from data recorded by Hernandez, 2013; Soendergaard, 2013; Sarkin et al., 2014; UN Human Rights Council, 2014; Hanson, 2015; Medina, 2020; CMP, 2022).

Skinner (1987) argues locating mass graves is relatively easy because of the number of potential informants and available equipment. When considering the results of Cyprus and the former Yugoslavia, this view could be deemed true. However, when plotted against the recovery rate for the other countries, their figures could be perceived as anomalies, due to them being so significantly higher. One area that needs to be considered is why some countries have such low recovery rates. A reason for this is that finding mass graves, particularly large-scale ones, is not a simple process. Indeed, Hanson (2016) highlights that Cyprus and the former Yugoslavia's higher recovery rates are the result of considerable resources and money, they have received to help identify, recover and investigate their mass graves.

However, this is not the only reason recovery rates of mass graves are low. The nature of each site also has an impact because a large-scale gravesite situated within vast remote areas will be harder to find than a smaller grave located in a domestic space. This could explain why the recovery rates for Iraq are so low, the desert nature of the decomposition sites means the grave could be anywhere within the vast open landscape, making it harder to pinpoint an exact location. There is also less likely to be a significant landmark within the desert, which could impact using witness testimonies when narrowing it down as everything is likely to look the same or similar.

Nevertheless, this explanation does not account for the low figures of Spain and Argentina as many of their mass graves already located have been found within cemeteries as unmarked graves. Examples of this can be seen in Case Study F1 (pg. 25) for Argentina and Case Study F2 (pg. 25-26) for Spain. Those working on recovering the Spanish civil war mass graves also do not have access to government funding, nor do the government support the efforts to excavate and identify the victims, hindering the recovery process.

Although the contextual nature of the mass grave needs to be taken into consideration when considering the low victim recovery rates; evidence suggests that the higher rates of recovery are linked to forensic teams having access to resources and funding. This assumption can be backed by Puerto and Tuller (2017: 223) who state that recovery rates are often low because of the shortage of experts who can aid investigations; limited facilities and equipment that can effectively deal with large-scale mass graves; a lack of experts who have first-hand experience of large-scale operations; lack witnesses who know where the graves are/willing to say; a lack of funding provided by governments and/or organisations to help with the investigation.

2.4 Conclusion

As a result of the low recovery rate for mass grave victims, this research into the subsoil and landscape changes of mass graves must be undertaken. Cheaper, more effective and less time-consuming methods that can effectively locate large-scale mass graves need to be found to ensure more families are provided with answers to what happened to their loved ones. Examining archaeological mass graves alongside their forensic counterparts can provide empirical knowledge of how the subsoil and surrounding landscape of a mass gravesite change over time, which could help inform forensic practices.

Chapter Three: Regulations

Collectively known as regulations; laws and legislation, and standards and guidance, make up an important part of both fieldwork and forensic investigations. Archaeologists locating, recovering and examining gravesites and human remains require awareness and understanding of the current regulations, particularly concerning the sensitivities surrounding human remains (Shelbourn, 2013). However, for those who have never studied or know little about them, regulations are confusing, partly because they are continuously being developed (Denham, 1983; Slapper and Kelly, 2014). The number and type of regulations that need upholding is also dependent on the casework being archaeological or forensic, domestic or international (Carman, 2012; Carman, 2014). Regardless, archaeologists are subject to strict regulations.

Archaeologically, cultural heritage and historic environments are fragile and valuable resources that need managing to ensure their protection (Watkins, 1999; Soderland and Lilley, 2015; CIfA, 2021). Even stricter are the constraints which surround how human remains are treated and studied within established research frameworks (Mays, 2017). As a result, a balance between preserving archaeological evidence and improving knowledge, through excavations and other destructive processes, needs to be maintained (Mays, 2017; CIfA, 2021). Archaeologists should weigh up the short and long-term pros and cons before proceeding with an investigation because failing to uphold any regulation could lead to the destruction of artefacts, incorrect recording, loss of historical data, and the potential for the archaeologist to lose their accreditation and professional standing within the field.

Forensically, the same level of care and consideration is followed. However, greater significance is placed on recording sites and remains correctly, as mistakes can jeopardise the investigation’s integrity and may prevent evidence from being used in court (Galloway et al., 1990; O’Connor, 2012). Greater emphasis is also placed on having an awareness of the legal system in the country they are working in, as the wrong procedure can cause evidence to be classified as inadmissible in court (Dilley, 2005). The late 1990s peacekeeping mission in Kosovo provides a great example of this. The mission was the first task force that gave United Nations (UN) police executive powers to arrest and interview alleged criminals linked to the Kosovo War (Friesendorf, 2012;

O'Connor, 2012). However, Kosovo's legal system requires an investigating judge, not a police officer to conduct interviews, causing already obtained evidence to become inadmissible in court and subsequently harmed the investigation (O'Connor, 2012). The UN police were unable to use already gathered evidence against the alleged criminals at trial. Whilst this example is not directly referring to archaeological casework, it identifies the importance of having a basic awareness of local regulations.

As such, this chapter sets out to provide archaeologists with a basic understanding of domestic legal traditions, the UK legal system, the international legal system, and the regulation most likely to affect them during archaeological and forensic casework in the UK.

3.1 Domestic vs International Legal Systems

Every country has a Domestic Legal System (DLS), which has been adapted from well-established historical legal traditions. However, these variations mean investigations are handled differently depending on the country. For example, in some countries, police carry out criminal investigations, whilst, in others, they are conducted by investigating judges. Whereas, International law is an entirely separate and relatively modern legal system, which has primarily expanded since the end of the Second World War. The International Legal System (ILS) has two main branches, the International Court of Justice (ICJ) and the International Criminal Court (ICC). This section focuses on the differences between domestic legal traditions, the legal system of the United Kingdom (UK) and ILS. Although there is not an in-depth reference to other international domestic systems, they have been referred to in the case studies presented in Chapter Two.

3.1.1 Domestic Legal Traditions

Legal traditions underpin every country's legal system; they are deep-rooted historical attitudes which form the nature, organisation and operation of modern law, its role within society, and how the law is made, studied, perfected, taught and applied (Merryman, 1969: 2; Merryman and Pérez-Perdomo, 2007; Duve, 2018).

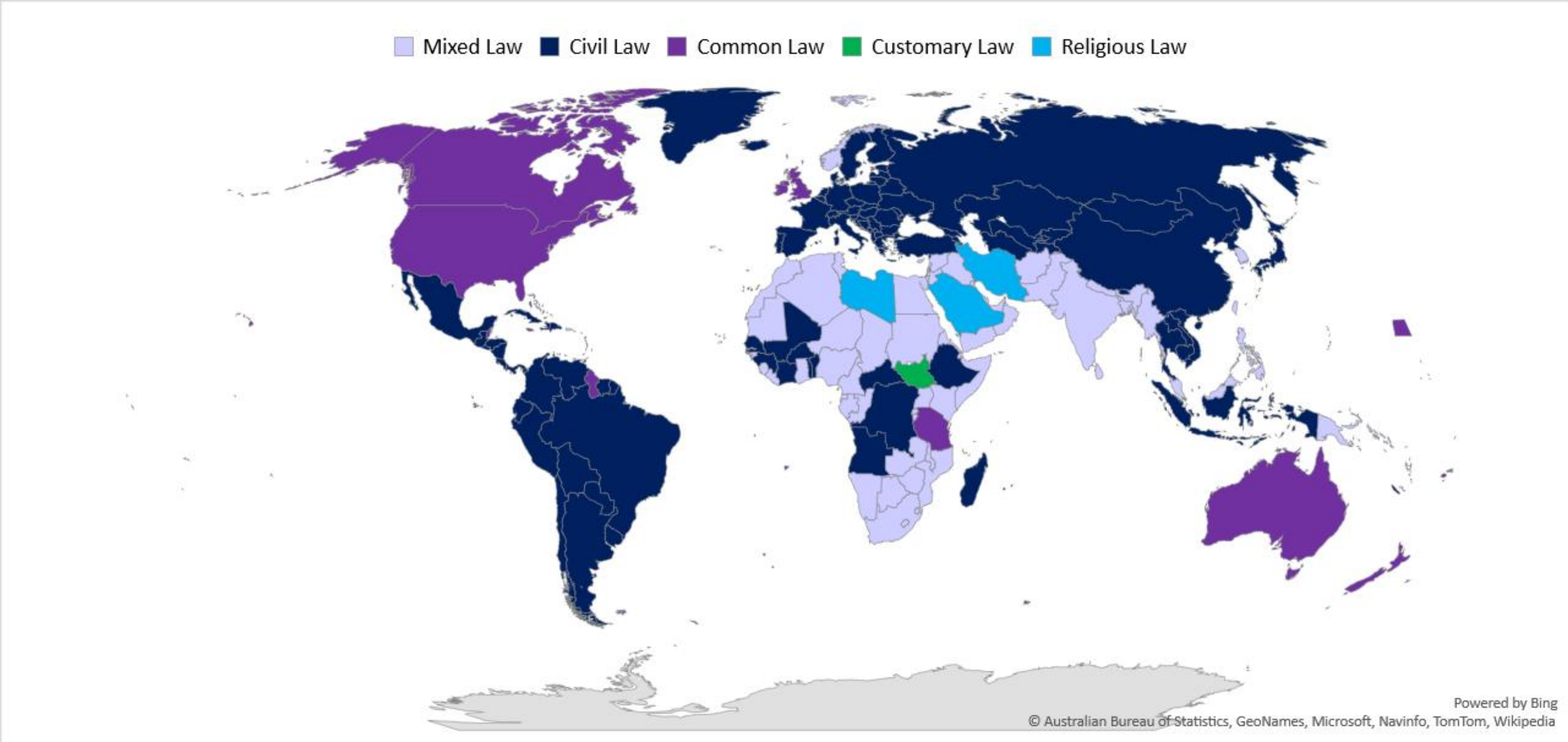


Figure 6: World map showing which countries use Common, Civil, Customary, Mixed and Religious Law (Data Collated from the CIA, 2022).

There are five main legal traditions used worldwide (see Figure 6 above), Civil Law, Common Law, Customary Law, Mixed Law and Religious Law. Across 255 countries, islands and territories, Figure 7 established that the most widespread legal tradition is Civil Law, followed by Mixed Law and Common Law. Less common are Religious Law and Customary Law.

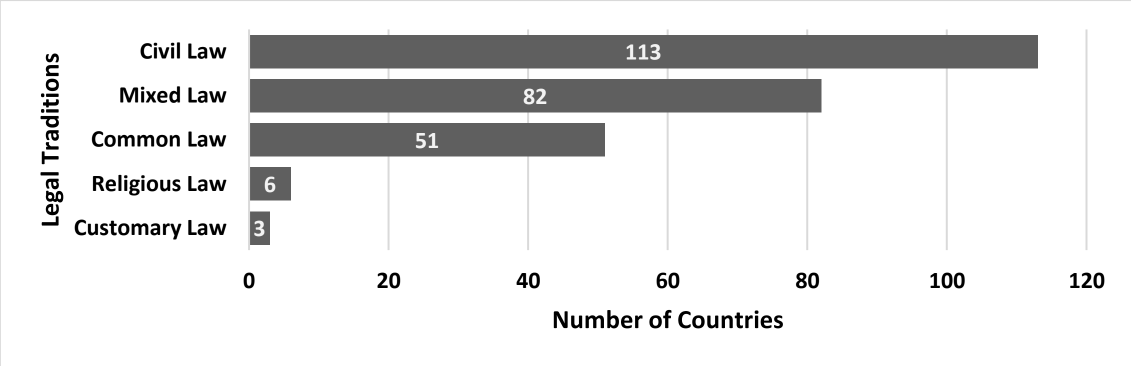


Figure 7: The number of countries following each legal tradition (Source: Author).

The Common Legal Tradition

Common Law was formed as a direct result of the 1066 Norman Conquest, although Anglo-Saxon law remained the dominant system in England until around the mid-12th century (Plucknett, 1956; Dainow, 1967; Milsom, 1981; Denham, 1983; O'Connor, 2012; Slapper and Kelly, 2014; Brouwer, 2018: Baker, 2019; Gow Calabresi, 2021). Under this system, the people of England were able to sit in court as members of the jury, because people were illiterate, the trials were predominantly verbal events; something which can still be seen in court today (O'Connor, 2012; Baker, 2019). Since its establishment, Common Law has spread throughout the world to numerous countries, including those listed in Table 2 below, all of which were at one point part of the British Empire. Many of them remain members of the Commonwealth, today.

Table 2: Countries following the Common Law legal system (Data collated from O'Connor, 2012; Gow Calabresi, 2021).

Australia	Botswana	Canada
Gambia	Ghana	India
Ireland	Israel	Kenya
Malawi	New Zealand	Nigeria
Pakistan	Sierra Leone	Somalia
South Africa	Tanzania	Uganda
United States of America	Wales	Zambia
Zimbabwe	Caribbean Islands	

Laws controlling cases are based on case-by-case legal benchmarks, developed by legislation and judges (Palomares, 2014). Meaning legislation is not the only source used to decide case outcomes, rather, principles of law developed during past key cases also bind judges' rulings in future trials (Dainow, 1967; Embley et al., 2020). Defence and prosecution teams argue a case before a judge and a panel of 12 jurors, and the jury, made up of people with no legal training, decides whether the facts presented are enough to give a guilty verdict (Corrado, 2010; Baker, 2019). In short, rulings are given by the jury, whilst the judge decides how the law is applied to ensure the sentence fits both the verdict and the committed crime.

The Civil Legal Tradition

Civil Law is the oldest and most widely spread legal system, having developed from Roman Law (Dainow, 1967; Cueto-Rua, 1977; Denham, 1983; O'Connor, 2012; Palomares, 2014; Slorach et al., 2017; Brouwer, 2018). However, it took much longer to spread than Common Law did. It didn't develop beyond Europe until European countries began colonising Africa, Asia, the Middle East and South America (O'Connor, 2012; Brouwer, 2018). Formed from a combination of cultural, ideological, political, technical, economic, and scientific elements Civil Law is an inquisitorial system (Cueto-Rua, 1977: 645; Corrado, 2010; Slorach et al., 2017). Therefore, an investigating judge gathers evidence, questions witnesses and the defendant, and presents all findings to the trial judges (Hodgson, 2005; Roberson and Das, 2008).

The Mixed Legal Tradition

Mixed Law, also known as Hybrid Law, is formed when two or more legal traditions operate within one legal system (Tetley, 2000; Palmer, 2007; Jousten, 2010; Siems, 2018). There are a variety of different combinations, including but not limited to Common and Religious Law, Civil and Religious Law, Civil and Customary Law, Common and Customary Law, Religious and Customary Law, and Common and Civil Law (Du Plessis, 2006; Palmer, 2012). Due to this, the patterns of law each country follows are numerous, this means there is often no common origin between nations and the application of law (Zartner, 2014; Siems, 2018). The majority of countries which use Mixed Law can be found in Africa, areas of the Middle East, and South and Southeast Asia; it stems from past invasions and colonisation (Jousten, 2010; Zartner, 2014; Siems, 2018).

The Religious Legal Tradition

Islamic, Hindu and Jewish Law are the main religions that fall under Religious Legal Traditions (Siems, 2018). The oldest and most commonly used of these is Islamic law, which is based on the divine teachings recorded in the Qur'an (Jousten, 2010; Zartner, 2014). Religious Law originated in the Arabian Peninsula, over the last century its influence has spread into regions of Northwest India, Central Asia, North Africa and the Iberian Peninsula (Jousten, 2010). Although moral obligations and religious duties vary between religions they all encompass a wide range of principles and teachings, grounded in religious texts (Shinar and Su, 2013). As such, religious courts view their authority as originating from a religious standardised system, which often prevents them from diverging from Religious Law (Scolnicov, 2006). Therefore, Religious Traditions are primarily based on very different ideas from that of Common and Civil Law, this is because scriptures like the Qur'an are divinely viewed and cannot be amended by legislators or set aside by judges (Jousten, 2010; Zartner, 2014).

The Customary Legal Tradition

Customary Law is based on the four other legal traditions used by nations across the globe (Chirayath et al., 2005; Tobin, 2011; Glenn, 2014). It is a set of principles, open to negotiation, that over time have been accepted and adopted as social norms (Tobin, 2011; Hinz, 2012; Shears-Moses, 2013). Customary Law is said to have emerged during the colonial era, as a tool for controlling a nation's resources (Berat and Gordon, 1991). However, it played an important role in the laws of a community and/or group long before this, although the law was never written down (Young, 1994; Siems, 2018). Whilst many nations use Customary Law in conjunction with other legal systems, today, only three countries rely solely on Customary Law; these are Guernsey, Jersey and South Sudan.

3.1.2 The Legal System in the United Kingdom

The UK is formed from the political union of England, Wales, Scotland and Northern Ireland. However, it does not operate under a single legal system due to the different geographical combinations (e.g. the British Isles includes the Channel Islands) (Boylan-Kemp, 2014; Wilson et al., 2016; Gillespie and Weare, 2021). England and Wales operate under one system, whilst Scotland

and Northern Ireland have completely separate systems and powers to create and apply legislation in their regions (Bailey et al., 2007; Boylan-Kemp, 2014). Despite their structures and systems being different, all UK courts deal with two branches of law, criminal and civil law.

The criminal justice system operates within the boundaries of criminal law, to decide who is guilty or innocent of a crime and establish a punishment that fits the nature of the committed crime (Sanders et al., 2010; Slorach et al., 2017; Monaghan, 2020; Allen and Edwards, 2021; Gillespie and Weare, 2021). Therefore, its purpose is to preserve public order, protect members of the public from offensive and injurious acts, and safeguard them from exploitation and corruption (Thomas, 2020). By setting the standard of behaviour that is expected to be followed, and presenting the conditions under which offenders are reprimanded (Monaghan, 2020; Herring, 2021). Padfield (2014: 3) and Thomas (2020) state that the UK criminal justice system:

- Enforces moral values
- Punishes those who deserve to be punished
- Protects the public from harm
- Reforms offenders
- Deters offenders/potential offenders
- Educates people about appropriate conduct and behaviour
- Protects vulnerable people from exploitation and corruption
- Protects individual rights and liberties
- Maintains public order
- Enforces legal rules and order
- Regulates human behaviour and relationships

Unlike the criminal justice system which deals with public law, the civil justice system encompasses public and private law. Private law refers to the relationship between individual people, whereas, public law concerns the relationship between an individual and the state (Cownie et al., 2013; Slapper and Kelly, 2014; Gillespie and Weare, 2021). It is commonly thought that civil disputes are resolved in court, however, they are more likely to be settled outside of the courtroom. The civil justice system simply provides individuals with the opportunity to find a resolution for disputes, by reimbursing or compensating the victim (Harris, 2007; Finch and Fafinski, 2017; Wilson et al., 2020).

Whilst there are differences between the criminal and civil justice systems, the boundaries between the two branches have become increasingly blurred and interlinked (Sanders et al., 2010; Jefferson, 2015). Although civil courts wait for criminal proceedings to be concluded and the defendant sentenced, civil law plays a part in criminal law by compensating the victims for their loss (Sanders et al., 2010; Slorach et al., 2017).

The Court System of England and Wales

All criminal cases start in the Magistrates Court (see Figure 8), and each case is presided over by two or three volunteers known as Justices of Peace or Magistrates (White, 1999; Slapper and Kelly, 2014; Wilson et al., 2016; Partington, 2019). Two different types of trials take place within this court. The first is the *summary trial*, these are minor criminal cases (i.e. common assault or traffic offences), which result in less serious sentences such as fines or community service (Kiralfy, 1990; Slapper and Kelly, 2014). The second is the pre-trial stage of a full criminal trial and is the first time a defendant appears before the court. Known as the *sending for trial*, Magistrates check the evidence is sufficient for the defendant to answer for their crimes and then send the case to the Crown Court (Partington, 2019). Within the Crown Court, all cases take place in front of a single judge and a panel of 12 jurors (Wilson et al., 2016). The prosecutor and defence barristers each give an opening statement, present evidence, examine and cross-examine witnesses and expert witnesses, and finally a closing statement (Boylan-Kemp, 2014). Members of the jury deliberate and give the verdict of either guilty or not guilty based on the evidence and testimonies they have heard throughout the trial. If the defendant is found not guilty then the judge dismisses the case. Should they be found guilty then the judge passes a sentence that matches the crime that has been committed. The role of archaeologists and/or anthropologists within the Crown Court is to appear as expert witnesses should they be called upon to present the findings of their investigation to the court.

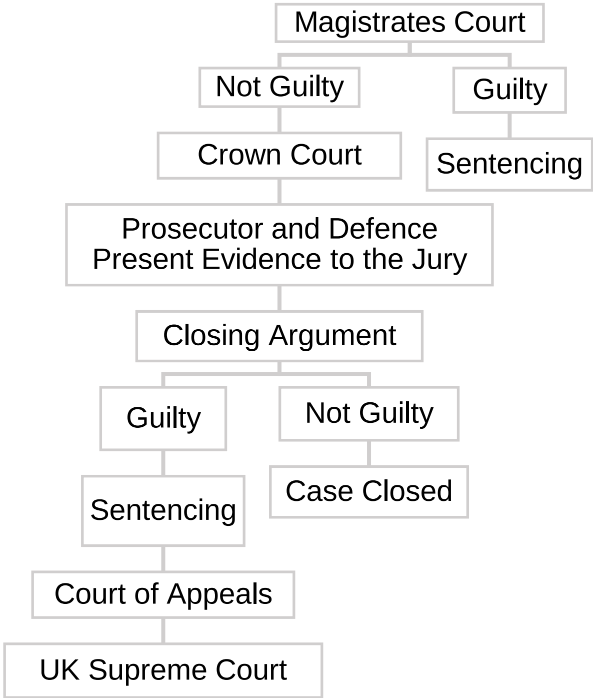


Figure 8: Criminal court structure in England and Wales (Source: Author).

Depending on the type of case, civil cases start in one of three courts, Magistrates Court, County Court or Family Court (see Figure 9). The County Court has the most jurisdiction over civil complaints requiring the High Court, it also provides locally accessible mediation for small-scale litigation such as small claims (Ward and Akhtar, 2011; Slapper and Kelly, 2014; Partington, 2019). The next stage is the High Court, which is divided into three divisions, the Queens Bench, Chancery and Family division (Boylan-Kemp, 2014; Slapper and Kelly, 2014; Partington, 2019). The Queens Bench deals with both criminal and civil cases, although its main role is to preside over cases referring to contract and tort law (Ward and Akhtar, 2011; Darbyshire, 2014). Whilst the Chancery division works on a wide range of civil cases such as mortgages, trusts, bankruptcy, insolvency and patents, to name but a few (Ward and Akhtar, 2011; Wild and Weinstein, 2013; Darbyshire, 2014). Finally, the Family Division deals with cases related to children under the Children Act 2004 such as adoption, guardianship, wardship, and family property (Martin, 2007; Wild and Weinstein, 2013; Darbyshire, 2014).

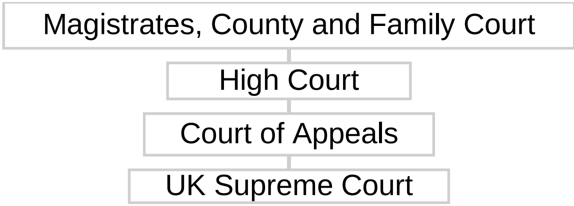


Figure 9: Civil court structure in England and Wales (Source: Author).

The Court System of Northern Ireland

The Northern Ireland court structure (Figure 10) is closely linked to the court structure used in England and Wales (Dickson, 2004; Goodall, 2004). Although the legislation is different, all criminal cases start in the Magistrates Court, with the most serious cases then being sent to the Crown Court (e.g. murder and manslaughter). Whilst the majority of civil cases also start in either the Magistrates or County Court, the main difference is the Enforcement of Judgements Office which enforces all civil cases related to the recovery of money, goods, and property of the court (Goodall, 2004; Department of Justice, 2021).

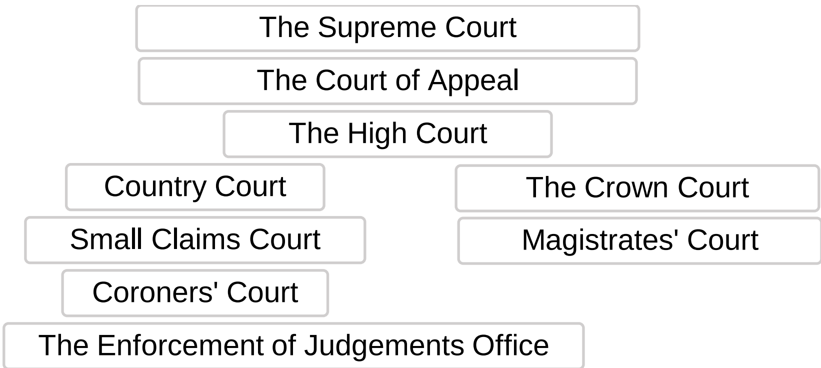


Figure 10: Court structure for Northern Ireland (Information obtained from Judiciary NI, 2021).

The Court System of Scotland

The Scottish legal system operates completely separately from the rest of the UK in terms of its court structure and legal tradition, as a hybrid system, it is comprised of both Common and Civil Law (Reid and Edwards, 2009). Civil courts in Scotland include the Sheriff Court, the Outer House of the Court of Session, the Inner House of the Court of Session and the House of Lords (Marshall, 1999). Where possible most civil cases are settled outside the court, as litigation is a slow, expensive and uncertain process (White and Willock, 2003). Criminal courts on the other hand include the District Courts, Sheriff Courts, the High Court of Justiciary (Trial) and the High Court of Justiciary (Appeals) (Marshall, 1999). Criminal cases are divided into two jurisdictions;

solemn cases which are tried on indictment and *summary cases* which are tried on the complaint and take place in front of a single sheriff or magistrate (Walker, 1981).

3.1.3 The International Legal System

International law, also known as public international law, is deeply rooted in history. It can be traced from Ancient Greece and Rome, through the Middle Ages, to the present day (Kaczorowska-Ireland, 2015). The modern form of international law developed after the French invasion of Italy in 1494, since then, nations have characterised the principle of international law as a balance of power and diplomacy between countries (Fassbender and Peters, 2012). In short, international law is a collaboration of agreements in the form of customs and treaties, which provide a framework for the order and stability of relationships between nations (Higgins, 1994; Watts, 2001; Gardiner, 2003; Baber and Bartlett, 2011).

The Development of International Criminal Law

The most influential event that first led to the development of International Criminal Law (ICL) was piracy, which in this context, refers to a broad range of violent acts that took place on the high sea (Simpson, 2007; Fichtelberg, 2008; Zou, 2009; Samuels, 2010). Piracy was considered a unique criminal problem because no single nation owned (or still does own) the oceans, meaning these crimes took place outside of the sovereign territory of any state (Fichtelberg, 2008; Samuels, 2010). Due to the threat they posed, the first international legal document to end piracy was enacted in 1856; known as the Treaty of Paris, it paved the way for the development of other specialised ICLs (Zou, 2009). The next major development was the signing of the Treaty of Versailles, which held countries accountable for their war crimes. The 1919's League of Nations was a forerunner for the United Nations (UN) and a pivotal moment in shaping modern international law (Kaczorowska-Ireland, 2015).

Following the Second World War, the International Military Tribunal at Nuremberg, known as the Nuremberg Trials, was created (Kittichaisaree, 2001). In total 24 major Nazi war criminals were prosecuted for offences related to war crimes, crimes against humanity and crimes against peace (Kittichaisaree, 2001; Bantekas, 2010). These trials meant that for the first time, individuals rather than states were held accountable for their war crimes and have subsequently become the foundation on which modern international criminal justice was formed (Overy, 2003; Fichtelberg, 2008). The acts carried out by the Nazis during the war also highlighted a lack of international laws surrounding the waging of aggressive wars, a dilemma which was solved during the 1949 Geneva Conventions (Fichtelberg, 2008). However, as Figure 11 shows, the greatest pace of ICL development did not occur until the 1990s, as a result of the Bosnian Ethnic Cleansing and the Rwanda Genocide (Broomhall, 2009; Ceretti, 2009; International Criminal Court, 2021a). The establishment of the International Criminal Tribunal for the former Yugoslavia (ICTY) and the International Tribunal for Rwanda (ICTR) led to the issue of not having an ICC being addressed. Consequently, the Rome Statute of the International Criminal Court was signed in the summer of 1998 and entered into force in 2002 (Guilfoyle, 2016; International Criminal Court, 2021a).

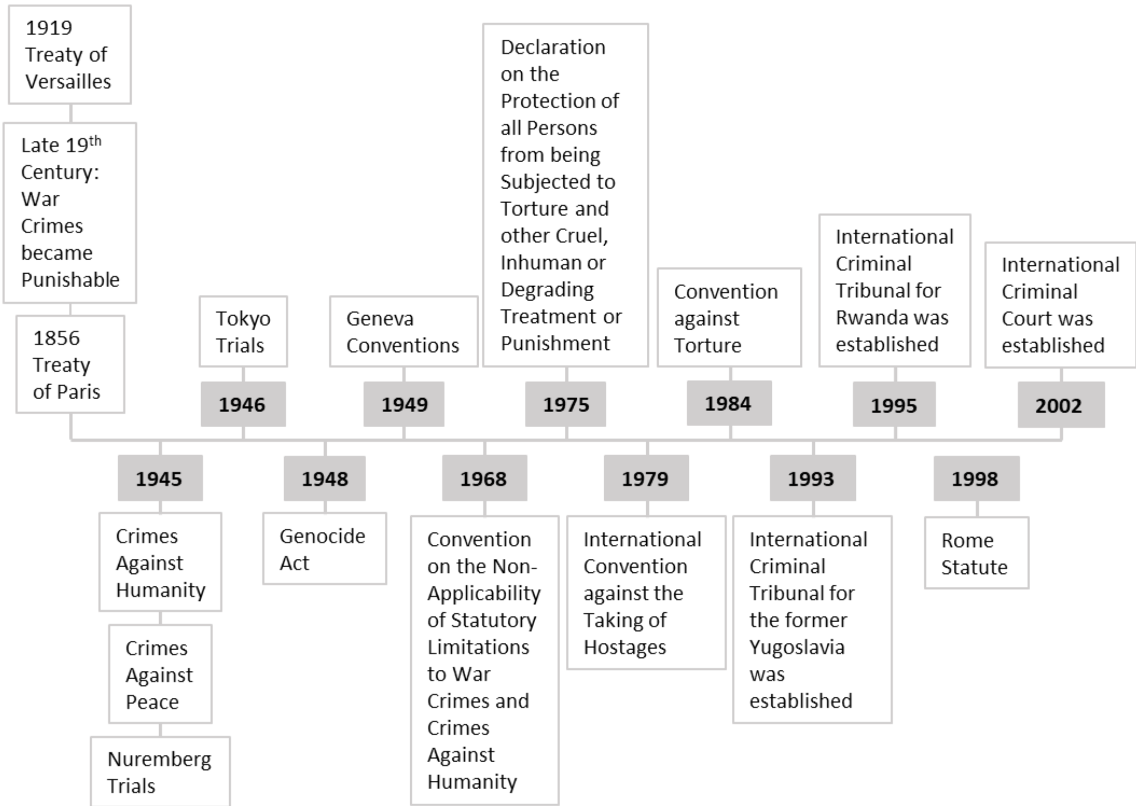


Figure 11: Timeline of key developments in International Criminal Law from the late 19th century until the establishment of the ICC in 2002 (Source: Author).

The United Nations

Since 1945, the UN has been the dominant organisation on the international stage. Originally formed to provide terms under which international justice and respect could be maintained following the Second World War, the main influence of the UN's development came from the Cold War era (Simons, 1994;

Pease, 2011). As stated in Article 1 of The Charter of the United Nations, its purpose is to maintain international peace and security, develop friendly relations among nations, achieve international cooperation in solving international problems, and be the centre for harmonising the actions of nations to achieve a common end (Goodrich et al., 1969: 25). The UN is open to all states, however, membership must be applied for which is then approved or turned down (Simons, 1994). Originally composed of 51 members, it is now comprised of 193 member states and two observer states (the Vatican and Palestine); observer states refer to non-members who have been given the ability to participate in UN activities (Kelsen, 1946; Blanchfield and Browne, 2014).

The International Court of Justice

Created in 1945 at the San Francisco UN Conference the ICJ is the UN's only judicial system run by 15 independent judges, who are elected by the UN's Security Council and General Assembly (Riggs and Plano, 1994; Simons, 1994). Whilst the court can deal with a broad range of issues, the ICJ plays no role in criminal cases, although it can advise on the progress and process of human rights (Ghandhi, 2011). Instead, they deal with legal disputes submitted by states, such as inter-state matters (Conforti, 1993; Crook, 2004). Although it is important to acknowledge the existence of the ICJ, archaeologists, regardless of the situation they are working in are unlikely to come into contact with them. Firstly, because the ICJ holds no jurisdiction over criminal cases and secondly because they deal with state legal issues rather than individual legal issues.

The International Criminal Court

The ICC is one of the most important advances in ICL, because of its potential to cover a worldwide jurisdiction (Zahar and Sluiter, 2008; Cryer et al., 2014). Currently, 123 countries have signed the Rome Statute, of these, 18 are Eastern European countries, 19 are Asian-Pacific, 25 are Western European and other States, 28 are Latin American, and 33 are African States (International Criminal Court, 2012b). The ICC is a completely separate organisation from the UN, although they cooperate closely under the Negotiated Relationship Agreement between the International Criminal Court and the United Nations. The Court's primary function is to try individuals accused of conducting war crimes, crimes against humanity, crimes against peace, genocide, torture, aggression and international terrorism; it also presents the ICL code which all countries under the Rome Statute are expected to follow (Broomhall, 2009; Cassese et al., 2013; Cryer et al., 2014; International Criminal Court, 2021a).

Made up of four organs known as the Presidency, Chambers, Office of the Prosecutor and the Registry (see Figure 12), each organ carries out unique roles throughout every stage of the court proceedings. Firstly, the Presidency is formed of the President, First Vice-President and Second Vice-President, whilst they are the overall head of the ICC they are mainly responsible for the administration of the other organs (Gallant, 2003; Day and Reilly, 2005; Schabas, 2011; Safferling, 2012). Secondly, the Registry is responsible for all non-judicial administration of the work and works for all the other organs (Day and Reilly, 2005; Safferling, 2012). Thirdly, the Office of the Prosecutor, led by the Prosecutor and divided into three division (Jurisdiction, Complementary and Cooperation division) they are responsible for receiving referrals and any substantiated information on crimes within the jurisdiction of the Court (International Criminal Court, 2011: 20).

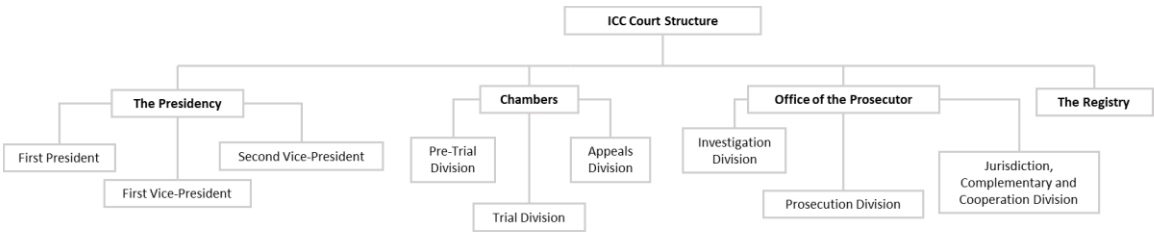


Figure 12: The overall ICC organ structure (Source: Author).

Finally, all cases that go before the ICC are heard by Chambers (see Figure 13), which is organised into three divisions known as the Pre-Trial, Trial, and Appeals division (Ciampi, 2004; Schabas, 2010; Guilfoyle, 2016).

Figure 13: ICC trial structure (Data collated from Ciampi, 2004; Schabas, 2011; Cryer et al., 2014; Guilfoyle, 2016).

There are four main categories in which the ICC investigate and prosecutes war crimes, crimes against humanity, crimes against peace and genocide. War crimes were first recorded during the 19th century (Green, 2003). Traditionally, they are defined as violations of warfare laws and customs committed by combatants during international armed conflicts (Cassese et al., 2013; Cryer et al., 2014). Article 6(b) of the Charter of the International Military Tribunal of Nürnberg (1945: 288) sets out these violations to include but are not limited to murder, ill-treatment or deportation of slave labour or any other purpose of the civilian population of or in occupied territory, murder or ill-treatment of prisoner of war or persons on the sea, killings of hostages, plunder of public or private property, wanton destruction of cities, towns or villages, or devastation not justified by military necessity.

Crimes against humanity were first referred to in 1915 after the massacre of Turkey's Armenian population (Cassese et al., 2013). However, the term was not used again until 1945 when it was recorded as one of three categories of offences tried within the Nuremberg Tribunals (Schabas, 2011; Cryer et al., 2014). Article 6(c) of the Charter of the International Military Tribunal of Nürnberg (1945: 288) states that crimes against humanity are namely murder, extermination, enslavement, deportation, and other inhumane acts committed against any civilian population, before or during the war. As such, the definition of what classes as a crime against humanity is very similar to that of a war crime, as it was initially created to bridge the gaps within the law and based on the same moral principles (Bassiouni, 1999; Cryer et al., 2014).

Crimes against peace, although an ambiguous term made aggressive wars illegal (Bantekas, 2010; Sellars, 2013). Article 6(a) of the Charter of the International Military Tribunal of Nürnberg (1945: 288) highlights that crimes against peace are namely the planning, preparation, initiation or waging of aggressive war or a war in violation of international treaties and/or agreements. More recently, the term crimes against peace have been changed to crimes of aggression, although under Article 8 bis of the Rome Statute for the International Criminal Court (2011) the definition is very similar to the original. Whilst crimes of aggression are attacks on humanity through the weakening of human rights protection, it is the only category from Nuremberg that is rarely brought to trial (May, 2009).

Genocide was given formal recognition within ICL when the UN adopted the Convention for the Prevention and Punishment of the Crime of Genocide in 1948, which developed as a response to the Holocaust (Sémelin, 2002; Schabas, 2009; Bantekas, 2010; Cassese et al., 2013; Cryer et al., 2014). Article 2 states that genocide is an act committed to destroying, in whole or in part, a national, ethnical, racial or religious group (Convention for the Prevention and Punishment of the Crime of Genocide, 1948). In its simplest form, genocide is mass murder with an agenda, because it is the denial of an entire group's right to exist, as homicide is to an individual's right to live (Fichtelberg, 2008; Cryer et al., 2014). By seeking to either physically eliminate a group until they are no longer perceived to be a threat or exist, whether that is because of national, racial, religious, or cultural reasons (Levene, 2005; Cassese et al., 2013). Nevertheless, genocide has evolved to also protect people from sickening human rights abuse, including those that are committed by their governments (Cryer et al., 2014).

Comparing Domestic and International Law

One similarity between the UK DLS and ILS is the statute of limitations. The statute of limitations refers to the period that a defendant may be charged with a criminal offence. Within the UK, there is no statute of limitation, internationally, however, the statute of limitations depends on the individual country but can range from 5-20 years after the crimes have been committed. Like the UK, crimes under the jurisdiction of the ICC also do not have a statute of limitations as it was removed in 1968 by the Convention on the Non-Applicability of Statutory Limitations to War Crimes and Crimes Against Humanity. To ensure that any Nazi war criminals not tried by 1969 would be held accountable for their actions (Miller, 1971).

Nevertheless, there are multiple differences, firstly, ICL is not as well-ordered or as clearly defined as domestic criminal law (DCL), nor are the laws surrounding international law as strong as it is a lot newer than DLS's (Fichtelberg, 2008; Mayans-Hermida and Holá, 2020). Jurisdiction over international crimes is also important as ICL and ICC only deal with crimes of international concern (Charney, 2001; Mayanes-Hermida and Holá, 2020). This is because the ICC is a specialist court, that targets high-level, public and politically significant mass atrocities, that have occurred as a result of political instability (Schabas, 2007; Bibas and Burke-White, 2010). Whilst there are some similarities between ILS and DLS, international law serves as a backstop or supplementary system for those countries that are unable to or refuse to deal with the most serious and complex forms of criminal activity (Delmas-Marty, 2006).

3.2 Regulations affecting Archaeologists and Forensic Archaeologists

Regulations affecting UK archaeological and forensic investigations are very different to the ones affecting forensic archaeologists working within an international context. As such, this section explores the legislation, standards and guidance affecting archaeological fieldwork and human remains, UK forensic casework and international forensic casework.

3.2.1 UK Archaeology

Presented in the Tables below are the legislation and standards and guidance that could affect UK archaeologists working in the field, in heritage, museums and/or with human remains. Whilst each Table shows the different regulations for all three UK jurisdictions, the bulk of each discussion centres around those which are likely to affect archaeologists carrying out fieldwork and/or working with human remains in England and Wales.

Legislation

The two main legislative act affecting archaeological fieldwork in England and Wales is the Ancient Monuments and Archaeological Areas Act 1979 and the Town and Country Planning Act 1990 (see Table 3 for all legislation). Passed in 1979, the Ancient Monuments and Archaeological Areas Act protect areas classed as archaeologically important, currently, these are the five historic city centres of Canterbury, Chester, Exeter, Hereford and York (Historic England, 2021). It also protects around 400 ancient monuments (Drewett, 1999). Two key sections are likely to have the most effect on archaeologists; section 33 prevents important archaeological sites from being damaged and/or destroyed without a basic investigation being conducted, and section 35 requires developers to ensure archaeologists carry out the correct surveying and recording of an area before any development projects are undertaken (Historic England, 2021). The Act also ensures the correct permission is obtained before archaeological work is conducted, for sites listed under the Act special permission is required from the Secretary of State for Culture, Media and Sport, whilst for others, all that is needed is consent from the land owner (Drewett, 1999). Whilst section 106 of the Town and Country Planning Act 1990 brought archaeologists to the forefront, as it allows them to access any threatened archaeological site whether known or unknown, it also prevents development projects from taking place until an archaeological survey has been completed (Drewett, 1999; Morel, 2019).

Table 3: Archaeological legislation for England and Wales, Scotland, and Northern Ireland

England and Wales	Scotland	Northern Ireland
Burial Act, 1857	Anatomy Act, 1984	Burial Grounds Regulations (Northern Ireland), 1992
Protection of Wrecks Act, 1973	National Heritage (Scotland) Act, 1985	National Monuments (Amendment) Act, 1994
Ancient Monuments and Archaeological Areas Act, 1979	Museum and Galleries Act, 1992	Historical Monuments and Archaeological Objects (NI) Order, 1995
Disused Burial Grounds (Amendment) Act, 1981	Human Tissue (Scotland) Act, 2006	Museum and Galleries Order (NI), 1998
Protection of Military Remains Act, 1986	Historic Environment Scotland Act, 2014. (*Amends the acts below*)	Northern Ireland (Location of Victims' Remains) Act, 1999
Planning (Listed Building & Conservation Areas) Act, 1990	Ancient Monuments and Archaeological Areas Act, 1979	Treasure (Designation) Order, 2002
Town and Country Planning Act, 1990	Planning (Listed Buildings and Conservation Area) (Scotland) Act, 1997	Human Tissue Act, 2004
National Heritage Act, 2002	Environmental Assessment (Scotland) Act, 2005	
Treasure (Designation) Order, 2002		
Human Tissue Act, 2004		

Human remains legislation was first introduced in the 19th century to prevent Body Snatchers from removing corpses from graves (White, 2011). Since then, it has been developed to incorporate the protection and correct treatment of archaeological human remains. Archaeologists need to have an awareness of three key pieces of legislation, the main one being the Burial Act of 1857. The other two, which play smaller roles are the Disused Burial Ground (Amendment) Act 1981 and the Human Tissue Act 2004. Under section 25 of the Burial Act 1857, it is an offence for remains to be removed from their place of burial unless approval has been granted by the court. Therefore, archaeologists planning to excavate human remains need to apply for a burial licence with the Ministry of Justice before the casework starts. Should human remains be discovered by accident, then work must be stopped immediately and cannot continue until the licence has been applied for and granted (see Case Study A2 in Chapter Two (pg. 23-24) for example). The Disused Burial Ground (Amendment) Act 1981 was created to protect human remains interred within former burial grounds under threat from development and works alongside the Burial Act 1857 (Spoerry, 1993). Section 2 of the Disused Burial Grounds (Amendment) Act 1981 states that development cannot take place on a disused burial ground unless the remains are removed and reinterred following the provisions set out within the Act. Whilst the majority of the Human Tissue Act 2004 falls outside the remit of archaeology, as it deals with remains up to 100 years old, it does regulate the storage of human remains (DCMS, 2005).

Standards and Guidance

UK archaeology has multiple standard and guidance documents, which cover general archaeology, heritage and human remains. Table 4 presents all the standards and guidance that are likely to affect archaeologists and anthropologists working with human remains. Whilst Table 5 lists all the general archaeological and heritage standards and guidance, many of which were developed by the Chartered Institute for Archaeologists (CIfA) to ensure a high standard of practice is upheld.

Table 4: Human Remains Standards and Guidance for England and Wales, Scotland, and Northern Ireland.

Human Remains Standard and Guidance		
England and Wales	**Scotland**	**Northern Ireland**
English Heritage - Human Bones from Archaeological Sites: Guideline for producing assessment documents and analytical reports, 2004	Guidelines for the care of human remains in Scottish museum collections, 2011.	IAI - The Treatment of Human Remain: Technical paper for archaeologists, 2004
IFA: Guidelines to the standards for recording human remains, 2004	National Trust for Scotland - Respecting Remains: A policy on the treatment of human remains, 2019	DCMS: Guidance for the care of human remains in museums, 2005
BABAO: A code of best practice for the care of human remains in museums, 2005		
DCMS: Guidance for the care of human remains in museums, 2005		
Science and the Dead: A guideline for the destructive sampling of archaeological human remains for scientific analysis, 2013		
BABAO: Advice and guidance about accessing collections of human remains in the United Kingdom, 2015		
Large Burial Grounds: Guidance on sampling in archaeological fieldwork projects, 2015		
CIfA: Updated guidelines to the standards for recording human remains, 2017		
Guidance for best practice for the treatment of human remains excavated from Christian burial grounds in England, 2017		
Historic England: The role of the human osteologist in an archaeological fieldwork project, 2018		

Table 5: General standard and guidance for England and Wales, Scotland, and Northern Ireland.

General Archaeology and Heritage Standard and Guidance		
England and Wales	**Scotland**	**Northern Ireland**
CIfA: Standard and guidance for archaeological field evaluation, 2014	West of Scotland Archaeological Services: Procedural guidance for archaeology and development, 2009	Archaeological archives in Northern Ireland: Legislation, guidance and comparison with other jurisdictions, 2011
CIfA: Standard and guidance for archaeological advice by historical environment services, 2014	Guidance on the minimum standards for the transfer of archaeological assemblages to museum Scotland, 2021	Northern Ireland Museum Council: Guidance to local museums on reporting archaeological finds and treasure, 2015
CIfA: Standard and guidance for the creation, complication, transfer and deposition of archaeological archives, 2014		DfC: Development and Archaeology - Guidance on archaeological works in the planning process, 2019
CIfA: Standard and guidance for the archaeological investigation and recording of standing buildings or structures, 2014		NIEA: Development and archaeology an NIEA guidance booklet, 2021
CIfA: Standard and guidance for the collection, documentation, conservation and research of archaeological material, 2014		
CIfA: Standard and guidance for commissioning work or providing consultancy advice on archaeology and the historic environment, 2014		
CIfA: Standard and guidance for desk-based assessments, 2014		
CIfA: Standard and guidance for archaeological excavation, 2014		
CIfA: Standard and guidance for geophysical survey, 2014		
CIfA: Standard and guidance for nautical recording and reconstruction, 2014		
CIfA: Standard and guidance for stewardship for the historical environment, 2014		

CIfA: Standard and guidance for an archaeological watching brief, 2014		
Society of Museum Archaeology: Standards and guidance in the care of archaeological collections, 2020		

3.2.2 UK Forensics

In the UK forensic archaeologists are recognised as experts by the courts and may be called upon by the police to assist during criminal investigations, particularly in cases involving buried or concealed human remains (Dilley, 2005; Bartelink et al., 2016). To ensure their work measures up to the high standard and quality expected by the criminal justice system, forensic archaeologists need to have a clear understanding of the national legislation they could be affected by and the standards and guidance that they are required to uphold throughout every case (CPS, 2022).

Legislation

Those working in the criminal justice sector are expected to adhere to the legislation set out in Table 6. However, before a search can take place, in the UK, a search warrant needs to be issued by the court. A search warrant grants the police and those working with them, permission to enter the premises and search for specific material, such as a grave (Law Commission, 2020). Following this, forensic archaeologists are mainly affected by the Criminal Procedure and Investigation Act (CPIA) 1996, Disclosure Manual 2005, and Police and Criminal Evidence Act (PACE) 1994. The CPIA 1996 and Disclosure Manual 2005, ensures that record-keeping, retention and the disclosure of documentation is conducted to a standard that can be used within a court of law (Bartelink et al., 2016: 292). Therefore, throughout the initial contact, briefing, search and excavation the forensic archaeologist should maintain detailed and accurate records, including the date and time of when things happened. Whilst the time limit set by the 'PACE clock' means archaeologists and anthropologists may be under pressure to produce enough preliminary information within a stipulated timeframe, so that police can either charge or release any suspects (Dilley, 2005: 184). This means archaeologists would have 24 hours to gather enough evidence from the area being searched, so the police can either charge their suspect, release them from custody or apply for an extension, which would allow them to hold the suspect for longer.

Whilst the Forensic Science Regulator Act 2021 has been recorded in Table 5, it does not have a direct impact on practising forensic archaeologists or forensic investigations. As it was enacted to provide the Forensic Science Regulator powers to enforce regulations in forensic science, to ensure high-quality standards are upheld.

Table 6: Legislation in England and Wales, Scotland, and Northern Ireland likely to affect criminal cases.

England and Wales	Scotland	Northern Ireland
Crown Court (Advanced Notice of Expert Evidence) Rules, 1987	Criminal Procedure (Scotland) Act, 1995	Criminal Law (Northern Ireland) Act, 1967
Police and Criminal Evidence (PACE) Act, 1994	Criminal Justice and Licensing (Scotland) Act, 2010	Police and Criminal Evidence (Northern Ireland) Order, 1989
Criminal Procedure and Investigation Act, 1996	Criminal Justice (Scotland) Act, 2016	Criminal Justice Evidence (Northern Ireland) Order, 2004
Criminal Justice Act, 2003		Criminal Justice (Northern Ireland) Order, 2008
Human Tissue Act, 2004		Criminal Justice Act (Northern Ireland), 2013
Disclosure Manual, 2005		
Criminal Evidence (Experts) Act, 2011		
Criminal Procedure Rules, 2011		
Forensic Science Regulator Act, 2021		

Standards and Guidance

Alongside the legislation, forensic archaeologists should comply with standards and guidance. The Forensic Science Regulator (FSR) was set up in 2008 to safeguard the appropriate standard of practice used across the whole criminal justice system, by setting out values and ideas in the form of codes of conduct (Janaway, 2015; CPS, 2022). The Forensic Science Regulator Draft Code of Practice was put to parliament in January 2023, and will subsequently come into force in England and Wales at 00:01 on the 2nd October 2023. This code of practice will help ensure that forensic practitioners provide high-quality forensic evidence, and protects the criminal justice system, by guarding against any miscarriages of justice.

Currently, there is one key regulation which has the most affect on forensic archaeologists standard of practice in the UK. The CIfA Forensic Archaeology Standard and Guidance 2014, which is endorsed by the Forensic Science Regulator. It sets out the key duties and responsibilities of the archaeologist, the required level of competency and expectation, and the specific standards required at every stage of a criminal investigation. Therefore, ensuring forensic archaeologists maintain high standards of practice during the initial contact, briefing, search, recovery and documentation stages of the investigations. For further details on the CIfA Forensic Standard and Guidance please refer directly to the document itself, the link can be found on page 211, under the heading *Forensic Standard and Guidance*.

Table 7: Standards and Guidance for Forensic Investigations across the United Kingdom

United Kingdom
RAI: Code of practice for forensic anthropology, 2018
CIfA: Standards and guidance for forensic archaeologists, 2014
FSR: Legal issues in forensic pathology and tissue retention, 2020
FSR: Codes of Practice and Conduct: For forensic science providers and practitioners in the criminal justice system, 2021
FSR: Draft Code of Practice, 2023 (Comes into force 00:01 on the 2nd October 2023)

3.2.3 International Forensics

Forensic archaeologists can be called upon to assist with many international investigations, including those related to war crimes, crimes against humanity, crimes against peace, and genocide. The development and implementation of frameworks can have a direct impact on the protocols they apply to mass grave investigations, as they ensure archaeologists work to a high standard and collect evidence which can be used within international, national and local courts (Cox et al., 2008: 1).

The Rome Statue 2002 and the Rule of Procedure and Evidence 2019 ensure provisions are in place for expert witnesses to follow to ensure that evidence is relevant and admissible in court. Case Study F3 (pg. 25) refers to the Rule of Procedure and Evidence in practice. During the investigation of the Tomašica mass grave, the prosecution ruled that under Rules 73, 85 and 89 the case against Radovan Karadžić could be reopened so that the evidence discovered during the excavation could be introduced during the trial.

Whilst the development of the Minnesota Protocol on the Investigation of Potentially Unlawful Death 2016, sets a common standard of protocols for the investigation of unlawful death or enforced disappearance and a shared set of principles and guidelines for States, as well as for institutions and individuals who play a role in the investigation (United Nations, 2017). Although the Minnesota Protocol details guidelines on the excavation of graves, it does not refer to the complexities that a mass grave will present.

Recently, work has been done to establish protocols and standard operating procedures during mass grave investigations. Bournemouth University in partnership with the ICMP developed the Bournemouth Protocol on Mass Grave Protection and Investigations in 2020. The Bournemouth Protocol was developed to improve the safeguarding and investigation of mass graves and provide a step forward in clarity on international norms and standards (Klinker and Smith, 2020).

However, due to every case being unique to the country and/or area in which the grave is located, regulations that regard international forensic casework need to be flexible so they can be applied, and meet specific aims and objectives, constraints and contexts (Cox et al., 2008: 2).

3.3 Conclusion

Although regulations across the UK and internationally are complicated, it is important to have a basic understanding of how they work, the legislation and standards and guidance most likely to affect practice. Archaeologically, this is to ensure that human remains and materials are protected from unnecessary destruction, so they are protected for years to come. Forensically, regulations help archaeologists to make sure all evidence is collated and recorded appropriately, thus ensuring that if a case is ever tried in court, the evidence can be presented.

Chapter Four: Desk-Based Assessments

To guarantee a search is coordinated effectively and resources target the site with the most potential, all fieldwork and investigations start with desk-based assessments (Killam, 2004; Darvill, 2021; Grant et al., 2008; Litherland et al., 2012; Hunter et al., 2013; CIfA, 2014; Connolly, 2014; Bartelink et al., 2016; Abate et al., 2019). Collating and reviewing any existing written, graphic, photographic and electronic information helps narrow down search areas, plan investigations, eliminate unlikely sites, define a parameter, and highlight the condition and significance of the potential site (Greene, 2002; Killam, 2004; Carver, 2009; Litherland et al., 2012; Hunter et al., 2013; CIfA, 2014; Connolly, 2014; Bartelink et al., 2016; Darvill et al., 2019). Typically, the sources evaluated during this process include but are not limited to cartography, aerial and satellite imagery, ground-level photographs, witness accounts, historical and environmental records, archives, and past archaeological publications (Greene, 2002; Grant et al., 2008; Hunter et al., 2013; Connolly, 2014; Darvill, 2021).

Therefore, this chapter sets out to critically examine how desk-based assessments inform and support the process of locating mass graves by exploring:

- What desk-based methods are used during the initial stage of an investigation?
- What are the advantages and drawbacks of each method?
- How do they inform the rest of an investigation?

4.1 A Witness-Led Approach

Eyewitness testimonies are commonly used in forensic investigations because they are often the only thing that provides forensic teams with the evidence needed to open an investigation (Schmitt, 2002; Card and Baker, 2014; Tuller, 2015; Hanson, 2016). This reliance on witness statements is because they can describe the events that occurred, as well as identify the location of one or more of the gravesites (Hanson, 2016). There are many reasons for someone to be classed as a witness: they may be a survivor; a member of the affected community; have observed the incident; someone coerced into participating; saw the location of the grave after the event; a member of the media or armed forces; the perpetrator(s) or a member of the perpetrator's group; or a member of the public who came across a suspicious site or artefact (Cheetham et al., 2008; Hanson, 2016). Witness testimonies are gathered by a range of agencies such as prosecutors, police, missing person organisations, international organisations, journalists, and/or governments (Hanson, 2016). These testimonies are often recorded as written statements, formal interviews using standardised questions, and/or accompanied site visits (Anderson et al., 2008; Hanson, 2016).

4.1.1 Archaeological Casework

Although Haglund et al., (2001) argue that a witness-led approach cannot be used to find archaeological mass graves, there are some instances when it has the potential to be successful in narrowing down a location. Particularly if there are diaries, historical commentaries or other documents associated with the event that could be used to narrow down the location. This can be seen in the Case Study WW1 (see Chapter Two: pg. 27-28) as archaeologists were able to narrow down/confirm the location of the Pheasant Wood mass grave using diaries and letters written by the soldiers at the time. However, it is important to remember that as time passes, the accuracy and relevance of such accounts fade and should be confirmed using other non-invasive techniques before conducting an excavation.

4.1.2 Forensic Casework

Mass graves are likely to be concealed in vast, remote and often unknown areas. Statements taken from witnesses are regularly the only information available to suggest the presence of an unknown gravesite and assist forensic teams with finding/narrowing down the whereabouts of the grave (Hanson et al., 2015; Tuller, 2015). A witness's ability to recall suspicious activities and potential sites can lead archaeologists to the grave or suspected areas (Haglund et al., 2001; Schmitt, 2002; Cheetham et al., 2008; Wright, 2010; Larson et al., 2011). The accuracy of this information has successfully led forensic teams to countless graves, many of which would have remained undiscovered if they had not had access to witness statements; for example, many of the primary graves found in Srebrenica were found due to the statements survivors gave to investigators (Tuller, 2015; Hanson, 2016).

However, several of the mass graves in Bosnia were disturbed by the perpetrators and the remains were redisposed in unknown secondary sites, which were often done without any witnesses being present (Hanson, 2016). There is also a significant risk that suspects will provide false or misguided information as they have a direct motive to mislead the search by sending investigators to the wrong location (Cutler and Penrod, 1995; Geberth, 2006; Cheetham et al., 2008; Hanson, 2016; Schmidt, 2017; Blau et al., 2018). Therefore, testimonies provided by suspects are not considered as reliable as statements provided by the victims, victims' families, the media or the military (Schmidt, 2017). Should suspect testimonies be used to locate a mass grave, they will need to be carefully checked against other desk-based methods to ensure that time and resources are not wasted. Finally, individuals and affected communities can develop narratives of what happened which can be aided by the recovery of the landscape, this means that over time their recollections can be seen as less accurate (Hanson et al., 2015; Hanson, 2016; Ossowski et al., 2018).

Accounts such as reports released by the police, media and/or prosecutor can weaken/affect a witness's memory by altering their recollections of the event (Stover, 2005; Wise et al., 2009; Loftus, 2019). This was evident in Bosnia. Forensic teams had greater success finding mass graves using witness statements in the early years after the war because there were more witnesses available and their memories were fresher (Hanson et al., 2015). Over time, memories can be influenced by not only external sources but can also fade, merge, change, and become partial or incomplete; causing the accuracy of the information to lessen (Ballbe and Steadman, 2008; Cheetham et al., 2008; Hanson, 2016). Therefore, delaying the start of an investigation can result in witnesses forgetting key things, or their memories becoming distorted, limiting the records of the missing and the incident (Cutler and Penrod, 1995; Hanson, 2016). However, Stover (2005) argues that sometimes delays in starting an investigation can be beneficial, as time often provides witnesses with a sense of detachment and perspective, therefore, aiding the witness's ability to remember specific details and provide a more cohesive statement.

Nevertheless, for an investigation to start or continue, the information available needs to be detailed enough to aid the case (Blau et al., 2018). In many mass grave-related cases, there is often only one witness; the information may be second or third-hand; the events were observed under extreme stress; the witnesses may be reluctant to return to the location; or there may be no witness, all of which affects the reliability of the information provided (Cheetham et al., 2008; Hanson et al., 2015; Hanson, 2016). Regardless, the use of witness statements is viewed as a vitally important component of a forensic investigation, not only because it can be used to locate gravesites, but because it can also inform the broader search strategy (Cheetham et al., 2008).

Witness statements provide essential location-based information; such as the terrain, which helps forensic teams to decide what equipment can be used within the area (Card and Baker, 2014). It also assists archaeologists in understanding how the grave was created, the types of tools used, the depth of the grave and the condition of the remains (Killam, 2004). This was particularly prominent in the investigation of the Kravica warehouse and associated mass graves in Bosnia. Witnesses described how the warehouse door was removed, upon excavation archaeologists found the door matching the description buried within the mass grave (Wright, 2010). Therefore, witness statements not only provide crucial information to aid in finding a grave but also assist with the corroborating physical evidence found at the scene to help forensic teams understand what happened (Schmitt, 2002; Cheetham et al., 2008).

However, unless there is a political agenda and/or organisations willing to start an investigation, then witnesses are not found and interviewed (Hanson, 2016). Nevertheless, even in cases where there is a dedicated organisation designed to investigate mass graves, there is still a decline in the number being found. A key example of this is the CMP investigation of the Cyprus Conflict (see Chapter Two, Figure 2 (pg.30) for evidence). This is partly because the CMP only investigates information when they receive it, rather than locating and interviewing everyone who witnesses the burials; as such it is becoming increasingly difficult to obtain information due to witnesses passing away (Abate et al., 2019). Not only this but, witnesses can also be reluctant to provide information out of fear of it being leaked or risk of being prosecuted or facing some form of retribution from either the perpetrators or the community (Stover, 2005; Hanson, 2016; Blau et al., 2018).

Whilst witnesses can lead forensic teams to mass graves, in many cases, there is simply not enough precise or available information to definitively pinpoint the gravesite (Corcoran et al., 2018). Instead, witnesses are only able to provide a general location which requires supplementary information to narrow it down further (Cheetham et al., 2008; Hanson et al., 2015; Hanson, 2016). Although there have been successes in solely using witness statements to find mass graves, forensic teams generally use them in conjunction with other methods to ensure time, cost, and resources are not being wasted.

4.2 Historical Records

As part of a desk-based assessment, historical records can be studied, particularly if the casework is archaeological as it provides a reference to what the area of interest was originally used for. Sources such as charters, registers, manuscript collections, contemporary published accounts, historic environment records, and archaeological excavation and survey records are some of the key historical records that could be examined before fieldwork commences (CIfA, 2014: 12). Documents such as the Tudor Chronicles were used to record the deaths and victories of battles (see Case Study A2, pg. 23-24). Whilst historical newspapers also recorded events such as the black death and the cholera epidemic. As can be seen in the Case Study WW1 (pg. 27-28), archaeologists also narrowed down the location of the Pheasant Wood mass grave by comparing the memoirs and letters of the British soldiers, with the German battalion war diary held in the Munich archives.

Whilst historical records are largely associated with archaeological casework, archival materials can also be relevant in forensic mass grave casework. Archives often hold images, elevation data, documentary records of witnesses and perpetrators, receipts, and logs of the logistics involved in mass murder (Cheetham et al., 2008: 195). All of these could prove useful when narrowing down the general area and/or specific location of the potential mass grave.

4.3 Aerial Images

One of the best sources of information is archival and modern aerial images, due to the number of photos available which have accidentally recorded gravesites (Ossowski et al., 2018). Aerial images are a series of overlapping, scaled photographs taken of a specific area, which can be used to monitor changes in the landscape and reveal patterns not easily visible from the ground (Hunter and Cox, 2005; Morgan et al., 2010; Burns, 2016). However, the use of aerial photographs is dependent on the type of setting the grave is located in, and how recently the photos were taken. Whilst a grave is likely to be visible and potentially easier to spot in an open field, if several years have passed the area will have recovered enough to reduce the visibility of the grave, making it harder to identify. Nevertheless, if a grave is relatively fresh at the time of the photograph being taken, then archaeologists can identify shadows created by the grave, variations in soil colour, changes in vegetation and marks in the soil (Killam, 2004; Greene and Moore, 2010). As seen in Case Study F1 (pg. 25), it can also be used as a way of confirming no other burials have taken place within the area of interest, prior to the suspected mass grave being created.

Since the 1960/1970s many traditional aerial photographic systems have been replaced with the remote sensing system, aerial photographs are still useful in showing how much a specific area has changed over time (Dong and Chen, 2017).

4.4 Ground-level Images

Ground-level photography and films are those taken from a range of different vantage points at ground level, they have been used to capture events throughout history and have the potential to indicate the past (Ferrándiz and Baer, 2008; Brutin, 2020). In recent years, digitalisation projects have resulted in the vast majority of historical photographs and films being uploaded to digital archives, making them more accessible to archaeologists (Niebling et al., 2018). Regardless, photographs and films have been used as visual evidence within a court of law at an international level since the Nuremberg and Tokyo trials, before this, there are no records of any court using graphic films as proof of criminal wrongdoing (Ristovska, 2017; Duffy, 2018). The ICTY also used footage of video interviews with witnesses and suspects, mass grave exhumations and sniper shot reconstructions during multiple investigations (Vukušić, 2013).

Images and films captured during WWI, WWII and subsequent conflicts could, therefore, show evidence of a mass grave and its potential location. During WWII, the 27th Australian Battalion took photographs of their comrade’s battlefield graves, but despite their best efforts to document the exact locations, not all of the graves were found when the war ended (Smart, 2016). Often little to no contextual information on the photographs or films survives, they may also be biased as they present the agenda of the photographer (Borchert, 1982). Nevertheless, ground-level photographs can be used in conjunction with other techniques to either narrow down the location of a potential mass grave or provide evidence to start an investigation.

4.5 Cartographic Analysis

Many types of cartography can be reviewed during the desk-based assessment to remove unlikely areas from a search, such as topographic, orthographic and geological (Cheetham et al., 2008; Hester et al., 2008; Dupras et al., 2012). Geological and topographical maps are commonly examined, as they depict visible, natural and built surface features, highlight areas which would be questionable for perpetrators to put a grave, show access routes to the area and indicate the history of a potential site (Cheetham et al., 2008; Dupras et al., 2012). Archaeological maps are a particularly useful tool to establish the history of a site, as it depicts the original landscape structures, which when compared to modern-day maps can highlight how the area has changed over time (Rocha and Branco, 2009; Wilkinson, 2020). Enabling archaeologists to determine how archaeological material interrelates with the surrounding environment and provide additional information about potential burial sites (Ozulu et al., 2012). However, the search for further mass graves related to the Battle of Towton (Case Study A2, pg. 23-24), highlights that there are drawbacks to using cartographic analysis as a method for locating mass graves. Sutherland and Schmidt (2003) were only able to establish how the medieval fields were once positioned, rather than pinpointing a potential location. Therefore, to be able to effectively use cartography as a desk-based assessment method it would need to be used in conjunction with other detection methods.

4.6 Sequence of Procedures

Desk-based assessments are the starting point of any archaeological and forensic investigation. Verifying existing records of the target area helps with the overall planning of the investigation by eliminating unlikely sites, providing an understanding of the area, and defining the potential parameter of the site (Killam, 2004; Litherland et al., 2012; Hunter et al., 2013; Darvill et al., 2019).

The application of the red-amber-green system, also known as *RAG* enables archaeologists and investigators to prioritise the areas most likely to contain a mass grave, allowing search resources to be utilised effectively (Donnelly and Harrison, 2013). The RAG colour-code system is applied to topographical maps and/or aerial imagery (Donnelly and Harrison, 2013; Somma et al., 2018). The red refers to the area with the highest probability of a grave being present, green is considered the least probable, whilst amber is midway between the two (Donnelly and Harrison, 2013; Ruffell and McAllister, 2015; Somma et al., 2018).

Effective preplanning across archaeology and forensics is crucial to the success of an investigation as it helps to ensure the highest standards of practice are maintained, to prevent any evidence/artefacts/remains from being damaged, destroyed or missed. Although the sequence of procedures is worded differently for both fields, they all follow a similar structure, as all fieldwork starts with non-invasive search techniques, before progressing to invasive and excavation stages.

Many researchers have recorded similar but different procedures that should be considered when carrying out archaeological fieldwork, Table 8 presents three of these. Each phase is broad, flexible and adaptable to meet the requirements of different site morphologies and preservation conditions. Whilst the three aforementioned procedures use different terms they all follow the same elements, starting with a research strategy, and then progressing to non-invasive evaluations of the site in question. If this stage uncovers possible findings or evidence, then invasive fieldwork takes place. Finally, finds are analysed and then published to inform the wider community of the archaeological significance of the site in question.

Table 8: Comparison of three different archaeological fieldwork procedures.

Phase	Renfrew and Bahn (1991:71)	Olsen et al., (2012: 62)	Carver (2009:35-37)
One	Formulation	Formulation of question	Reconnaissance
Two	Collecting and recording evidence	Research design	Evaluation
Three	Processing and analysis	Survey/excavation strategies	Strategy
Four	Publication	Actual fieldwork	Implementation
Five		Finds processing	Analysis
Six		Analysis	Publication
Seven		Synthesis and argumentation	

As with archaeological fieldwork, forensic investigations also follow broad and flexible procedures, which ensure the highest possible standard is maintained when recording the area of interest (Anderson et al., 2008). Recorded in Table 9 are five different investigation procedures. Whilst there are variations between them all, each shows that an investigation should begin with the search and initial assessment of the site, then progress to its excavation and recovery of remains, and finally the analysis and final report. Cheetham et al., (2008) have written the standard operating procedures for the investigation and excavation of mass graves, which have been applied to Case Study WW1 (pg. 27-28).

Table 9: Five different procedures for forensic investigations.

Phase	Skinner (1987:276)	Haglund et al., (2001:59-61)	Killam (2004:11)	Cheetham et al., (2008: 189)	Christensen et al., (2014:152-153)
One	Search and discovery	Documentation of site	Planning, phase one	Site assessment and evaluation	Systematic search
Two	Mapping	Recovery and analysis of surface remains	Investigation	Site excavation and evidence recovery	Evaluation of an area of significance
Three	Excavation	Excavation and analysis of buried remains	Planning, phase two		Recovery
Four	Evidence processing		Search operation		Interpretation and reporting
Five	Site shutdown		Excavation/ recovery		

4.7 Conclusion

In conclusion, the desk-based methods that are commonly used vary depending on where the case is archaeological or forensic. Within archaeological casework, archaeologists will commonly use historical records and maps to build up an understanding of a potential site. Whereas, in forensic casework, archaeologists rely on a witness-led approach, and maps to establish the potential location of a mass grave. More information gathered during the desk-based assessment stage helps to inform the rest of the investigation, as it provides archaeologists with a direction to go in and saves time, money and resources.

Chapter Five: Physical Alterations

The creation of a grave, no matter the size, physically alters the landscape directly over and around the deposition site (Corcoran et al., 2018). As the body/bodies progress through decomposition and time since burial elapses, the physical characteristics of the landscape also shift. Whether forensic or archaeological, each gravesite is unique in terms of how it was created and its physical characteristics (Ghanem and Sobh, 2021). Nevertheless, there are four main signs, that, if identified can indicate a grave is present; these are the signs of human disturbance, vegetation changes, compression and depression of the surface over the grave, and increased signs of animal activity. Understanding how these landscape signatures change over time can assist archaeologists when searching for mass graves, which in turn could lead to rapid and more accurate identification of a deposition site (Barbazon et al., 2020; Watson et al., 2020).

By exploring the questions listed below, this chapter aims to understand these processes, how they can assist archaeologists in locating mass graves, and the methods that can be applied to physically detect these alterations.

- What are the physical alterations that occur when a grave is created?
- How do these alterations change over time?
- Can they be used to effectively indicate the presence of a mass grave?
- What methods can be used to detect these changes?
- What are the advantages and drawbacks of each method?

5.1 Detecting Physical Changes in the Landscape

Identifying depositions sites, particularly when a significant amount of time has passed is challenging for both archaeological and forensic investigations (Berezowski et al., 2021). Physical changes in the landscape are considered to be one of the best indicators of a grave being present, as a variety of surface alterations occur during the disposal of the body and the decomposition process. Whilst these changes alter over time, many remain present long after the grave has been backfilled (Hunter and Martin, 2002; Dupras et al., 2012; Watson et al., 2020). Changes discussed in this section include the evidence of human disturbance caused by tool marks and/or heavy machinery during the digging and backfilling of the grave, the alterations that happen to the vegetation, and the surface compression and depression of the soil.

5.1.1 Evidence of Human Disturbance

Evidence of human disturbance refers to the impressions of footprints, tool marks and heavy machinery tracks left within the immediate vicinity of the grave and along the access routes in and out of the area (Morse et al., 1983; Hochrein, 1997; Hunter, 2014; Evis et al., 2016). This evidence provides an understanding of how the grave was created, the equipment used, and the potential number of perpetrators, which, can suggest how much forethought and planning went into creating the grave (Dupras et al., 2012). Mass graves with visual traces of heavy machinery, like the one exhumed at Ovčara (Vukovar, Croatia) in 1996, suggest they were dug deliberately due to the amount of forethought needed to get the equipment onsite (Ekštajn et al., 2021). Impressions can also indicate the type of deposition site it is, the heavy machinery marks presented in Case Study F3 (pg. 26) suggested the grave was a primary site that had been disturbed before the investigation.

However, Hochrein (2002a) and Hanson (2004) argue there is a common misconception that evidence of human disturbance does not survive, meaning these impressions have been overlooked in the past. This is particularly evident in archaeological casework as most excavation reports do not consider how the grave was originally dug or backfilled. The excavation of the Battle of Fromelles mass grave (see Case Study WW1, pg. 27-28) is a great example of this. Loe et al., (2014: 190-191) recorded that the analysis of how the grave was dug and later backfilled was not a primary aim, the use of mechanical equipment to create a pedestal removed the sides of the grave, making it impossible to see if signs of tool marks remained. Nevertheless, how well these impressions are preserved in the ground is dependent on the type of soil and ground moisture at the time it was created. Graves that are dug into clay soils are more likely to remain impressions than other soil types (see Chapter Six for details on soil characteristics: pg. 104-105) (Hanson, 2004; Dupras et al., 2012; Hunter, 2014).

5.1.2 Vegetation Alterations

Although the relationship between vegetation and buried remains is poorly understood, the physical alterations a grave causes to the landscape are well documented (Morse et al., 1983; Hall, 1997; Watson and Forbes, 2008;

Caccianiga et al., 2012; Lubit, 2012; Cholewa et al., 2022). To create a grave, the soil must first be removed from the ground, causing the existing vegetation to become uprooted and/or destroyed (Wright et al., 2005). In most cases, this excavated soil is placed adjacent to the grave (Figure 14b) damaging the surrounding vegetation, once the victim's bodies have been placed (or thrown) into the grave (Figure 14c) the soil is then backfilled (Figure 14d). However, excavating the soil causes it to become aerated, and the victim's bodies also take up space within the grave, this means there will be surplus soil, which either remains piled beside the grave or spread around its perimeter intermixing with the topsoil (Morse et al., 1983; Byers, 2011).

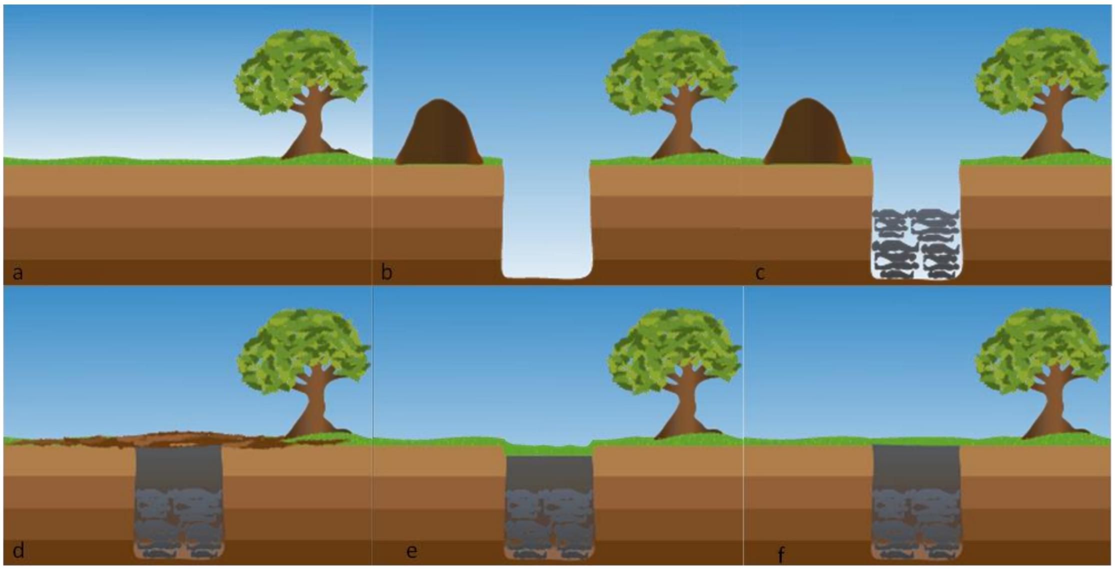


Figure 14: (a) Prior to the grave being dug. (b) Soil is removed and placed on top of the vegetation adjacent to the grave. (c) the remains are added. (d) the grave is backfilled, and some of the soil will stay intermixed with the surrounding vegetation. (e) over time the vegetation starts to recover and new vegetation grows over the grave. (f) the vegetation recovers enough that the grave is harder to detect, although the vegetation direct above the grave will be younger than the surrounding vegetation (Source: Author).

This process and the chemical alterations caused by the decomposing bodies (see Chapter Seven: pg. 108-112) affect the vegetation in different ways, which is often easily distinguishable from the undisturbed surroundings (Bajerlein et al., 2015). Coyle et al., (2005) research establishes that disturbed soil will follow a set pattern of vegetation recolonisation, firstly grasses will grow back, followed by shrubs, and finally trees. However, vegetation responses to the grave environment are unique and largely dependent on the species, soil characteristics, climate, and grave depth (Ruotsala, 2020).

In some cases, vegetation regrowth increases. This is because the soil has become more aerated enabling better drainage, there is also excess moisture in the soil and/or a change in mineral concentration which helps to stimulate plant growth (Hall, 1997; Killam, 2004; Ruffell and McKinley, 2008; Watson and Forbes, 2008; Caccianiga et al., 2012; Dupras et al., 2012; Lubit, 2012; Bajerlein et al., 2015). Research conducted by Kalacska et al., (2009) supports this, they compared a mass grave created using animal carcasses against an identically constructed false grave. They observed that by 16 months post-burial the false grave was no longer distinguishable, whilst regeneration could be seen on the mass grave the edges remained vegetation-free (Kalacska et al., 2009: 163). This means there is potential to detect mass graves using vegetation differences, for an extended period after construction. Although the vegetation over the decomposition site will be younger than the surrounding undisturbed vegetation, the area will appear recovered making the grave harder to detect.

However, the presence of a grave can also have the opposite effect, especially if the root system of the vegetation is destroyed or restricted (Bajerlein et al., 2015; Ruotsala, 2020). This can also be evident around the grave, as there will be signs of plants being bent, broken or trampled from the digging and backfilling of the grave, pilling of soil near the edge, footprints and vehicle activity (Byers, 2011; Ruotsala, 2020). The use of heavy machinery or indeed any tools may also be visible on the roots of plants, particularly if there is a tree close to the grave, as such botanical evidence in the form of the slice or cut marks in the roots caused during the digging process may be a good indication of a grave being present (Willey and Heilman, 1987; Bock and Norris, 1997).

Vegetation can also play a key role in indicating the time since burial, and time of death if the bodies were buried in a prior geographical location, as vegetation fragments can end up buried within the grave (Hall, 1997; Aquila et al., 2014). This means it can be used to establish links between primary and secondary deposition sites (Aquila et al., 2014). Pioneer species can also be introduced to the area by the perpetrator(s) to conceal the grave for example they may deliberately plant trees and/or shrubs over the grave (Trzciński and Borkowski, 2015). This can be seen in the mass graves associated with the Katyń forest massacre, which were deliberately planted with young pine trees, during the investigation cross-sections were taken from the trees determining they had been planted at the time of the massacre (Reszeja and Chróścielewski, 1994: 5).

Overall, the vegetation response to the presence of a grave is dependent on the environment and will be different from region to region, and country to country, due to the different variety of vegetation species and conditions (Watson et al., 2020). Making it harder to determine the exact changing nature of physical vegetation indicators over time. In one area grass may appear first and cover the grave quickly, in another, it could be nettles that are first to grow. Therefore, forensic archaeologists should have an awareness of vegetation changes, however, during forensic casework specialists in botany should be consulted. The perpetrator's need to disguise the presence of a mass grave also requires consideration, as the Brcko mass grave in Bosnia had 25,000 tonnes of demolished buildings and soil placed on top of the grave to hide it which completely alter the vegetation and the landscape (Wright et al., 2005).

5.1.3 Pollen and Spore Analysis

Pollen analysis, also known as palynology, is the study of modern and fossilised pollen and spore assemblages, and can also be used as a vegetation disturbance indicator. These assemblages can be preserved for many years due to their extreme resistance to biological, chemical and mechanical degradation (Mildenhall et al., 2006; Walsh and Horrocks, 2008; Alotaibi et al., 2020). The small grain size makes them easily transferable, as they attach themselves to surfaces such as vehicles, evidence and clothing without anyone being aware of it (Walsh and Horrocks, 2008; Alotaibi et al., 2020). The longevity of pollen and spores means palynological analysis occurs within archaeology and forensics. Forensic palynology, the application of pollen and spore analysis to a legal context, has been used in criminal investigation since the 1950s, particularly within the UK, USA, Australia and New Zealand (Erdtman, 1969; Frei, 1982; Stanley, 1987; Mildenhall, 1990; Wiltshire, 2004).

It has successfully been used to establish links between evidence, crime scenes, burial sites, suspects and victims (Coyle et al., 2001; Dunbar and Murphy, 2009; Bryant, 2013; Kumari et al., 2017). Palynological analysis was one of the techniques employed during the investigation of the Srebrenica mass graves. Pollen samples were collected and analysed, and the results provided links between the primary and secondary mass graves, as well as linking the execution sites with the primary graves (Brown, 2006; Long, 2006). Through these samples, investigators were also able to forge links with other evidence, such as clothing, documents and shell casing, to the primary and secondary graves (Long, 2006).

The analysis of pollen and spores show that different plants produce different results, therefore, they can be traced back to the environment they came from (Mildenhall et al., 2006). Thus enabling investigators to locate the mass graves, as suspects, vehicles and evidence might be carrying pollen graves which can be traced to the potential location, provide clues to the source of the times and the characteristics of the environment from which the material was sourced (Mildenhall et al., 2006). However, there is currently a lack of complete information on the location and techniques available to collect the samples necessary to conduct an investigation (Alotaibi et al., 2020).

5.1.4 Compression and Depression of the Soil

Over time, the reconsolidation of the ground causes the soil to compact, creating a visible depression on the surface, this is because the soils from different levels of the grave have intermixed during the excavation and backfilling (Byers, 2011). Compression marks in the surrounding landscape also include prints from the suspect’s shoes, tyres and tracks of vehicles, backs of shovels, and hands and knees are commonly visible (Dupras et al., 2012).

The depression and compression of the grave's surface causes the disturbed earth to pull away from the grave cut, forming small cracks around the perimeter of the grave (Morse et al., 1983). This causes changes to surface elevation, particularly around the edges of the grave cut (Corcoran et al., 2018).

5.2 Visual Foot Search

Visual foot searches are a well-established technique used across archaeological and forensic investigations, as it is a cheap, effective, non-invasive method of examining sites (Gerrard et al., 2007; Grant et al., 2008; Dupras et al., 2012). Archaeologically, foot searches are used to collect and record evidence on the surface of the ground, to establish the function and period of the site without excavating. However, land access must first be granted either because the area is private property or because it is protected. Forensically, a site must be searched thoroughly and systematically to find and record physical evidence such as imprints and compressions (e.g. shoe prints, tyre, track, and tool marks) and trace evidence (e.g. paint, pollen, and hair fibres), which can be used to locate a grave (Birzer, 2012; Ghanem and Sobh, 2021). It is also important to consider the area a search is being conducted in. Searches being carried out on land used for arable or pastoral farming can only take place during certain times of the agricultural cycle (Grant et al., 2008). Whilst the undergrowth and tree roots may make it harder to identify evidence as they can be more hidden in woodland areas.

Nevertheless, before a foot search takes place, an outer search boundary is established, which often follows visible naturally formed boundaries such as streams, hedges or ridgelines (Larson et al., 2011; Dupras et al., 2012; Donnelly and Harrison, 2017). However, defining the perimeter in an open area that has few physical features is difficult (Donnelly and Harrison, 2017). Although the information gathered from witnesses or through the other desk-based techniques (see Chapter Four) can aid in establishing suitable boundaries for the search to take place within.

5.2.1 Linear Search Patterns

Linear, which means arranged or extended in a straight or nearly straight line covers the search methods of the strip, line, grid, and interlocking. Searchers walk along a transect in a series of lines or grids that has been marked by flags or poles (Grant et al., 2008).

Line Search

Line searches are carried out by a team of searchers, making them suitable for large areas of interest (Gerrard et al., 2007; Bell, 2019). Searchers stand side by side, then proceed to walk the area in a straight or nearly straight line (see Figure 15), whilst scanning the ground for indications of human disturbance (Mann and Sanderson, 2009; Byers, 2011; Bell, 2013). In straight and wavy line searches shown in Figure 15a and Figure 15b, searchers start at one side of the boundary, standing close enough that their field of view overlaps (Killam, 2004; Dupras et al., 2012; Bell, 2013). They then move slowly to the opposite side, along the way marking anything of interest or any potential evidence with flags (Dupras et al., 2012; Ghanem and Sobh, 2021). The interlocking pattern shown in Figure 15c can be used to achieve a more thorough search, two rows of searchers face each other on opposite sides of the boundaries and then proceed to walk to the other side, passing each other in the middle (Killam, 2004: 26). Although the advantage of a line search is it allows for all the ground to be covered, which reduces the likelihood that evidence will be missed, it requires access to a large group of searchers (Byers, 2011). Particularly if the interlocking pattern is used, because it would require a team on both sides of the area.

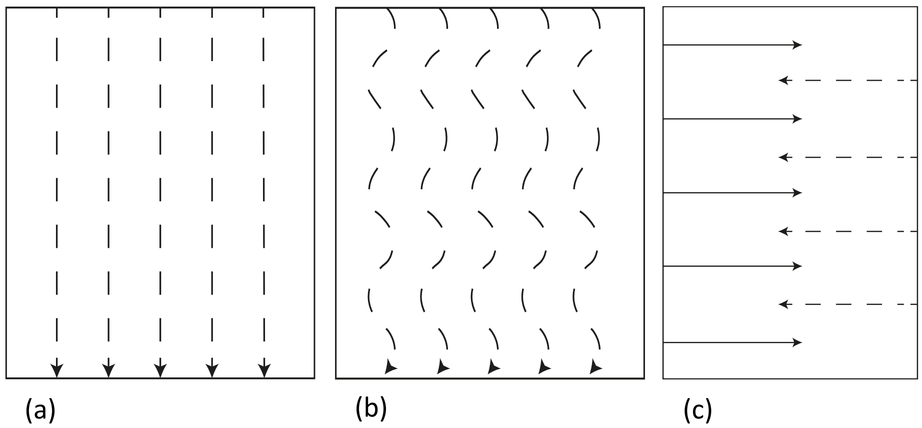


Figure 15: (a) the area of interest is searched by walking in straight narrow lines. (b) searchers walk in a slight wavey line. (c) the search is carried out in an interlocking pattern where two separate groups of searchers pass in the middle (Source: Author).

Strip Search

A strip search pattern is very similar to that of a line search but has been designed so that one searcher can survey the area of interest. The site is divided into multiple rows, marked out by rope or flags, each row is referred to as a strip (see Figure 16). The investigator then proceeds to either walk one strip at a time or back and forth until the entire area within the marked boundary has been completely searched (Birzer, 2012; Dupras et al., 2012; Bell, 2013; Ghanem and Sobh, 2021).

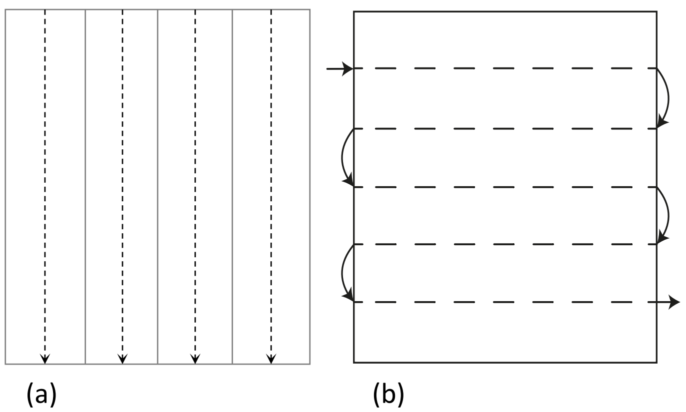


Figure 16: (a) the area is divided into strips which are then searched one at a time. (b) searchers walk up and down the area in a zig-zag pattern (Source: Author).

Grid Search

Another variation of the line search is the grid search (see Figure 17), which can either be carried out by an individual or a search team. Once the line search is complete, a second search of the area is undertaken in a perpendicular direction to the first search (Birzer, 2012). There are two variations of a grid search pattern, Figure 17a shows the second search being carried out on a vertical transect, whilst Figure 17b shows the search looping around in one corner of the boundary and the second search being carried out vertically to the first. This search pattern is more time-consuming but is more likely to yield evidence or flag areas of interest because the ground is searched twice and from a different angle. This is particularly effective if the terrain is uneven, there are bushes/ground cover, or the light and/or wind direction is affecting the search (Dupras et al., 2012; Ghanem and Sobh, 2021). Searching at different angles means evidence not visible during the first search could be visible during the second pass.

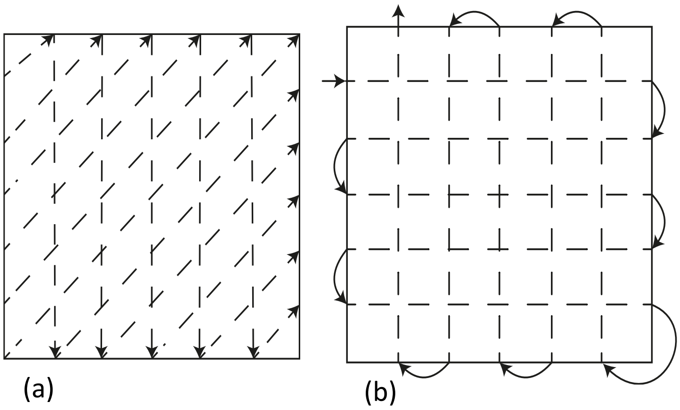
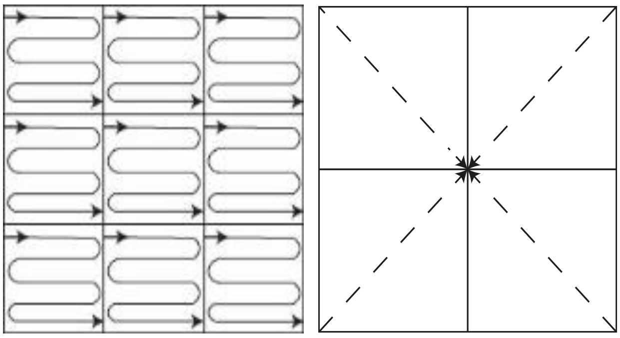


Figure 17: (a) the first search is a line search, and then a second search is carried out on the diagonal transect. (b) The first pass is a line search which then loops around and a second search is carried out perpendicular to the first (Source: Author).

5.2.2 Quadrant Search Patterns

Investigator and/or the search area is larger because it subdivides into smaller more manageable zones (Grant et al., 2008; Mann and Sanderson, 2009; Birzer, 2012; Bell, 2013; Bell, 2019; Harris and Lee, 2019; Ghanem and Sobh, 2021). Baselines are laid out across the area from the established boundary and marked by pegs, rope or tape measures, to allow for accurate recording. The zones are either $10m^2$ or $20m^2$ (Foard, 1977; Mann and Sanderson, 2009). Two variations of the quadrant method are presented below in Figure 18. In Figure 18a the area of interest is divided into zones, each zone is then searched using the strip zig-zag pattern. Although Figure 18b is also divided into zones, the investigator walks along a diagonal transect from the outside boundary into the centre, this can be completed by one investigator or a team of searchers.



(a) (b)

Figure 18: (a) the area is divided into zones and then walked using a zig-zag pattern. (b) each zone is searched on a diagonal transect starting at the edge and walking towards the centre (Source: Author).

5.2.3 Alternative Search Patterns

The spiral search pattern (see Figures 19a and 19b) can be used starting from the centre of the site or the boundary, investigators then either search in decreasing or increasing concentric circles (Miller, 2002; Birzer, 2012; Dupras et al., 2012; Bell, 2013; Ghanem and Sobh, 2021). The reverse spiral (Figure 19a) can be applied when human remains or a grave have already been located, the search starts there are then spirals outwards, allowing searchers/search teams to find any evidence that may have been dispersed around the site (Hall, 1982; Dupras et al., 2012; Bell, 2013). Figure 19c presents the wheel search pattern, similar to the spiral pattern, the search area is considered circular, it is then divided into zones, searchers start in the centre and then proceed to walk outwards to the boundary (Birzer, 2012; Ghanem and Sobh, 2021). This search pattern is considered to work best on smaller sites, although it can be adapted to work in larger search areas (Miller, 2002). However, the reverse spiral and the wheel search pattern can cause investigators to accidentally disturb or destroy evidence as they make their way to the centre to start the search (Birzer, 2012; Ghanem and Sobh, 2021). As such, it is important that if alternative search patterns are applied to casework, search teams are mindful of where they are walking before the search has even started to prevent the unnecessary disruption of evidence.

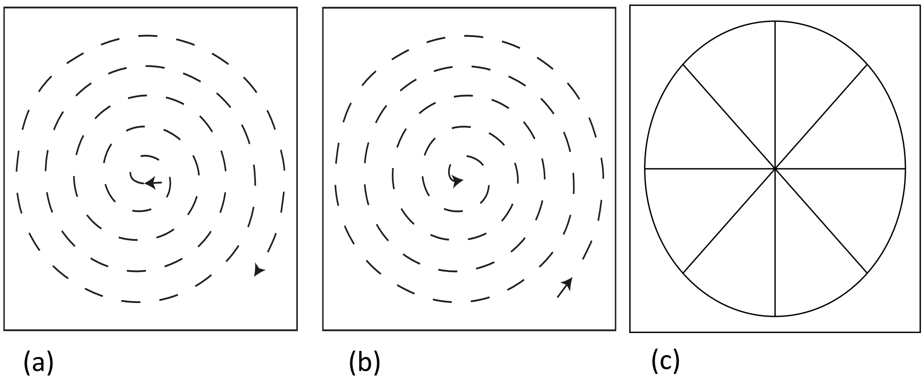


Figure 19: (a) This spiral search pattern starts in the centre of the site and spirals outwards. (b) The spiral search pattern starts at the outside of the site and spirals into the centre. (c) Wheel search pattern, search teams start in the centre and walk to the boundary (Source: Author).

5.2.4 Foot Searches in Relation to Mass Graves

This method is a well-established technique for two reasons. Firstly, it is cheap to employ as search teams are often made up of volunteers. Secondly, it is non-invasive which means it does not destroy potential evidence concealed within the subterranean landscape. The use of search patterns helps maintain organisation and structure, ensuring any evidence is not missed and/or lost during the process. However, before a foot search can take place permission to access the location needs to be obtained. For archaeological investigations, this permission comes from the landowner, whereas during forensic investigations access is granted in the form of a search warrant, if necessary.

Despite obtaining permission, archaeological field searches are often restricted to certain stages of the agricultural cycle, such as when the field has been or is ready to be ploughed because they cannot occur during the growing season. Search perimeters can also be hard to define, particularly if naturally occurring boundaries are not present (i.e. trees and hedgerows), however, information gathered during the desk-based assessment can help provide an idea of where to place the boundary. There may also be difficulty in conducting a thorough foot search if the ground cover is dense, as it is harder to find physical evidence or evidence of the grave itself. Although this can often be overcome by selecting a search pattern that allows the site to be searched from different angles or by having the team search closer together.

As such, foot searches are an effective non-invasive method for locating surface evidence and physical alterations created by the presence of a grave across archaeological and forensic casework. This surmises that it can be successfully applied during the search for mass graves because the array of search patterns means they can be applied and adapted to fit both smaller and larger sites. However, it is important to remember that the scale of a mass grave site means that many of the physical markers may be more challenging to see. Sites containing potential mass graves related to human rights atrocities and/or war crimes should also be surveyed for buried mines and declared safe before a foot search can take place. Not doing so will cause this technique to be unsuitable.

The application of search patterns ensures the exploration of a site is organised and well structured, this helps to minimise the risk of evidence being missed, damaged or lost during the initial processes. Whilst there is not a standard search pattern, the array of patterns discussed above are most commonly used. Selecting one of the patterns once on-site provides search teams with the flexibility needed to adapt to different locations while ensuring the search is managed and well-coordinated.

5.3 The Application of Remote Sensing

Remote sensing is the process of acquiring information about a site or object without physically coming into contact with it (Lillesand et al., 2015). It has been widely researched and applied to many fields, such as agriculture, computer science, defence, forestry, geology, and national security (Murray et al., 2018). Although remote sensing is used in archaeology and forensic archaeology, when it comes to the detection of human remains it is still in the early stages of development (Barbazon et al., 2020). Nevertheless, it has been applied to mass grave casework. Investigators working in Bosnia combined data collected from satellite imagery, limited spectral analysis and Geographical Information Systems (GIS) to locate some of the sites (Wheatley and Gillings, 2002).

The classification of the different types of remote sensing, such as Visible, Near-Infrared, Thermal-Infrared (see Chapter Seven: pg. 121), and Microwaves, is based on the values of pixel brightness and spatial gradients which are used to differentiate surface features to build an image of the area (Babic et al., 2000; Jia et al., 2016; Murray et al., 2018).

This section focuses on the different remote sensing techniques that are either used or could be used to locate mass graves; such as GIS, Light Detecting and

Ranging Systems (LIDAR), Multispectral, Hyperspectral and Infrared Sensors, and Structure from Motion (SfM).

5.3.1 Geographical Information Systems

GIS is a database and mapping system used to capture, store and manipulate geographical data (Bearman, 2021; Darvill, 2021). By combing layers of data, such as drainage, traces of human activity, and topography, archaeologists can build up a digital image of the landscape (Bray and Frieman, 2008). This means it is an extremely effective tool for plotting and analysing sites of interest against other data collected from other sources such as aerial images and digital maps (Darvill, 2021).

By comparing the landscape against aerial images, archaeologists can show changes in the landscape consistent with those created during the digging of a mass grave. Several researchers such as Hirschfield and Bowers (2001), Somma et al., (2018) and Spera et al., (2020) suggest that GIS has the potential for detecting areas of interest like a gravesite. As a visualisation tool, surveyed data collected from a site can be uploaded into computer software, like ArcGIS (Spera et al., 2020). Once the GIS databases are established, mapping the data into a form that can be used is possible from the outset, allowing archaeologists and investigators to explore the spatial patterns present in the results from the start of the analysis process (Gregory, 2003). This would be particularly important when working on a time-sensitive case, as it means results can be accessed quickly. GIS was successfully used to narrow down potential burial locations in Eastern Bosnia (Reddick, 2006). However, more research into how GIS can be utilised as a locator tool is needed.

5.3.2 Light Detecting and Ranging Systems

Light Detecting and Ranging Systems (LiDAR) was also not originally developed for archaeological use, rather it is a technology that has been adopted by archaeologists who saw its potential (Historic England, 2018). LiDAR records the time it takes for a pulse of near-infrared or visible green light to hit the surface of the earth and get reflected by the sensor (Corcoran, 2016; Dong and Chen, 2017; Koopman, 2017; McManamon, 2019). Calculating this means it is possible to record the location of points on the ground with a high level of accuracy, the data can then be used to develop 3D models of the ground (Dong and Chen, 2017; Historic England, 2018). The data sets themselves are referred to as ‘point clouds’, these points represent the coordinates of every place the pulse interacted with an object (Corcoran, 2016; Decker and Borghetti, 2022). As an active sensing technique, numerous data points are continuously accumulated causing an increase in the overall density of the point cloud (Zheng and Weng, 2014; Corcoran, 2016). By building a 3D model of the ground, archaeologists can see depressions and/or structural outlines in the surface of the earth which could be interpreted as gravesites.

This technique has been extensively applied to archaeological casework, to map known burial mounds and cemetery grave plots, predict the location of unknown mounds and detect ground elevation changes as grave fill settles (Riley, 2009; Chase et al., 2011; Weitman, 2012; Artz et al., 2013; Corcoran, 2016; Koopman, 2017; Corcoran et al., 2018). Suggesting this technique could be effectively applied to mass grave casework, however, currently, there is little to no research in terms of using LiDAR to detect mass graves or its uses within a forensic capacity. This could be because without extensive investigation there is no definitive way of confirming that the depression is a grave, nevertheless, it could be used to facilitate other data collection techniques. LiDAR also relies on light and cannot see through trees or any other solid object, as this is what causes the light pulse to bounce back to the sensor (Historic England, 2018). Instead, LiDAR can measure through gaps in the vegetation or tree canopy, as long as the gaps are sufficient (Corcoran, 2016; Historic England, 2018). Therefore, if the grave is situated in dense vegetation or forest, data results would be poor, as it makes it difficult to automatically filter out the vegetation from the point cloud (Riley, 2009).

5.3.3 Multispectral Sensing

Multispectral sensing obtains images by recording separate wavelength intervals using a remote sensing radiometer, each interval is represented in the form of pixels and ranges from 5-12 bands (Sabins, 1996; Adão et al., 2017). Once processed, one of the ways the data can be displayed is through a reflectivity map, however, multispectral imagery collates large amounts of surface feature data which can make the processing and analysis stage difficult (He and Zhao, 2018; Janoušek et al., 2021).

Research carried out by Rocke and Ruffell (2022: 73) suggests there is the potential to combine multispectral data with digital terrain modelling, as they can be used to detect micro-topography created by ground disturbances, which outlast anomalies associated with vegetation alterations. Suggesting this technique would be effective as a tool for locating mass graves. Multispectral wavelength bands (for example blue, green and red) also interact with vegetation differently, depending on solar radiation and chemical composition (see Chapter Seven: pg. 113-114) (Janoušek et al., 2021). This means multispectral imagery can be used to detect stresses in the vegetation which could be a sign that a mass grave is present. However, the nature and quality of data are immense, whilst there is potential for this technology to detect both single and mass graves, research into the long-term recovery trends and detection limitations are yet to be published (Rocke and Ruffell, 2022: 85).

5.3.4 Hyperspectral Sensing

Hyperspectral sensing is more sensitive than multispectral sensing as it consists of hundreds or even thousands of wavelength bands that are simultaneously imaged (Sabins, 1996; Adão et al., 2017; Murray et al., 2018; Decker and Borghetti, 2022). Each pixel represents the intensity of emittance or reflectance at a specific electromagnetic wavelength, which is used to detect and discriminate between objects on the surface of the ground (Murray et al., 2018; Decker and Borghetti, 2022). This means details that may be missed when using multispectral imaging could be detected in the hyperspectral data, as it builds a more detailed picture (Adão et al., 2017).

However, there are multiple drawbacks currently associated with hyperspectral imaging. If improved, this technique could result in an abundance of data, that could be applied to the detection and documentation of mass grave investigations (Murray et al., 2018). These drawbacks include:

- Hyperspectral sensors collected massive amounts of data which need to be stored, this can limit flight time and coverage (Anand et al., 2017; Murray et al., 2018).
- The collected data needs to be processed and due to the amount of data, this can be a time-consuming process.
- Processing the data is currently a complex procedure due to the hundreds/thousands of narrow bands that need to be processed, it can

be difficult to manage in real-time without up-to-date computer resources (Adão et al., 2017).

Although hyperspectral imagery has the potential to detect soil and vegetation anomalies better than multispectral sensing, analysis of the data requires complex computer algorithms, that many working within humanitarian organisations and the police may not understand (Bioucas-Dias et al., 2013). Nevertheless, the development of hyperspectral sensing is still an ongoing process across agriculture, forestry, archaeology and other related fields (Adão et al., 2017).

In recent years, research has been conducted to determine if it can be used as a potential search method. Experiments performed by Kalacska et al., (2009) and Leblanc et al., (2014) show the promise of using hyperspectral imaging to detect gravesites. Kalacska et al., (2009) research analysed the spectral reflectance of a set of animal mass graves and identically constructed false graves, the results indicated that the reflectance spectra of the mass grave were easily discernible from the false grave. Leblanc et al., (2014) performed blind tests using hyperspectral imaging to locate pig carcasses their results also showed the promise of using hyperspectral imagery as those involved were successfully able to predict where the graves were within a 10m GPS error range. More recent research conducted by Barbazon et al., (2020) suggests that reflectivity markers and fluorescent spectra can provide valuable information, which can be applied to the detection of plant anomalies. This is because younger vegetation shows up differently from that older vegetation, therefore, spectra responses from the surrounding trees, shrubs and grasses could act as a guide for finding gravesites (Ruffell and McKinley, 2008; Barbazon et al., 2020).

As such, hyperspectral sensing shows promise in being used to detect single and mass graves. It can also be used to search large areas that would otherwise be inaccessible by foot.

5.3.5 Near-Infrared Sensing

The use of near-infrared sensing to detect single clandestine graves is a new concept, for both forensics and archaeology (Evers and Masters, 2018). When comparing soil and vegetation using the near-infrared spectrum, vegetation has higher reflectance in the very near-infrared range and a lower reflectance in red wavelengths (Murray et al., 2018). This means it can be very easy to detect vegetation that has been stressed by changes to the soil nutrients and aeration using near-infrared (Carter, 1993; Murray et al., 2018). Research carried out by Verhoeven (2008) establishes that using near-infrared imagery when surveying archaeological areas of interest is beneficial for locating less noticeable features. However, the position of the sun influences the shadowing of features and vegetation, this can cause their appearance in the image to alter (Evers and Masters, 2018). There is also the issue of the images not being clear enough to use, this can be seen in an experiment carried out by Evers and Masters (2018: 413) approximately 300 images were captured during a single flight over the experimental site, but when analysed later many were unusable due to motion blur and distortion. Therefore, whilst it is possible to locate a gravesite using near-infrared imagery, further testing is needed.

5.3.6 Structure from Motion

SfM, like LiDAR, creates 3D images, the difference is that SfM data is collected using a single camera attached to a moving platform like a UAV (Ozyesil et al., 2017; Historic England, 2018; Murray et al., 2018). As a photogrammetry technique, it is used to produce very accurate digital models of the ground and estimate plant features, such as height and light exposure (Shafiekhani et al., 2017; Historic England, 2018).

SfM can map small to medium-sized areas more accurately than LiDAR can, it is also able to collect data whilst offline, which is particularly helpful if the area of interest is in a remote location (Historic England, 2018; Murray et al., 2018). However, there are still some drawbacks, firstly the number of images is restricted by the battery life and the need for overlap between images (Historic England, 2018).

Research has begun to explore the possibility of using SfM to build 3D reconstructions of non-clandestine graves and surface remains for archaeological purposes, however, there are challenges that SfM presents that need to be understood before it is applied to forensic casework (Levy et al., 2014; Murray et al., 2018). This is because SfM is most commonly used to record structured environments, such as urban areas, mass graves occur in much more remote and discrete locations where vegetation often covers the surface of the ground, it is also not clear how much of the scene would need to be imaged to detect the grave (Murray et al., 2018).

5.4 Conclusion

When a mass grave is created, the use of heavy machinery, tools and vehicles causes damage to the vegetation and surrounding landscape. Whilst the vegetation can recover, should enough time pass, the process is relatively slow. Therefore, taphonomic signatures that physically alter the landscape can be used to indicate the presence of a mass grave. Across archaeology and forensic archaeology, these alterations have been successfully identified through the use of a foot search. However, it is not always possible to use this technique, particularly if the casework is undertaken in conflict or post-conflict zones, where the area may be inaccessible or unsafe. Remote sensing methods present an alternative, or complementary technique in situations where foot searches are unable to be conducted, given the potential it has shown in archaeological contexts. Although more research is needed to fully assess its applicability to mass grave casework.

Chapter Six: Stratigraphic Alterations

The interdisciplinary study of stratigraphic alterations draws upon knowledge and understanding from a range of different fields, particularly archaeology and geology (Steffen, 2016). Whilst one of the most distinctive features of a mass grave or indeed any grave is the visible evidence of disturbed soil, it also causes changes to the stratigraphy of the subsoil (Bevan, 1991). Which, if recognised could provide archaeologists with the means of identifying and confirming the presence of a mass grave within the landscape. Therefore, this chapter focuses on analysing the following questions:

- What are stratification and stratigraphy?
- What techniques can be used to detect stratigraphic disturbances?
- What are the advantages and disadvantages of these techniques?
- What geotaphonomic alterations can they detect?
- Do these alterations change over time?
- Does soil type have an impact?
- Can these alterations be used to indicate the presence of a mass grave?

6.1 Site Formation: Geological vs Archaeological Stratification and Stratigraphy

Stratification and stratigraphy originated in the field of geology. Whilst archaeological stratigraphy follows the same processes and concepts, there are key differences that archaeologists, particularly those based within the UK are expected to adhere to.

6.1.1 Geological Stratification and Stratigraphy

Stratification is the process of geological strata (layers), made up of rock, soil, and sediments, building up continuously over time to form a series of sequential layers (Dunbar, 1958; Renfrew, 1973; Barker, 1993; Harris, 1989; Lemon, 1990; Evis, 2016; Banning, 2020). Whereas, stratigraphy is the overall study of stratification, with the view to arranging geological strata into a chronological sequence (Renfrew, 1973; Harris, 1989; Barker, 1993; Evis, 2016: 4). As such, every new layer forms on top of a pre-existing one (see Figure 20), therefore, the deeper layers are older than the ones at the surface (Waters, 1992; Herz and Garrison, 1998; Killam, 2004; Dupras et al., 2012; Holland and Connell, 2016).

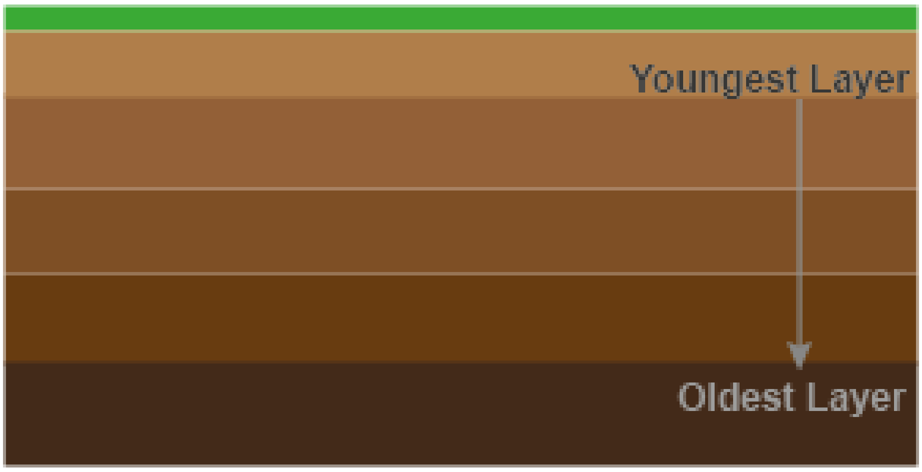


Figure 20: Sequence of stratification layers, youngest down to oldest (Source: Author).

Geological strata occur naturally and are formed of five master layers and several minor layers, every layer is given a designated letter and is known as a horizon (see Figure 21), the master layers are O, A, B, C, and R (Limbrey, 1975; Courtney and Trudgill, 1976; Steila, 1976; Herrmann et al., 2018). Horizon O is the organic layer, containing high levels of organic matter, dark in colour it contains fresh or partially decomposed leaf litter, needles, twigs, moss and/or lichen (Lou et al., 2021). Horizon A, the topsoil, is a mixture of both mineral and organic materials, whereas horizon B, the subsoil, contains all the materials filtered down from A (Limbrey, 1975). Horizon C, the parent material, is formed of deposits of soil believed to have developed from horizon R, the underlying unaltered bedrock (Limbrey, 1975; Courtney and Trudgill, 1976; Steila, 1976; Banning, 2020).

Figure 21: Soil horizons, showing the organic layer (O), topsoil layer (A), subsoil layer (B), parent rock (C), and bedrock (R) (Source: Author).

6.1.2 Archaeological Stratification and Stratigraphy

Archaeological sites are formed by human activity and natural processes. The formation of artefacts and features provides evidence of past societies, over time they become buried by natural processes (Schiffer, 1983). As is the case in geology, archaeological stratification is the process of each layer continually forming, whilst stratigraphy is the chronological study of the formation sequence (Dirkmaat and Adovasio, 1997; Evis, 2016). However, similarities end there. The stratification of a site is composed of layers and interfaces (see Figure 22), caused by a disturbance to the earth's natural strata (Harris, 1979a; Evis, 2016). A layer has a physical presence within the site and has been deposited there either by natural processes or more likely by the actions of people (Barker, 1993; Harris, 1979a; Harris, 1989; Evis, 2016). Whereas, an interface or surface which is created by the deposition or removal of a layer, can either be vertical or horizontal, however, it cannot be excavated and should be recorded where it is found (Evis, 2016: 5).

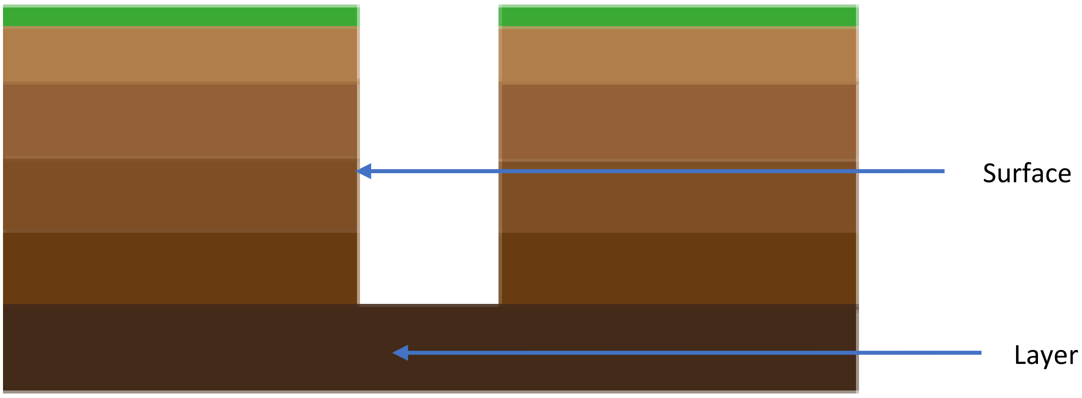


Figure 22: Surfaces and Layers (Source: Author).

6.1.3 Principles of Stratigraphy

The process by which archaeological stratification occurs is governed by the Principles of Stratigraphy (Evis, 2016: 5). These are:

- *Principle of Superposition*: Strata are deposited sequentially on pre-existing layers, this means stratigraphic layers nearest the surface are the youngest and the deeper layers get progressively older (Dunbar, 1958; Harris, 1979a; Herz and Garrison, 1998; Allaby, 2020; Darvill, 2021).
- *Principle of Original Horizontality*: Strata are deposited horizontally or near horizontally (Harris, 1979a; Herz and Garrison, 1998; Allaby, 2020).

- *Principle of Original Continuity*: Each stratum was originally considered whole without any exposed edges, when the underlying layers are exposed through excavation or erosion, its continuity is sought or absence explained (Woodford, 1965; Harris, 1979b; Herz and Garrison, 1998).
- *Principle of Stratigraphical Succession*: Archaeological stratification takes its place in the stratigraphic sequence of a site from its position between the oldest and youngest strata, which lies directly above and below it in direct physical contact (Harris, 1979b; Herz and Garrison, 1998).
- *Principle of Intercutting*: A feature or deposit that cuts across or into an existing layer of strata that must be more recent than the existing layers (Darvill, 2021; 1530).
- *Principle of Incorporation*: All material found within a stratigraphic unit must be the same age or older than the strata itself (Darvill, 2021: 1530).
- *Principle of Correlation*: Comparisons can be identified between strata that have the same features, contain the same array of artefacts and organic materials, and occupy a similar stratigraphic position within the associated stratigraphic sequence (Darvill, 2021:1530-1531).

Following these principles enables archaeologists to understand the sequence of events that took place, provide information on when evidence and/or remains were buried, and reconstruct the events surrounding the creation of a grave (Hochrein, 2002a; Hunter and Cox, 2005; Dupras et al., 2012; Darvill, 2021).

Each context is allocated a unique identification code and its position within the stratigraphic sequence is identified (see Figure 23) and recorded using the Harris Matrix (see Figure 24) (Harris, 1975; 1979a; 1979b; Harris et al., 1993).

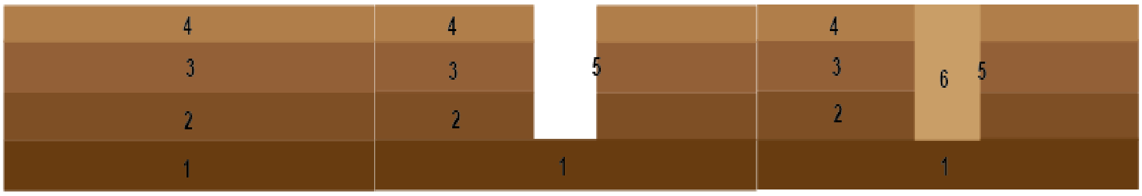


Figure 23: Example stratigraphic sequence with identification number recorded (Source: Author).

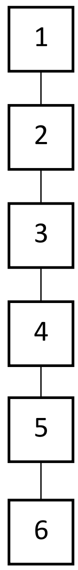


Figure 24: Example of a stratigraphic sequence recorded as a Harris Matrix (Source: Author).

6.1.4 Stratigraphy and Stratification in Grave Formation

The digging of a grave cuts through the existing strata (see Figures 25a and 25b), permanently interrupting and mixing the soil layers (Hochrein, 2002a; Evis et al., 2016; Holland and Connell, 2016). The subsequent backfilling of the grave (Figure 25c) causes the formation of new layers and surfaces (Evis et al., 2016). This is because the disturbance of the subsoil is considered an irreversible process, that can only be altered, rather than returned to its original state (Harris, 1979a). It also alters the soil's colour, density and physical properties which can be picked up through visual techniques (see Chapter Five), or through non-invasive and invasive techniques discussed later in the chapter.

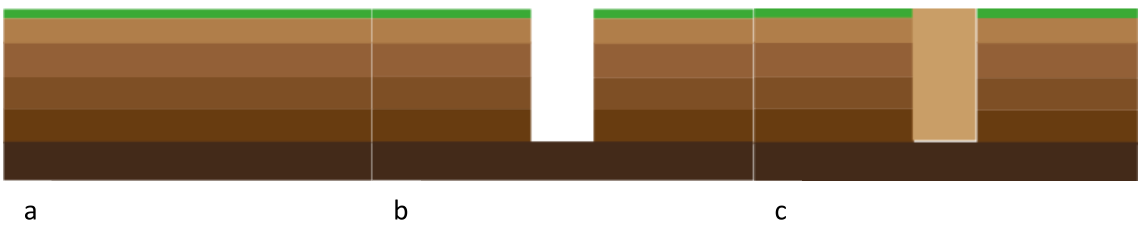


Figure 25: (a) undisturbed soil layers. (b) layer cut caused by digging a grave. (c) a new layer formed with the backfilling of soil (Source: Author).

6.2 Identifying Stratigraphic Disturbance: Non-Invasive Approaches

Non-invasive approaches enable archaeologists to narrow down the possible location, size, and depth of a suspected mass grave site without destroying the area of interest (Gaffney and Gater, 2003; Hunter and Cox, 2005; Blau et al., 2018; ICMP, 2022). Minimising the risk of potential evidence or artefacts being destroyed, reduces the demand on resources, increases efficiency and is cost-effective (Parrott et al., 2019). In forensic casework particularly, the use of non-invasive approaches also minimises the risk of alerting anyone to the fact a mass grave has been located (ICMP, 2022).

Non-invasive techniques include but are not limited to visual foot searches (see Chapter Five: pg. 75-81), remote sensing (see Chapter Five: pg. 81-87), and geophysical prospections (discussed further in this chapter).

6.3 Geophysical Prospection

Geophysical equipment is often used to survey archaeological and forensic sites, as it is the most effective way of locating stratigraphic disturbances related to the digging of a grave (Berezowski et al., 2021). Frequently used techniques include magnetometry, ground penetrating radar (GPR), and resistivity, although there are others which could potentially be used to locate a mass grave. Buried anomalies constitute the majority of the features recorded by geophysical means, typically these include but are not limited to ditches, walls, hearths, pits, and graves (Hunter and Martin, 1996: 97). By measuring the variations in physical properties (magnetic, gravity, or electrical), these features can be detected by the contrast in signatures that their formation has created in comparison to the undisturbed areas in the survey zone (Batey, 1987; Gaffney et al., 2002; Herz and Garrison, 1996; Hunter and Martin, 1996; Reynolds, 2011).

6.3.1 Magnetometry

Magnetometry surveys detect slight variations in the earth’s magnetic field, enabling archaeologists to map structures and features without any destructive removal of soil or contact with the ground (Conyers, 2018; von der Osten-Woldenburg, 2020). One type of magnetometer commonly used is the dual-sensor gradiometer, seen below in Figure 26 (Schlinger, 1990; von der Osten-Woldenburg, 2020). Carried out at a steady continuous pace, they pass over vegetation and obstructions easily, and aid with the coverage of large areas in quick succession as the measurements are continually taken (Fenning and Donnelly, 2004; Conyers, 2018).

Figure 26: Gradiometer Surveying (Image: Author).

The collected data is then processed into visual maps allowing archaeologists to see visual patterns caused by buried material, the extent and potential nature of the buried archaeological site, and other buried features in the landscape (Benech, 2007; Mohamed-Ali et al., 2012). Whilst they are effectively applied in archaeology, magnetometry is too sensitive for forensic casework. An area with considerable disturbance and/or metal debris creates background noise which could be misinterpreted as a feature (Hunter and Martin, 1996). Therefore, surveys carried out near metal fences, pipelines, powerlines, and metal debris, or if the surveyor has metal on them, could produce false readings (Neubauer et al., 2003; Kalacska et al., 2008; Dupras et al., 2012). These readings can cause archaeologists to spend valuable time investigating and carrying out further investigations on an area that shows up falsely as an area of interest but that does not contain a mass grave, meaning valuable resources and time is wasted. However, mass graves are typically situated in remote rural areas, where there is less likely to be a large amount of metallic debris, the presence of any metallic anomalies may also cause a feature to stand out from the surrounding area. Therefore, magnetometry could be applied to forensic casework under this circumstance.

6.3.2 Ground Penetrating Radar

GPR (see Figure 27) transmits short pulses of radar waves from an antenna into the ground and records the time taken for the pulse to be reflected

(Bagaskara et al., 2021; Banning, 2002; Hunter and Martin, 1996; Moffat, 2015; Roskams, 2001). Providing reliable, rapid and high-resolution 3D images of buried structures (Verdonck et al., 2020).

Figure 27: GPR Surveying (Image: Author).

Research conducted by Damiata et al., (2013: 277) explored the possibility of using GPR to detect human remains, their results indicated that skeletal remains with good preservation recorded strong reflections, particularly over the thoracic and long bone regions. More recent research carried out by Bagaskara et al., (2021) supports and adds to these findings, using a GPR with a 700MHz antenna frequency, they established that recently buried bodies produced higher contrast anomalies than skeletal remains. However, GPR detects changes within the subsoil, provided those changes are significant enough, a single skeleton is not likely to create a big enough alteration. It is the differences between the grave fill and undisturbed surrounding soil that is being recorded, as GPR is considered good at mapping brick and stone foundations and locating buried objects, structures and pits (Gaffney and Gater, 2003; Herz and Garrison, 1998). Knaub's (2019:12) GPR results showed clear high-frequency anomalies over the area containing the six-person mass grave, with almost no anomalies present over the empty grave or control area. Suggesting that GPR would be an effective prospection technique for locating mass graves, as it is unlikely to produce false positives.

However, the effectiveness of GPR when detecting mass graves is often dependent on the grave's depth, size, and soil composition (Powell, 2004; Pringle et al., 2008; Ruffell et al., 2009). As data readings can be different depending on the soil type and amount of moisture present in the ground. Sandy and drier soils are more translucent to radar, which means the pulse passes through easily, whereas, wet or clay soils only allow the pulse to penetrate a few centimetres (Herz and Garrison, 1998; Hammon et al., 2000; Ristić et al., 2020; Bagaskara et al., 2021; Berezowski et al., 2021). This is evident in research conducted by Schultz et al., (2006) which showed that GPR was able to detect a grave in sandy soil 21.5 months after burial, whereas the presence of a grave in clay was only detectable for the first 6 months.

6.3.3 Resistivity

Resistivity measures the resistance of electrical currents within the subsoil, to detect buried objects and features (Herz and Garrison, 1998; Banning, 2002; Gaffney and Gater, 2003; Dupras et al., 2012; Schmidt, 2013; Berezowski et al., 2021). Two metal probes, known as electrodes, are inserted into the ground (see Figure 28) at 1m intervals along a grid, and electrical currents pass between the probes into the soil where a measurement of the resistance is taken (Hunter and Martin, 1996; Dupras et al., 2012; Dick et al., 2017). The recorded resistance is either a high or low anomaly, features which allow electrical currents to flow with ease are known as low resistance and can be a result of a ditch, pit, grave or metal pipe (Banning, 2002; Gaffney and Gater, 2003; Dupras et al., 2012). Whereas high resistance is caused when the flow is interrupted, such as in a buried stone feature or coffin (Banning, 2002; Gaffney and Gater, 2003).

Figure 28: Resistivity survey (Image: Author).

Resistivity can detect unmarked graves through the disturbed soil, which creates low resistivity anomalies, therefore, the grave will show up differently from that of the surrounding undisturbed soil (Hansen et al., 2014; Moffat, 2015). However, a paper written by Willmott et al., (2020) on the mass grave found at Thornton Abbey does not support this, as the data presented highly resistant anomalies, which initially led the team to believe the site was a subsidiary post-medieval structure. They proposed that the results were caused by the sandy soil and density of body mass, which resulted in a looser grave fill, allowing water to drain with ease (Willmott, 2020: 183). This suggestion is conclusive with Berezowski et al., (2021: 12) who state the effectiveness of resistivity is dependent on the amount of moisture in the soil, implying that an understanding of seasonal and moisture changes is vital when conducting this type of survey. Although a forensic grave may be detectable regardless of the season, as long as there is still decomposition fluid present, soil can retain moisture for a considerable time after burial (Dick et al., 2017; Berezowski et al., 2021). Most archaeological and forensic surveys are conducted with the probes set at a constant distance apart. However, vertical sections of resistance can be generated by altering the distance between the probe separation, the greater the separation the deeper the resistivity can take readings (Gaffney and Gater, 2003).

Nevertheless, resistivity can only be used in certain locations, as the probes need to be inserted directly into the ground, therefore, a mass grave concealed under tarmac, concrete and/or another hard surface will not be detected (Hansen et al., 2014).

6.3.4 Other Geophysical Prospections Under Consideration

Whilst the three prospection techniques above are the ones most commonly used in archaeology and/or forensics in the UK, there below have the potential to detect mass graves or aid with the search and safety of a potential site.

Electromagnetic

Electromagnetic (EM) surveying measures electrical conductivity and magnetic susceptibility differences in the ground (Dalan et al., 2010; Dupras et al., 2012). An Electromagnetic field generated by passing an alternating current through a transmitter coil induces electrical currents into the ground, simulating a magnetic field, a receiver then detects and measures the contrast in soil conductivity (Banning, 2002; Gaffney and Gater, 2003; Cheetham, 2005). It has the potential to map large areas for subsurface changes in quick succession, as it does not need to come into contact with the ground (Cheetham, 2005; McKenzie and Ryan, 2008; Reynolds, 2011; Pringle et al., 2012). Therefore, with enough contrast between the grave fill and undisturbed soil, electromagnetic systems could detect a mass grave or any metallic artefacts buried with the remains (Cheetham, 2005; Dalan et al., 2010; Dupras et al., 2012). However, research conducted by Molina et al., (2016) suggests electromagnetic surveying was not successful at detecting simulated graves, as they were unable to identify anomalies.

Gravity

Gravity meters or gravimeters measure variations in the earth’s gravitational field caused by density differences in the subsoil (Mariita, 2007; Moffat, 2015). In archaeology, it is used to detect subsurface cavities, such as those created by caves, graves, and mine shafts, as there is physical contrast between the density of the soil and/or rocks and the air-filled space in the ground (Alsadi and Baban, 2020; Fenning and Donnelly, 2004). However, Panisova et al., (2013) and Sarris et al., (2007) argue this surveying technique is unsuitable for locating coffins or clandestine graves as there is insufficient contrast between the grave and undisturbed soil. Whilst there is no research into using gravity surveys to locate mass graves, they are larger than single burials and could present sufficient contrast. Although further research to confirm this would be required.

Metal Detector

Metal detectors transmit a magnetic field from the instrument into the ground, any buried metal within the magnetic field includes a secondary current, also known as an *eddy current* (Sharawi and Sharawi, 2007; Madavha et al., 2020). All metals have different electrical conductivity, making it possible to discriminate between ferrous and non-ferrous metals (Connor and Scott, 1998). Ferrous metals, such as cast iron and steel, contain iron which causes them to be magnetic, good electrical conductors and easily detectable with a metal detector (Connor and Scott, 1998; Madavha et al., 2020). Whilst non-ferrous covers all metals which do not contain iron, such as bronze and copper, regardless, they are generally good conductors, meaning they can also be detected using a metal detector (Madavha et al., 2020). As such, the presence of buried metal is detected by variations in the induced voltages in the receiving loop of the metal detector (Sharawi and Sharawi, 2007). Being able to distinguish between different ferrous and non-ferrous metals is important for determining whether the buried object is a potential threat or non-threat, this is vital when working in war zones as there is the risk of buried landmines (Bedenik et at., 2019). They can also effectively find other items such as weapons, bullets, bullet casings, metal grave goods, metal artefacts, and coils (Dupras et al., 2012).

Metal detectors (Figure 10) can detect conducting metals and some minerals. They can therefore be used to identify sites that have no visible surface evidence, this means they are commonly applied to fields such as archaeology, mining and landmine detection (Bedenik et al., 2019; Haecker et al., 2019). Whilst they cannot directly identify the grave itself, they could be used to detect any metal buried within the grave (Stoutamire, 1983; Gaffney and Garter, 2003).


Figure 29: Metal Detecting (Image: Author).

3.3.5 Can Geophysical Prospection Detect Mass Graves?

Large-scale mass graves are frequently located in very open, remote and/or hard-to-access locations. Therefore, the geophysical prospection technique is largely dependent on the terrain. For example, a mass grave placed in a very open flat landscape can only be found by the most rapid of techniques, such as those which can be vehicle-towed. This is due to the whole area needing to be surveyed to ensure the grave cut is located; minimising the risk of the mass grave being missed. The need for raid coverage of a vast area can be seen in Case Study F3 (pg. 26), measuring c. 5000m^2 it was investigated three times before the full extent of the area was uncovered.

The area of land which can be covered by each technique in a day is dependent on the terrain and number of people conducting the surveying, as such, there are very few published figures. Nevertheless, Cheetham (2005: 75) does record that resistivity surveying using twin electrodes can cover 400m^2 per hour, taking readings every 0.5m intervals, this means an area of 40 x 60m or more can be surveyed in a day. In regards to magnetometry surveying the BAJR Practical Guide 18 (2008: 4) states that this technique can typically cover about 1-1.5 hectares of open land per machine per day, depending on the ground conditions. Whilst no specific figures could be found in regards to GPR, Historic

England (2023) states the efficient use of time in a large-scale search would be to use GPR which can be vehicle-towed and produces detailed measures over large areas.

Therefore, out of the main three prospection techniques readily applied to casework, GPR appears to be the best for detecting mass graves. Whilst magnetometry and resistivity are regularly used in archaeology, they could be unsuitable for locating mass graves. Firstly, magnetometry is very sensitive to background metal debris, causing false readings, particularly in an area containing landmines. However, in remote areas, where there is little to no metal debris, it could be considered an effective technique. Secondly, resistivity requires probes to be inserted into the ground, if the mass grave has been concealed under a building or a tarmac road this would prevent the technique from being used.

Out of the three other geophysical prospection techniques, research into EM surveying, a method commonly used in the US, has been unsuccessful at identifying anomalies created by simulated graves. Whilst there is currently no research into how effective gravimeters would be. Therefore, without further experimental research being conducted, EM and gravimeters would be ineffective at finding mass graves. Finally, metal detectors, if used alongside other surveying methods could be used to detect ferrous and non-ferrous metals buried within a mass grave and could therefore indirectly locate a mass grave.

6.4 Invasive Approaches

Whilst non-invasive approaches enable archaeologists to prioritise the site with the greatest potential for further investigation, an invasive approach can be employed to follow up and confirm the presence of a feature and/or grave. However, invasive techniques are ultimately destructive causing vital information, evidence and/or remains to be unintentionally destroyed or damaged (Owsley, 1995; Haglund et al., 2001; Roskams, 2001; Killam, 2004; Dupras et al., 2012). Invasive techniques range from the less destructive soil probing and coring to the more destructive test pits and trenching.

6.4.1 Soil Probing

Soil probing is used to determine subsoil density differences, the probe is inserted into the ground at regular intervals along a survey grid/search pattern, using equal pressure to assess the compactness of the soil (Morse et al., 1983; Killam, 2004; Dupras et al., 2012; Holland and Connell, 2016). There are two types of probes, the T-bar and penetrometer, of the two the T-bar is most frequently used by archaeologists. A metal probe, the T-bar measures approximately 1m in length, with a crossbar handle to form a T-shape (Morse et al., 1983; Schmitt, 2002; Ruffell, 2005; Dupras et al., 2012; Holland and Connell, 2016). Whilst the penetrometer has a weight/pressure gauge attached to it, as it records the amount of pressure it takes for the probe to sink into the soil (Ruffell, 2005; Dupras et al., 2012). Once the suspected perimeter of the grave has been defined by geophysical prospection, archaeologists can use the probe to either confirm the grave boundary and/or detect where their greatest concentration of bodies is located (Wright et al., 2005; Bartelink et al., 2016). The ground where the soil has been disturbed, particularly very recently backfilled graves, will be less dense allowing the probe to pass through with more ease than the undisturbed soil (Connor, 2007; Dupras et al., 2012).

However, probing in archaeology and forensic casework should be kept to a minimum and in some countries, such as the UK is discouraged from being used (Wright et al., 2005; Bartelink et al., 2016). As the archaeologist is probing blind, whilst geophysical prospection may have detected the grave boundaries and depth, there is no way of knowing how much soil is between the suspected bodies and the surface, causing potential damage to crucial evidence and/or the remains (Wright et al., 2005; Fiedler et al., 2009). Therefore, probing should only be used if there is no other way of obtaining the required information, and the pathologist is warned which remains may show evidence of probe penetration marks so it is not misinterpreted as an injury caused by the perpetrator(s) (Wright et al., 2005).

6.4.2 Soil Coring

Similar to a probe, a soil corer is a hollow metal probe which gets inserted into the ground and a core of soil is removed (Banning, 2002; Holland and Connell, 2016; Banning, 2020). Removing and examining cores of soil at regular intervals along a survey grid/search pattern within the area, to determine the boundary of the grave and disturbed soil (Dupras et al., 2012). Soil cores taken from undisturbed soil will appear stratigraphically accurate, whilst disturbed soil will have no obvious layers due to the mixing that takes place during the excavation and backfilling processes when the grave is created (Holland and Connell, 2016).

Whilst research conducted by Fiedler et al., (2009) shows that soil coring has successfully pinpointed World War Two mass graves in Germany, the extracting of soil cores has the potential to damage evidence and/or buried remains (Dupras et al., 2012; Holland and Connell, 2016). Therefore, as with soil probing, it is not recommended during forensic and archaeological casework, and if it is, then any damage caused to the remains or evidence needs to be documented.

6.4.3 Test Pits and Trenching

Test pits and trenching are essentially the same technique, the only significant difference is the size and way they are excavated. Generally, test pits are smaller than trenches, their standard size and depth are 1m x 1m x 1m, because of this they are excavated using hand tools such as a mattock, shovel and trowel (Banning, 2002; Carver, 2009; Bartelink et al., 2016). Test pits are used to gain an understanding of the stratigraphy of the site, once an area of interest has been established, a remote test pit, set back from the main site is excavated to determine the natural/manmade stratigraphic sequence (Anderson et al., 2008; Grant et al., 2008; Carver, 2009; Bartelink et al., 2016). This acts as a guide for archaeologists to compare the area of interest. Further test pits are then strategically or randomly placed around the site and excavated layer by layer to detect areas of disturbed stratigraphy, and the presence, absence and/or concentration of human remains/potential evidence (Bartelink et al., 2016: 283).

Although trenches can be excavated manually, it is quicker and more efficient when clearing a larger area and establishing a deeper soil profile using heavy machinery (Schmitt, 2002; Anderson et al., 2008; Bartelink et al., 2016; Holland and Connell, 2016). Placed at specifically spaced intervals, the width of the trench is determined by the dimensions of the digger's bucket, the length and depth tend to vary depending on the archaeologist's specification (Grant et al., 2008; Carver, 2009). For example, when trenching was used during the mass grave excavated in El Maguelar, Honduras in 1995, archaeologists excavated five major trenches measuring 30m x 1.5m x 1.2m and four minor trenches measuring 9m x 1.5m x 1.2m, order to find the graves perimeter and skeletal remains (Schmitt, 2002: 281). Therefore, trenches are used to identify changes to the soil, human remains, potential evidence and its depth without carrying out a full-scale excavation (Anderson et al., 2008). However, trenching is dependent on the area and suspected depth of the human remains and/or potential evidence, as it is a destructive process which destroys parts of the site without it being understood or recorded, and should therefore be kept to a minimum (Barker, 1993; Anderson et al., 2008; Bartelink et al., 2016).

Test pits and trenching are often carried out during the final stages of an archaeological and forensic search, due to their destructive nature (Pringle et al., 2012). Nevertheless, they are considered the most reliable and standard technique for detecting/confirming the presence of an archaeological site/feature, a grave/mass grave, and evaluating the stratigraphy of the area, without a full-scale excavation (Barker, 1993; Schmitt, 2002; Grant et al., 2008; Carver, 2009; Pringle et al., 2012). For this reason, it is a technique used in most archaeological and forensic casework, including when locating mass graves, for example, see Case Study F1 (pg. 25).

6.4.4 Detecting Geotaphonomic Phenomena in Mass Graves

Invasive techniques are not only used to confirm the presence of stratigraphic disturbance, evidence/human remains and/or the grave boundary. They can also be used to detect other geotaphonomic phenomena, such as soil characteristics, sedimentation and internal compaction.

Soil Characteristics

There are several different soil types that a grave could be found in, these are chalk, clay, gravel, loam, peat, sandy, and silt. The variations between them are down to their biological, chemical, mineralogical, and physical properties which alter the colour, texture, and structure (Courtney and Trudgill, 1976; Dupras et al., 2012; Fitzpatrick, 2008; Hester et al., 2008). For example, sandy soils are highly absorbent but have poor water retention, which means very few surface cracks would develop, and sandy soils are also very acidic (Osman, 2018; Steila, 1976). Silty soils are similar to sandy soils, however, they can retain more water (Steila, 1976). Peat soils have a high water absorbency and retention, their anaerobic conditions also slow down the process of decomposition (Osman, 2018). As with peat, clay soils are also highly absorbent and able to hold more water than many of the other soil types. Due to their water-retaining abilities, peat and clay soils are sticky when wet, as they dry out they shrink, which means they are prone to cracking when dry (Banning, 2020; Steila, 1976). These distinguishable differences could mean that a grave located within each soil type may appear different, as well as cause alteration in geophysical readings.

Sedimentation

Digging and backfilling a grave creates exposed surfaces and loose grave fill. This allows water to flow over and/or through the grave with ease and in the process collects all the loose sediments (Hochrein, 2002a; Dupras et al., 2012). The pooling, evaporation, and drying of water and sediments produce cracking on the surface of the grave (see Figure 30), making the grave identifiable (Morse et al., 1983; Hochrein, 2002a; Dupras et al., 2012). Research conducted by Watson et al., (2020) highlighted that surface cracks were visible 13 days after the experiment commenced. Suggesting sedimentation cracking can be applied by archaeologists as a visual identification marker fairly soon after the grave is created. Their experiment also established that both the cracking and the perimeter of the grave were evident within the landscape 35 months after it was created (Watson et al., 2020). However, how distinctive and deep the cracks are is largely dependent on the soil type, as sandy soils show less cracking than clay and peat.

Figure 30: Surface cracking caused by sedimentation (Image: Author).

Internal Compaction vs Natural Postmortem Movement

Internal compaction refers to a compressed area of the grave fill which has been caused by the movement of a victim being buried alive (Hochrein, 2002a: 62). Due to the ethical issues surrounding experimental research involving live burials, it is the least explored area of geotaphonomy (Hochrein, 2002b). Nevertheless, there is one known documented forensic case which shows evidence of internal compaction, the case in question is that of the 1988 serial murderer Dorothea Montalvo Puente. Puente was convicted of killing seven elderly men and women who were staying in her home (Hochrein, 2002b). Investigators, when reviewing the crime scene photographs noticed unusual compaction on either side of the victim's legs, and a mountain-like effect in the soil above the knees (Wood, 1994). Whilst it cannot be backed by experimental research, these features are suggestive of movement within the grave as if the legs were moving from side to side, presenting a clear indication that the victims were buried alive. However, developing an understanding of naturally occurring postmortem movement could further aid the understanding of internal compaction.

As the body decomposes, voids are created within the grave which causes the remains to shift into them. This postmortem movement has the potential to leave behind a body compression mark in the soil where they were originally positioned. This theory has recently been explored by Mickleburgh et al., (2022:

560) who upon excavation discovered there was clear evidence of soft tissue impressions, particularly within clay soils. By researching and understanding this naturally occurring postmortem movement, archaeologists and anthropologists can reconstruct the remains' original position and could provide a visual comparison to determine if the movement within the grave is natural or due to the individual originally being buried alive. Equally, it could also help establish that an empty cut feature once held remains, which would be particularly useful for detecting primary deposition sites, as the grave will show evidence of soft tissue marks, suggesting the victim or victims once laid either.

6.5 Conclusion

The process of digging and backfilling a grave changes the stratigraphic sequence of a site, these alterations are irreversible. Although there is evidence that surface cracking caused by sedimentation changes over time, stratigraphic alterations remain unchanged unless the grave is disturbed. These alterations can be detected using geophysical prospection, from the research collated in section 6.3 GPR is suggested to be the most effective at locating burial sites across archaeology and forensics, whilst magnetometry and resistivity have been effectively applied to archaeological casework. However, an invasive approach is required to confirm the anomalies recorded by geophysical prospection are a mass grave. Even though probing and coring can detect disturbed areas of subsoil they are discouraged from being used in the UK due to the risk of damaging the remains, and if they are used then any potential damage must be recorded. The most effective and reliable invasive approach is that of test pits and trenching as they enable archaeologists to confirm the presence or absence of a mass grave and record the stratigraphy of the site without conducting a full excavation. However, due to its destructive nature, it is the last technique to be used and should be fully recorded.

Chapter Seven: Chemical Alterations

A mass grave and the decomposing remains concealed within undergo significant chemical changes, creating a complex and unique chemical environment (Haslam and Tibbett, 2009; Westcott, 2018; Collins et al., 2020). Decomposition is a naturally occurring continuous process, which can be affected by abiotic and biotic factors, the number of remains in the grave, and the soil itself (Schotsmans et al., 2014; Szelecz et al., 2018; Westcott, 2018). Using both non-invasive and invasive methods, such as cadaver dogs and soil analysis techniques, it is possible to identify these changes. Understanding the effect that decomposition has on the subsoil and surrounding landscape, and how it changes over time can further assist archaeologists in the search for mass graves.

Therefore, this chapter summarises these processes, explains how they can assist archaeologists in locating and understanding mass graves and explores the techniques that can be applied to detect these chemical alterations by investigating the following questions:

- What causes chemical changes within a grave?
- What chemical alterations take place within a grave environment?
- How do these alterations change over time?
- Can these alterations indicate the presence of a mass grave?
- What techniques can detect these changes?
- What are the advantages and drawbacks of these techniques?

7.1 Decomposition and the causes of Chemical Alterations

Defined as the permanent termination of the cardiovascular, respiratory, and nervous systems, death occurs when the body's major organs are unable to obtain enough oxygen to function (Madea, 2016). Decomposition begins immediately after death, initially, the effects of decay happen internally and are only visible on the body's surface as it progresses (Collins et al., 2020).

Decomposition is a continuous process driven by autolysis, putrefactions, and many intrinsic and extrinsic factors (Mann et al., 1990; Janaway et al., 2009). The microenvironment created by these chemical processes has a profound impact on the subsoil, and the immediate vicinity of the grave (Forbes and Dadour, 2010; Forbes et al., 2017). If detected these chemical alterations can be used to confirm the presence of a mass grave. The changes discussed within this section include the processes of decomposition and the biotic and abiotic factors which affect decomposition and alter the surrounding soil.

7.1.1 The Stages of Decomposition

To understand the processes of decomposition better researchers have categorised it into distinct successive stages (see Table 8), based on visual changes to the body to determine the postmortem interval (Damann and Carter, 2014; Forbes et al., 2017; Griffiths et al., 2020; Emmons et al., 2022). The most widely recognised is Payne's (1965) classification system which divides decomposition into six stages; fresh, bloated, active, advanced, dry and remains.

Table 10: The stages of decomposition. (Information extracted from research presented by: Payne (1965: 595-598), Goff (1993: 85-86), Megyesi et al., (2005: 2), Powers (2005: 6), Carter et al., (2007: 14-16), Lane Tabor Kreitlow (2010: 253-255), and Swann et al., (2010a: 10-11)).

Stage of Decomposition	Description
Fresh/Autolysis Stage	0-2 days. Begins at the moment of death. Autolysis takes place. Minimal tissue changes. Livor, Rigor, and Algor mortis take place. Lack of odour. Ends as putrefaction starts.
Bloated/Putrefaction Stage	2-6 days. Putrefaction starts. Gases cause the body to bloat. Changes to skin colour. The odour of decay is more noticeable.
Decay/Black Putrefaction Stage	5-11 days. The abdominal wall ruptures causing gases to escape. Body deflates. Significant soft-tissue loss. Strong odour. The body appears moist and blackened.
Dry/Post-decay Stage	10-25 days. Remains reduced to skin, cartilage, and bones.
Remains/Skeletal Stage	>25 days. Greater than 50% skeletal exposure – mainly only bones and hair left. No significant odour.

However, decomposition is a complex and individual process affected by multiple variables such as temperature, season, geological location, body fat content, injury, intoxication and the presence of clothing and/or wrappings, which can alter the rate of decay (Tsokos, 2004; Damann and Carter, 2014; Shedge et al., 2021). Each stage also overlaps, causing a lack of clearly defined start and end points (Brook, 2016). As a result, this section has been divided into early and late postmortem changes.

Early Postmortem Changes

Three key changes take place immediately after death, these are known as *livor mortis*, *rigor mortis*, and *algor mortis* (Collins et al., 2020; Saber et al., 2021; Almulhim and Menezes, 2022). They are classed as early changes because they start within the first few hours after death and end within 24 hours.

Livor Mortis

Livor mortis is the earliest of the three to start and is the settling of blood within the body (Byer, 2011; Damann and Carter, 2014). Once the heart stops beating, the circulation of blood also comes to a halt, due to the effects of gravity the blood moves towards the lowest parts of the body (Goff, 2009; Hayman and Oxenham, 2014; Kori, 2018; Joshi, 2021; Shedge et al., 2021; Almulhim and Menezes, 2022). *Livor mortis* or lividity appears as patches of reddish blue staining 30 minutes – 1 hour after death (Goff, 2009; Kori, 2018; Shedge et al., 2021). Within 6-8 hours it becomes fixed, meaning when pressure is applied to an area of staining it no longer disappears (Hayman and Oxenham, 2016; Kori, 2018; Shedge et al., 2021).

Rigor Mortis

Rigor mortis which is the stiffening of the muscles is the next change to begin (Vain et al., 1996; Prahlow and Byard, 2012; Shedge et al., 2021; Almulhim and Menezes, 2022). Immediately after death the body's muscles relax, within 1-2 hours adenosine triphosphate (ATP), which helps the muscles to relax, decreases causing the muscles to become stiff and rigid (Goff, 2009; Shedge et al., 2021; Shrestha et al., 2022). Once formed, *rigor mortis* lasts for 12-24 hours (Goff, 2009; Janaway et al., 2009; Hayman and Oxenham, 2016). As putrefaction (see pg. 111-112) starts, the chemicals in the muscles are consumed and they gradually begin to relax again (Hayman and Oxenham, 2016; Kori, 2018; Shedge et al., 2021; Almulhim and Menezes, 2022).

Algor Mortis

The final change to happen during early decomposition is *algor mortis*, which is the cooling of the body (Byers, 2011; Kori, 2018). After death, the transference of heat comes to a halt, as there is no heat being produced within the body (Shedge et al., 2021). The average temperature of a body at death is 37℃, within 12-18 hours the body's temperature falls until it equilibrates with the surrounding environment (Clark et al., 1997; Goff, 2009; Damann and Carter, 2014; Kori, 2018; Almulhim and Menezes, 2022). Although the time it takes is dependent on ambient temperature, body mass, body position, clothing/other coverings, and whether the remains are on the surface or buried (Madea, 2016).

Late Postmortem Changes

Two processes are primarily involved with the later decomposition changes, these are referred to as autolysis and putrefaction (Powers, 2005; Forbes et al., 2017; Almulhim and Menezes, 2022). They are classed as late changes because they happen after the initial 24 hours (Prahlow and Byard, 2012).

Autolysis

Autolysis is an internal chemical process caused by the body's enzymes (Fiedler and Graw, 2003; Carter et al., 2007; Forbes, 2008; Stadler et al., 2013; Hau et al., 2014; Brooks, 2016; Ioan et al., 2017). Following death, a spontaneous chain reaction occurs, firstly the body depletes oxygen, and then cell membranes break down causing the release of enzymes which self-digest the cells (Brooks, 2016; Wu and Liu, 2018; Shedge et al., 2021). Autolysis is quick and mainly affects tissues and cells with a high enzyme and water content, it also paves the way for putrefaction (Vass, 2001; Powers, 2005; Statheropoulos et al., 2005; Stadler et al., 2013; Ioan et al., 2017).

Putrefaction

Caused by bacterial proliferation and consumption, signs of putrefaction are visible on the body approximately 4-10 days after death (Brooks, 2016; Joshi, 2021). As the cells of the digestive system break down, bacteria enter the blood vessels and spreads throughout the body (Powers, 2005; Shedge et al., 2021). At the same time, the body depletes of oxygen, causing gases to build up which results in the body bloating, skin discolouration, and skin slippage (Powers, 2005; Carter et al., 2007; Goff, 2009; Stadler et al., 2013; Hau et al., 2014;

Marais-Werner et al., 2017; Watson et al., 2020; Shedge et al., 2021). As the pressure increases, putrefactive liquid and gases are purged from the body through orifices, such as the nose, mouth, eyes, ears, and anus (Tracqui, 2000; Pinheiro, 2006; Goff, 2009; Bristow et al., 2011; Hau et al., 2014; Ueland et al., 2015; Watson et al., 2020).

7.1.2 Biotic Factors

Biotic factors affecting decomposition are all those relating to or resulting from biological organisms, such as insect activity, chemical composition, microbial changes, and volatile organic compounds (VOCs). Not only do these factors influence decomposition, but they also individually impact the soil adding to the complexity of the burial environment and offering valuable information about the location of the grave (Hoffman et al., 2009; Finley et al., 2016; Ioan et al., 2017; Szelecz et al., 2018).

Insect Activity

Under ambient conditions, insects follow a predictable pattern of colonisation on decomposing remains, indicating it can be used to determine the postmortem interval. The type and number of insects present are dependent on the body's stage of decay (Rodriguez and Bass, 1983; Payne et al., 1968; Joseph et al., 2011; Benbow et al., 2013). As can be seen in Table 9, the first flies begin to arrive on the body during autolysis, although their presence does not peak until putrefaction sets in and the odour of decay becomes more prominent (Carter et al., 2006; Forbes and Dadour, 2010; Lane Tabor Kreitlow, 2010). At this point, female flies lay eggs in the body's orifices, once hatched the larvae feed on the decaying remains in large maggot masses until most of the soft tissue is gone (Goff, 1993; Forbes and Dadour, 2010; Lane Tabor Kreitlow, 2010). As post-decay sets in, most of the flies and maggots have gone, allowing various beetles to feed on the remaining flesh, once the body enters the skeletal stage all that is left are mites (Lane Tabor Kreitlow, 2010: 255). Therefore, larvae degrade the majority of soft tissue through the secretion of enzymes and bacterial as they feed on the body (Forbes and Dadour, 2010). This secretion is likely to mix with the soil environment and could be detected when carrying out soil analysis on areas of interest.

Table 11: Breakdown of insect activity during the stages of decomposition (Information extracted from Lane Tabor Kreitlow, 2010: 253-255).

Stage of Decomposition	Insect Activity
Fresh/Autolysis Stage	Blowflies and flesh flies start to appear.
Bloated/Putrefaction Stage	A peak in the number of flies, which lay eggs in the body's orifices.
Decay/Black Putrefaction Stage	Larvae feed on the remains until most of the soft tissue is gone.
Dry/Post-decay Stage	Various beetles feed on the remaining dried-out flesh.
Remains/Skeletal Stage	Previous taxa have left, leaving only mites present.

However, burying remains limits insect access to the body, meaning they are less likely to affect soft tissue decomposition (Mann et al., 1990; Marais-Werner et al., 2017; Rai et al., 2022). Nevertheless, some insects can access buried remains through macropores/cracks in the soil, or by laying their eggs on the surface of the ground so that the larvae can burrow down to the bodies once they have hatched (Rodriguez and Bass, 1985; Smith, 1986; Vanlaerhoven and Anderson, 1999; Szpila et al., 2010; Gunn and Bird, 2011; Corrêa et al., 2014; Rysavy and Goff, 2015). Although this is dependent on the depth of the grave because the deeper the grave the less likely the odour will penetrate through to the surface (Rodriguez and Bass, 1985). There is also currently limited knowledge on how far insects will travel to colonise buried remains (Rai et al., 2022: 606). The presence of insect activity within a grave also indicates how many days it took for the victims to be buried, this can be seen in Case Study WWI (pg. 27-28), fly pupae found in the grave showed the bodies were buried 5-10 days after the battle took place. This information enables archaeologists to determine if the bodies were buried immediately or if they were left and buried at a later date.

Chemical Composition

During decomposition, the body's lipids, proteins, and carbohydrates are degraded into simpler molecules which are released into the soil in the form of decomposition fluid (Dent et al., 2004; Statheropoulos et al., 2005; Boumba et al., 2008; Janaway et al., 2009; Stuart, 2013; Ueland et al., 2015). These molecules are nitrogen, carbon, phosphorus, potassium, and magnesium, which form a nutrient-rich island around the remains and impact the vegetation and organisms residing in the soil (Dent et al., 2004; Carter et al., 2007; Benninger et al., 2008; Forbes, 2008; Szelecz et al., 2014; Szelecz et al., 2016). They also cause detectable changes in the total carbon, nitrogen, soil-extractable phosphorous, and lipid phosphorus levels found in the soil (Benninger et al., 2008; Larizza and Forbes, 2013; Ioan et al., 2017).

Experimental research carried out by Benninger et al., (2008) compared soil containing pig cadavers with controlled soil to determine if these changes were detectable. Their results indicated no significant differences between the grave soil and control soil for the levels of total carbon, whilst the total nitrogen and lipid-phosphorus results initially increased but by day 100 had returned to base levels (Benninger et al., 2008: 72-73). Whereas, the soil-extractable phosphorus results like the total nitrogen and lipid-phosphorus increases in the grave soil but did not return to base levels by day 100 (Benninger et al., 2008: 73). These findings support the research of Provan (1971: 48) who suggested that phosphorus accumulates in the soil and may be detectable for thousands of years. Therefore, changes in the chemical composition of the soil could be used to detect the presence of both archaeological and forensic mass graves, particularly when analysing soil-extractable phosphorus.

Typically, in archaeological casework, if the chemical composition of the soil is considered then it is an increase in phosphorus levels that is used to indicate the presence of archaeological human remains (Farswan and Nautiyal, 1997). Phosphorus one of the main elements of bone, leaches into the soil during decomposition and binds to other elements, such as calcium, iron and aluminium, which form a stable inorganic compound (Kolb, 2016: 18; García-López et al., 2022: 7). Research conducted by García-López et al., (2022) established that phosphorus could be detected in two post-Roman burials. Nevertheless, Pickering et al., (2018) research on the retention of decomposition molecular information from a Roman grave, Anglo-Scandinavian grave, and control samples, indicated that other organic signatures can survive and could be detected.

Microbial Changes

Microbes or microorganisms is the collective term for bacteria and fungi (Janaway, 1996). Bacteria naturally reside within the human body and the soil. Its growth is dependent on the availability of food, moisture, pH, temperature and oxygen (Forbes and Dadour, 2010). To survive and reproduce, soil bacteria require moisture, which means in dry soils microbial activity decreases, whilst, in moist soils, it increases (Janaway, 1996). Fungi, however, only occur within the soil and require organic matter such as dead plants, animals and human remains to grow and develop, it also produces enzymes that aid with the degrading of decomposing remains (Forbes and Dadour, 2010).

Decomposing bodies both alter and are affected by the naturally occurring microbes found in the soil (Carter and Tibbett, 2003; Carter et al., 2010; Pechal et al., 2013; Cobaugh et al., 2015; Damann et al., 2015; Hauther et al., 2015). The increase in maggot activity and the purging of decomposition fluids causes a chain reaction to occur, as the level of soil nutrients increases, so does the soil microbial biomass (Carter et al., 2007; Forbes and Dadour, 2010). Whilst there is variability in microbial makers across different graves, soil microbes interact with buried remains around 24 hours after deposition (Pickering et al., 2018). Research by Metcalf et al., (2015) suggests that this is because soil microbes mediate decomposition, as they become very similar to decomposition microbes.

Volatile Organic Compounds

As the body decomposes odours made up of chemical compounds known as volatile organic compounds (VOCs) are released, which change as decomposition progresses (Vass, 2012; Caraballo, 2014; Rosier et al., 2016; Dargan and Forbes, 2021). These changes are a result of cellular degradation, microbial activity, the breakdown of complex molecules, and insect and larvae activity (Westcott, 2018; Dargan and Forbes, 2021). Many studies have been conducted which have identified numerous VOCs associated with decomposing remains, such as Statheropoulos et al., (2005), Vass et al., (2008), Hoffman et al., (2009), Rosier et al., (2015), Stefanuto et al., (2017) and Glavaš and Pintar (2019). Research carried out by Vass et al., (2008) determined that there are 478 individual VOCs produced during decomposition. VOCs are what attract the flies to the remains (Paczkowski et al., 2012; Westcott, 2018). Temperature and humidity influence the profile of the VOCs released during the putrefaction process, however, the effect they have on the breakdown of proteins and carbohydrates, microorganisms and insects which colonise the body is not yet understood (Vass et al., 1992; Vass et al., 2002; Statheropoulos et al., 2005). Thus, there is a need for further research to determine how the odour profile changes in different situations and during the different stages of decomposition (Westcott, 2018).

7.1.3 Abiotic Factors

Abiotic factors are physical rather than biological, this means it is the characteristics of the burial environment which affect decomposition and the soil; these factors include soil pH, temperature, and moisture content (Henderson, 1987; Vass et al., 1992; Gill-King, 1997; Vass et al., 2002; Vass et al., 2008; Larizza and Forbes, 2013; Szelecz et al., 2018; Westcott, 2018).

Moisture Content

The moisture content present within the soil is considered a primary factor in the rate of decomposition in buried remains. The presence of water in the soil can create a cooler, anaerobic (oxygen-free) environment, which slows down the rate of decomposition (Ayers, 2010). It could also result in the formation of adipocere, a layer of waxy decomposition produce that forms over the body when bacteria are unable to completely break down lipids (Mellen et al., 1993). However, research conducted by Carter et al., (2010) found that the moisture content in the soil can increase microbial activity potentially speeding up the rate of decomposition because it aids with microbial mobility and the diffusion of nutrients and waste.

During decomposition water from decaying soft tissue either collects around the body or becomes part of the soil moisture content, this suggests that when tested the moisture content of the grave fill is likely to be higher than the surrounding soil (Vass, 2011). However, research carried out by Benninger et al., (2008) established that there was no significant increase in the soil moisture content when comparing grave soil with control soil. Although the moisture content of a mass grave is likely to be higher than a single grave, this research suggests that testing the soil moisture content is unlikely to be a viable way of confirming the presence of a grave.

Soil pH

Soil pH has a major impact on buried remains and soil microbes, as it influences the chemical reactions taking place during decomposition, and fluctuations in soil temperature (Alexander, 1980; Neher et al., 2003; Hansel et al., 2008; Westcott, 2018). Decomposition fluid also affects the pH levels in the soil, initially causing it to become more basic and then decreasing to become more acidic (Rodriguez and Bass, 1985; Vass et al., 1992; Benninger et al., 2008; Haslam and Tibbett, 2009; Bachmann and Simmons, 2010; Schotsmans et al., 2011; Schotsmans et al., 2012; Szelecz et al., 2018; Silva-Bessa et al., 2022).

Carter et al., (2008) establish that regardless of the basal pH, graves containing cadavers increase to a pH of 8/8.1. This reaction has been attributed to ammonium, a by-product of amino acids which is released during the bloating and active stages of decay (Hopkins et al., 2000; Wilson et al., 2007; Szelecz et al., 2018). Soil pH then decreases to a pH of 6 or below as the anaerobic bacterial in the intestinal tract and acidic by-products are released (Vass et al., 1992; Gill-King, 1997; Forbes and Dadour, 2010; Swann et al., 2010; Swann et al., 2010b). These steady fluctuations can be seen in Benninger et al., (2008) experiment comparing grave soil alongside a controlled site. They found that soil pH increased on days 14 and 23, then decreased to become lower than the control site on day 43, and then dropped further on days 72 and 100 (Benninger et al., 2008). Archaeologically, devices such as a pH probe are already used to locate buried habitation sites and funeral pits (Rodriguez and Bass, 1985: 851). Whilst the findings presented here suggest changes in pH could be detected in a mass grave over an extended period, further longer-term research is required to determine at what point the soil returns to/does it return to its basal levels.

Temperature

Soil temperature plays a significant role in taphonomy because of its direct effect on autolysis and putrefaction, as increases in temperature speed up decomposition, whilst decreases in temperature slow it down (Junkins and Carter, 2017). Higher temperatures increase microbial activity and biological and chemical reactions which break down the body into its chemical compounds that then enter the soil (Carter and Tibbett, 2008; Carter et al., 2008). However, the effect decomposition has on the soil temperature is very limited (Prangnell and McGowan, 2009). Therefore, further research is needed to determine if decomposition alters the soil temperature and how long this reaction is detectable.

7.1.4 Decomposition within a Mass Grave

The process of decomposition in buried and surface remains is the same. As the body/bodies decay, decomposition fluid leaks into the soil environment, creating a cadaver decomposition island (CDI) (Carter et al., 2007). A CDI is a nutrient-rich island around the remains, which appears as a dark stain, it is also so rich that it kills the surrounding vegetation, and is associated with increased soil microbial biomass and activity (Carter et al., 2007; Benninger et al., 2008; Aitkenhead-Peterson et al., 2012; Larizza and Forbes, 2013).

Whilst the process is the same, the rate of decomposition is often very different and is considered to be approximately eight times slower when the remains are buried (Rodriguez, 1997; Vanlaerhoven and Anderson, 1999; Schotsmans et al., 2012; Corrêa et al., 2014). This is because bodies on the surface are exposed to a greater number of variables, such as scavenger, insect activity, temperature and weather fluctuations which cause greater destruction to soft tissue and accelerate decomposition (Mann et al, 1990; Rodriguez, 1997; Fiedler and Graw, 2003; Troutman et al., 2014; Marais-Werner et al., 2018). Due to this, Marais-Werner et al., (2018: 302) believe the stages of decomposition do not always accurately describe the decomposition process because under different conditions the patterns and speed change.

Decomposition rates are also different when comparing single and mass graves. A mass grave contains a dense body mass, rather than a single body, creating a unique depositional environment and microenvironment (Haglund, 2002; Troutman et al., 2014). Casework in Bosnia (see Case Study F3 (pg. 26) for example) has demonstrated that remains will appear to be at different stages of decomposition; the bodies at the centre of the mass grave be more preserved than the ones at the outer edge (Mant, 1987; Haglund, 2002; Troutman et al., 2014). This effect is created because the central bodies produce their taphonomic environment as they are isolated from the surrounding soil, and can trap in moisture such as decomposition fluids which help to preserve them (Haglund, 2002). Whereas, the remains at the edge connect two taphonomic boundaries, the body mass and the surrounding soil, causing them to decompose faster than the centre of the mass because they are exposed to factors within the soil (Mant, 1950, Haglund, 2002).

Research carried out by Troutman et al., (2014) highlights this, in their experiment, the rabbit carcasses at the centre of the mass decomposed at a much slower rate than those at the edge, except for the remains at the base of the grave. This slower rate of decomposition suggests that physical, stratigraphic, and chemical alterations may be present for longer than those of single burials. It could also mean archaeologists may come across a confusing grave context, as they may find both flesh and skeletal remains.

7.2 Cadaver Detection Dogs

The use of dogs aiding with forensic casework in the UK can be dated back to 1888 when two bloodhounds were unsuccessfully used during the case of Jack the Ripper (Blum, 2017). Whilst the first reported use of cadaver detection dogs (CDD) was in the 1960s when investigators were searching Saddleworth Moor for the bodies of Ian Brady and Myra Hindley’s murder victims (Topping and Ritchie, 1989). Two bodies were discovered during the initial search, with an additional two bodies found when the case was reopened in the 1980s (Buis, 2016). Since then, dogs have aided forensic investigations, search and rescue teams, the military, private corporations, and the emergency services with the detection of missing persons, homicides, biological specimens, explosives, narcotics, flammable liquids, money, and other contraband (Komar, 1999; Lasseter et al., 2003; Ensminger and Papet, 2012; Buis et al., 2019). This is because they have a sense of smell between 10,000 and 100,000 times more powerful than that of a human (Walker et al., 2006; Sankaran et al., 2012). Making them capable of detecting the smell of most of the aforementioned, in both soil and water, without the presence of visual clues (Alexander et al., 2015; Glavaš and Pintar, 2019).

7.2.1 Forensic Casework

CDDs are typically called on to search a designated area, with the focus of finding human remains, such as building sites, crash sites, potential crime scenes, and archaeological sites (Glavaš and Pintar, 2019). They are trained to locate and indicate the strongest concentration of human-specific odour at various stages of decomposition and in different geological settings (Alexander et al., 2016). It is thought that when searching for deceased individuals, CDDs detect VOCs which specific to human decomposition odour profiles (Stejskal, 2013; Westcott, 2018; Glavaš and Pintar, 2019). However, it is unknown whether they respond to the complex combinations of VOCs or core VOCs, making it hard to standardise CDD training (Stadler et al., 2012; Dargan and Forbes, 2021). As such, determining human-specific compounds present during decomposition will aid in the development of training aids for CDDs and the development of detection instrumentation (Westcott, 2018).

7.2.2 Archaeological Casework

CDDs are rarely used to detect buried remains classed as archaeological, thus associated research is also limited. Nevertheless, Glavaš and Pintar (2019) argue that human decomposition odour can be preserved in the soil for several millennia and as such can be used to locate archaeological remains. Grebenkemper et al., (2021: 228) back this view, stating that dogs trained to detect historic remains can smell the scent of decomposition even if the remains are no longer present. Research recorded by Pototschnig (2013), Baxter and Hargrave (2015), Glavaš and Pintar (2019), and Grebenkemper et al., (2021) advocate the use of CDDs in archaeological casework, although their results show varying success. Firstly, Baxter and Hargrave (2015: 41) used CDDs in Clements Cemetery, where the earliest gravestones dated to 1810-1820 to locate unmarked graves within a group of known graves. Whilst Glavaš and Pintar (2019) used them to find an Iron Age site in Cyprus. Finally, Grebenkemper et al., (2021) used them to locate potential ancestral burials at Native American archaeological sites without disturbing the ground. Each of these case studies claims to have had some success in the use of CDDs for finding archaeological grave sites. However, Pototschnig's (2013) use of CDDs to find World War Two mass graves in Austria was unsuccessful in finding the graves. At present, there is a lack of evidence and research into using CDDs in archaeological casework, more substantial research is needed before it is possible to say, with certainty, that they can be used to find archaeological mass graves.

7.2.3 Experimental Research

Vass et al., (2008) determined that for the first 17 days after burial, no VOCs are detected at the surface of the grave; this means CDDs will not alert even if there is a grave present in the area. Odour profiles can also change until they no longer represent decomposition, causing a false negative response from the CDDs (Buis et al., 2019). Soil type may also affect the CDD's ability to detect decomposition gases, as sandy soil aids detection, whilst clay soil prevents odours from escaping making them less detectable (Alexander et al., 2016). As such, CDDs should be exposed to the widest variety of odour profiles during their training to enhance their ability in the field (Buis et al., 2019).

7.3 Thermal Imaging

Thermal imaging collects and displays thermal patterns emitted by objects without requiring visual light, and enables the possibility to differentiate between two objects with as little as ≤0.1°C temperature difference (Vollmer and Möllmann, 2010; DesMarais, 2014; Amendt et al., 2017). This ability to detect even the slightest temperature increase means infrared thermography can pick up the heat signatures of human remains (France et al., 1992; Killam, 2004; Geberth, 2006; Lee et al., 2018). However, as discussed previously, algor mortis causes the human body temperature to decrease rapidly following death until it becomes equal with the surrounding environment. Thus, thermal imaging can only be used to detect remains for a short time after death (Lee et al., 2018).

Nevertheless, research suggests that larval masses generate a substantial amount of heat, which can exceed ambient temperatures depending on the time of year (Payne, 1965; Rodriguez and Bass, 1985; Goodbrod and Goff, 1990; Anderson and Vanlaerhoven, 1996; Joy et al., 2006; Slone and Gruner, 2007). Although available research is limited, it shows that heat signatures from larval masses were more prominent during active decay and then decreased as the larvae disperse as the remains become dry (Anderson and Vanlaerhoven, 1996; DesMarais, 2014; Lee et al., 2018). This provides a window of opportunity to aid with searching for and locating remains, however, environmental conditions, such as if they remain on the surface or buried, geographical regions and the time of year need to be considered (Voss et al., 2011). Contrastingly, buried remains are likely to heat up/cool down the surrounding soil slower than those on the surface and can therefore be detected using different thermography which observes soil temperature anomalies (Davenport, 2017; Silván-Cárdenas et al., 2021). The thermal recording of the soil at a mass grave will likely be greater than the surrounding soil due to the number of bodies interred within, and therefore, thermal imaging has the potential to be used across forensics and archaeological casework.

7.4 Soil Analysis

Soil analysis methods are used regularly in both archaeology and forensics, as it is often considered the starting point of detecting biochemical changes within the soil, which could be a sign of a grave being present (Vranová et al., 2015). Whilst there are multiple analytical methods available, this section explores two: gas chromatography and mass spectrometry.

7.4.1 Gas Chromatography

Two-dimensional gas chromatography (GC x GC) is the most commonly used analytical technique for detecting VOCs, and biotic and abiotic factors (Stefanuto et al., 2017; Dubois et al., 2018). It uses two separate dimensions, connected, to increase the separation power and improve target analysis (Brasseur et al., 2012; Dekeirsschieter et al., 2012; Stadler et al., 2013; Gruber et al., 2016; Stefanuto et al., 2017). Allowing for reliable and rapid chemical identification, and characterisation of complex odour profiles in suspected decomposition sites (van den Bogaard et al., 1986; Hordijk et al., 1990; Manni and Caron, 1995; Willig et al., 2004; Gruber et al., 2016; Prebihalo et al., 2018).

7.4.2 Mass Spectrometry

Often used hand-in-hand with GC x GC, mass spectrometry (MS) is used to identify organic molecules released during decomposition (Colombini and Modugno, 2009; Dubois et al., 2018). MS is a widely used technique, which can accurately measure molecular mass by separating charged atoms and molecular fragments into smaller components (Tamara et al., 2022).

7.4.3 Soil Analysis and Mass Graves

By detecting chemical compounds and VOCs associated with decomposition, the aforementioned GC-MS techniques can be used to further pinpoint the location of a mass grave. However, despite progress being made in terms of individual soil methods, at present, the impact each has on the other is not yet fully understood and needs more research.

7.5 Conclusion

Chemical changes within a grave are caused by decomposition and the associated biotic and abiotic factors. A mass grave creates a very unique environment, largely due to the volume of remains within the body mass, causing the remains in the centre to decompose at a slower rate. This has the potential to elongate the decomposition process, making certain factors like pH, temperature and chemical changes present for longer. Chemical alterations in forensic mass graves can be detected successfully using cadaver dogs, however, further research is needed before it is possible to argue that it has the same efficacy when searching for archaeological mass graves. Likewise, thermal imaging also has the potential to locate archaeological and forensic mass graves, but further research is needed. Finally, GC x GC and MS can be used to successfully detect VOCs and biotic and abiotic factors associated with decomposition across the archaeological and forensic spectrum.

Chapter Eight: Key Findings

This chapter presents the key findings from the previous chapters in the form of tables showing which taphonomic signatures can be present in archaeological and/or forensic mass graves. It also sets out to highlight the most effective methods for locating these signatures and mass graves across both types of casework.

8.1 Taphonomic Signatures

Below are three tables which show which physical, stratigraphic, and chemical alterations are present in archaeological and/or forensic mass graves.

Table 12: Physical alterations that can be identified in mass graves across archaeological and forensic casework.

Physical Alterations			
Alteration	**Archaeology**	**Forensic**	**Comment**
Human Disturbance	?	✓	No known archaeological case
Vegetation Changes	?	✓	Harder to identify in archaeological casework
Pollen and Spore Analysis	✓	✓	
Compression/ Depressions	✓	✓	Harder to identify in archaeological casework

Table 13: Stratigraphic alterations that can be identified in mass graves associated with archaeological and forensic casework.

Stratigraphic Alterations			
Alteration	**Archaeology**	**Forensic**	**Comment**
Disturbed Stratigraphy	✓	✓	
Sedimentation	?	✓	No known archaeological case
Internal Compaction	?	✓	No known archaeological case

Table 14: Chemical Alterations detectable in archaeological and forensic mass graves.

Chemical Alterations			
Alteration	**Archaeology**	**Forensic**	**Comment**
Chemical Composition	✓	✓	
Insect Activity	✓	✓	
Microbial Changes	?	✓	No known archaeological case
VOCs	?	✓	Further research needed
Moisture Content	×	×	No detectable change occurs
Soil pH	?	✓	Potential for long-term change
Soil Temperature	×	✓	Short-term can be seen in forensic graves

8.2 Techniques for Locating Taphonomic Signatures

Below are three tables highlighting which techniques can be applied when attempting to locate mass graves during archaeological and/or forensic casework. It covers desk-based assessments alongside non-invasive and invasive approaches.

Table 15: Desk-based assessment techniques which can be applied to archaeological and/or forensic casework.

Desk-Based Assessment			
Technique	**Archaeology**	**Forensic**	**Comment**
Witness-Led Approach	?	✓	Could use diaries, letters, commentaries and chronicles from the time if they exist
Cartographics	✓	✓	
Historical Records	✓	?	Depends on if forensic casework is recent or a cold case
Aerial Images	?	✓	From WWI onwards
Ground-level Images	?	✓	From WWI onwards

Table 16: Techniques for identifying physical alterations associated with mass graves.

Physical Alterations			
Technique	**Archaeology**	**Forensic**	**Comment**
Visual Foot Search	✓	✓	
GIS	?	?	Further research needed
LIDAR	✓	?	No forensic example at present
Multispectral Imaging	✓	✓	
Hyperspectral Imaging	✓	✓	
Near-Infrared Imaging	?	?	Potential but further experimental research needed
Structure from Motion	?	?	Potential but further experimental research needed

Table 17: Techniques for identifying stratigraphic alterations associated with mass graves.

Stratigraphic Alterations			
Technique	**Archaeology**	**Forensic**	**Comment**
Magnetometry/Gradiometer	✓	?	Dependent on location
Gravity Surveying	✗	✗	
GPR	✓	✓	
Electromagnetic Surveying	?	?	Further research needed
Resistivity	✓	✓	
Metal Detecting	✓	✓	Detects burial items
Soil Probing	?	?	Accidental disturbance needs recording
Soil Coring	✓	✓	Accidental disturbance needs recording
Test Pit/Trenching	✓	✓	

Table 18: Techniques for identifying chemical alterations associated with mass graves.

Chemical Alterations			
Technique	**Archaeology**	**Forensic**	**Comment**
Cadaver Dogs	?	✓	More archaeological research is needed
Thermal Imaging	×	✓	Can be used for a very recent grave only
Gas Chromatography	✓	✓	
Mass Spectrometry	✓	✓	

8.3 Summary of Findings

These tables show a range of physical, stratigraphic and chemical alterations which occur when a mass grave is created. They have the potential to be detected regardless of whether the grave is archaeological or forensic. They also show that many of the ‘locating techniques’ are also compatible across the two fields.

Chapter Nine: Discussion

This chapter discusses the findings of this research project in conjunction with the overall research question, aims, and objectives, by answering the following questions:

- What taphonomic signatures do mass graves create?
- What is their effect on the subsoil and surrounding landscape?
- What techniques are most effective for identifying these signatures?

9.1 Taphonomic Signatures of a Mass Grave

The key findings tables presented in Chapter 8, Section 8.1 (pg. 124) highlight that forensic mass graves could show signs of human disturbance, vegetation changes, pollen and spores, soil compression/depressions, disturbed stratigraphy, sedimentation, internal compaction, chemical composition changes, insect activity, microbial activity, VOCs, pH and temperature changes. Whilst archaeological mass graves could exhibit vegetation changes, pollen and spores, soil compressions/depressions, chemical composition changes, and insect activity. They may also present signs of human disturbance sedimentation, internal compaction, microbial changes, VOCs and soil pH changes; however, there are currently no known archaeological exemplars and further research is needed to confirm this. Finally, the findings table shows that changes in the moisture content of the soils are not detectable.

9.2 The Effects Taphonomic Signatures have on the Subsoil and Surrounding Landscape

Mass graves create taphonomic signatures that leave visual, subsoil and chemical traces within the soil and surrounding landscape, which archaeologists can use to identify their presence.

9.2.1 Visual Traces

Visual traces refer to those taphonomic signatures which are visible on the surface, either on or near the grave. These signatures are evidence of human disturbance, vegetation disturbance, surface depressions, and sedimentation.

Human disturbances refer to the presence of footprint impressions, tool marks, and heavy machinery tracks left near the grave and along access routes. The identification of these impressions enables archaeologists to develop a clearer understanding of how the grave was dug, the type of equipment used, and the potential number of perpetrators (Morse et al., 1983; Hochrein, 1997; Dupras et al., 2012; Hunter, 2014; Evis et al., 2016). They also suggest how much planning and forethought went into the digging of the grave, and indicate if the grave has been disturbed, as the site is likely to have two different types of prints or cut marks in the soil if the grave was dug twice. Although tool marks and machine tracks are recorded during forensic investigations and are used as evidence, they are often overlooked during archaeological casework. Hochrein (2002) and Hanson (2004) argue that archaeologists believe these marks do not survive the process of time. Despite this, it is possible to see these kinds of marks years after the grave was created, particularly in clay soils (Hanson, 2004; Dupras et al., 2012; Hunter, 2014). The identification of tool marks in archaeological mass graves could provide insight into the time, manpower, and equipment used, as they would have been created manually rather than with heavy machinery.

The digging and backfilling of a mass grave also alter the vegetation over the grave and within the immediate vicinity because it damages and/or destroys the existing vegetation (Wright et al., 2005). Providing archaeologists with a clear visual marker, unless the area is deliberately concealed, as it will initially appear bare until the vegetation recovers. Nevertheless, even after sufficient time has passed, archaeologists can still use vegetation changes as an indicator that a mass grave is present. Firstly, the aerated soil provides better drainage, aiding vegetation regrowth because the roots can spread with ease and not become waterlogged. Secondly, increases in mineral and nutrient concentration, caused by decomposition, can also stimulate regrowth. Therefore, the vegetation over and immediately surrounding the mass grave will appear healthy and more abundant than those further from the grave. However, this change in mineral and nutrient levels can also have the opposite effect, as increases in concentration can kill vegetation. The invasiveness of digging a grave also potentially damages and/or restricts root systems causing vegetation regrowth to decrease (Bajerlein et al., 2015; Ruotsala, 2020). This damage provides archaeologists with further visual means of identifying the grave because there will be signs of broken, bent and/or trampled vegetation. Marks created by heavy machinery and tools such as spades or mattocks may also be visible on tree roots and trunks closely situated to the grave, the scars of which could remain visible long after the area has recovered (Willey and Heilman, 1987; Bock and Norris, 1997). Although the varied vegetation response can be challenging to interpret, due to every environment being so different, these changes can be used to signify the presence of a mass grave, particularly in forensic casework. Whilst this can also be applied to archaeological casework, these indicators will be harder to identify.

Disturbance to the vegetation leaves invisible traces. Pollen and spore analysis can remain preserved in the landscape and subsoil for many years after the grave was created. This is because they are extremely resistant to biological, chemical and mechanical degradation (Mildenhall et al., 2006; Walsh and Horrocks, 2008; Alotaibi et al., 2020). Suggesting that long after the vegetation has recovered, pollen and spore analysis could take place across forensic and archaeological casework. Due to their small grain size, pollen and spores can be easily transferred between one area and another, therefore, through analysis, they can establish links between evidence, crime scenes, burial sites, suspects and the victims (Walsh and Horrocks, 2008; Alotaibi et al., 2020). As such, pollen and spore analysis has already been successfully used to link primary and secondary graves, including during the investigation into the mass graves connected to the Srebrenica massacre (Long, 2006). However, there is a lack of complete information on where different plants are located, and the techniques which can be used to collect pollen and spore samples necessary to conduct an investigation (Alotaibi et al., 2020). One notable reference containing thorough information on pollen analysis is by Moore et al., (1991), nevertheless, archaeologists would either need to be trained within the field of palynology or a specialist brought in for this technique to be used, particularly in forensic casework.

Finally, the settling of soil within the mass grave creates a visible depression within the landscape. This can be identified through the formation of cracking around the perimeter of the grave caused by the fill pulling away from the grave walls (Morse et al., 1983). Further cracking on the grave's surface is also caused by sedimentation (Morse et al., 1983; Hochrein, 2002a; Dupras et al., 2012). Although it is possible to identify forensic graves with these signatures, there is currently no known archaeological example or experimental research to suggest how long these signatures remain present in the landscape.

9.2.2 Subsoil Traces

Subsoil traces refer to the taphonomic signatures that take place within the soil of the grave, these signatures are disturbed stratigraphy, internal compaction, natural postmortem movement and insect activity.

Digging a grave disturbs the underlying stratigraphy, as it cuts through the strata, permanently interrupting and mixing the removed soil, the subsequent backfilling then causes the formation of new layers and surfaces (Hochrein, 2002a; Evis et al., 2016; Holland and Connell, 2016). This disturbance creates long-lasting signatures in the subsoil as it is an irreversible process, that can only be altered rather than returned to its original state (Harris, 1979a). This disturbed soil will also visually appear different to the undisturbed soil as the mixing of the different layers causes the colour and density to change. Archaeologists can use these features to determine the location of a mass grave in both archaeological and forensic casework.

Internal compaction is caused by the movement of a victim buried alive, creating compaction on either side of the legs and a mountain-like pile of soil above the knees (Wood, 1994; Hochrein, 2002a: 62). Whilst there is a single documented forensic case which shows evidence internal compaction, the case in question is that of the 1988 serial killer Dorothea Montalvo Puente, there is no known archaeological example. Whereas natural postmortem movement is caused by the opening of voids within the grave, as the body decomposes, voids are created that the remains shift into leaving an impression in the soil of where the used to be (Mickleburgh et al., 2022: 560).

Finally, insect colonisation of decomposing bodies under ambient conditions follows a predictable pattern, which can be used to determine the post-mortem interval as the type of insect present is dependent on the stage of decay (Rodriguez and Bass, 1983; Payne et al., 1968; Joseph et al., 2011; Benbow et al., 2013). This means it can be used to identify how long after death the bodies were buried.

However, internal compaction, natural postmortem movement and insect colonisation cannot be used to identify the location of the mass grave. Instead, they can be picked up during the excavation of a test pit or trench, when archaeologists confirm that the presence of subsurface anomalies is a mass grave. Although it is more likely that they will not be discovered until a full excavation is conducted.

9.2.3 Chemical Traces

Chemical traces refer to the taphonomic signatures that chemically alter the soil, these signatures are chemical composition, microbial changes, VOCs, soil moisture content, pH and temperature.

Decomposing remains alter the chemical composition of the soil, decomposition fluid released by the bodies contains nitrogen, carbon, phosphorus, potassium and magnesium (Dent et al., 2004; Statheropoulos et al., 2005; Carter et al., 2007; Benninger et al., 2008; Boumba et al., 2008; Forbes, 2008; Janaway et al., 2009; Stuart et al., 2013; Szelecz et al., 2014; Ueland et al., 2015; Szelecz et al., 2016). This release of nutrients creates a nutrient-rich island around the remains, which impacts both the vegetation and the organisms residing in the soil (Dent et al., 2004; Carter et al., 2007; Benninger et al., 2008; Forbes, 2008; Szelecz et al., 2014; Szelecz et al., 2016). These changes can be detected and used to confirm the presence of a mass grave, however, most of these changes, i.e. total carbon and nitrogen, are only present up to 100 days from decomposition starting (Benninger et al., 2008: 72-73). Suggesting they can only be detected in forensic casework rather than archaeological casework. Nevertheless, phosphorus is regularly tested in archaeological work to indicate the presence of human remains (Farswan and Nautiyal, 1997). García-López et al., (2022) research confirms this, as they were able to detect increased phosphorus levels in two post-Roman burials. Therefore, it can be used to detect and confirm the presence of both archaeological and forensic mass graves.

Decomposition also alters and is affected by the microbes that live within the soil (Carter and Tibbett, 2003; Carter et al., 2010; Pechal et al., 2013; Cobaugh et al., 2015; Damann et al., 2015; Hauther et al., 2015). Metcalf et al., (2015) suggest that soil microbes act as a mediator, which means they become very similar to decomposition microbes found within the body. They respond to the decomposing remains within 24 hours of deposition, thus when the soil is tested using GCxGC-MS, the presence of microbial activity provides archaeologists with another indicator that a mass grave is present. However, currently, it is not known how long microbial changes last, therefore, it could be used to indicate the presence of a recently created forensic mass grave but further research is needed before it can be considered as a way of identifying the presence of an archaeological mass grave.

VOCs make up the odour released during decomposition and change as the body progresses through the stages of decay (Vass, 2012; Caraballo, 2014; Rosier et al., 2016; Dargan and Forbes, 2021). There are 478 VOCs produced during decomposition, 30 of which are unique to decomposing human remains (Vass et al., 2008). This means that they can be used to detect forensic mass graves either through the use of CDDs or using GC-MS. However, further research is needed to determine how the odour profile changes over time and how long it remains detectable.

Regardless of what the soil pH base levels are, decomposition fluid causes it to initially become more basic and then decrease to be more acidic (Rodriguez and Bass, 1985; Vass et al., 1992; Benninger et al., 2008; Haslam and Tibbett, 2009; Bachmann and Simmons, 2010; Schotsmans et al., 2011; Schotsmans et al., 2012; Szelecz et al., 2018; Silva-Bessa et al., 2022). This alteration can be detected in forensic mass graves using pH probes. Although the efficacy of these probes and this approach has not yet been tested in archaeological casework. Therefore, further longer-termed research is required to determine at what point the soil returns to, or whether it returns to its original levels.

Finally, whilst temperature increase speeds up decomposition and temperature decrease slows it down, knowledge of how decomposition affects the temperature of the soil has not been researched (Prangnell and McGowan, 2009; Junkins and Carter, 2017). Again further research is needed to determine if decomposition alters the soil temperature and how long this reaction is detectable.

9.3 Locating Techniques

The key findings tables presented in Chapter 8, Section 8.2 (pg. 125-126) demonstrate that forensic mass graves could be located using a witness-led approach, cartographics, aerial and ground-level images, visual foot search, multispectral imaging, hyperspectral imaging, GPR, EM surveying, resistivity, metal detecting, probing, coring, test pits/trenching, CDDs, thermal imaging, GC, and MS. They may also be detected using historical records, GIS, near-infrared, structure from motion, and LiDAR, however, further research is needed to as there is little research and/or no forensic casework which currently using these methods. The results tables also demonstrate that magnetometry and gravity surveying should not be used as they would prove ineffective.

Archaeological mass graves, on the other hand, could be located using cartographics, historical records, visual foot search, LiDAR, multispectral imaging, hyperspectral imaging, magnetometry, GPR, EM surveying, resistivity, metal detecting, probing, coring, test pits/trenching, GS and MS. There is the potential for near-infrared, structure from motion, CDDs, witness-led approaches and GIS to also be effective in locating archaeological mass graves, however, further research is needed to confirm this. Aerial and ground-level images could also be used to locate mass graves, however, due to the development of photography they are likely to only locate mass graves from WWI onwards. The results tables also show that gravity surveying and thermal imaging should not be used as they would be ineffective.

9.4 Detecting Taphonomic Signatures in Archaeological and Forensic Mass Graves

The application of potentially available tools of detection is dependent on the nature of the mass graves, whilst there are techniques which are more commonly used than others there is no standard approach. This lack of standardisation enables archaeologists and forensic archaeologists to select the tools they believe would be best suited for the environment in which the potential mass grave is located. This can be seen when looking at a number of the case studies presented in Chapter Two, Thornton Abbey (A3) used geophysical and topographical surveys as well as trenching, whilst San Vincente Cemetery (F1) discusses the use of aerial photographs, trenching and witness testimonies. Pheasant Wood (WWI) used aerial photographs, historical records such as a letter written by one of the soldiers, a soldiers memoirs, and the 21st Bavarian Reserve’s war diary, they also applied topography, geophysics, GPR, metal detecting and test excavations. Often the detection tools used are the ones that best suit the environment or which can cover a large area in a short space of time.

Section 9.3 establishes that there is a wide range of different techniques that could be used to detect the presence of taphonomic signatures associated with archaeological and forensic mass graves. However, it also highlights that several techniques would be unsuitable. As such, this section discusses each of the techniques that could be used in archaeological and/or forensic casework, summarises what each technique is and the taphonomic signature(s) it could detect.

9.4.1 Initial Detection

Witness testimonies are regularly used in forensic mass grave casework, as they are often the only information available to suggest the presence of an undiscovered mass grave. However, for an investigation to start or continue, the available information needs to be detailed enough to aid with the case (Blau et al., 2018). A witness-led approach uses testimonies recorded in the form of either a witness statement, formal interview, and/or an accompanied site visit (Anderson et al., 2008; Hanson, 2016). Witnesses can provide location-based information, such as the general area the mass grave is located in, the potential number of victims interred within possible access routes, and the type of terrain. This information not only leads the archaeologists to the potential site, but also acts as a guide for the type of equipment that can be used in the area, and informs the broader search strategy (Cheetham et al., 2008; Card and Baker, 2014).

Rather than being used to detect taphonomic signatures, cartographics and historical records are used to narrow down the general area of interest. Geological and topographical maps are commonly examined to identify visible, natural and built features, highlight areas where a mass grave is unlikely to be dug, show the access routes in and out of the area, and indicate the history of the potential site (Cheetham et al., 2008; Dupras et al., 2012). As such, it is used across both archaeological and forensic casework. Whereas, historical records provide references to what the area may have been used for prior to the grave’s creation. Archives often hold images, elevation data, documentary records of witnesses and perpetrators, receipts, and logs of the logistics involved in mass murder (Cheetham et al., 2008: 195). Whilst the use of historical records is largely associated with archaeological casework, it can also be relevant in forensic casework as there is often a delay between the act of creating a grave and the investigation of it due to the instability in the region.

A further initial detection technique used to narrow down the general location is aerial imagery. Aerial images are a series of overlapping scaled photographs taken of a specific area, which can be used to monitor changes in the landscape and reveal patterns not easily visible from the ground (Reeves, 1936; Hunter and Cox, 2005; Morgan et al., 2010; Burns, 2016). Archaeologists can identify shadows created by the grave, variations in soil colour, changes in vegetation and marks in the soil (Killam, 2004; Greene and Moore, 2010). Therefore, it can be used to detect vegetation alterations, disturbed stratigraphy, evidence of human disturbance and surface depressions. However, the effectiveness of using aerial images is dependent on the type of setting the mass grave is located. A grave situated within a dense forest cannot be captured by aerial images because the lens cannot see through the tree canopy. Whilst it is potentially easier to detect a grave situated in an open field, this is also dependent on if the images were taken before the area had a chance to recover. Nevertheless, aerial images could be used to detect forensic mass graves and those dug during either the First or Second World Wars. However, whilst it can show archaeological monuments and structures, there is no way of knowing, from aerial imagery alone, if the patterns in the ground are that of an archaeological mass grave.

Ground-level photographs are taken from different vantage points on the ground, often they are captured during or just after an event (Ferrándiz and Baer, 2008; Brutin, 2020). Since the Nuremberg and Tokyo trials, they have been successfully used as visual evidence within international trials (Ristovska, 2017; Duffy, 2018). The example provided in Chapter Four (pg. 65-66) highlights that these photographs could show evidence of a mass grave and its potential location. However, there is often little to no context surrounding these images that and the changes that occur to the landscape over time make it hard to pinpoint a location (Borcher, 1982). Nevertheless, when applied in conjunction with the other initial techniques, they could be used to narrow down the location of a potential mass grave and/or provide archaeological and forensic teams with the evidence needed to start an investigation.

9.4.2 Remote Sensing

Using the information gathered during the initial stages of the search, remote sensing is used to narrow down the general area of interest by acquiring information about a site or object without physically coming into contact with it (Lillesand et al., 2015). This is particularly helpful for mass grave casework because they are often located in remote areas and politically unstable/war-torn countries.

Hyperspectral sensing captures hundreds/thousands of electromagnetic wavebands, which can be used to detect and discriminate between objects on the surface of the ground (Sabins, 1996; Adão et al., 2017; Murray et al., 2018; Decker and Borghetti, 2022). This means it can be used to detect vegetation anomalies and soil disturbances caused by the digging and backfilling of a mass grave. This is because hyperspectral sensing can detect differences in the spectra emitted/reflected by both younger and older vegetation (Ruffell and McKinley, 2008; Barbazon et al., 2020). Whilst this technique shows promise in locating both archaeological and forensic mass graves, processing and analysing the data is complex and time-consuming due to how much data it captures (Adão et al., 2017). As with hyperspectral sensing, multispectral sensing obtains images by recording separate wavelength intervals which can be used to detect vegetation alterations and micro-topography created by ground disturbances (Sabins, 1996; Adão et al., 2017; Rocke and Ruffell, 2022). Whilst multispectral sensing can be applied to the detection of both archaeological and forensic mass graves, it collects a large amount of surface data which makes the processing and analysis stage complex (He and Zhao, 2018; Janoušek et al., 2021).

Thermal imaging devices, on the other hand, collect and display thermal patterns emitted by objects without requiring visible light (Vollmer and Möllmann, 2010; DesMarais, 2014; Amendt et al., 2017). This means it could be used to detect temperature changes in the soil of a mass grave. However, the cooling of the body during algor mortis means this signature is only visible for a short time, although research has shown that larval masses generate heat, potentially expanding the search window with this technique (Payne, 1965; Rodriguez and Bass, 1985; Goodbrod and Goff, 1990; Anderson and Vanlaerhoven, 1996; Joy et al., 2006; Slone and Gruner, 2007). Nevertheless, environmental conditions also need to be considered. Although a mass grave will emit a bigger heat signature than a single grave, due to the body mass, the depth of the grave, geographical region and season can cause this technique to be ineffective (Voss et al., 2011). Therefore, it has the potential to be used in forensic mass graves but would be ineffective in older/archaeological mass graves.

Near-infrared sensing can be used to detect vegetation that has been stressed by changes to the soil nutrients and aeration (Carter, 1993; Murray et al., 2018). Whilst these changes could be caused by the presence of a mass grave, further research is needed to determine if it is possible to use this technique to detect archaeological and forensic mass graves.

LiDAR records the time it takes for a pulse of near-infrared or visible green light to hit the surface of the earth and gets reflected back to the sensor (Corcoran, 2016; Dong and Chen, 2017; Koopman, 2017; McManamon, 2019). This records specific location points with a high degree of accuracy, which is then generated into 3D models of the ground (Dong and Chen, 2017; Historic England, 2018). These models show depressions and/or structural outlines on the surface of the earth. This technique has been extensively applied to archaeological casework to map known burial mounds and cemetery grave plots, predict the location of unknown burial mounds and detect ground elevation changes as the grave fill settles (Riley, 2009; Chase et al., 2011; Weitman, 2012; Artz et al., 2013; Corcoran, 2016; Koopman, 2017; Corcoran et al., 2018). This indicates that LiDAR would be an effective technique for detecting surface depressions caused by the presence of a mass grave. Whilst this technique is widely used throughout the field of archaeology, there is currently little to no research or evidence of its application within forensics. Nevertheless, with further experimental research, this technique could be used alongside others, such as a visual foot search, multispectral and hyperspectral sensing, and geophysics, to facilitate the process of locating a mass grave.

SfM is a photogrammetry technique used to produce accurate 3D digital models of the ground, which can map small to medium-sized areas with more accuracy than LiDAR (Shafiekhani et al., 2017; Historic England, 2018; Murray et al., 2018). It can also be used to collect data in remote areas, as it can work offline, making it effective in mass grave casework as they are regularly situated in remote locations (Historic England, 2018; Murray et al., 2018). Although research into the use of SfM in reconstructing archaeological non-clandestine graves and surface remains has been successful, further research is needed into its applicability in locating mass graves (Levy et al., 2014; Murray et al., 2018).

Finally, GIS can be used to build digital images of the landscape by combining layers of data (Bray and Frieman, 2008). By plotting and analysing sites of interest against aerial images and digital maps, archaeologists can see how the area has changed over time (Darvill, 2022). In the case of locating mass graves, archaeologists may be able to detect vegetation changes, disturbed stratigraphy and evidence of human disturbance. However, further research into how it can be utilised as a locating technique is required.

9.4.3 Initial Site Visit

The use of a foot search is well-established across archaeology and forensics. It is used to collect and record surface evidence. This evidence could be in the form of vegetation alterations, disturbed soil, trace evidence, prints and compression marks left behind by tools, shoes and vehicle tracks (Birzer, 2012; Ghanem and Sobh, 2021). There are several search patterns which archaeologists or search teams can select to ensure the search is organised and structured, and to minimise the risk of damaging or missing evidence.

Alongside a visual foot search, CDDs can also be used to search a designated area of interest, as they are trained to locate and indicate the strongest concentration of human-specific odours at various stages of decomposition and in different geological settings (Redmann, 2011; Alexander et al., 2016). The taphonomic signature that CDDs detect is VOCs, however, it is unknown whether they respond to the complex combinations of VOCs or core VOCs making it hard to standardise CDD training (Stadler et al., 2012; Stejskal, 2013; Westcott, 2018; Glavaš and Pintar, 2019; Dargan and Forbes, 2021). Whilst they are used in forensic casework and have the potential to be successful in locating forensic mass graves, there is currently a lack of substantial evidence and research into using CDDs in archaeological casework. Therefore, further research is needed before it is possible to say that they can be used to find archaeological mass graves.

9.4.4 Geophysics

Another detection technique used once the general area has been narrowed down is geophysical surveying, as it is the most effective way of locating stratigraphic disturbances related to the digging and backfilling of a grave (Berezowski et al., 2021).

One geophysical technique is EM surveying, which has the potential to map large areas for subsurface changes in quick succession because it does not need to make direct contact with the ground (Cheetham, 2005; McKenzie and Ryan, 2008; Reynolds, 2011; Pringle et al., 2012). With enough contrast between the grave fill and undisturbed soil, it can be used to detect differences in the ground's electrical conductivity and magnetic susceptibility which could be caused by the mass grave and/or metallic artefacts buried with the remains (Cheetham, 2005; Dalan et al., 2010; Dupras et al., 2012). However, further research is needed into its applicability in archaeological and forensic casework, as studies by Molina et al., (2016) indicate that it was ineffective at detecting simulated graves.

One method that is already well-established across archaeology and forensics is GPR. GPR detects and records changes in the grave fill and undisturbed soil (Gaffney and Gater, 2003; Herz and Garrison, 1998). However, its effectiveness is dependent on the grave’s depth, size and soil composition (Powell, 2004; Pringle et al., 2008; Ruffell et al., 2009). This is because in very wet soils the pulse is only able to penetrate a few centimetres meaning that it may struggle to detect a deeply buried mass grave (Herz and Garrison, 1998; Hammon et al., 2000; Ristić et al., 2020; Bagaskara et al., 2021; Berezowski et al., 2021). Mass graves are also large, the area being sampled may be directly over the top of the grave, preventing archaeologists from seeing a contrast in the disturbed and undisturbed soil.

Magnetometry detects variations in the earth’s magnetic field to map buried structures and/or features without excavating or making direct contact with the ground (Conyers, 2018; von der Osten-Woldenburg, 2020). These variations are caused by disturbance to the natural stratigraphy of the soil. Once the raw data is processed into a visual map of the surveyed area, it is possible to see patterns caused by the buried features and determine if the anomaly is a potential mass grave (Benech, 2007; Mohamed-Ali et al., 2012). Whilst it is another technique that is effectively applied to archaeological casework and could be used to detect an archaeological mass grave, however, it is too sensitive to be used in a forensic capacity. This is because considerable soil disturbance or metallic debris is picked up as background noise, causing false readings and misinterpretation of data (Hunter and Martin, 1996; Neubauer et al., 2003; Kalacska et al., 2008; Dupras et al., 2012). However, mass graves are typically situated within remote areas, implying there may not be a lot of background disturbance. The presence of a magnetic anomaly may also cause a feature to standout from the surrounding area as it is an unusual result. Therefore, in certain locations, the use of magnetometry to detect forensic mass graves could potentially be considered.

A third well-established technique, used for locating grave sites associated with both archaeology and forensics is resistivity. Resistivity measures the resistance of electrical currents within the subsoil to detect a buried feature and/or object, the disturbed soil created when a mass grave is dug forms a low resistance anomaly (Herz and Garrison, 1998; Banning, 2002; Gaffney and Gater, 2003; Dupras et al., 2012; Schmidt, 2013; Berezowski et al., 2021). However, it can only be used in certain locations because the probes need direct contact with the ground. This means a mass grave concealed under tarmac, concrete and/or another hard surface will not be detectable with resistivity (Hansen et al., 2014).

Finally, metal detectors can be used to detect objects that may be concealed within archaeological and forensic mass graves, such as bullet casings and/or artefacts. Although a metal detector can pick up traces of iron more easily due it is metallic properties, it can also detect nickel, aluminium and zinc.

9.4.5 Destructive Detection

Destructive detection, also known as an invasive approach is used to confirm the presence of a mass grave.

Soil probing can determine the differences in subsoil density and compactness (Morse et al., 1983; Killam, 2004; Dupras et al., 2012; Holland and Connell, 2016). Whilst it is used in both archaeology and forensics, it should only be applied when there are no other options, as there is no way of knowing how far under the surface the body mass is, which could cause damage to the remains (Wright et al., 2005; Fiedler et al., 2009).

Similar to probing, soil coring removes cores of soil at regular intervals in and around the area of interest, to identify disturbed and undisturbed stratigraphy (Banning, 2002; Dupras et al., 2012; Holland and Connell, 2016; Banning, 2020). Extracted cores can also be sent for soil analysis, through the use of GC and MS, archaeologists can detect the presence of organic molecules and VOCs associated with the decomposition of human remains (Colombini and Modugno, 2009; Stefanuto et al., 2017; Dubois et al., 2018; Gruber et al., 2018). Whilst GC and MS are used regularly across archaeology and forensics, soil coring should be used with extreme caution to avoid damaging the buried remains and evidence.

Finally, the use of test pits and trenching is carried out during the final stages of the search, due to their destructive nature (Pringle et al., 2012). Considered a reliable and standard technique across both fields, they are used to identify changes in the soil, human remains, potential evidence and the depth of the grave without conducting a full-scale excavation (Anderson et al., 2008). By initially digging a test pit or trench away from the area of interest and then within, archaeologists can confirm if the stratigraphy has been disturbed, and the presence, absence and/or concentration of human remains to verify the existence of a mass grave (Anderson et al., 2008; Bartelink et al., 2016: 283).

Chapter Ten: Conclusion

The overall aim of this project was to determine, which, if any, of the taphonomic signatures commonly found at burial sites can be used as a method for locating both archaeological and forensic mass graves.

It is evident from this research that three key taphonomic signatures have a long-term visual impact on the subsoil and surrounding landscape and could be used as a method for detecting a mass grave. Firstly, tool marks, vehicle tracks and shoe print impressions left within the immediate vicinity of the mass grave and along access routes can be recovered, as was evidenced during the investigations of numerous mass graves associated with the Yugoslav wars. These impressions not only provide a visual marker in the landscape that archaeologists can use to locate the mass grave, but they can also provide an understanding of how the grave was dug and whether it was later disturbed. This enables archaeologists to determine if further searches for secondary mass graves are needed. Whilst this taphonomic signature is already considered and recorded during a forensic investigation, it is often overlooked in archaeological casework as it is generally assumed that it will not survive and is therefore of little interest to archaeological practitioners.

Secondly, vegetation alterations can also be used to detect the presence of a mass grave. Due to the size of a mass grave, large areas of vegetation are likely to be initially uprooted and the grave can be detected through the presence of bare soil over the grave’s surface and surplus soil piled or spread around its perimeter. Once the vegetation has recovered, there are still markers that can be used to detect mass graves. Therefore, although harder to spot, vegetation alterations could be used to locate both archaeological and forensic mass graves. Pollen and spore analysis can also be used along side this to identify links between the mass graves, execution sites and/or other evidence.

Thirdly, disturbed stratigraphy can initially be detected visually within the landscape because the disturbed soil may appear to have a different colour to the surrounding undisturbed soil due to the mixing of the strata layers. Although the stratigraphy of the area will never return to its natural state, once the area has had time to recover, other techniques would need to be used to detect the disturbed stratigraphy.

Whilst three aforementioned taphonomic signatures can cause distinctive visual changes to the landscape, there are many other signatures which, if detected, can also indicate the presence of a mass grave.

Archaeological and forensic investigations start with an initial desk-based assessment, which is designed to gather information about a potential mass grave site. The research presented in Chapter Four shows that in a forensic mass grave casework an investigation often cannot take place without the information provided by witnesses. Aerial and available ground-based images can then be used in conjunction with these statements to corroborate witness testimonies and can show changes in the landscape caused by the digging of a mass grave. Archaeologically, it is often historical records that hold the best source of information about the potential location of a mass grave.

Whilst foot searches can be successfully used to locate the taphonomic signatures mentioned above, it is not always possible to use this technique, particularly if the casework is undertaken in conflict or post-conflict zones, where the area may be inaccessible or unsafe. Nevertheless, remote sensing methods could be used as an alternative, or complementary, search technique, as they could be used to detect many of the taphonomic signatures discussed within this research in both archaeological and forensic contexts. Research into the use of geophysics to detect subsoil taphonomic signatures has shown that GPR is most effective at locating mass graves across archaeology and forensics, whilst magnetometry and resistivity have been effectively applied to archaeological casework.

However, invasive techniques are required to confirm the presence of a mass grave, the most effective and reliable of which is the use of test pits or trenching, as they enable archaeologists to confirm the presence or absence of a mass grave and record the site’s stratigraphy without conducting a full excavation. Finally, chemical changes within the grave also provide archaeologists with an indication of the presence of a mass grave because it creates a unique environment due to the volume of remains within the body mass. As decomposition in a mass grave is an elongated process, there is the potential for archaeologists to use factors such as soil pH and chemical changes to either confirm the presence of a grave using soil analysis techniques or detect the grave through the use of cadaver dogs.

This project has highlighted that, internationally, there is currently a low recovery rate of mass grave victims. It is, therefore, necessary for cheaper, less time-consuming and more effective methods to be considered in the hope that this will improve existing recovery rates. This study has achieved this by critically evaluating existing approaches used in archaeological and forensic practice, and through using this dataset, has identified which methods and taphonomic signatures offer the best chances of success thereby providing empirical data to inform forensic practice.

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Personal Communication

Dr Laura Evis

Appendices

Archaeology Legislation

England and Wales

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